10th INTERNATIONAL SCIENTIFIC CONFERENCE ON KINESIOLOGY

OPATIJA, CROATIA, SEPTEMBER 12-15, 2024

CURRENT TRENDS AND INNOVATIONS IN KINESIOLOGY RESEARCH:

PROCEEDINGS

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Dario Novak and Dario Škegro

Organiser:

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CURRENT TRENDS AND INNOVATIONS IN KINESIOLOGY RESEARCH: PROCEEDINGS

FOREWORD

Dear Conference participants,

With great pride and enthusiasm, we present the Proceedings of the 10th International Scientific Conference on Kinesiology, titled "Current Trends and Innovations in Kinesiology Research." This milestone event marks the tenth jubilee gathering since our inaugural conference in 1997 in the historic city of Dubrovnik. Over the years, this conference has grown in scope and significance, becoming a pivotal platform for exchanging knowledge and ideas in the field of kinesiology.

This year, we are delighted to feature more than 200 papers and abstracts, which will be presented in oral and poster formats. These contributions reflect the diverse and dynamic nature of current research in kinesiology, spanning a wide array of topics. We are honored to host ten invited lectures by esteemed scientists from around the globe, who will share their insights in the following sections: Adapted Physical Activity and Kinesitherapy, Medicine of Sport and Exercise, Biomechanics and Motor Control, Physical Education, Sports Recreation, Top-level Sport, Social Sciences and Humanities, Physical Conditioning and Injury Prevention, Management of Sport, Research Methodologies, Data Science, and Emerging Research Methods. We hope that everyone will find topics of interest and will advance their scientific and practical knowledge.

This conference brings together over 350 participants from 29 countries, underscoring the international appeal and collaborative spirit of our scientific community. Besides the fact that our institution educate professionals for Physical Education system wich is of crucial importance to us, we also educate professionals in the field of top-level sports. Some of those professionals were on the teams of Croatian athletes who won seven Olympic medals at the recent Olympic Games and we are especially proud of it.

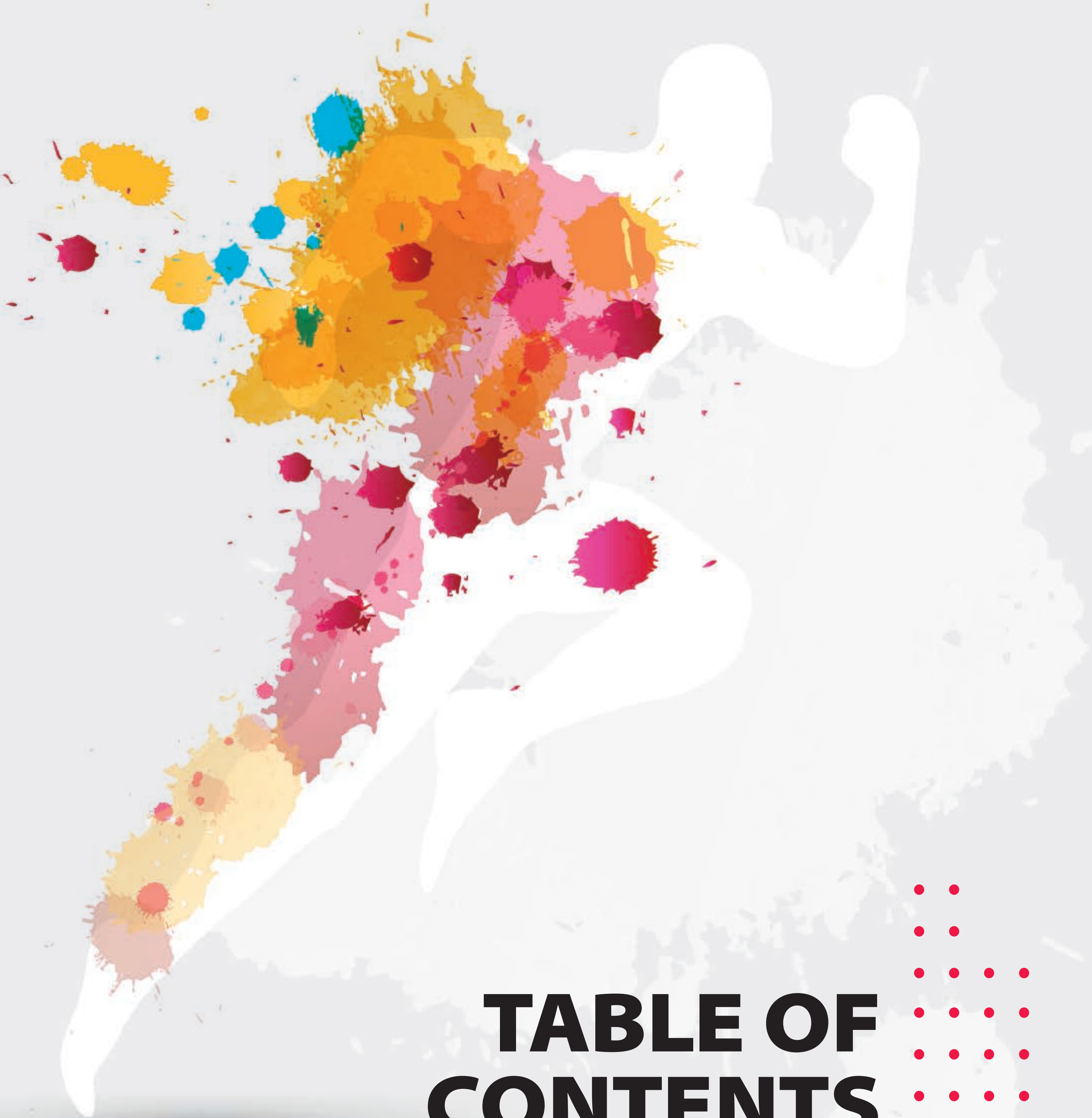
For the first time, the conference is co-organized with the Croatian Academy of Sciences and Arts, the most esteemed scientific institution in Croatia. This collaboration, along with our seven partner institutions: Masaryk University Faculty of Sports Studies; Comenius University Bratislava Faculty of Physical Education and Sport; University of Novi Sad Faculty of Sport and Physical Education; Sports University of Tirana; University of Split Faculty of Kinesiology; Josip Juraj Strossmayer University in Osijek Faculty of Kinesiology; Beijing Sport University, and our collaborating institution, University of Ljubljana Faculty of Sport, exemplifies the strength and unity of our academic network.

We extend our heartfelt gratitude to all the authors, more than 500 of them, for their invaluable contributions. Special thanks go to the section editors for their tremendous editorial work, the technical editors of the Proceedings book, and all the individuals involved in organizing this successful scientific event. Your dedication and hard work have made this conference a great success.

This conference not only showcases the latest scientific advancements but also enhances the visibility of the Faculty of Kinesiology, University of Zagreb, on the world scientific map. We look forward to continuing this journey in 2027.

Editors

CURRENT TRENDS AND INNOVATIONS IN KINESIOLOGY RESEARCH: PROCEEDINGS



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CURRENT TRENDS AND INNOVATIONS IN KINESIOLOGY RESEARCH: PROCEEDINGS

INVITED LECTURES

INVITED LECTURE

PERSPECTIVES OF ARTIFICIAL INTELLIGENCE IN HUMAN MOTION ANALYSIS

Arnold Baca
University of Vienna, Centre for Sport Science and University Sport, Austria

Introduction Introduction As in many other fields of application, the availability of miniaturized sensors for measuring a wide variety of parameters, powerful computer technologies and a wide range of artificial intelligence methods open more and more support possibilities for human motion analysis. **Methods** We present current technologies [1], developments and prospects for the use of respective systems and illustrate this by examples from our research. **Results** These advances include technologies and systems based on the automated recognition of human poses and human movements, which, for example, enable to make recommendations in the event of incorrectly executed forms of movement (e.g. [2]), assist in identifying events, enable automated classification of classes of executed movements, initiate immediate reactions in critical situations or allow interaction in virtual environments. In addition, systems for providing feedback and recommending individual exercises based on personal performance levels, as well as data-based methods for training control or predicting performance gains through the type and amount of training that do not interfere with physical activity, are highlighted. The expected potential of such innovative approaches, limitations and risks are critically reflected. Among those, the black box approach of respective multidimensional statistical procedures is discussed. Recommendations derived from the algorithm typically have a certain probability of error and can only be weakly justified, which also has ethical implications. Explainable AI (XAI) methods could provide a way out to a certain extent in the future (e.g. [3]). **Conclusion** The potential of AI methods shows a broad spectrum of possibilities to support human motion analysis and its practical application, but also to change it significantly.

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INVITED LECTURE

NEUROMUSCULAR TRAINING FOR PERFORMANCE DEVELOPMENT AND INJURY PREVENTION IN YOUTH ATHLETES

Urs Granacher
University of Freiburg, Department of Sport and Sport Science, Germany

Long-term athlete development (LTAD) is a structured pathway to optimize the development from talented children into elite athletes. LTAD is a risky pathway with many pitfalls which is why only few youth athletes have the physiological and psychological potential to become an elite athlete. To enable a successful and injury-free talent development, adequate and age-appropriate training regimes are needed. Neuromuscular training is a multimodal training regime involving exercises for the promotion of muscle strength and power (including plyometrics), balance, agility, and change-of-direction speed. Over the past years, original research studies and systematic reviews with meta-analyses proved the effectiveness of neuromuscular training on muscular fitness, motor skills, sports performance, and resistance to injuries in youth athletes (1, 2). The aim of my talk will be to provide empirical evidence on the performance and injury preventive effects and dose-response relations of neuromuscular training conducted with youth athletes.

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INVITED LECTURE

OPTIMIZING SPORT ENVIRONMENTS TO SUPPORT ATHLETE MENTAL HEALTH

Kristoffer Henriksen
University of Southern Denmark, Institute of Sport Science and Clinical Biomechanics, Denmark

While physical prowess and performance have historically dominated the discourse surrounding athletic excellence, the significance of athlete mental health in optimizing athletic performance and overall welfare is increasingly recognized. Today, we agree that mental health is a core component of any culture of excellence, but it is also complex, and key stakeholders in elite sport struggle to negotiate their roles and responsibilities in promoting it.

The majority of research in athlete mental health has taken an individual perspective and looked at the prevalence of specific disorders, individual risk and protective factors, coping strategies and evidence based methods of treatment. Although very important, this research cannot stand alone, because athlete mental health is not an individual affair. Indeed, sport environments can nourish or malnourish athlete mental health and influence help-seeking behaviour and stigma processes (Henriksen, Schinke, McCann et al., 2020).

In this talk, I will invite you to look beyond the individual athlete and understand how athletes' mental health is very linked to the environments in which they train and compete. The recently published Team Denmark applied model of mental health (Henriksen, Diment et al., 2023) reveals layers of the environment – the training environment, leadership, everyday life, and cultural norms – that influence mental well-being. The model posits firstly that efforts to promote mental health should target all athletes and not only those that are languishing, and secondly that prevention, detection, and treatment processes should include all levels of the environment. The model provides stakeholders with a lens through which they can analyze, talk about, and optimize how their sport environments support the mental health of their athletes.

Such a holistic and ecological perspective suggests that elite sport is not a win-at-all-costs endeavor. Rather, sports organizations should openly and critically review the degree to which their environment is a resource for their athletes' mental health.

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INVITED LECTURE

OPTIMIZING PATIENT OUTCOMES WITH COOLING STRATEGIES IN CLINICAL SETTINGS

Antonia Kaltsatou
University of Thessaly School of Physical Education and Sports Science, Greece

Introduction
Climate change poses a significant challenge to global health, particularly by exacerbating thermoregulatory problems in vulnerable populations. As global temperatures continue to rise, the incidence of heat-related illnesses is expected to increase. This places a greater burden on healthcare systems and disproportionately affects individuals with impaired thermoregulatory functions, such as the elderly, patients with chronic illnesses, and those with neurodegenerative disorders. Effective cooling strategies are essential in clinical settings to mitigate these risks and optimize patient outcomes. Aim: To present the current state of cooling technologies and methodologies, highlighting their application and effectiveness in various clinical conditions.

Methods
A comprehensive literature search was conducted to gather relevant studies and data on cooling strategies used in clinical settings. The review focused on evaluating the efficacy of these strategies in managing heat-related illnesses and improving thermoregulation in vulnerable patient populations such as patients with multiple sclerosis.

Results
Evidence from recent clinical studies demonstrates the efficacy of various cooling strategies in improving patient outcomes. The results show that these strategies are effective in reducing core and skin temperatures and enhancing patient comfort. Key findings include a. the effectiveness of cooling methods in lowering body temperature, b. comparative analysis of different cooling technologies and their application in clinical settings, c. patient outcomes related to comfort and overall health improvements.

Conclusions
Future directions for cooling strategies in clinical practice will be addressed, emphasizing the need for continued research and innovation to develop more efficient, patient-friendly solutions. By adopting and optimizing these cooling strategies, healthcare providers can significantly enhance the quality of care for patients with thermoregulatory problems, ultimately improving their health outcomes in the face of a warming climate.

INVITED LECTURE

MACHINE LEARNING IN PERFORMANCE ANALYSIS - KING'S ROAD OR PLAYING GROUND?

Martin Lames
Technical University of Munich, Germany

Abstract
In recent years, performance analysis (PA) has evolved more and more into a big data science. At least for the most prestigious competitions, such as leagues and championships in team sports with a high degree of professionalization, for each match a huge amount of information is recorded containing video images, action feeds and position data. Machine Learning (ML) is a bundle of different methods each designed for and capable of conducting analyses on large data sets. This presentation starts with a brief introduction on different ML-approaches (supervised, unsupervised and reinforcement learning) with examples from sports.

Three typical scenarios are mentioned, how ML is in use in sports. Many applications import ML as a tool for sports problems such as pattern recognition and image understanding for position or limb detection in football. Then, sports phenomena are used as show-cases for ML research aiming at improving ML methods, frequently by sports fans ("playing ground"). Finally, there are ML applications designed specifically for sports studies ("king's road"), either trying to analyze the structure of performances (theoretical performance analysis) and/or of supplying support for sports practice (practical performance analysis) (Lames, 2023).

Some problems are discussed that prevent effective ML-studies in sports. Many studies using ML with sports data are not designed for PA purposes, frequently they do not ask the right questions due to lacking domain knowledge, and thus fail to give real support. Moreover, it is critically discussed whether ML applications that aim at facilitating the work of analysts, for example by structuring matches in rallies resp. ball possession phases or automatically detect configurations of interest on the pitch, are of the same scientific value like studies that try to create new insights in PA, for example by modelling new performance indicators not available so far.

Based on these considerations, necessary requirements are listed that facilitate the successful use of ML in sports. A core role plays "true" interdisciplinarity which not only means that a ML project in sports employs expertise from informatics as well as sports science and practice, but also a deep mutual understanding of the two sides.

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INVITED LECTURE

APPLYING BEHAVIORAL ECONOMICS TO PROMOTE PHYSICAL ACTIVITY

Ichiro Kawachi
John Lehman Loeb
Frances Lehman Loeb
Harvard University T. H. Chan School of Public Health, United States of America

According to the World Health Organization, 31% of adults and 80% of adolescents in the world do not meet the recommended levels of physical activity. There are many barriers to achieving daily exercise goals, including lack of health literacy, budget constraints (time and money to engage in regular exercise), and environmental barriers (e.g., absence of neighborhood greenspace). The field of behavioral economics focuses on one particular barrier, known as want/should conflicts. That is, many people are aware that they should be exercising regularly, but they want to relax on the couch and watch television instead. Behavioral economics provides a number of insights and recommendations for helping to close the gap between people's intentions and actions. These include the use of temptation bundling, message framing, the optimal design of incentives (financial and nonfinancial), commitment devices, the use of social norms, and gamification. In my talk I will discuss the application of these concepts from behavioral economics to improve the design of interventions to increase compliance with daily physical activity recommendations.

INVITED LECTURE

THE POLITICS OF SPORT AND HEALTH: HOW NEOLIBERALISM INFORMS PHYSICAL ACTIVITY POLICY AND LIMITS ITS SUCCESS

Dominic Malcolm
Loughborough University, School of Sport, Exercise and Health Sciences, United Kingdom

Introduction/Purpose
Policies promoting physical activity for health have rapidly developed across the globe in recent years. They enjoy broad political support and are largely uncritically accepted across the academic community. While the speed and scale of this development is partly attributable to the developing scientific knowledge base, it is a truism that 'all policy is political'. Consequently, these policy developments must be understood with reference to the politics of global health and, in particular, neoliberalism.

Methods
A multi-method approach, combining: historical analysis of policy development; critical discourse analysis of policy content; qualitative interview data with members of the public; time series survey data of physical activity trends.

Results
The World Health Organization's (WHO) endorsement of physical activity coincided with the organisation's strategic re-alignment with neoliberal principles. Analysis of the most recent and globally significant WHO (2020) Guidelines on Physical Activity and Sedentary Behaviour, shows that the underlying logics of neoliberalism inform policy goals and the selection of evidence evaluating policy. Interview data demonstrate how neoliberalism fosters particularly ideologies of health which in turn promote forms of exercise which diverge from health maximising behaviours. Time-series survey data show that policies promoting physical activity lead to the extension rather than reduction of health inequalities.

Conclusions
Policies promoting physical activity closely align with the neoliberal political ideologies of WHO and many Western nations. Neoliberalism has both enabled the rapid development and broad political acceptance of PAHP, but concomitantly leads to outcomes which limit and confound the broader policy goals.

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INVITED LECTURE

ENDOCRINE ASPECTS OF SPACE PHYSIOLOGY

Felice Strollo
IRCCS San Raffaele Pisana, Rome, Italy

In space, most systems – especially those regulating bone/muscle metabolism and reproduction – undergo changes resembling those observed during senescence but recover within weeks or months after return. This suggests space as a possible experimental model for studying "reversible aging processes." Meanwhile, we are preparing for extensive and systematic human space exploration, which is made possible by the many studies showing no life-threatening consequences of microgravity. A well-known effect of space flight is bone demineralization accompanied by hypercalcemia, as repeatedly described after the first missions. The loss of anti-gravitational muscle tone and tendon tension, and especially the lack of weight-bearing function in micro-gravity, causes unloading-dependent sarcopenia due to increased protein breakdown with reduced muscle mass/strength and bone atrophy consequent to osteoblast inhibition and osteoclast activation with initially relatively high, yet luckily self-limiting over time calcium losses in urine and stool. Only a few studies have addressed possible hormonal changes behind that, so many questions are still unanswered. However, active Vitamin D3 and parathyroid hormone levels are regular in space. At the same time, testosterone production tends to decrease in the beginning and returns to normal over time. Also, cortisol levels, expected to increase due to an unusual environment interpreted as stressful by the layman, were found either stable or decreasing over time and so not directly involved in the abovementioned changes. The subtle hypothyroid state often described in astronauts and the frequently reported low-grade inflammation due to insulin-resistance could also be part of the game by increasing muscle fat content and hindering bone apposition mechanisms. However, most recent studies under normal iodine intake conditions do not support such a hypothesis. So, due to the still unclear endocrine picture attained, well-designed, specific studies should try and compensate for shortcomings in this area. The widespread use of repeated treadmill exercise sessions against elastic bungees in microgravity partially explains the significant slowing down of the devastating catabolic trend described in the first decades of space flight. Still, no specific prevention tool has proven entirely effective so far. Such consideration should encourage conducting more in-depth space-related studies on combined nutritional-exercise strategies against osteo-sarcopenia to exploit their results on Earth for successful rehabilitation.

INVITED LECTURE

THE PHYSIOLOGY OF ENDURANCE EXERCISE PERFORMANCE: MORE MENTION FOR THE FOURTH DIMENSION

Andrew M. Jones
University of Exeter, Department of Sport and Health Sciences, United Kingdom

This talk will introduce the concept of physiological resilience or durability and highlight its importance as an independent determinant of endurance exercise performance. This can be illustrated through studies on truly elite athletes. For example, in Nike's 'Breaking 2' marathon project, measurements of VO2max, fractional utilization of VO2max and running economy in a fresh condition provided reasonably accurate predictions of performance and were used to identify which elite athletes were best equipped physiologically to attempt to break the 2-hour marathon barrier. Of the athletes selected, however, only Eliud Kipchoge has achieved this feat, and his performances are exceptional compared to his peers – suggesting that he has superior resilience compared to his rivals. Recent studies indicate that not only do physiological variables such as exercise efficiency and critical power deteriorate during prolonged, fatiguing exercise, but that the extent of this deterioration is highly variable between individuals (for example, 1-32% for critical power). Moreover, in the field, the degree of uncoupling between heart rate and speed during endurance exercise has been shown to be an important metric of performance. The basis for these differences in neuromuscular fatigability and metabolic stability will be discussed with comparisons drawn between elite East African runners and their Caucasian counterparts. With greater recognition of the importance of physiological resilience to success in endurance sports, it is important to consider and/or develop interventions which might help athletes improve their resilience and therefore their performance. These interventions may include training methods, nutrition (particularly carbohydrate intake), ergogenic aids, pacing strategy and advancements in sports technology (including running "super shoes").

INVITED LECTURE

(UN)HEALTHY USE OF TIME IN THE POPULATION: WHAT IS KNOWN AND HOW TO FIND OUT MORE?

Željko Pedišić
Victoria University, Australia

The use of time is a health-related factor that each individual in the population is exposed to 24 hours per day. Therefore, to better understand and potentially improve public health, it is important to conduct epidemiological research on health-related time-use compositions and methods for promoting healthy time use in the population. Such research has recently been termed *time-use epidemiology*, and it is becoming increasingly popular internationally. The most studied time-use composition in this newly conceptualised field of research consists of the amounts of time spent sleeping, in sedentary behaviour, and in physical activity. In public health research, these components of time use were traditionally considered as independent factors and studied separately. However, through a series of methodological articles published over the past 10 years, we have promoted a new, integrative approach to studying sleep, sedentary behaviour, and physical activity and provided recommendations for future research. As part of this work, we developed the Viable Integrative Research in Time-Use Epidemiology (VIRTUE) framework, defining the following research areas: (1) methods in time-use epidemiology; (2) outcomes of (un)healthy time use; (3) prevalence and trends of (un)healthy time-use compositions; (4) determinants of (un)healthy use of time; and (5) interventions to improve time use in the population. Alongside summarising the VIRTUE framework, in this lecture I will present findings of my recent studies in each of its five research areas. This will encompass two main lines of research in time-use epidemiology; one exploring time-use compositions using compositional data analysis and the other related to recently issued public health guidelines that incorporate recommendations for sleep, sedentary behaviour, and physical activity. The presentation will conclude with a gift.

ADAPTED PHYSICAL ACTIVITY AND KINESITHERAPY

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SYMPTOMS OF NECK MUSCULOSKELETAL DISORDERS IN WOMEN AND MEN ADMINISTRATIVE WORKERS

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Abstract
The aim of this study is to determine the existence of differences in the influence of age, gender, and incorrect seating habits as risk factors for the prevalence of MSDs neck Symptoms between women and men administrative workers in the Republic of Croatia. The results show that almost 75% of women and more than 59% of men administrative workers experienced MSDs neck Symptoms in the last 12 months. The difference in the prevalence of MSDs neck Symptoms between women and men is statistically significant ($p<0.00$). There were no statistically significant age differences in either women ($p<0.27$) or men ($p<0.95$) with and without MSDs neck Symptoms. This study showed that incorrect sitting with pronounced spinal flexion are a significant risk factor for the higher prevalence of MSDs Symptoms in both women and men administrative workers.

Keywords: Musculoskeletal disorder Symptoms, neck, administrative workers, postural and movement habits, spinal flexion, men, women.

Introduction

Information technology is evolving rapidly, leading administrative workers to spend longer hours seated and working at computers. Consequently, this impacts the musculoskeletal system of administrative workers. Previous studies have documented the existence of neck Symptoms of musculoskeletal disorders (MSD) among administrative workers over the past 12 months. The rates range from 38,6% (Kumar et al., 2015), 45% (Johansson, 1994), 47% (Melrose et al., 2007), 48% (Prodanovska-Stojcevska et al., 2012), 51% (Juul-Kristensen & Jensen, 2005), 55% (Klussmann et al., 2008), 55,6% (Zejda et al., 2009), 64% (Ayanniyi et al., 2010) to 76% (Griffiths et al., 2011). It can be assumed that MSDs in general, including MSDs in the neck area, are one of the major health and financial challenges. MSDs can impair the health of workers, reduce productivity, cause sick leave, and strain the healthcare system. The etiology of MSD, including neck problems, is complex and multifaceted.

Among the above-mentioned risk factors for the occurrence of MSDs in the cervical part of the spine, special emphasis is placed on physical and biomechanical risk factors such as repetitive movements, uncomfortable and static body positions, and prolonged sitting or standing in the same position. The natural aging process involves the deterioration of hydrophilic proteins (Thiret, 2018) and gradually alters the relationship between the vertebrae, thus affecting the overall statics of human organisms. Altered statics, i.e. poor posture while working at the computer, can contribute to MSDs neck Symptoms, both in the workers and in the school population. For example, a study conducted in Croatia on students of science and mathematics gymnasium who spend a significant portion of their day at the computer (Kovač et al., 2017) revealed that even in high school age, 24% of students experienced neck problems. Based on the above, the question arises regarding incorrect posture and age as risk factors for the onset and progression of MSDs Symptoms in the neck. Another question that emerges is whether there is a difference in the representation and risk factors of the prevalence of MSDs Symptoms in the neck area between men and women. It is known that women tend to be more flexible than men (Alter, 1996), have weaker upper body strength compared to men in relative terms (Wilmore, 1974) a higher amounts of adipose tissue, and a higher heart rate (Šimek, Nakić and Trošt, 2003), etc. Therefore, the purpose of this study is to determine the existence of differences in the influence of age, gender, and postural and movement seating habits as risk factors for the prevalence of MSDs neck Symptoms among women and men administrative workers in the Republic of Croatia. The objectives of this study are to determine in women and men administrative workers: a) the prevalence of MSDs neck Symptoms (ache, pain, discomfort), b) whether gender is a significant risk factor for the prevalence of MSDs Symptoms in the neck area, c) to determine whether age is a significant risk factor for the prevalence of MSDs Symptoms in the neck area, and d) the association of MSDs Symptoms in the neck area with pronounced spinal flexion during sitting.

Methods

Sample of subjects

The sample of subjects consists of women and men administrative workers employed in the Republic of Croatia. In November 2021, a link to an anonymous online survey questionnaire created through the digital Google platform, was sent to the official e-mail addresses of the data subject. A total of 1,620 respondents responded to the questionnaire. After the exclusion of non-administrative work respondents and respondents who had acute lifelong trauma, 1,307 respondents entered data processing, out of which 68.17% (N 891) were women and 31.82% (N 416) were men.

Sample of variables

Standardised Nordic questionnaires for the analysis of musculoskeletal Symptoms (Kuorinka et al., 1987) was applied to determine the prevalence of Symptoms of MSDs by self-assessment. To determine postural-movement habits, respondents answered 10 independently designed questions with photos. For this study, only data related to the neck and postural movement habits related to question number 1 were processed, i.e. correct and incorrect sitting. The original questionnaire can be found at the link: https://forms.gle/dnezaeLfda19dy6b9.

Data analysis

The results were processed by the STATISTICA 14.0.0.15 software package. Descriptive statistics methods were applied to determine the prevalence of MSDs neck Symptoms and postural movement habits in women and men administrative workers. To determine the statistical significance of differences between subjects with and without Symptoms of MSDs by age, a t-test for independent samples was used. The association between the MSDs Symptoms in the neck area and subject's sitting posture was determined through a series of logistic regression analyses. These analyses included age, body mass, gender, service, and weekly workload in hours, thereby adjusting the *odds ratio* (OR) for the influence of these variables on the association between the MSDs Symptoms and postural-movement habits of subjects. To determine the statistical significance of differences between subjects with and without MSDs neck Symptoms in relation to the regularity of postural-moving habits, a Chi-square test was applied with a descriptive presentation of the frequencies of individual groups.

RESULTS AND DISCUSSION

Prevalence of MSDs neck Symptoms

The results of descriptive statistics (Table 1) show that almost 75% of women and more than 59% of men administrative workers in the Republic of Croatia experienced MSDs neck Symptoms in the last 12 months.

Table 1: Number of subjects, percentages of MSDs neck Symptoms in women and men and Chi-square test to determine the statistical significance of differences of MSDs Symptoms in relation to gender

Body part	Gender	MSDs Symptoms YES	MSDs Symptoms NO	Chi-square	*p*	Phi
Neck	W	N 667 74,86 %	N 224 25,14 %	32,34	*p*<0,00	*0,16*
	M	N 247 59,38 %	N 169 40,62 %			

Gender as a risk factor for the prevalence of MSDs neck Symptoms Table 2: T-test for independent samples to determine the statistical significance of differences between subjects with and without MSDs neck Symptoms at age

The results of the Chi-square test (Table 1) shows that the difference in the prevalence of MSDs neck Symptoms between women and men is statistically significant (*p<0.00*). Neck MSDs Symptoms were higher for the female population and in a Jon et. al. (2015) study. The neck is the part of the body that most often lacks stability (Cook, 2003). It is also known that women are more flexible than men (Alter, 2004). Perhaps, increased cervical spinal women flexibility (the part of the body that most often lacks stability) is one of the risk factors for a higher prevalence of MSDs neck Symptoms in women in comparison to men subjects.

Age as a risk factor for the prevalence of MSDs neck Symptoms

Age is one of the factors that is often mentioned in the literature as a risk factor for MSDs occurrence and progression (Kazeminasab et.al., 2022). T-test for independent samples was used to determine the statistical significance of differences in both, men and women subjects, with and without MSDs neck Symptoms, in regard to age (Table 2).

Table 2: T-test for independent samples to determine the statistical significance of differences between subjects with and without MSDs neck Symptoms at age

Body part	Gender	Mean Age With MSDs neck Symptoms	Mean Age Without MSDs neck Symptoms	N With MSDs neck Symptoms	N Without MSDs neck Symptoms	*p*
Neck	W	41,79	42,60	667	224	0,27
	M	41,86	41,92	247	169	0,95

The results of descriptive statistics show that the average age of both women and men is approximately 42 years. The results of the t-test for independent samples showed that there was no statistically significant age difference in either women ($p<0.27$) or men ($p<0.95$) with and without MSDs neck Symptoms . Although it is generally accepted that the age of subjects is to be identified with the Symptoms of MSDs (Jesus, 2020), the results of this study indicated differently. Age differences within genders were not evident for neck MSDs Symptoms nor in the Jon et. al. (2015) study. This conclusion should be cautiously interpreted and considered that there are probably some other risk factors due to which administrative workers have neck problems even in younger chronological age.

The association of MSDs neck Symptoms in relation to correct or incorrect way of sitting

The association of MSDs neck Symptoms in relation to correct or incorrect way of sitting was determined by applying logistic regression analysis, and the significance of differences was calculated by the Chi-square test among both women and men.

The results of descriptive statistics (Table 3) show that 58.32% of women who have MSDs neck Symptoms apply an incorrect seating pattern daily. OR logistic regression analysis suggests that these women subjects who sit daily with a spine flexion, which is an incorrect body position, are 1.32 times more likely (95% CI, 2.07-5.69) to have higher prevalence of MSDs neck Symptoms compared to those subjects who avoid this mechanism of cumulative trauma. The Chi-square test showed that the difference between women who have and who do not have MSDs neck Symptoms in relation to way of sitting is statistically significant (*Chi-square 3.76, $p<0.05$, Phi 0.06*).

Table 3. Descriptive statistics, logistic regression analysis and Chi-square test of female subjects who have and do not have MSDs neck Symptoms, and who sit correct or incorrect

Women – Incorrect seating with spinal flexion - Neck			
OR 1.32, (95% CI, 0.97-1.80) Chi-square 3.76, $p<0.05$, Phi 0.06			
MSDs neck Symptoms	Incorrect	Correct	Σ N
Yes	389	278	667
	58,32%	41,68%	
No	114	110	224
	50,89%	49,11%	
Σ	503	388	891

The results of descriptive statistics show that 71.66% of respondents who have MSDs neck Symptoms apply an incorrect seating pattern daily. OR logistic regression analysis suggests that men subjects who sit daily with a spine flexion, which is an incorrect body position, are 3.2 times more likely (95% CI, 2.10-4.85) to have prevalence of MSDs neck Symptoms compared to those subjects who avoid this mechanism of cumulative trauma. The Chi-square test showed that the difference between subjects who have and who do not have MSDs neck Symptoms in relation to the regularity of postural-moving habits is statistically significant (Chi-square 31.27, p<0.00, Phi 0.27).

Table 4. Descriptive statistics, logistic regression analysis and Chi-square test subjects who have and do not have MSDs neck Symptoms, and who sit correct or incorrect

Men – Incorrect seating with spinal flexion - Neck			
OR 3.2, (95% CI, 2.10-4.85), Chi-square 31.27, p<0.00, Phi 0.27			
MSDs neck Symptoms	Incorrect	Correct	Σ N
Yes	177	70	247
	71,66%	28,34%	
No	75	94	169

It is known that the prevalence of MSDs Symptoms is influenced by several factors from physical and biomechanical, through organizational and psychosocial to individual risk factors. Some of them can be influenced and some cannot be influenced. This paper dealt with the issue of two risk factors, one of which is possible to influence (postural and movement habits) while the other is not (age). This study showed that incorrect sitting with pronounced flexion in the lumbar and thoracic part of the spine and the protraction in the cervical part of the spine is a significant risk factor for the higher prevalence of MSDs Symptoms in both women and men administrative workers, regardless of age.

Conclusion

The results of this research have shown that the presence of MSDs neck Symptoms in administrative workers in Croatia are in line with the results of a research in the world according to the available literature. This study showed that women have a statistically significantly higher prevalence of MSDs Symptoms compared to men. But men who sit incorrectly are more likely to have increased MSDs neck Symptoms than women. It can be concluded that although it is completely clear that it is extremely important for both women and men to adopt and automate correct postural and movement habits, it seems that this importance is somewhat higher in men than in women. The results of the study showed that there is no statistically significant age difference in either women or men with and without Symptoms of MSDs neck Symptoms. It is assumed that neither women nor men age is a not significant risk factor for the occurrence and progression of MSDs neck Symptoms. For business sustainability, it is important to eliminate the MSDs risks. This study showed that incorrect sitting is a significant risk factor for the prevalence of MSDs Symptoms among both women and men administrative workers, regardless of age. The limits of this study are reflected in the testing of a lesser number of risk factors for the occurrence and progression of MSDs neck Symptoms. Future research, along with other risk factors, should examine the quantity and quality of postural movement habits in parallel, all-in order to obtain information on the magnitude of the impact of certain risk factors on the prevalence of MSDs neck Symptoms in administrative workers.

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UNVEILING THE MYSTERIES OF RYR-1: PHYSIOTHERAPY RESULTS OF ACHIEVING MOTOR CONTROL

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Abstract
Neonatal hypotonia requires early intervention from different professionals and neurologists. The aim of this paper is to emphasise the importance of neurological physiotherapist's intervention in a case study of a child with the ryanodine receptor type 1 (RYR-1) rare disease (RD).

An early physiotherapy assessment was completed by the neuro-developmental Bobath physical therapist at home and the therapy started on the 16th day after the birth of the child. The Vojta therapy started a few days after this. So, physiotherapy started even before the condition was genetically diagnosed. 61 physical therapy sessions took place with two trained and experienced physiotherapists. The child's head control – as a key feature of motor control – was delayed in first trimester because the child had axial hypotonia. That is very low muscle tone, affecting the neck and the trunk of the body, with onset at birth.

The child´s motor control was improving and at the age of 10 months old, his development is no longer delayed. Motor control is established and he is able to stand independently. He took his first independent steps at the age of 12 months and 5 days. Further long-term recommendations are interdisciplinary management and support.

Keywords: achieving motor control, neuro motor development, neuro-physiotherapy, rare disease, ryanodine receptor type 1 (RYR-1).

Introduction
Calcium signalling in muscle cells triggers muscle contraction, a key physiological function necessary for postural control: posture achievement and maintenance, movement and various bodily activities. During muscle activation, the action potential triggers the release of calcium - from the sarcoplasmic reticulum into the cytoplasm - through calcium release channels called ryanodine receptors type 1 (Endo, 2009).

In neuro-physiology of skeletal muscle, calcium signalling is a critical process for initiating and regulating muscle contraction. In response to excitation signals, the ryanodine receptor type 1 (RYR-1) channels play the key role in releasing calcium ions from the sarcoplasmic reticulum into the cell fluid.

Rare disease ryanodine receptor type 1 (RYR-1) is genetic muscle disease and there is another equivalent term: RYR-1 myopathy (Clinical Care Guidelines, RYR-1 foundation, 2020).

It is characterized by hypotonia or low muscle tone, which can result in mild to severe muscle weakness, which interferes with motor development. Some babies with RYR-1 gene conditions may have difficulties with swallowing, chewing and breathing rhythm caused by hypotonic muscles.

The clinical picture may also include stiffness, cramps and spasms and slowly progressive or non-progressive muscle weakness. Each combination of RYR-1 gene mutation is different.

Hypotonia is related with myopathies. It can cause muscle weakness and lack of spontaneous movement. Lack of experience would lead to lack of coordinated movement. Hypotonia also leads to increased range of motion and hypermobility. Hypermobility interferes with stability. If muscle tone normalization is not achieved through physiotherapy, it can lead to difficulties with posture and movement control.

Certain forms of RYR-1 related diseases can lead to heat intolerance and severe form of muscle breakdown, called rhabdomyolysis. A potentially fatal reaction to certain forms of anaesthesia, known as malignant hyperthermia, can appear.
In the literature, it is difficult to find more specified detailed data concerning newborns related to a genetic RYR-1 rare disease and the achievement of motor development.

Currently, no specific medicine nor treatment recommendations exists for RYR-1 rare disease, so physiotherapists concentrated in therapy on optimizing posture and movement patterns and motor coordination to facilitate functional mobility and independence.

Educating parents on appropriate handling techniques, positioning strategies and home exercises is crucial for supporting the infant's motor development and optimizing functional outcomes. Parental involvement in therapy promotes consistency and reinforces therapeutic goals between sessions.

The goal is to build-up muscle tone and to facilitate the acquisition of motor skills.

Methods

A male baby was born very hypotonic, from the healthy parents. The methods that were used in establishing a diagnosis and establishing neuro-motor control:

- Genetic testing (WES Blueprint genetics, Espoo, Finland) The results show that the patient is compound heterozygous for two variants in the RYR-1 gene, both of which are pathogenic.
- Electromyography test measures presents signs of myopathy in the tested muscles.
- Neurologist prescribed medicine Pyridostigmine which indirectly increases the concentration of neurotransmitter acetylcholine at the neuromuscular junction. The medicine was taken on a trial basis, from the 3rd to the 7th month of the baby´s age. It was decided to discontinue the medicine, because the child made excellent motor progress even after the medicine was discontinued.
- Therapeutic strategies targeting RYR-1 dysfunction included neuro-physiotherapy according to Bobath and also to the Vojta. The Bobath physiotherapist started initial assessment with the baby on the 16th day of his life. There were 36 neurodevelopmental Bobath treatments undertaken at the child´s home and at the same time 25 Vojta treatment were done at the clinic, until the child was 10.5 months old.

Results

Physiotherapy plays a crucial role in the management of babies with RYR-1 gene conditions.
With an emphasis on the neuro-physiotherapy, in first ten months of life the child actively mastered all milestones. At the age of 10.5 months the child could stand up independently while holding on to furniture.

In first trimester of life the head control was not established. It was established in 5th month.

On the end of second trimester, when the child was 6 months old, trunk control was not completely established due to lower basic muscle tone. Independent sitting was marginally insecure at the beginning of the 7th month of life and the child sat in a kyphotic back pattern.

In the middle of third trimester, when the child was 8 months old, the basic muscle tone was more established (table 1). Most of the time, the basic muscle tone was normal but was periodically interrupted by hypo. The child was actively changing positioning from prone - over the side - to the sitting on the floor. And vice versa.

On the beginning of fourth trimester, when the child was 10 months old, he was actively and independently mastering standing up through one point kneeling.

Table 1. Motor development of gross motor skills of child with RYR-1 rare disease in first year of life
He took his first independent steps when 12 months and 5 days old. In terms of motor skills, mastering balanced standing and walking as such, is a process that follows. The most important thing is that the child´s development is no more delayed.

Trimester	I	II	III	IV
Months	0 - 3	4 - 6	7 - 9	10 - 12
Normal timing for control of a:	head delayed	trunk	pelvis	legs
Motor control	- some head	marginally delayed	in time	in time
Achievements	control	- head control - sitting with kyphotic back	- stable sitting - from prone to sitting & vice versa - 4-point kneeling - high kneeling	- actively standing up when 10 months old - first independent steps when 12 months and 5 days old

Discussion

Currently, no specific treatment exists for most of myopathies, due to RyR-1 mutations (Robinson et all, 2006). Physiotherapy meets the specific needs of a baby with a RYR-1 gene condition, aiming to optimize the baby´s motor development.

Early intervention has a crucial role: it started before any abnormality appeared. In this case neuro-physiotherapy started shortly after the birth: on the 16th day of a baby´s life, even before the condition was genetically diagnosed. The first treatment started with an initial assessment of a baby´s status, the things he can/not do. There was constant oxygen saturation monitoring and apnea monitoring. Based on assessment, physiotherapist set specific goals in collaboration with the parents regarding facilitation of normal motor development. The physiotherapy interventions included chest physiotherapy: breathing exercises and early positioning techniques.

The goal was to build-up muscle tone and to facilitate the acquisition of motor skills. By achieving motor control at the child´s 10th month of age, orthopedic problems were avoided. Play-based activities were used to encourage skill acquisition.

Conclusion

Neuro physiotherapy was carried out from the very beginning.

The set goal has been met by achieving developmental milestones: to achieve verticalization, hand manipulation and independence. All of the above would not have been achieved if motor control had not been mastered.

Due to physiology of RYR-1 rare disease, long-term management and support of physiotherapists is an on-going process that evolves as the baby grows and develops. Physiotherapists monitor the baby´s progress, adjust treatment plans as needed and provide long-term support to address changing needs and challenges associated with the RYR-1 gene condition. Preventive measures include limiting exercise in hot and humid environments and consulting a physiotherapist to develop a structured incremental exercise program at lower intensities (NORD Rare Diseases, 2021).

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CORRELATIONS BETWEEN ANTHROPOMETRIC VARIABLES AND VARIABLES FOR THE ASSESSMENT OF MOTOR AND CARDIORESPIRATORY FITNESS

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Summary
The military system requires maintaining a desirable level of anthropometric status and physical fitness throughout the career of military personnel, which requires their constant monitoring, evaluation and guidance. Accordingly, the aim of the study is to determine which anthropometric characteristics affect the success in tests of muscular and cardiorespiratory endurance. The research involved 2351 soldiers, eight variables in order to acess nutritional status (body height, body weight, waist circumference, hip circumference, neck circumference, Waist-hip ratio, Body Mass Indeks, Body Adiposity Indeks), five tests to assess muscular and cardiorespiratory endurance (push-up, sut-ups, pull-up, 3200 m run and 270 m run) and a questionnaire for the number of smokers. The obtained results were processed using descriptive statistics and correlation analysis methods. The results indicate that there is a low to medium high correlation of most anthropometric variables and variables for endurance assessment in both categories. The highest negative correlation was obtained between body weight and variable pull-up (-0.58) in smokers, and the highest positive between variable abdominal circumference and variable running 3200 m (0.47) in non-smokers. The obtained results indicate that a relatively large percentage of active military personnel in the tested sample smoke, and in addition to the above has an increased risk to health. Because of the above, it is necessary to intervene in order to encourage military personnel to reduce undesirable physique and cigarette consumption.

Keywords: nutritional status, physical fitness, smoking status

Introduction

Insufficient levels of physical activity and sedentary lifestyle are factors that negatively affect human health and are consequently responsible for an increased risk of developing chronic diseases and contribute to increased mortality. Physical activity has a preventive effect on human health and has a positive effect on reducing the incidence of cardiovascular disease, while a decrease in physical activity levels is associated with lower productivity and a greater number of absences from work. These trends are increasingly visible in particular populations where maintaining an optimal level of physical fitness is often of vital importance. Namely, physical fitness is the basic assumption for reaching a desirable level of combat readiness and together with psychological stability represents the basis for conducting combat operations. A high level of physical and psychological readiness enables successful execution of combat tasks and allows better reaction to stressful situations. Therefore, the importance that fitness preparation has in the military training system is evident, regardless at the military specialty. The aim being to develope and stabilize primary and specific functional motor skills, focused primarily on the development of strength and muscular endurance (Carlson, 2016, Burley et al. 2018.).

Despite this, research indicates that the consequences of a sedentary lifestyle and inappropriate nutrition are also present in particular populations and cause an increase in overweightness and a decrease in physical activity. The problem of obesity is related to metabolic syndrome (MS), respectively to an increased blood pressure, a higher incidence of high blood pressure, disorders in lipid metabolism and elevated plasma glucose levels, which ultimately extremely negatively affects the training and readiness of military personnel, and consequently reduces the overall combat readiness. In addition, according to research, in military systems the prevalence of smoking is higher than that of the civilian population, which further increases the health risk and ultimately negatively affects the performance of military tasks. The military vocation implies maintaining physical fitness at the required level, for many years, which requires continuous monitoring and guidance, in order to prevent injuries and prevent undesirable deviations (Carlson, 2016, Knapik et al. 2017.). Research indicates a negative association of BMI, WHR index, waist and neck circumference with muscular endurance. Therefore, one of the goals of this study is to examine the correlations between anthropometric variables and variables for assessment of motor and cardiorespiratory fitness.

Due to the simplicity of calculation and the satisfactory reliability of the body mass index (BMI) it is used in research as a framework measure of nutritional status (Mišigoj-Duraković et al. 2014). However, in the military population, care should be taken when interpreting this index, because the majority of population are men with a high proportion of muscle mass.
Research indicates that a measure of waist circumference is a better predictor of metabolic syndrome because the distribution of body fat in the upper body represents a greater risk for the development of the disease. Research also indicates that a

measure of abdominal circumference is more correlated with muscular endurance in military individuals rather than BMI and the percentage of fat tissue (Dyrstad et al. 2019., Pavelić Karamatić, 2021.).

In accordance with the above, and the fact that research indicates that body composition assessment is an effective method for assessing physical fitness, a study was conducted, on a sample of soldiers, with the aim of obtaining knowledge about their anthropometric, smoking and motor status and in order to determine possible correlations between anthropometric variables and variables for the assessment of motor and cardiorespiratory fitness.

Methods

The study was conducted on a sample of 2351 soldiers, male, based on the regulations on determining health, mental, physical and safety conditions for entering the system. The sample of variables consisted of five anthropometric variables (body height, body mass, abdomen circumference, hip circumference and neck circumference). ITM, WHR and BAI were obtained from the measurements. Muscular and cardiorespiratory endurance was tested in accordance with the above regulations, with the following tests: push-ups in 2 minutes, sit-ups in 2 minutes, pull-ups, running 3200 m and running 270 m.

The subjects first passed anthropometric measurement. Body height was measured by an anthropometer, and the body height value was read with an accuracy of 0.5 cm by measuring the distance from the floor to the top of the scalp. Body weight was measured with a digital scale, with an accuracy of 0.5 kg. Then, their waist, hips and neck circumference was measured, using a centimeter tape, with the measurement accuracy of 0.1 cm. After anthropometric measurement, the subjects performed tests for muscular and cardiorespiratory endurance. The tests were conducted with a 20 minute break after the first test and 10 minute break after each consecitive test, beginning with 270 m run,push-ups, sit-ups, pull-ups and concluded with running 3200. Data on smoking status was collected through a questionnaire. The questionnaire had only one question - smoker/non-smoker. A smoker was considered a subject who had smoked at least one cigarette in the last three months.

Statistica for Windows software package (ver. 13.0) was used to process the collected data. The level of statistical significance $p < 0.05$ was applied. For all variables, central and dispersive parameters were calculated: arithmetic mean (AS), minimum (MIN) and maximum (MAX), standard deviation (SD), and the normality of the distribution was tested by the Kolmogorov-Smirnov test. The results obtained are presented in Table 1.

Body mass index (BMI) was obtained from the ratio of body mass to body height square (TM/TV2 (kg/m2)). According to the World Health Organization, soldiers who had a BMI < 18.5 kg/m2 were classified in the group of underweight, BMI > of 18.5 and < 24.9 in the group of normally nutritional status, BMI > of 25 and < 29.9 in the group of overweight and BMI > 30 were classified in the group of obese. Waist-hip ratio (WHR) was obtained from the ratio of waist circumference and hip circumference (OB/OT (cm)). WHR index above 0.9 in men and 0.8 in women is an indicator of the risk type of obesity.

The body adiposity index (BAI) was obtained from the ratio of the hip circumference to the product of height and root height and by subtracting the number 18 (BAI = ((hypocircumference)/((height)1.5) - 18)).

According to the circumference of the abdomen, the subjects were classified into three groups with regard to increased risk to health: low or health-friendly (OT < 94 cm for men and OT < 80 cm for women), high or excessive (OT 94 – 101.9 cm for men and 80 – 87.9 cm for women), very high with an increased risk for health (OT > 102 cm for men and OT > 88 cm for women).

Partial correlation analysis was used to determine the association between anthropometric variables and variables for the assessment of muscular and cardiorespiratory endurance. The obtained Pearson correlation coefficients are shown in Table 2.

Results

Table 1. shows descriptive parameters for age, body mass, body height, waist circumference, hip circumference, neck circumference, BMI, WHR, BAI, push-up, sit-up, pull-up, running 3200 m and running 270 m. Of the total sample, 1.0% (0.04%) of the respondents were underweight, 932 (39.6%) had a normal nutritional status, 1301 (55.3%) were overweight and 117 (4.9%) were obese.

According to the obtained values, the WHR value above 0.9 had 1494 subjects, which implies that 63.5% of respondents have a risky type of thickness. According to the circumference of the abdomen, the respondents were classified into three groups. 1380 soldiers (58.7%) were classified in the low or acceptable risk group, 633 soldiers (26.9%) in the high or excessive risk group and 338 (14.4%) in the very high-risk group for health. In total, there were 1094 smokers (46.53%) and 1257 non-smokers (53.46%).

Table 1. Descriptive indicators of anthropometric and motor variables

VARIABLE	C	N	AS	MIN	MAX	SD
AGE (year)	T	2351	31,1	19,0	55,0	7,6
	S	1094	31,3	19,0	53,0	7,6
	N	1257	30,9	20,0	55,0	7,6
BODY MASS (kg)	T	2351	84,3	53,0	128,0	10,7
	S	1094	89,5	57,0	124,0	11,6
	N	1257	84,7	53,0	128,0	10,5
BODY HEIGHT (cm)	T	2351	180,0	153,0	206,0	6,6
	S	1094	180,0	159,0	206,0	6,4
	N	1257	180,0	153,0	200,0	6,7
WAIST CIRUMFERENCE (cm)	T	2351	91,3	59,0	128,0	9,6
	S	1094	91,4	62,0	128,0	9,6
	N	1257	91,3	59,0	127,0	9,7
CHIP CIRCUMFERENCE (cm)	U	2351	99,3	60,0	123,0	7,8
	S	1094	99,1	60,0	121,0	7,8
	N	1257	99,5	61,0	123,0	7,9
NECK CIRCUMFERENCE (cm)	T	2351	39,3	24,0	48,0	2,5
	S	1094	39,1	24,0	47,0	2,5
	N	1257	39,4	27,0	48,0	2,6
ITM (kg/m2)	T	2351	25,9	17,5	37,6	2,8
	S	1094	25,7	18,9	37,6	2,9
	N	1257	26,0	18,5	36,4	2,7
WHR (cm)	T	2351	0,9	0,6	1,3	0,1
	S	1094	0,9	0,7	1,2	0,1
	N	1257	0,9	0,6	1,3	0,1
BAI	T	2351	23,04	5,8	38,7	3,5
	S	1094	22,9	5,8	33,4	3,4
	N	1257	23,2	8,6	38,7	3,6
PUSH-UP	T	2351	51,7	4,0	95,0	11,7
	S	1094	49,9	4,0	88,0	10,4
	N	1257	53,3	23,0	95,0	12,4
SIT-UP	T	2351	59,3	26,0	100,0	14,0
	S	1094	57,0	26,0	100,0	13,1
	N	1257	61,4	28,0	100,00	14,4
PULL-UP	T	74	9,6	4,0	20,0	4,0
	S	32	8,9	4,0	20,0	4,3
	N	42	10,2	4,0	18,0	3,7
RUN 3200m (sec)	T	2351	938,6	660,0	1183,0	88,5
	S	1094	953,9	690,0	1183,0	83,6
	N	1257	925,6	660,0	1157,0	90,3
RUN 270M (sec)	T	1080	63,6	50,0	82,0	4,7
	S	484	63,9	50,0	81,0	4,5
	N	596	63,2	53,0	82,0	4,8

LEGEND:
C–category, T–total, S-smoker,N-non-smoker,N –sample of respondents, AS – arithmetic mean, MIN – minimum score, MAX-maximum score, SD- standard deviation.

Table 2. shows partial correlation values between anthropometric variables and variables for assessing muscular and cardiorespiratory endurance in the overall sample, in smokers and non-smokers. Correlation coefficients that are statistically significant are indicated in red. The same indicate a low to medium high correlation between variables.

The highest negative correlation was obtained between variables body weight and variable pull-up (-0.58) in smokers, and the highest positive between variable waist circumference and variable running 3200 m (0.47) in non-smokers. The study found a relatively large percentage of smokers (46.53%) and people who had a risky type of obesity (63.5%), and a high or very high risk to health (41.3%). The highest percentage of soldiers were in the group of overweight (55.3%).

Table 2. Correlation values between anthropometric and motor variables

VARIABLE	CATEGORY	PUSH-UP	SIT-UP	PULL-UP	RUN 3200M	RUN 270 M
BODY MASS	TOTAL	-0,30	-0,31	-0,32	0,34	0,31
	SMOKER	-0,29	-0,28	-0,58	0,34	0,28
	NON SMOKER	-0,33	-0,36	-0,13	0,37	0,33
BODY WEIGHT	TOTAL	-0,10	0,01	-0,21	-0,02	-0,02
	SMOKER	-0,10	0,01	-0.20	-0,02	-0,03
	NON SMOKER	-0,09	0,00	-0,21	-0,03	-0,03
BMI	TOTAL	-0,29	-0,37	-0,22	0,41	0,38
	SMOKER	-0,27	-0,34	-0,51	0,41	0,35
	NON SMOKER	-0,32	-0,43	0,01	0,45	0,42
WHR	TOTAL	-0,29	-0,36	-0,19	0,33	0,33
	SMOKER	-0,27	-0,36	-0,16	0,33	0,34
	NON SMOKER	-0,29	-0,37	-0,20	0,33	0,33
BAI	TOTAL	-0,20	-0,27	-0,20	0,29	0,24
	SMOKER	-0,16	-0,24	-0,42	0,28	0,21
	NON SMOKER	-0,24	-0,30	-0,04	0,31	0,26
WAIST CIRUMFERENCE	TOTAL	-0,41	-0,45	-0,39	0,44	0,41
	SMOKER	-0,35	-0,42	-0,53	0,42	0,37
	NON SMOKER	-0,45	-0,49	-0,26	0,47	0,44
HIP CIRUMFERENCE	TOTAL	-0,29	-0,29	-0,35	0,30	0,25
	SMOKER	-0,23	-0,25	-0,57	0,28	0,20
	NON SMOKER	-0,33	-0,32	-0,18	0,32	0,29
NECK CIRUMFERENCE	TOTAL	-0,25	-0,30	-0,31	0,32	0,30
	SMOKER	-0,26	-0,29	-0,49	0,32	0,26
	NON SMOKER	-0,25	-0,33	-0,15	0,35	0,34

Legend:
BMI – body mass indeks, WHR – waist – hip ratio, BAI – body adiposity indeks.
The marked p-values are significant with $p \leq 0.05$

Discussion
The results of the study confirmed and supplemented the already known developments in terms of the problem studied. The obtained correlation coefficients indicate a statistically significant correlation between most anthropometric, motor and cardiorespiratory variables. Pearson correlation coefficients indicate the greatest negative association between anthropometric variables and the pull-up variable, in the smoking category. All other motor and cardiorespiratory variables are most correlated with the variable waist circumference. Of the derived BMI indices most were associated with the variable running 3200 m, the WHR index with the variable sit-ups and the BAI index with the variable running 3200m. The study obtained a relatively high percentage of smokers in a sample that is higher than the percentage of smokers in civil society, and the percentage of smokers in military systems obtained from other studies.

Conclusion

The obtained results confirm the results of other studies, according to which the measure of waist circumference is a better indicator of obesity and increased risk for health than BMI, and is more related to results in tests for the assessment of motor and cardiorespiratory fitness. In accordance with the results of the research, and with the aim of preventing and eliminating undesirable conditions, it is necessary to carry out systematic monitoring of anthropometric, motor and smoking status. It is also necessary to give greater importance to the measure of the circumference of the abdomen when assessing the health and motor-functional status of military personnel.

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PARA BADMINTON WORLD CHAMPIONSHIPS PERSPECTIVES FROM 2013 TO 2024

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Abstract
Para Badminton is a sport gaining increasing popularity worldwide, which has led to its inclusion as a full medal sport at the Paralympic Games 2021 in Tokyo. Each athlete is classified into one of the six Sport Classes before competing at the international level, ensuring fair competition by grouping athletes based on how their physical impairment affects their performance as badminton players. For this paper, the available data about the played matches from Para Badminton World Championships in 2024 and 2013 were compared in order to gain a clearer understanding of the ten-year development of Para Badminton as a sport. In wheelchair classes, there was a significant difference between matches' duration of Men's Singles in 2024 and 2013, with the first lasting longer, as well as Men's Singles in 2024 and Women's Singles in 2024. In the comparison of standing classes, there was no statistical significance, but the trend of longer matches' durations in 2024 was evident. The difference shown could witness Para Badminton development over the years by describing a better quality of players' performance, leading to a longer matches' duration.

Keywords: racket sport, physical disability, parasport

Introduction

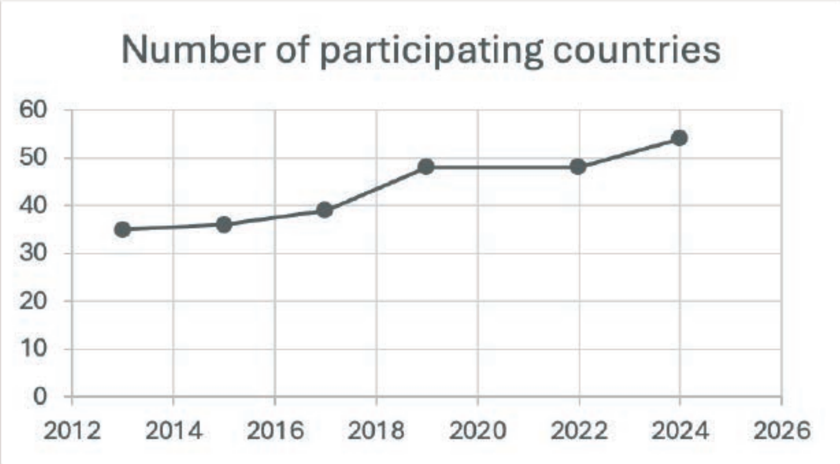
Para Badminton is a sport that has been gaining increasing popularity worldwide, leading to its inclusion as a full medal event at the 2021 Paralympic Games in Tokyo. The Para Badminton World Championships (PWCH), an individual bi-annual event, has been organized by the Badminton World Federation (BWF) since 2011 (Janiaczyk, 2015). Previously, from 1998 to 2009, it was organized under the Para Badminton World Federation (PBWF) (World Abilitysport, 2011; Olympics, 2024). Para Badminton players compete across five categories: Men's Singles (MS), Women's Singles (WS), Men's Doubles (MD), Women's Doubles (WD), and Mixed Doubles (XD). Within categories, each athlete is classified into one of the six Sport Classes before competing at the international level, ensuring fair competition by grouping athletes based on how their physical impairment affects their performance (BWF, 2024; Strapasson et. al., 2021). The classification process, conducted by internationally certified classifiers, involves a medical examination and assessment of badminton movements (BWF, 2024). The six Sport Classes are: WH 1 and WH 2 for wheelchair users; SL 3, SL 4, and SU 5 for standing players; and SH 6 for short stature players (BWF, 2024). Over the years, the interest of both athletes and international organizations in Para Badminton has increased. The greater popularity of the sport certainly affects the number of players and potentially the variability of playing techniques, which inevitably leads to changes and development of the game itself. It is important to monitor the dynamic of these changes in order to support the quality development of the sport in the best possible way. Such an approach could bring benefits to both the organization of para sports and the players themselves. In this paper, a comparison of matches' duration from 2024 and 2013 was conducted with the aim of gaining a clearer understanding of the ten-year development of Para Badminton as a sport, by analyzing two World Championships.

Methodology

Data from PWCH in 2024 and 2013 was collected from the official website of BWF - Tournament Software. This included: the number of countries that participated in PWCH from year 2013 to 2024; the number of countries that participated in Badminton World Championship (BWCH) in the years 2013 and 2023; and duration of matches in PWCH from the year 2024, from quarterfinals to finals in MS and WS, as well as the duration from the PWCH from the year 2013, in MS. All collected data were processed and analyzed using the Statistica (Statistica.ink TIBCO). Descriptive statistics method was used for obtaining descriptive indicators of match duration. To determine differences in duration between classes from PWCH in 2013 and in 2024, the independent samples t-test was utilized.

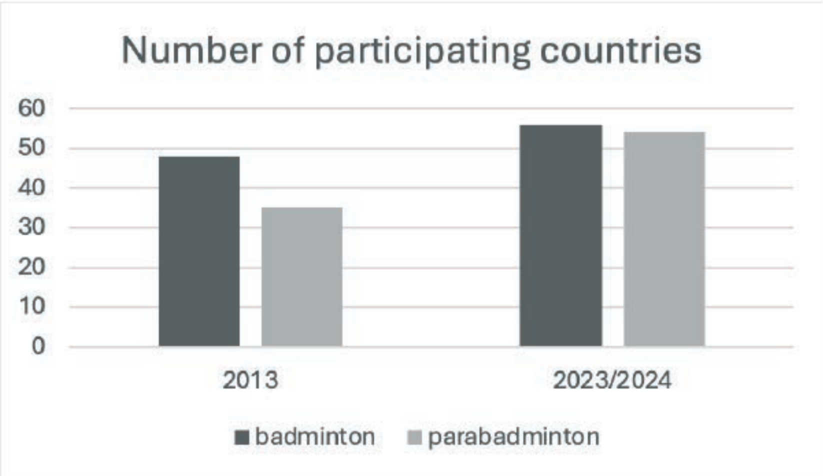
Results

An increase in the number of participating countries in the PWCH from 2013 to 2024 can be seen in Figure 1. A clear increase is evident since the number of countries participating in the PWCH rises from 35 in 2013 to 54 in 2024.
Fig. 1. The increase in the number of participating countries over the last 6 World Para Badminton Championships



In figure 2, the number of participating countries in the BWCH and PWCH is shown for the year 2013 and the most recent Championships. It is evident that the number of countries participating in the most recent PWCH has almost equaled that in the most recent BWCH, whereas in 2013 there was a noticeable difference between the two.

Fig. 2. Comparison of the number of participating countries between two World Championships in badminton and para badminton



Tables 1, 2, and 3 display the mean and standard deviation of match duration from quarterfinals up to the finals, as well as the duration of quarterfinals, semi-finals and finals combined, for the standing and wheelchair classes, from PWCH in 2024 and 2013. All results are displayed in minutes. The mean duration of quarterfinals to finals combined in 2024, for MS in classes SL 3, SL 4, and SU 5 is 47,95 ± 22,70, with the longest match being 100 min; MS in classes WH 1 and WH 2 is 42,29 ± 16,29, with the longest match of 78 min; WS in classes SL 3, SL 4, and SU 5 is 27,62 ± 8,33, with the longest match of 50 min; WS in classes WH 1 and WH 2 28,29 ± 9,30, with the longest match of 50 min. In PWCH 2013, the mean duration of quarterfinals to finals combined for MS in classes SL 3, SL 4, and SU 5 is 29,76 ± 6,60, with the longest match being 52 min; and for MS in classes WH 1 and WH 2 is 30,21 ± 11,78, with the longest match of 59 min.

Table 1. The basic statistical parameters of the match duration from the quarterfinals to the finals, as well as the duration of the quarterfinals, semifinals, and finals combined, for the MS in the year 2024

Playing category and classes	elimination rounds	n	Mean ± SD	min	max
MS (SL 3, SL 4, SU 5)	QF	12	40,75 ± 19,17	21	89
	SF	6	53,17 ± 22,16	31	87
	F	3	66,33 ± 31,72	37	100
	QF, SF, F	21	47,95 ± 22,70	21	100
MS (WH 1, WH 2)	QF	12	42,88 ± 20,02	17	78
	SF	6	36,75 ± 6,50	28	43
	F	3	51,00 ± 15,56	40	62
	QF, SF, F	21	42,29 ± 16,29	17	78

MS – men's single; QF – quarterfinal; SF – semi-final; F – final; QF, SF, F - quarterfinal, semi-final and final combined; n – number of played matches; SD – standard deviation

Table 2. The basic statistical parameters of the match duration from the quarterfinals to the finals, as well as the duration of the quarterfinals, semifinals, and finals combined, for the WS in the year 2024

Playing category and classes	elimination rounds	n	Mean ± SD	min	max
WS (SL 3, SL 4, SU 5)	QF	12	24,83 ± 6,07	16	40
	SF	6	33 ± 11,21	24	50
	F	3	28 ± 6,56	21	34
	QF, SF, F	21	27,62 ± 8,33	16	50
WS (WH 1, WH 2)	QF	12	26 ± 10,11	19	50
	SF	6	34,75 ± 6,99	28	43
	F	3	24,5 ± 4,95	21	28
	QF, SF, F	21	28,29 ± 9,30	19	50

WS – women's single; QF – quarterfinal; SF – semi-final; F – final; QF, SF, F - quarterfinal, semi-final and final combined; n – number of played matches; SD – standard deviation

Table 3. The basic statistical parameters of the match duration from the quarterfinals to the finals, as well as the duration of the quarterfinals, semifinals, and finals combined, for the MS in the year 2013L 3, SL 4, and SU 5 is 29,76 ± 6,60, with the longest match being 52 min; and for MS in classes WH 1 and WH 2 is 30,21 ± 11,78, with the longest match of 59 min.

Playing category and classes	elimination rounds	n	Mean ± SD	min	max
MS (SL 3, SL 4, SU 5)	QF	12	29,75 ± 7,91	23	52
	SF	6	30,50 ± 12,06	29	38
	F	3	26,00 ± 1,00	25	27
	QF, SF, F	21	29,76 ± 6,60	23	52
MS (WH 1, WH 2)	QF	12	26,63 ± 10,27	19	49
	SF	6	37,75 ± 15,39	25	59
	F	3	29,50 ± 4,95	26	33
	QF, SF, F	21	30,21 ± 11,78	19	59

MS – men's single; QF – quarterfinal; SF – semi-final; F – final; QF, SF, F - quarterfinal, semi-final and final combined; n – number of played matches; SD – standard deviation

Differences between the duration of matches

Differences in duration at PWCH 2024 between MS and WS in all standing classes, MS and WS in wheelchair classes as well as the differences between MS in standing and wheelchair classes from PWCH in 2024 and 2013, are shown in table 4. Statistical significance was found when comparing PWCH in 2024 and 2013, for MS in wheelchair classes ($p = 0,03$), as well as when men's and women's wheelchair classes from PWCH in 2024 ($p = 0,01$) are compared.

Table 4. Differences in the duration of matches between different classes.

Playing category and classes	mean	SD	p
24 MS (SL 3, SL 4, SU 5)	47,95	17,51	0,15
13 MS (SL 3, SL 4, SU 5)	29,76	2,01	
24 MS (WH 1, WH 2)	42,29	0,4	0,03*
13 MS (WH 1, WH 2)	30,21	2,93	
24 MS (SL 3, SL 4, SU 5)	47,95	17,51	0,12
24 WS (SL 3, SL 4, SU 5)	27,62	2,14	
24 MS (WH 1, WH 2)	42,29	0,4	0,01*
24 WS (WH 1, WH 2)	28,29	2,02	

24 MS – men's single in the 2024 WCH; 13 MS - men's single in the 2013 WCH; 24 WS – women's single in the 2024 WCH; n – number of played matches; SD – standard deviation

Discussion

While the duration of matches when quarterfinals, semi-finals and finals are combined is similar in most of observed categories, when comparing MS (WH 1 and WH 2) from PWCH in 2024 to either WS from the same year or MS, but from PWCH in 2013, a significant difference was obtained, with results of p = 0,01 and p = 0,03, respectively. The duration of MS in 2024 in WH 1 and WH 2 classes is longer, in both comparisons. The difference shown between MS in two given PWCH suggests that, with the development of the sport over the years, the level of player preparedness has also increased. Consequently, at the most recent PWCH, players were more evenly matched in terms of performance quality, requiring more time to secure the points required for victory. When comparing MS to WS in the same classes, a difference in overall duration is also evident. This can be interpreted in a way that men are more balanced in terms of sport skill than women and tend to fight longer for their win. On the other hand, the differences between women's players are more pronounced making it easier for better players to win quickly. This assumption is supported by a previous study carried out on table tennis players, which stated that matches last longer when higher quality players play against each other (Katsikadelis et at., 2007). Additionally, in a study on youth and elite badminton players, it was also suggested that match durations extend in players that show higher quality performance (Loon Leong and Krasilshchnikov, 2016). Although a statistically significant difference was not obtained, the comparison of MS to WS from PWCH in 2024, also to MS from PWCH in 2013, in classes SL 3, SL 4, and SU 5, shows an increased match duration (47.95 ± 17.51; 27.62 ± 2.14; 29,76 ± 2,01), which could support the previous assumption. Given that fewer matches were held in 2013, the duration of women's matches was taken only from the most recent PWCH.

Conclusion

In conclusion, the development of Para Badminton over the years is evident through various variables, such as the number of participating countries in World Championships. This trend is observable both within Para Badminton and in comparison to the number of countries participating in standard Badminton. Additionally, the longer match durations can be interpreted as an increase in player quality, requiring more time to achieve the necessary points for victory. Future studies could compare two Paralympic Games (Tokyo 2021 and Paris 2024) in order to gain a better insight into more possible changes at the highest level of this relatively new para sport.

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SIX-MINUTE WALK TEST IN ADULTS WITH DOWN SYNDROME: TEST-RETEST RELIABILITY

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The six-minute walk distance test (6MWT) is a simple, practical, feasible, objective and inexpensive field test that is easy to perform and suitable for individuals with Down Syndrome (DS). However, although the test has proven to be valid in people with DS, there is few of research related to that subject. The aim of this study was to evaluate the test-retest reliability of the Six-minute Walk Test (6MWT) in Croatian adults with Down syndrome. Twenty-eight adults with Down syndrome (11 men and 17 women), aged between 18 and 46 years, completed the 6MWT on two separate occasions within a two-week period. Participants were instructed to complete as many laps as possible within the allotted 6 minutes. Reliability analysis and T-test were utilized. The test-retest reliability of the Six-minute Walk Test in adults with Down syndrome demonstrated an intraclass correlation coefficient of 0.975. Additionally, there was no significant difference in the distance walked between the two test sessions. Our results showed that overall test-retest reliability was excellent. In practice, this means that the 6MWT has high repeatability and can be used as a measure of the development of functional abilities in adults with Down syndrome.

Keywords: Down syndrome; Rehabilitation; Aerobic capacity; Physical fitness

Introduction

Down Syndrome (DS) is the most widely recognized chromosomal abnormality in humans with various gene articulation (Raffi et al., 2019). The result is physical and psychological disabilities that vary from mild to severe forms (Coppedè, 2016). The incidence is approximately 1:700 live-born children (Sherman et al.,2007; Murthy et al., 2006; Wahab et al., 2006). According to the "Croatian Institute for Public Health" report from 2022, 1,907 people with Down syndrome live in Croatia (HZZO, 2022). They are characterized by many movement problems, such as low aerobic capacity, peak heart rate and low isokinetic muscle strength, which limits their functional performance (Fernhall, 2001; Rimmer et al., 2004; Whitt-Glover et al., 2006). The body composition, muscular strength and aerobic capacity of adults with DS are a poor compared with general population and individuals with intellectual disability (ID) without DS (Baynard et al., 2008; Melville et al., 2007; Carmeli et al., 2002; Croce et al., 1996). Low aerobic capacity is regarded as a risk factor for cardiovascular disease (González-Agüero et al., 2010). Aerobic capacity of adult with DS has improved with different training modalities (Cowley et al., 2011; Mendonca et al., 2011; Mendoca & Pereira, 2009; Rimmer, Heller & Valerio, 2004).

Most kinesiologists and healthcare professionals do not have access to sophisticated laboratory tests for the analysis and supervision of the adult aerobic capacity with DS. Indeed, these tests are expensive, inaccessible and long -lasting (Lee, 2008). On the other side, a six-minute walk test (6MWT) is a simple, feasible, practical, objective and cheap field test that is easy to perform and suitable for individuals with DS (Boer & Moss, 2016; Casey et al., 2012; Vis et al., 2009). This test measures aerobic endurance and functional capacity, which are essential for various daily activities such as walking long distances, shopping, and sightseeing while on vacation, etc. (Nasuti et al., 2013; Rikli & Jones, 2013). In addition, walking is reported to be the most popular daily physical activity for people with DS (Temple, 2007), as opposed to cycling or treadmill riding. Precisely, Oreskovic et al. (2022) reported that caregivers of adults with DS cited dancing, followed by walking, as the main type of physical activity that adults with DS would like to do. Therefore, the 6MWT could be suggested as enjoyable and, thus, practical to conduct among DS individuals.

Although there are several studies regarding the 6MWT in the DS population, the results differ in the measured distance and age of the participants. Vis et al. (2009) in their research reported that the measured distance covered is from 195 m to 318 m in participants aged 28 to 50, while Casey et al. (2012) reported a range of distance from 343 m to 471 m in DS individuals aged 11 to 26. Furthermore, Boer and Moss (2016a) reported an average distance traveled of 513 m and 518 m, respectively, in DS people between the ages of 18 and 50 years.

Therefore, as previous studies noted differences in the distance traveled and the age of the participants, we aimed to conduct a 6MWT on DS adults aged 18-46 years from Croatia, with gender stratified results. Also, the aim of this study was to conduct a test-retest reliability of 6MWT among adults with DS to investigate whether this test is appropriate for measuring aerobic capacity of Croatian adults with DS.

Methods

Twenty-eight adults with Down syndrome (11 men and 17 women), ages 18 to 46, were selected from two care facilities for people with intellectual disabilities (Juraj Bonači and Udruga Down 21 Split). In addition to filling out a health questionnaire that was modified from the Physical Activity Readiness Questionnaire, the parents or legal guardians signed an informed consent form. There were seven inquiries on the participant's health in this questionnaire. A medical professional was consulted for additional assessment if a participant replied "yes" to any of the questions.

The following conditions had to be satisfied for a participant to be considered for the study: they had to be 18 years of age or older, have a diagnosis of Down syndrome, be able to understand and accurately complete the exercises, give written informed consent, and successfully complete the health questionnaire. Individuals with congestive heart disease or any other physical, mental, or health problem that would prevent them from participating in the study were not eligible. Over the course of two weeks, each participant completed the Six-minute Walk Test twice.

Procedures

At the initial visit, the primary researcher presented the study to interested participants and their guardians/parents. Information sheets and the health questionnaire were provided to those who expressed interest, and during a subsequent visit, consent forms and completed questionnaires were collected. Ethical approval for the study was obtained from the Ethics Committee of the Faculty of Kinesiology, University of Split (003-08/21-04/001). One week before the study initiation participants were familiarized with the test procedure.

Mesasurements

The 6MWT was conducted on a flat and hard indoor ground of sports hall. The goal was for participants to walk, without running or jogging, as many laps of 30 meters as they could in the allotted six minutes. They were reminded of the same during all 6 minutes of walking. Participants were permitted to take rest at any moment, however were encouraged to go back to walking as quickly as possible. There was no warm-up activity for each participant as the guidelines recommended by American Thoracic Society (ATS, 2002). The researcher did not walk with the participant but a single volunteer stood on the other side to ensure that the participants followed the path and walked at their own pace. During the whole time, they were encouraged and motivated according to the guidelines of American Thoracic Society (ATS, 2002) e.g. "You are doing well. You have 5 minutes to go." A stopwatch was used to time for the test. The participants were instructed to stop where they were after six minutes, and the researcher noted the number of laps completed and the extra distance they had walked. The walking distance was measuerd to the closest metre.

Statistical analysis

Statistical analyses were performed with Statistic v.13. Descriptive statistics outlining participants characteristics including age, height, weight, and BMI were summarized by sample mean, sample standard deviation, and range, while categorical variable gender was described by class frequency and class percentage. Independent sample t-test was conducted to determine the differences 9in all variables according to gender. Paired T-test were used to compare the differences of the 6-minute walk distance between 2 testing points. Intraclass correlation (ICC) was also conducted, with values of 0.90 to 0.99 reflecting high reliability, 0.80 to 0.89 good reliability, 0.70 to 0.79 fair reliability, and any score under 0.69 poor reliability (Shrout & Fleiss, 1979).

Results

All 28 DS adults who were selected from two facilities that provide care for people with intellectual disabilities performed the 6MWT. Descriptive statistics of the sample are visible in the Table 1. we can see that the average age of the participants is 28.34, with an average BMI of 30.32 (kg/m2) and an average 6MWD of 480.07 m for the first measurement and 477.86 for the second measurement. Males have higher body height and reached longer distance in the first testing point of the 6MWT.

Table 1. Descriptive statistics and differences between male and female individuals with DS

Variable	Total sample (n=28)		Female (n=17)		Male (n=11)		t test	
	Mean	SD	Mean	SD	Mean	SD	t-value	p
Age	28.39	8.04	30.35	9.37	25.36	4.20	1.65	0.11
Body height	153.57	7.89	149.04	5.33	160.57	5.84	-5.39	0.00
Body mass	71.15	18.11	71.85	20.55	70.07	14.42	0.25	0.81
Body mass index	30.32	8.15	32.31	8.89	27.25	5.97	1.66	0.11
6MWT I.	480.07	109.68	445.94	100.96	532.82	105.51	-2.19	0.04
6MWT II.	477.86	108.58	450.76	105.83	519.73	103.62	-1.70	0.10

Note: SD – standard deviation, 6MWT – six-minute walk test distance

In the Figure 1 is displayed a graphical presentation about the differences between two testing points of 6MWT for the total sample. It is visible that there are no differences between the two testing points. The ICC (95% confidence interval) is 0.98, reflecting high reliability.

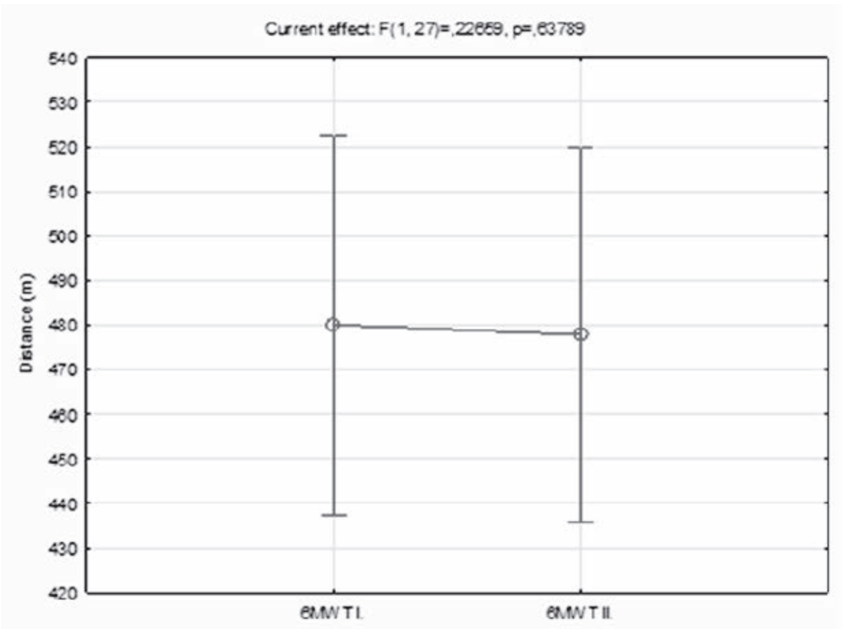

Figure 1.

Discussion

ICC showed high reliability between two measurements like in study Boer and Moss (2016). Furthermore, in the study of adolescents and young with DS by Casey et al. (2012) the ICC between the four 6MWTs was 0.84 and increased to 0.95 when the first test was omitted and 0.97 when the first 2 tests were omitted. They also demonstrated there was a significant difference in the distance traveled in the 6MWT. It should be noted that they were not familiar with the test before the testing. Therefore, it would be advisable for the participant to be familiar with the test before the actual testing.

Previous studies of Vis et al. (2009) and Boer and Moss (2016) also found no statistically significant difference in the distance covered during the 6MWT among DS adults. In these studies, there was no statistically significant difference in the distance traveled between the two measurements. The results suggest that the 6MWT is a reliable test. Therefore, the 6MWT could be considered as appropriate for assessing aerobic endurance and functional capacity, which are critical for various daily activities.

Conclusions

Our results showed that overall test-retest reliability was excellent. In practice, this means that the 6MWT has high repeatability and can be used as a measure of the development of functional abilities in adults with Down syndrome. Scientific significance could be found in the fact that this is the first research on this topic in Croatian contributes.

One of limitation of the current study is the inability to determine the level of intellectual disability (ID) because ID centers were not available for most participants information related to intelligence quotient. Nevertheless, all participants in the present study comprehended the instructions and information provided. It is also a limitation that only those who successfully completed the health questionnaire could access the testing. Future studies could investigate the influence of other variables on the 6MWT, such as BMI, level ID, heart rate, limb strength, etc. Also, it should be try to increase the sample, although it might be difficult because the incidence is approximately 1:700 live-born with DS.

However, the strength of this research is that we included individuals with DS, which is important for determining how to affect their lifestyle and improve health.

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DIFFERENCES BETWEEN STUDENTS WITH DISABILITIES IN ADOPTING SOME GUIDELINES OF EDUCATIONAL WORK IN THE TEACHING OF P.E.

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Abstract
Adaptation of the curriculum according to the type and degree of the student's disability is essential for facilitating integration and encouraging active participation in the P.E. class. Individual approach, inclusive environment, diversity and adaptation of content and work methods, creation of a positive environment and regular assessment and adaptation are key elements in achieving this goal. The objective of this paper was to examine whether there are differences between students with disabilities in adopting some guidelines of educational work in P.E. classes, regarding the type of student's disability. This research is part of a wider research on didactic-methodical difficulties in elementary school classroom teaching with students with disabilities. The sample included 185 teachers who at the time had at least one student with disabilities in their class. The student subsample includes a wide range of disabilities, including intellectual disabilities (n=64), language-speech-voice communication impairments and specific learning disabilities (n=51), ADHD (n=32) and autism spectrum disorder (n=25), while other difficulties were represented to a lesser extent and made up one group in the observed sample. Nonparametric methods were used in the paper. The results of the Kruskal-Wallis test showed that there are difficulties in adopting educational work guidelines, namely: in educational work guidelines *($\chi2(4) = 27.09$, $p = .000$)* and anthropological work guidelines *($\chi2(4) = 28.07$, $p = .000$)*, especially in students with autism spectrum disorders and students with ADHD. Further analysis, using the Mann Whitney test, determined differences between students with regard to the type of disability.

Keywords: adaptation, elementary school class teaching, physical education, students with disabilities, work guidelines

Introduction

When choosing exercise activities, the appropriateness of these activities to the chronological age, assessment of the student's overall condition and his characteristics, and their connection with cultural and family factors should be considered (Vatavuk, 1996). Also, when working with children of younger school age, the laws of growth and development of children of that age and especially children with disabilities should be taken into account (Blažević, 2016). Numerous fundamental, clinical and epidemiological studies clearly support the importance of regular physical exercise in preventing chronic diseases and improving the general health of children and adults (Beets et al., 2009). These studies highlight the importance of incorporating physical activity into everyday life in order to promote general health and prevent various diseases. The main goals of increasing the level of physical activity of children and young people with disabilities are to reduce the loss of aerobic abilities due to lack of mobility, to optimize their physical abilities and to improve general well-being. Regular kinesiological activity is essential for the development and maintenance of normal muscle strength, flexibility, postural control and other motor skills that can slow down the deterioration of movement functionality in that group, encouraging their independence (Durstine et al., 2000). Children, students and young people with disabilities and disabled adults show a lower level of physical activity compared to their peers, which leads to an increased risk of obesity and related health problems (Bandini et al., 2005; Fragala-Pinkham et al., 2005). The psychosocial consequences of lack of physical activity include reduced self-esteem, limited social integration, and ultimately, greater dependence on others in everyday life (Murphy & Carbone, 2008). Regular participation in moderate kinesiological activities can reduce the frequency of stereotyped movements, inappropriate behaviours and fatigue, especially in children with autism spectrum disorder, but also in children with other developmental and behavioural disabilities (Dykens et al., 1998; Fragala-Pinkham et al., 2005, Gabler-Halle et al., 1993). Furthermore, engaging in kinesiological activities can encourage the development of independence, stimulate the competitive spirit and develop the ability to work as a team in children, students and young disabled people (Patel & Greydanus, 2002).

The objective of this paper was to examine whether there are differences between students with disabilities in adopting the work guidelines in the P.E. teaching, regarding the type of student's disability. We expect that there are no difficulties in adopting the work guidelines in the P.E. teaching for students with disabilities, considering the type of student's disability.

Methodology

Participant sample

The sample includes 309 elementary school classroom teachers from different regions of the Republic of Croatia who had previous experience working with students with disabilities. Out of the total sample, 185 teachers (59.9%) were at the time teaching at least one student with disabilities in their class. The student subsample includes a wide range of disabilities, including intellectual disabilities (n=64), language-speech-voice communication impairments and specific learning disabilities (n=51), ADHD (n=32) and autism spectrum disorder (n=25), while other difficulties were represented to a lesser extent and made up one group in the observed sample.

Measuring instrument

For the purpose of the research, an evaluation questionnaire was designed in the application of methodological laws in the organization of physical exercise in P.E. classes, which is part of the institutional project "Didactic-methodological difficulties in elementary school classroom teaching with students with special educational needs".

The first part of the questionnaire collected data on sociodemographic characteristics. The second part of the questionnaire consisted of 10 scales: Basics of the organization of physical exercise (α = .954), Organizational settings of physical exercise (α = .977), Classroom work - types of lessons (α = .966), Methods of presenting the motor task (α = .940), Methods of learning a motor task (α= .975), Methods of exercise (α = .972), Safety methods (α = .972), Supervision methods, Structure of the P.E. lesson (α = .957), Educational guidelines of work in P.E. (α = .916).

Results

Table 1. The results of the descriptive statistics of educational work guidelines - EWG

	N	Mean	SD	min	max
The student has difficulties in adopting and developing the EDUCATIONAL WORK GUIDELINES	183	2.49	1.21	1	5
Disability type	183	2.48	1.31	1	5

Table 2. Results of the Kruskal-Wallis test (N=183)

Disability type	N	Mean Rank	SD	χ2	df	p
ID*	64	85.03				
ASD*	25	124.10				
LSVD*	50	71.59	2.48	27.09	4	.000
ADHD	31	117.63				
OTHER**	13	81.96				

*ID – intellectual disabilites, ASD – autism spectrum disorder, LSVD – language-speech-voice disabilities and specific learning disabilities
** other – motor disorders, health difficulties, visual impairment, hearing impairment

The results of the Kruskal-Wallis test (Table 2) show that there are statistically significant differences between students with disabilities in adopting and developing the educational guidelines of work in P.E. classes. Students with an autism spectrum disorder and students with ADHD show that they have the most difficulties with the educational guidelines of work in P.E. classes.

Table 3. The results of the descriptive statistics of anthropological work guidelines - AWG

	N	Mean	SD	min	max
The student has difficulty in adopting and developing the ANTHROPOLOGICAL WORK GUIDELINES	183	2.70	1.16	1	5
Disability type	183	2.48	1.31	1	5

Table 4. Results of the Kruskal-Wallis test (N=183)

Disability type*	N	Mean Rank	SD	χ2	df	p
ID	64	91.34				
ASD	25	131.00				
LSVD	50	66.57	2.48	28.07	4	.000
ADHD	31	101.82				
OTHER**	13	94.65				

*ID – intellectual disabilites, ASD – autism spectrum disorder, LSVD – language-speech-voice disabilities and specific learning disabilities
** other – motor disorders, health difficulties, visual impairment, hearing impairment

The results of the Kruskal-Wallis test (Table 4) show that there are statistically significant differences between students with disabilities in adopting and developing anthropological work guidelines when in P.E. classes. Students with an autism spectrum disorder and students with ADHD show that they have the most difficulties with the anthropological guidelines of work in P.E. classes.

Table 5. Results of the Mann-Whitney U test (EWG)

Disability type	N	Mean Rank	SD	U	z	p
ID	64	39.63	1.31	456.50	-3.226	.000
ASD	25	58.74				
ID	64	42.37	1.31	631.50	-2.954	.000
ADHD	31	59.63				
ASD	25	51.82	1.31	279.50	-4.008	.000
LSVD	50	31.09				
LSVD	50	33.32	1.31	391.00	-3.864	.000
ADHD	31	53.39				

Table 6. Results of the Mann-Whitney U test (AWG)

Disability type	N	Mean Rank	SD	U	z	p
ID	64	39.63	1.31	450.50	-3.299	.001
ASD	25	58.74				
ASD	25	55.10	1.31	197.50	-4.947	.000
LSVD	50	29.45				
LSVD	50	34.97	1.31	473.50	-3.038	.002
ADHD	31	50.73				

The results of the Mann-Whitney U test show that there are statistically significant differences between students with disabilities with regard to the type of their disability when adopting and developing educational and anthropological work guidelines. Tables 5 and 6 show that there are differences between students with intellectual disabilities and students with an autism spectrum disorder *(p = .000; p = .001)* and students with ADHD *(p = .003)*. Differences are also visible between students with language-speech-voice disorders and specific disabilities, and students with ADHD *(p = .000; p = .002)* and students with autism spectrum disorder *(p = .000; p = .000)*.

Discussion

The results show that students with disabilities are included in the P.E. class, since engaging in a specific physical activity for students with disabilities brings numerous benefits to their overall development. However, there are also certain difficulties in conducting the P.E. class for certain groups of students with disabilities. The above results are expected and show that students with autism spectrum disorders and students with ADHD have the most difficulties in adopting and developing educational and anthropological guidelines for work in P.E. classes. A high level of unproductive activities and stereotyped behaviors represents a significant challenge in working with students with autism spectrum disorders. These behaviors can significantly interfere with their ability to concentrate, learn and participate in activities (Quill et al., 1989). Students with an autism spectrum disorder often have many difficulties when performing certain physical activities, such as: anxious reactions, resistance, insufficient attention, slowed motor activities, reduced ability to synthesize, inappropriate behavior and lack of attention. This is precisely the reason for the reduced influence on the optimal development of anthropological status, as research shows that students with autism spectrum disorders have lower results in the amount of fat tissue, hand grip strength, abdominal muscle strength, and trunk flexibility. Lower results were also obtained in tasks that require the integration of motor skills, in imitation tasks and in qualitative motor performances (Blažević, 2016). In order to reduce learning difficulties and facilitate participation in physical activities, it is important to adapt the approach and apply support strategies (Blažević et al., 2006), especially direct manipulation with verbal instruction and visual support. Also, it is very important to maintain motivation because it is important for safety and independence during the performance (Blažević, 2016). Some authors emphasize that the observed lower level of motivation can have a bad effect on the performance of new motor skills and the maintenance of already acquired ones (Blažević 2016; Koegel & Mentis, 1976), while other authors point out that there may be avoidance of performing tasks by repeatedly experiencing failure (Blažević, 2016; Clark & Rutter, 1979; McMillian, 1971). In the case of students with ADHD, attention should be paid to their specificities, which may result from additional developmental disabilities. If there are inappropriate forms of behavior displayed, it is necessary to work with them individually. Strategies that can be used to reduce unproductive activities and stereotypic behaviors in students with autism spectrum disorders and students with ADHD are a structured environment, visual support, positive reinforcement, individualized approach, understanding of sensory needs, and cooperation between teachers and parents.

Furthermore, the results of the Mann-Whitney U test showed that there are also differences in the adoption and development of educational and anthropological work guidelines between students with regard to the type of their disability. Tables 5 and 6 show that there are differences between students with intellectual disabilities and students with autism spectrum disorders and students with ADHD. Differences are also visible between students with language-speech-voice disorders and specific disabilities, and students with ADHD and students with autism spectrum disorders.

It was to be expected that such a structure would be obtained in the differences between students with intellectual disabilities and students with autism spectrum disorders and ADHD, since students with intellectual disabilities have difficulties in the field of cognitive development, perception, attention, memory, time-space orientation and movement coordination. Maximum individualization of the learning content is essential for the successful inclusion of students with intellectual disabilities in motor activities that should be appropriate to the students' cognitive, motor and orientation abilities (Prskalo et al., 2014). Also, due to their below-average general intellectual functioning, numerous repetitions and a slower pace of work are required (Kiš-Glavaš, 2016). Although motor tasks are a problem for students with specific disabilities and in the area of motor skills children with dyslexia perform worse than children with normal development (Brookman et al., 2013; Lenček et al., 2017; Nicolson & Fawcett, 1995), the results show that these students also differ from other students with disabilities, which assumes that they are still more successful in acquiring and developing educational and anthropological work guidelines with regard to other students with disabilities.

Conclusion

In this paper, we started from the null hypothesis. The results of the Kruskal Wallis test show that students with disabilities have difficulties in adopting and developing the educational and anthropological guidelines of work in P.E. classes. The hypothesis that students do not have difficulties was rejected at the p = .05 level. Although these data are useful for understanding the current state, further research could provide deeper insight into teachers' experiences, the effectiveness of support, and the needs of students with different disabilities to successfully participate in P.E. classes. Taken as a whole, these data provide valuable insight into the involvement of elementary school classroom teachers in working with students with disabilities in the Republic of Croatia, as well as the variety of difficulties encountered in P.E. classes, which has not yet been investigated in such a comprehensive way.

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FACTORS INFLUENCING THE PARTICIPATION OF ELITE CROATIAN DEAF ATHLETES IN SPORTS

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Abstract
The primary aim of the research was to identify the factors influencing the participation of elite deaf athletes in Croatia, while the secondary aim was to collect data on their hearing status and their family's hearing status, the use of hearing aids and communication methods, educational level, sports initiation, and preferences regarding coaches and competitions. The research was conducted on a sample of 31 elite deaf athletes (20 men and 11 women) from seven sports. A questionnaire on the participation of elite deaf athletes in sports was used, encompassing structured sections related to influencing factors. All surveyed deaf athletes participate in domestic competitions within the regular competition system alongside hearing athletes, which plays an important role in their integration into the hearing community. The results of the research indicate a desire among deaf athletes for greater opportunities to participate in their chosen sport, often necessitating their integration into the standard sports system. It is also confirmed the positive role of parents in supporting and nurturing their child's desire to engage in sports. Most elite Croatian deaf athletes begin participating in sports during the upper grades of primary school, highlighting the need for increased promotion of the importance of including children with hearing impairments in sports activities, as well as raising awareness among parents and professionals in health and educational institutions about the possibilities of including children with hearing impairments in both regular and deaf sports systems from an early age.

Keywords: communication, deaf athletes, integrated competitions, separate competitions, sports initiation

Introduction
Under the term "deaf athlete," we refer to an athlete with hearing impairment, including deaf, hard of hearing, or an athlete with a cochlear implant (whether or not they use a hearing aid or the external part of the cochlear implant). The only restriction pertains to meeting the criterion of a minimum hearing loss of 55 dB in the better ear, averaged over the speech frequencies of 500, 1000, and 2000 Hz, to qualify for participation in international elite competitions for deaf athletes, where the use of hearing aids or the external part of the cochlear implant is prohibited during competition (ICSD, 2015).

International elite competitions for deaf athletes include major sporting events such as the Deaflympics, World, and continental deaf championships (European and other championships) in Olympic and non-Olympic sports. Among all sports organizations supporting athletes with disabilities, the International Committee of Sports for the Deaf (ICSD) has the longest history in overseeing athletes with hearing impairments (Ammons, 2009; ICSD, 2015; IPC, 2015). The Deaflympics have been held since 1924, unlike the better-known Paralympic Games, which have a shorter history (since 1960).

Deaf individuals often emphasize belonging to a "special culture" or sociolinguistic community whose members share similar cultural values, sign language, and attitudes towards deafness (Stewart, 1986; Scheetz, 2004). Involvement in the deaf community is not solely based on the degree of hearing loss or whether the individual has one or two deaf parents but rather on the individual "acting deaf," in line with community expectations and values (Scheetz, 2004). Accordingly, in deaf sports, many deaf athletes use sign language during the Deaflympics and other deaf competitions as a means of communication among deaf individuals. However, with the increasing number of deaf athletes who communicate orally rather than using sign language, paradoxically, they may experience social isolation (Kurkova, 2005). Deaf athletes integrated into mainstream education and competition systems often miss the opportunity to engage with the deaf community and culture. The downside of this integration is also that deaf athletes there are often not informed about the possibilities of participating in competitions for deaf athletes, while competitions with hearing athletes ensure higher quality competition (Kurkova, 2001).

Research on factors affecting participation in sports among elite deaf athletes is scarce, especially regarding elite deaf athletes in Croatia. A study of 21 deaf athletes who participated in the Deaflympics (then known as the World Games for the Deaf) in Christchurch, New Zealand, in 1989, aimed to describe the bio-demographic characteristics and socialization processes leading to their initiation into deaf sports (Stewart, Robinson, & McCarty, 1991). A study of 53 elite European deaf athletes provided insights into the factors influencing their participation in sports (Kurkova, Valkova, & Scheetz, 2011).

Based on previous research, the aim of this study was established. The objective was to explore the factors influencing the participation of elite Croatian deaf athletes in sports, and to gather information on their and their family's hearing status, use of hearing aids and communication methods, education, sports initiation, and preferences towards coaches and competitions.

Methodology

The research sample included a total of 31 athletes (20 male athletes and 11 female athletes) from 7 sports (athletics, curling, bowling, handball, table tennis, shooting, and chess). The study included athletes who met the following four criteria: (1) minimum bilateral hearing impairment of 55 dB in the better ear (averaged over speech frequencies of 500, 1000, and 2000 Hz), (2) member of the Croatian Sports Association for the Deaf, (3) active member of the Croatian national team nominated to participate in elite international competitions (Deaflympics, World and European senior or junior championships), and (4) won a medal or achieved significant results in elite international competitions within the past two years from the time of the research. The total population of deaf athletes meeting all these criteria at the time of the research was 53 athletes from 8 sports (athletics, curling, bowling, handball, skiing, table tennis, shooting, and chess), meaning that 58.5% of the entire population of elite Croatian deaf athletes were included in the study.

For this research, a questionnaire on the participation of elite deaf athletes in sports was used. The questionnaire was designed and used for investigating factors influencing the participation of European elite deaf athletes in sports (Kurkova et al., 2011). The research was conducted with the approval of the Croatian Sports Association for the Deaf, which also carried out the initial selection of its members, i.e., athletes who met all the necessary criteria for participation in the research.

Results

Athletes' and Family Hearing Status - The hearing status of parents and siblings was examined to gain insight into possible origins of hearing impairments. Research results on family hearing status (Table 1) show that the majority of elite deaf athletes in Croatia have hearing parents (83.9%) and hearing siblings (70.4%). The highest percentage of athletes were either born deaf or became deaf during their first two years of life (67.7%) and have profound hearing loss, meaning a hearing impairment greater than 90% (51.6%).

Use of Hearing Aid and Communication - The majority of elite deaf athletes rely on hearing aids (80.6%) (Table 2), with 10 using one, 9 using two, and 6 having cochlear implants. Hearing aids notably aid in communication (77.4%), particularly in speech (87.5%) and sound perception (12.5%). Over half combine sign language, speech, lip reading, and written text (61.3%) or use total communication. Many deaf athletes (41.9%) believe hearing individuals lack knowledge about communication methods, causing issues, while 32.2% perceive no problems. Those without issues primarily use speech (6 athletes) or total communication (4 athletes). Limited reliance on sign language may be due to its lack of recognition in Croatia and absence from schools. Communication challenges often arise early in life, especially when hearing loss occurs before speech development, requiring varied communication methods (Kurkova et al., 2011).

Table 1. Athletes' and Family Hearing Status

	N	%
Parental Hearing Status (N=31)		
Both hearing parents	26	83,9
Both deaf parents	3	9,7
One deaf parent	2	6,4
Siblings' Hearing Status (N=27)		
Hearing individuals	19	70,4
Deaf individuals	6	22,2
Hearing and/or deaf individuals	2	7,4
Athletes' Age of Hearing Loss Onset (N=31)		
From birth to 2 years	21	67,7
From 3 to 6 years	4	12,9
Later	6	19,4
Degree of Hearing Loss in Percentage (N=31)		
60-79%	12	38,7
80-89%	3	9,7
90-100%	16	51,6

Table 2. Use of Hearing Aid and Communication among Elite Deaf Athletes

	N	%
Use of Hearing Aid (N=31)		
Yes	25	80,6
No	6	19,4
Assistance of Hearing Aid in Communication (N=31)		
Yes	24	77,4
No	7	22,6
How Hearing Aid Helps Athletes (N=24)		
Facilitates communication	21	87,5
Better perception of sounds in the environment	3	12,5
Primary Means of Communication (N=31)		
Sign language	1	3,2
Speech	11	35,5
Total communication	19	61,3
Communication Difficulties with Hearing Individuals (N=31)		
Lack of information	13	41,9
Lack of interest	1	3,2
Lack of information and interest	2	6,5
No communication problems	10	32,3
Inability to communicate	5	16,1

Education of Elite Croatian Deaf Athletes - Research results on the education of deaf athletes show a small difference in preschool education, specifically in attendance at deaf preschools (41.9%) versus regular preschools (32.3%) (Table 3). The majority of deaf athletes attended regular schools for primary (51.6%) and secondary education (83.9%). Almost all athletes passed their final exams (90.3%), and two athletes (6.5%) are still enrolled in high schools. Five athletes (16.1%) have completed higher education, i.e., obtained a university degree, and one athlete (3.2%) has completed vocational education.

Table 3. Education of Elite Croatian Deaf Athletes

	N	%
Preschool Education (N=31)		
At home	7	22,6
Regular preschool	10	32,3
Deaf preschool	13	41,9
Combination	1	3,2
Primary Education (N=31)		
School for the Deaf	9	29
Regular school	16	51,6
Combination	6	19,4
Secondary Education (N=31)		
School for the Deaf	4	12,9
Regular school	26	83,9
Combination	1	3,2
Final Exam (N=31)		
Passed	28	90,3
Not passed	1	3,2
Still enrolled	2	6,5

Table 4. Sports Initiation of Elite Croatian Deaf Athletes

	N	%
Parental Participation in Sports (N=31)		
Both parents participated in sports	7	22,6
Neither parent participated in sports	14	45,1
Only the father participated in sports	10	32,3
Compared to other EU member states $\chi2$-test 13,6760, df=2,p=,001072		
Sports Initiation of Deaf Athletes (N=31)		
Parents	10	31,3
Coach and/or teacher	5	15,6
Self-initiation	7	21,8
Compared to other EU member states $\chi2$-test 37,4226, df=2, p=,000000		
Presence of a Coach (N=31)		
Yes	18	58,1
No	13	41,9
Compared to other EU member states $\chi2$-test 7,51552, df=1, p=,006117		
Preferred Type of Coach (N=31)		
Hearing coach	8	25,8
Not important	21	67,7
No choice available	2	6,5
Compared to other EU member states $\chi2$-test 23,2231, df=2, p=,000009		

Sports Initiation and Participation of Deaf Athletes in Competitions - Parental involvement in sports among elite Croatian deaf athletes shows that 45.1% of parents were not engaged in sports, neither at an elite nor recreational level (Table 4). Deaf athletes mostly initiated their own sports involvement (54.7%) or were encouraged by their parents (32.3%), with nearly half (47.1%) motivated by parents who were involved in sports (54.9%).

Elite Croatian deaf athletes typically started organized sports at 10.5 years (range: 6 to 27 years) and entered their elite status sport at 18.6 years (range: 7 to 40 years). Six athletes also excelled in another sport at international deaf competitions. Majority of them have coaches (58.1%), mainly hearing individuals (83.3%) (Table 4). Twelve athletes (38.7%) belong to deaf-exclusive clubs, while 9 (29.9%) are in regular clubs, and 10 (32.3%) have dual membership.

All surveyed deaf athletes compete in Croatia's regular competition system alongside hearing athletes, with 51.6% having no preference for integrated or separate competitions. However, nine athletes prefer separate competitions for deaf athletes, citing fair conditions (55.6%) and improved communication (44.4%) (Table 5).

Table 5. Participation and Preference of Elite Croatian Deaf Athletes towards Competitions

	N	%
Competition with Hearing Athletes (N=31)		
Yes	31	100
No	0	0
Preference for Separate Competition System (only with deaf athletes) (N=31)		
Yes	9	29
No	6	19,4
Not important	15	51,6
Reasons for Separate Competition System (N=9)		
Better communication	4	44,4
Fair conditions for all	5	55,6
Reasons for Integrated Competition System (N=24)		
Better promotion and expansion	12	50,0
No reason	12	50,0

Discussion

The presented study is the first research conducted in the Republic of Croatia aimed at gathering information about elite Croatian deaf athletes, focusing on their and their family's hearing status, use of hearing aids and communication, education, sports initiation and coaches, as well as preferences regarding competitions. The results showed that the majority of elite deaf athletes have hearing parents and siblings, which is consistent with other research, such as the report by the Gallaudet Research Institute (Gallaudet Research Institute, 2006), where 83.4% of children were born into hearing families, and the study on elite European deaf athletes (Kurkova et al., 2011), where 84.9% of them came from hearing families. The hearing impairment in most deaf athletes occurred either at birth or developed within the first two years of life. Considering the high frequency of hearing aid usage, most deaf athletes rely on the ability to communicate using total communication. It is noteworthy that deaf athletes who use sign language also rely on their ability to communicate through speech, lipreading, and fingerspelling, which aligns with previous research findings (Scheetz, 2004; Kurkova et al., 2011).

The primary mode of communication is associated with the degree of hearing loss, the timeliness of diagnosis, the quality of rehabilitation, the type of school, and the socio-cultural environment in which the child was educated (Kurkova, 2001; Scheetz, 2004). It is assumed that these factors influence deaf athletes' inclination towards competing solely with deaf athletes or solely with hearing athletes and the athlete's sense of understanding and interest shown by the hearing community towards the communication forms of the deaf (Kurkova et al., 2011). During sports competitions, there is often a common misunderstanding about the communication needs of deaf individuals (Kurkova, 2005). In these situations, deaf individuals often do not inform hearing individuals about their communication problems or may not communicate with the majority in society at all, thus remaining isolated. For example, when a deaf person asks for information to be repeated, a hearing person may perceive it as a demand due to a lack of understanding or attention (Martin & Bat-Chava, 2003). Even different modes of speech among deaf individuals can sometimes become discouraging for understanding among hearing individuals.

The results of this study confirm the positive role of parents in supporting and developing a child's desire to participate in sports. Children with more physically active parents are six times more likely to exhibit similar lifestyles compared to children with sedentary parents. There may also be unique factors associated with hearing impairment in parents; hearing parents may be frightened by their children's participation in sports and limit their involvement in such activities, while parents with hearing impairments may not be overly protective due to their understanding of this type of disability (Ellis, 2001). Parental attitudes towards physical activity strongly influence physical activity habits in children, and this has been confirmed for children with hearing impairments as well (Kurkova & Sigmund, 2010; Ellis, Lieberman, & Dummer, 2014).

It is considered that a deaf individual's personal sense of comfort in the hearing community may later influence their inclination towards participation in an integrated or separate sports system, as well as their choice of coach (Kurkova et al., 2011). In this study, the majority of deaf athletes have hearing coaches, which appears to be a crucial factor in providing support to deaf athletes during their integration into the regular sports system. Croatian elite deaf athletes do not prioritize the hearing status of their coach, but rather their professional competence, understanding, care shown towards the athlete, and knowledge of how to communicate with deaf athletes.

All deaf athletes who participated in this study compete in the regular competition system with hearing athletes, which is in line with research conducted on elite European deaf athletes (Kurkova et al., 2011). One of the fundamental reasons for this may be the lack of sufficient domestic sports competitions for deaf athletes. The integration of deaf athletes into the training and competition system with hearing athletes helps to enhance their training quality and preparation for domestic and international deaf competitions, and also allows them to evaluate their current achievements with others throughout the competitive season.

In this study, several deaf athletes indicated a preference for a separate competition system, which suggests negative socialization and is also consistent with research conducted on elite European deaf athletes (Kurkova et al., 2011). They believe that in a segregated competition system, better communication conditions are present, as well as fair conditions for all athletes. Deaf athletes do not have a physical or mental disability, but their disability is noticeable during verbal communication. As deaf athletes are not limited by their disability, unless the vestibular system is impaired, they have the choice to compete with hearing or deaf athletes. This research confirmed the stance from the research on elite European deaf athletes (Kurkova et al., 2011) that, although deaf athletes prefer to compete with other such athletes because of socialization and communication opportunities that arise, they also appreciate the opportunity to participate in the regular competition system with hearing athletes. They believe that this provides them with the opportunity to evaluate their athletic success, as well as promoting and increasing recognition of deaf athletes.

Conclusion

The study shows deaf athletes' strong desire for increased participation in sports, leading them to integrate into mainstream sports systems. Integration enhances their training quality and prepares them for domestic and international deaf competitions, allowing them to assess their progress against others. It also highlights the positive influence of parents in supporting children's sports interests. However, there's a need to promote early involvement of deaf children in sports and educate parents and professionals about the opportunities in both mainstream and deaf sports systems. It's important to emphasize the legal equality of the deaf sports system with other sports systems.

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CURRENT TRENDS AND INNOVATIONS IN KINESIOLOGY RESEARCH: PROCEEDINGS

BIOMECHANICS AND MOTOR CONTROL

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THE EFFECT OF REPEATED COUNTERMOVEMENT JUMPS TO FAILURE ON VERTICAL JUMP PERFORMANCE

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Abstract
The aim of this study is to determine changes through repeated countermovement jumps to failure and to determine which of these changes persist after the induction of fatigue. Twenty-eight students (mean age of 19.24±0,99 years, height of 176.90±8.93 cm, and body weight of 73.45±11.48 kg) were included in this study. The participants completed three vertical jumps using the Optogait device, followed by three sets of repeated countermovement jumps to failure, also utilizing the Optogait device, and concluded with three additional vertical jumps recorded on the Optogait device. The selected parameters for analysis included contact time, flight time, jump height, power, pace, reactive strength index, jumping point, jumping point gap, used area, and verticality. The results obtained in this study indicate that three sets of countermovement jumps to failure significantly lower flight time (p=0.04), jump height (p=0.03) and verticality (p=0.03) in male participants, while flight time (p=0.02), jump height (p=0.02), power (p=0.01) and reactivity strength index (p=0.02) were significantly lower in female participants. Contact time, flight time, jump height, power and reactivity strength index exhibited moderate to strong significant association with number of repeated countermovement jumps. Further research is warranted to explore the impact of repeated countermovement jumps to failure on various fatigue parameters and assess different recovery strategies following this fatigue-inducing protocol.

Keywords: *Fatigue, Fatiguing protocol, Optogait*

Introduction
Improving vertical jump performance is becoming a topic of traditional interest in competitive sports (Nishiumi et al., 2023). One of the main reasons is that vertical jumping ability is an important component for successful performance in various team sports (Karatranstou et al., 2019). Moreover, vertical jumping ability is associated with sprinting (Loturco et al., 2015) and change of direction ability (Hernandez-Davo et al., 2021), factors integral to numerous athletic disciplines. Plyometric training has been found to produce significant increments in vertical jump height and power (Luebbers et al., 2003), leading to the widespread implementation of this type of training in both team and individual sports. While plyometric training offers numerous benefits across various performance factors crucial in sports, it is imperative to monitor training load.. Although jumps have shown to be a very important factor both of training and competitions, researchers usually tend to use laboratory conditions or stimulated fatigue rather than using jumps as fatiguing element. Recently Smajla et al (2024) used repeated countermovement jumps as fatigue protocol where participants performed repetitive countermovement jumps until the 20% reduction in maximal countermovement jump height was observed. They found that this led to a decrease in the dynamic strength index, representing an athlete's ability to utilize force capacity during dynamic tasks. To our knowledge, no studies have investigated changes in various vertical jump parameters during repeated jumps and their effects on fatigue induced by repeated countermovement jumps. Thus, the aim of this study was to determine changes in various vertical jump parameters throughout repeated countermovement jumps to failure and to identify which changes among those parameters persist. We hypothesized that there will be significant changes in all parameters and that changes will persist.

Methods
Subjects
A convenience sample of 28 first-year students participated in this study, with mean age of 19.24±0,99 years, height of 176.90±8.93 cm, and body weight of 73.45±11.48 kg. The inclusion criteria for participation in this study were absence of musculoskeletal injuries within the last 6 months and having no underlying health issues. All participants provided written consent after being informed about the study's objectives and potential risks. They were also informed of their right to withdraw from the study at any time. This study was approved by the Ethics Committee of the Faculty of Kinesiology at the University of Osijek (Classification mark:029-01/24-01/05 and register number: 2158-110-01-24-13) and conducted in accordance with current Declaration of Helsinki.

Experimental procedure
Participants completed two sessions, separated at least 48 hours and not more than 7 days, consisting of a preliminary session and a main testing session. During the preliminary session, after a 5-minute warm-up period, participants were

introduced to countermovement jumps (CMJ) and completed one series of repeated countermovement jumps to failure (RCMJF) without utilization of Optogait device. Researchers provided detailed instructions to ensure that all participants performed the test according to the guidelines. In the main testing session, after the same warm-up, participants executed three vertical jumps with the Optogait device to assess initial vertical jumps variables. After 3 minutes of resting, participants completed three sets of RCMJF with a 1-minute pause between sets, utilizing the Optogait device for data collection. After a 3-minute rest, participants performed a final set of three vertical jumps with the Optogait device.

Vertical jump

Each participant performed three bilateral jumps with hands placed on the hips, and the highest jump value was included in the analysis. Participants were instructed to execute a rapid vertical jump (Kozinc et al., 2022) and to avoid bending their knees in the air (Marković et al., 2004). The outcomes of this test were: contact time (VJ_Tc), flight time (VJ_Tv), jump height (VJ_Th), power (VJ_P), pace (VJ_Pc), reactive strength index (VJ_RSI), jumping point (VJ_JP), jumping point gap (VJ_JPG) used area (VJ_UA) and verticality (VJ_Ver).

Repeated Countermovement jumps to failure

The test consisted of three sets of RCMJF performed on two Optogait device plates (version 1.6.4.0., Microgate, Bolzano, Italy). During the jumps, participants stood in place with hands on hips and feet shoulder-width apart. Upon the signal from the measurer, participants descended into a squat of arbitrary depth and executed RCMJF with maximum intensity until they were unable to perform any further repetitions. The outcome variables measured in this test were identical to those employed in the vertical jump test.

Statistical analysis

For this study, TIBCO Statistica Enterprise (version 13.4.0.14) was utilized. Normality was checked using the Shapiro-Wilk W test. Descriptive statistics, including mean (M) and standard deviation (SD), were computed for all participants, and separately for males and females. Paired t-tests and Wilcoxon signed-rank tests were employed for normally and non-normally distributed variables, respectively, to compare initial and final vertical jump parameters. Friedman analysis of variance (ANOVA) was used to assess differences among the three jumping sets. For further analysis of the detected significantly different results, the Wilcoxon signed-rank test was used. To assess association between number of performed jumps in each set with each Optogait parameters for each participant, Spearman correlation coefficient was used and presented as mean and standard deviation for each Optogait parameter. To assess differences in association between number of jumps performed during each set and Optogait parameters with different set, Fridman analysis of variance (ANOVA) was used, followed by the Wilcoxon signed-rank test in case of observed statistical significance. Statistical significance was set at $p<0.05$.

Results

Descriptive parameters for all participants, as well as for male and female students separately with statistical significance are presented in table 1. Significant differences were present in VJ_Tv ($p=0.04$), VJ_Th ($p=0.03$) and VJ_Ver ($p=0.03$) for male participants, while VJ_Tv ($p=0.02$), VJ_Th ($p=0.02$), CMJ_P (0.01), and VJ_RSI ($p=0.02$) exhibited significant differences for female participants. All significant parameters were lower in final testing compared to the initial measurements.

Table 1. Descriptive parameters and differences between initial and final Vertical jumps

	ALL (N=28)		M (N=18)		INC/ FIN	W (N=10)		INC/ FIN
	INC	FIN	INC	FIN		INC	FIN	
	M±SD	M±SD	M±SD	M±SD		M±SD	M±SD	
VJ_Tc	0,85±0,48	0,76±0,18	0,86±0,58	0,68±0,11	0,68#	0,83±0,25	0,88±0,21	0,14#
VJ_Tv	0,51±0,07	0,50±0,07	0,56±0,05	0,54±0,03	0,04#	0,43±0,03	0,42±0,03	0,02
VJ_Th	32,81±9,36	30,88±8,37	38,16±7,03	36,12±4,79	0,03#	23,17±3,02	21,46±3,67	0,02
VJ_P	21,61±4,84	20,97±5,49	24,51±3,26	24,17±3,77	0,18#	16,40±1,79	15,20±2,47	0,01
VJ_Pc	0,86±0,12	0,85±0,08	0,83±0,12	0,86±0,07	0,81#	0,90±0,10	0,84±0,10	0,07
VJ_RSI	0,48±0,17	0,47±0,20	0,57±0,14	0,57±0,15	0,31#	0,32±0,06	0,27±0,09	0,02
VJ_JP	2,93±4,74	2,30±4,98	3,16±4,17	2,49±5,78	0,59	2,51±5,84	1,96±3,34	0,82
VJ_JPG	4,43±3,41	4,00±5,33	4,83±3,69	4,65±6,39	0,42#	3,69±2,85	2,82±2,39	0,32
VJ_UA	57,60±8,01	61,94±9,46	58,46±8,97	64,62±10,63	0,06	56,06±6,02	57,11±3,82	0,44
VJ_Ver	39,14±53,65	65,55±76,37	34,80±42,35	72,33±84,73	0,03#	46,95±71,70	53,34±60,65	0,65#

Legend: # - Wilcoxon signed-rank test; INC/FIN – differences between initial and final testing; VJ – indicating vertical jump parameters

Differences between sets of RCMJF are presented in table 2n the initial set of RCMJF, participants completed a minimum of 17 jumps and a maximum of 66, with a mean of 35.00 and a standard deviation of 9.91. In the second set, the range was from 18 to 54 jumps, with a mean of 29.79 and a standard deviation of 8.46. In the third set, the number of jumps ranged from 15 to 69, with a mean of 27.79 and a standard deviation of 10.56. For male participants, significant differences were observed between the first and second set in RCMJF_Tv (p=0.05) and RCMJF_Th (p=0.05). Similarly, differences were observed between the second and third set in the same parameters (p=0.00 for both), indicating a significant decrease in these parameters as the sets progressed. However, no significant differences were found between the second and third set. For female participants, significant differences were observed between first and second set in RCMJF_Tv (p=0.01), RCMJF_Th (p=0.02), RCMJF_P (p=0.01), RCMJF_RSI (p=0.00) and RCMJF_UA (p=0.00). Additionally, differences were observed between the second and third set in RCMJF_Tc (p=0.03), RCMJF_Th (p=0.01), RCMJF_P (p=0.01), RCMJF_RSI (p=0.00) and RCMJF_UA (p=0.01). Significant differences between the second and third set were observed in RCMJF_Tv (p=0.03) and RCMJF_Th (p=0.05). RCMJF_Tc and RCMJ_UA were the only variables that showed higher results as the sets progressed, while other variables showed decrease values.

Table 2. Descriptive parameters and differences between jumping sets

Varijable	ALL (N=28)			M (N=18)			W (N=10)		
	First	Second	Third	First	Second	Third	First	Second	Third
	M±SD	M±SD	M±SD	M±SD	M±SD	M±SD	M±SD	M±SD	M±SD
RCMJF_Tc	0,67±0,09	0,68±0,12	0,68±0,13	0,64±0,08	0,63±0,09	0,62±0,10	0,72±0,09 Ţ	0,78±0,11	0,79±0,12‡
RCMJF_Tv	0,42±0,08	0,41±0,08	0,40±0,08	0,47±0,05†Ţ	0,46±0,06‡	0,45±0,06‡	0,34±0,03#†Ţ	0,32±0,04# ‡Ţ	0,32±0,04#‡
RCMJF_Th	22,86±8,26	21,67±8,58	21,05±8,37	27,64±6,02†Ţ	26,40±6,72‡	25,74±6,38‡	14,25±2,82#†Ţ	13,16±3,22#‡ Ţ	12,61±3,17#‡
RCMJF_P	17,20±4,90	16,47±5,14	16,24±5,14	20,04±3,57	19,45±3,82	19,28±3,64	12,10±1,69†Ţ	11,11±1,40‡	10,76±1,57‡
RCMJF_Pc	0,93±0,08	0,93±0,09	0,94±0,11	0,91±0,07#	0,93±0,09#	0,94±0,11#	0,96±0,08	0,93±0,10	0,92±0,11
RCMJF_RSI	0,36±0,16	0,34±0,16	0,33±0,16	0,45±0,13	0,43±0,13	0,43±0,12	0,21±0,05†Ţ	0,17±0,03‡	0,16±0,04‡
RCMJF_JP	1,27±7,50	0,00±4,62	-0,41±5,36	1,37±8,98#	-0,42±4,88#	-1,78±5,11#	1,10±4,02	0,75±4,25	2,07±5,13
RCMJF_JPG	0,09±0,36	0,10±0,21	0,04±0,40	0,13±0,42#	0,13±0,24#	-0,06±0,38#	0,03±0,20#	0,05±0,13#	0,22±0,40#
RCMJF_UA	56,31±7,78	58,52±7,21	58,55±7,31	56,87±9,09	59,13±7,99	59,30±8,34	55,30±4,88†Ţ	57,43±5,78‡	57,20±5,09‡
RCMJF_Ver	19,79±8,04	20,77±9,19	20,97±9,31	21,67±9,31#	23,91±9,83#	24,48±9,63#	16,40±3,20	15,12±3,99	14,66±3,97

Legend: # - Wilcoxon signed-rank test; † - significant difference with second set; Ţ - significant difference with third set; ‡ - significant difference with first set; M – indicating mean value; RCMJF – indicating repeated countermovement jumps to failure

The mean values of Spearman correlation coefficient between the number of performed jumps and each Optogait parameter, along with standard deviation and differences between jumping sets, are presented in table 3. RCMJF_Pc, RCMJF_JP, RCMJF_JPG, RCMJF_UA, and RCMJF_Ver did not exhibit statistically significant association with number of jumps performed, whereas significant association was observed for all other variables. According to Dancey and Reidy (2007), the variable RCMJF_Tc demonstrated a moderate association in both the first and second set for male participants, whereas all other variables displayed a strong association. No significant differences were observed.

Table 3. Descriptive parameters and differences between association between number of jumps and Optogait parameters with jumping sets

Varijable	ALL (N=28)			M (N=18)			W (N=10)		
	First	Second	Third	First	Second	Third	First	Second	Third
RCMJF_Tc	0,64±0,36	0,68±0,33	0,76±0,24	0,58±0,37#	0,64±0,33#	0,72±0,26#	0,76±0,32#	0,76±0,32#	0,83±0,18#
RCMJF_Tv	-0,90±0,11	-0,88±0,15	-0,91±0,07	-0,90±0,08#	-0,89±0,07#	-0,90±0,08#	-0,90±0,16#	-0,86±0,24#	-0,92±0,05#
RCMJF_Th	-0,91±0,08	-0,89±0,11	-0,91±0,07	-0,90±0,07#	-0,90±0,07#	-0,90±0,09#	-0,92±0,10#	-0,88±0,16#	-0,91±0,04#
RCMJF_P	-0,90±0,10	-0,89±0,12	-0,92±0,06	-0,89±0,10#	-0,89±0,10#	-0,92±0,08#	-0,92±0,12#	-0,88±0,15#	-0,93±0,04#
RCMJF_RSI	-0,89±0,12	-0,88±0,12	-0,92±0,06	-0,87±0,14#	-0,88±0,12#	-0,92±0,07#	-0,92±0,08#	-0,87±0,14#	-0,92±0,05#

Legend: # - Wilcoxon signed-rank test; † - significant difference with second set; Ț - significant difference with third set; ‡ - significant difference with first set; RCMJF – indicating repeated countermovement jumps to failure; r – indicating Spearman correlation coefficient

Discussion

The main findings of this study revealed that (1) performing RCMJF resulted in a decrease in VJ_Tv, VJ_Th, and VJ_Ver for male participants, while female participants experienced a decrease in VJ_Tv, VJ_Th, VJ_P, and VJ_RSI. Additionally, (2) significant differences were observed in RCMJF parameters between sets across various parameters. Furthermore, (3) a significant association was found between the number of performed jumps and all parameters except RCMJF_Pc, RCMJF_JP, RCMJF_JPG, RCMJF_UA, and RCMJF_Ver. Our results align with those of Smajla et al. (2024), showing that repeated countermovement jumps impact certain aspects of vertical jump performance, yet not all parameters exhibit changes. This suggests that fatigue induced by repeated jumping, a common occurrence in sports, can affect various parameters of vertical jump performance. Consequently, further research into this method of inducing fatigue is needed to better develop training strategies and recovery during and after training and competition. Furthermore, this study was conducted on a student population, the majority of whom are not professional athletes. Therefore, repeating this study on professional athletes could yield different results. Therefore, conducting such research on professional athletes would be beneficial.

Conclusion

We found that repeated countermovement jumps to failure can lead to a reduction in some vertical jump parameters but not all. These reductions were observed during the execution of repeated countermovement jumps to failure. Different vertical jump parameters were influenced by repeated countermovement jumps to failure in both male and female participants. Further research is needed to investigate the effects of repeated countermovement jumps to failure on various fatigue parameters and to evaluate different recovery methods following this type of fatiguing protocol.

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THE APPLICATION OF THE SKI TRACK SIMULATOR IN MASTERING THE FUNDAMENTALS OF ALPINE SKIING

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Abstract
From the perspective of recreational skiers, alpine skiing is a seasonal sport available only during the winter months. Engaging in this sport requires conditions that can only be met in certain locations. Alpine skiing offers numerous positive health benefits for the human body. The movements performed are specific and are not common for ski novices. The simulator allows partial learning of the fundamentals of alpine skiing technique. This study aims to determine if there are kinematic differences in the lower extremities and in which phases of the turn are significant, comparing turns performed on the ski simulator and the ski slope. The sample consisted of four alpine ski ISIA-level instructors. All participants had previous experience with ski simulators. MANOVA was used to detect differences between turns executed on the ski simulator and the ski slope. Following the conducted MANOVA analysis, statistically significant differences were observed in the kinematic parameters of turns performed on the simulator compared to those on the ski slope across all three observed phases (Phase 1 - $F=16.70$, $p=0.00$; Phase 2 - $F=125.24$, $p=0.00$; Phase 3 - $F=71.14$, $p=0.00$). In the final phase of the turn, four out of the total six observed kinematic variables differ between the simulator and the ski slope. Although groups significantly differ in this phase of the turn, the largest detected differences were observed in the first phase of the turn. Based on the results of this study, it can be concluded that it is possible to learn the basics of alpine skiing on a simulator. Additionally, it can serve excellently as a means of specific conditioning preparation. However, one must be aware of the limitations in imitating the conditions of a ski slope.

Keywords: *kinematic analysis, ski novices, Xsens inertial suit, ski school*

Introduction

Alpine skiing is a widely practiced winter sport with a long-standing tradition, involving approximately 400 million skiers across various age groups, in over 2000 ski resorts worldwide (Burtscher et al., 2019). This activity is typically conducted in cold conditions, in a natural outdoor environment, and at altitudes mostly exceeding 1500 meters. Given these circumstances, such engagement can yield significant health effects. It positively impacts the cardiorespiratory system (Niederseer et al., 2021), individuals benefit from exposure to hypoxia and cold (Burtscher and Ruedl, 2015), it stimulates the body's balance and postural control (Burtscher et al., 2019; Paillard, 2017), contributes to muscle hypertrophy and increased bone mineral density (Burtscher et al., 2019; Schipilow et al., 2013), and positively impacts an individual's psychological state (Lee et al. 2013). Considering all the mentioned, it would be advisable to make alpine skiing more accessible to a broader population across all age groups. The specific conditions in which skiing takes place make it significantly more popular and accessible to residents of Alpine countries (Burtscher et al., 2013). The lack of suitable climatic conditions in non-Alpine regions requires people to travel to distant countries and engage in recreational skiing. In addition to travel, accommodation, renting, or purchasing appropriate equipment, novice skiers allocate certain financial resources for joining ski schools, representing a significant burden. Therefore, recreational skiers often opt not to attend ski schools, and attempt to master skiing techniques by themselves. This leads to falls and injuries, thereby increasing the costs of skiing trips (Ekeland et al., 2018). Additionally, one of the factors contributing to injuries is the poor physical preparation of recreational skiers. The movements performed while skiing are specific and not common for ski novices. So, to maximize the ski learning process, it is necessary to have a certain level of physical preparedness. It is well known that physically fitter novice skiers are better at acquiring skiing knowledge due to better tolerance of physical stress and exercise (Aerenhouts et al., 2015). Hébert-Losier & Holmberg (2013) suggest physical conditioning before skiing as the most effective preventive measure for minimizing the risk of injuries. In that sense ski simulators can be used while they enable the execution of movements, that are to a certain extent, biomechanically similar to skiing (Moon et al., 2015). Consequently, the motivation and interest of recreational skiers for physical conditioning before skiing trips could increase, leading to a subsequent reduction in the risk of injuries on the slopes. The simulator allows for partial learning of the fundamentals of alpine skiing technique. While a beginner skier may not fully be able to conquer the ski slope, they will perform specific movements biomechanically resembling those on the skiing terrain and become acquainted with the equipment. The Ski Track simulator is a movable platform that, with the help of a hydraulic system with adjustable slope and speed, simulates various terrain conditions, from gentle ski slopes to steeper ones. Given this setup, executing turns on the Ski Track simulator enables the performance of turns that structurally resemble those on the ski slope. Basic skiing movements and phases of turns can be detected during turns on the simulator. To reliably establish the simulator's effectiveness, it is necessary to conduct biomechanical analysis of turns performed on the simulator. Therefore, this study aims to determine if there are kinematic differences in the lower extremities and in which phases of the turn are significant, comparing turns performed on the ski simulator and the ski slope. We believe that certain differences between turns executed on the ski simulator and ski slope exist and will be detected in the 3rd phase of the turn, considering the movable platform and bringing the ski into the final phase perpendicular to the fall line. It is hypothesized that significant differences in turns will be identified precisely due to the movable platform.

Methods

Participants: The sample consisted of four alpine ski instructors, ISIA level (age- 35 ± 9,66; height- 180,25 ± 7,80 cm; weight- 79,50 ± 8,43 kg). Participants had no prior injuries that could affect their technique or kinematic variables during turn performance on the ski simulator and the slope. All participants had previous experience with the ski simulator. Participants gave their written consent to participate in this study after being informed in detail about the aims and protocol of the research. The University of Zagreb (Croatia) Faculty of Kinesiology Ethics Committee approved the study, which was performed following the ethical standards of the Declaration of Helsinki.

Variables and equipment: All parameters were measured during the execution of a snowplough turn, and differences in turn performance on the ski slope and ski track were observed. The parameters were analysed at 3 time points during the turn. The first time point refers to the 1st phase of the turn (approach to the fall line) when the skier is in maximum lower extremity extension immediately before beginning the downward vertical movement into a lower skiing position. The second time point corresponds to the 2nd phase of the turn (passing through the fall line) when the skis are parallel to the fall line. The third time point refers to the 3rd phase of the turn (departure from the fall line) when the skier is in maximum lower extremity flexion immediately before beginning the upward vertical movement and outward movement of the outer ski's edge away from the slope. Six turns were analyzed on each side (a total of 12) for each participant. The following is a list of the analyzed kinematic parameters: knee flexion of the outside leg, hip flexion of the outside leg, hip abduction of the outside leg, knee flexion of the inside leg, hip flexion of the inside leg, hip abduction of the inside leg. Variables are expressed in degrees (°) and 180° represents a fully extended leg.

Protocol of investigation: Kinematic parameters were measured using the Xsens MVN Link inertial suit system. The data were analyzed using the appropriate software MVN BIOMECH (Xsens, MVN Studio 4.4, firmware version 4.3.1, Enschede, Netherlands). Previous studies have confirmed the reliability and validity of the Xsens motion capture suit for analyzing kinematic parameters in activities like those in this study (Supej, 2010; Brodie et al., 2010). The protocol was the same for all participants and included measurement of anthropometric characteristics and calibration of the kinematic system performed according to the standard procedure recommended by the manufacturer. After a brief warm-up on the ski track, the participant began executing snowplough turns. Each participant performed 10 turns on each side, with the first two and last two turns subsequently excluded from the analysis. The slope inclination was set to 10° to correspond to the gentle slope typically used for snowplough turns. Testing on the ski slope was conducted in Italy, Sappada, during the winter months of 2023. The testing protocol was identical to the one on the simulator. An identical number of turns were executed on the ski slope, with the first two and last two turns excluded from the analysis. The slope inclination was approximately 10°.

Statistical analysis: Statistical package Statistica version 14.0. (TIBCO Software Inc., Palo Alto, CA) was used for data analysis. Basic descriptive parameters for all measured variables were calculated. The normality of data distribution was tested by the Shapiro-Wilk test. MANOVA was used to detect the differences between turns executed on the ski simulator and the ski slope. The results were considered significant when $p < 0.05$.

Results

Following the conducted MANOVA analysis, statistically significant differences were observed in the kinematic parameters of turns performed on the simulator compared to those on the ski slope across all three observed phases (Phase 1 - $F=16.70$, $p=0.00$; Phase 2 - $F=125.24$, $p=0.00$; Phase 3 - $F=71.14$, $p=0.00$).

Basic descriptive parameters of each tested kinematic variable on the ski simulator and ski slope are shown in Table 1.

Table 1. Basic descriptive parameters for phases of the turn for both simulator and slope.

	Phase 1		**Phase 2**		**Phase 3**	
	Simulator	**Slope**	**Simulator**	**Slope**	**Simulator**	**Slope**
Variable	**Mean±SD**	**Mean±SD**	**Mean±SD**	**Mean±SD**	**Mean±SD**	**Mean±SD**
Knee_Out	153.43±7.58	165.98±2.36	138.86±5.26	153.37±4.10	128.34±7.51	134.87±6.75
Hip_Out_FL	156.43±5.19	166.86±4.72	144.79±6.72	146.76±9.44	136.87±5.44	134.23±11.78
Hip_Out_AB	170.44±2.43	169.52±3.20	167.42±4.55	156.48±2.41	168.10±4.52	154.68±3.11
Knee_Ins	153.31±10.06	172.47±4.22	145.92±6.16	147.96±6.90	142.92±5.08	140.25±9.43
Hip_Ins_FL	154.94±6.80	167.45±4.97	143.35±6.81	136.54±7.90	135.86±5.45	120.54±7.57
Hip_Ins_AB	185.90±3.27	188.69±2.77	181.73±5.72	180.30±3.25	181.75±6.12	176.55±3.69

Legend: Knee_Out- knee flexion of the outside leg; Hip_Out_FL- hip flexion of the outside leg; Hip_Out_AB- hip abduction of the outside leg; Knee_Ins- knee flexion of the inside leg; Hip_Ins_FL- hip flexion of the inside leg; Hip_Ins_AB- hip abduction of the inside leg.

Based on the descriptive parameters from Table 1, it is apparent that all observed variables exhibit greater flexion as the turn progresses towards its completion (Phase 3) with the same pattern regardless of the condition. Moreover, regardless of the turn phase, the mean values of kinematic parameters measured on the slope are higher than those on the ski simulator. Table 2 presents the results of the MANOVA for each tested variable in three phases of the turn.

Table 2. Results of MANOVA for all three phases of the turn.

	Phase 1		**Phase 2**		**Phase 3**	
Variable	**F**	**p**	**F**	**p**	**F**	**p**
Knee_Out	57.70	<0.01*	110.64	<0.01*	9.79	<0.01*
Hip_Out_FL	51.83	<0.01*	0.69	0.41	0.99	0.33
Hip_Out_AB	1.24	0.27	104.73	<0.01*	139.48	<0.01*
Knee_Ins	71.32	<0.01*	1.15	0.29	1.48	0.23
Hip_Ins_FL	51.45	<0.01*	10.05	<0.01*	63.84	<0.01*
Hip_Ins_AB	9.99	<0.01*	1.09	0.30	12.31	<0.01*

Legend: Knee_Out- knee flexion of the outside leg; Hip_Out_FL- hip flexion of the outside leg; Hip_Out_AB- hip abduction of the outside leg; Knee_Ins- knee flexion of the inside leg; Hip_Ins_FL- hip flexion of the inside leg; Hip_Ins_AB- hip abduction of the inside leg; * $p<0.05$.

In Table 2, it is evident that significant differences exist between the two conditions in which the kinematic variables of the turns were tested across all three turn phases. In the first phase of the turn, the only variable in which no difference was found between turns executed on the simulator and on the ski slope is hip abduction of the outside leg (Hip_Out_AB - $p=0.27$). Observing the second phase of the turn, it can be noted from Table 1 that the least number of the tested variables differs (Knee_Out - $p=0.00$; Hip_Out_AB - $p=0.00$; Hip_Ins_AB - $p=0.00$) between the two conditions compared to the first and third phases of the turn. In the third phase of the turn, four out of six observed kinematic variables significantly differ. No difference was recorded in hip flexion of the outside leg and knee flexion of the inside leg variables.

Discussion

We hypothesized that differences between turns performed on the ski simulator and the ski slope exist mostly in the completion of the turn, namely phase 3, mainly due to the movable treadmill and perpendicular position of the skis to the fall line. The main finding of this study partially confirms the hypothesis. In the final phase of the turn, four out of the total six observed kinematic variables differ between the simulator and the ski slope. Although groups significantly differ in this turn phase, the largest detected differences in five out of six kinematic variables were observed during the first phase. The only variable with no significant difference detected is hip joint abduction of the outside leg (Hip_Out_AB- $p=0.27$). In the initial phase of the turn, the skier nearly fully extends the joints of the lower extremities and loses the lateral bent of the body, which is pronounced during the turn. These movements allow the skier to unload the skis (especially the outer ski) and transfer the load to the next outside ski (Falda-Buscaioti et al., 2017). During the snowplough turn, the upper legs are mutually separated to increase the support base beneath the skier, providing stability and speed control. Due to this position, the skier's lateral bent is not particularly pronounced if performed on suitable (gentle) ski terrain (Komissarov, 2022). This may be why no significant difference was observed between the groups in the aforementioned variable. On the other hand, all other kinematic variables during this phase differ, suggesting different completion of the turn on the simulator compared to the ski slope. Consequently, the preparation for the next turn, which occurs during the transition phase and the initial phase of the turn, differs due to the position of a skier at the end of the previous turn (Panizzolo et al, 2013). Comparing the overall amplitude in the joints between the simulator and the ski slope during the turn, it can be observed that greater amplitude in this study was measured in all joints during the turns performed on the ski slope. A study by Panizzolo et al. (2013), compared skiing on a slope with two types of simulators, one of which was a treadmill with adjustable incline capabilities. Among other variables, the knee flexion angle during the turn was measured. In their study (simulator- 30.5°, slope- 41.1° amplitude compared to our study simulator- 25,09°, slope- 31,11), results were obtained that align with those in this study. Somewhat higher values were recorded by Panizzolo et al., (2013), due to the measurement of parameters during a more dynamic skiing element. The knee joint amplitude, observed from the first to the final phase of the turn, was significantly smaller than that on the ski slope. A possible explanation for these results is the incline and speed of the treadmill. Despite adjusting parameters on a ski simulator to mimic a gentle ski slope, it is impossible to fully replicate the snow conditions and the friction of the ski slope. For this reason, the amplitude in all measured joints was somewhat smaller on the ski simulator. This explanation is further supported by the results of EMG muscle activity from the study by Panizzolo et al., (2013). In addition to reduced amplitude, the authors found significantly lower quadriceps muscle activity. The treadmill parameters were set to correspond to performing carving turns in the middle corridor, a type of turn that requires high dynamics. In our study, parameters were measured during snowplough turns to match the skill level of ski novices. Additionally, the aim was to investigate whether a ski simulator can be a substitute for the initial days of skiing, making the sport more accessible to a broader population.

Conclusion

From the perspective of recreational skiers, alpine skiing is a seasonal sport available only during the winter months. Engaging in this sport requires specific conditions that can only be met in certain locations. Consequently, recreational skiers allocate significant financial resources to participate in alpine skiing. Different types of ski simulators have become more accessible in the last decade, allowing for the imitation of snow movements to varying degrees throughout the year. Simulators operating on the treadmill principle can adequately mimic the conditions of a ski slope. As a result, beginner recreational skiers can learn skiing techniques more cost-effectively by starting their training on a simulator. Based on the results of this study, it is possible to learn the basics of alpine skiing on a simulator. Additionally, the simulator can serve excellently as a means of specific conditioning preparation. However, one must be aware of the limitations in imitating the conditions of a ski slope, particularly in terms of friction and the fact that on a simulator, the skier remains stationary while the treadmill moves compared to a ski slope, where the skier moves while the surface remains stationary.

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DIFFERENCES BETWEEN ATHLETES FROM CONTACT AND NON-CONTACT SPORTS IN KNEE MOBILITY DEGREE AND FUNCTIONAL HAMSTRING TO QUADRICEPS STRENGTH RATIO

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Abstract
Hypermobility has been associated with poor knee performance, including impaired proprioception, isokinetic and isometric knee strength and increased risk of injuries. The degree of mobility and isokinetic knee parameters have not been investigated in contact and non-contact athletes so far. Therefore, this study aimed to investigate the differences in knee mobility and strength parameters in healthy athletes from contact and non-contact sports. The sample consisted of 47 healthy athletes without knee injuries aged 23.48±3.54 years. Athletes from various sports were categorized as contact or non-contact sports athletes. The variables included the degree of knee hypermobility, isokinetic parameters of hamstrings and quadriceps muscles, and anthropometric indices. A T-test for independent samples was used to determine the differences between the groups. Significant differences were noted in the degree of knee hypermobility of the left ($t=2.29$, $p=0.03$) and right ($t=2.26$, $p=0.03$) leg, with non-contact athletes having a higher degree. A probable explanation for non-contact athletes having a higher degree of knee hypermobility than contact athletes is that athletes in contact sports have more force on joints due to pressures and increased demands on the joints, which make joints more rigid. Future research should include a larger sample size and more targeted athletes from contact and non-contact sports as this research included athletes from various sports.

Keywords: *muscle performance, sports medicine, injuries, joints*

Introduction

Hypermobility is common among young patients and is linked to an increased risk of musculoskeletal injury (Wolf et al., 2011). It is thought that GJH lowers joint stability, which increases the risk of joint and soft tissue injuries during sports exercise (Nathan et al., 2018). Indeed, people with GJH are more prone to experience dislocations, subluxations, and sprains when participating in physically demanding activities, particularly those involving the lower limbs (Kim et al., 2010; Pacey et al., 2010; Sundemo et al., 2019). Furthermore, a review research that assessed the relationship between GJH and the risk of lower limb injuries during sports found that joint hypermobility was most typically associated with an increased chance of lower-limb injuries, particularly knee ligament injuries (Pacey et al., 2010). Specifically, it is well known that hypermobility, particularly hyperextension of the knee joint, are the most significant risk factor for noncontact injuries such as the anterior cruciate ligament (ACL) damage.

Hyperextension of the knee, also known as hypermobile knee (genu recurvatum), is defined as an overextension of the knee by 10° or more than full extension. When standing upright, it has a hypotonized quadriceps muscle and a stretched biceps femoris muscle (Larson et al., 2017). Furthermore, the hypermobile knee has slightly more stretched cruciate ligaments and greater pressure from the femoral condyles on the menisci and tibial condyles when standing, which may explain why people with hypermobile knees can't stand for long periods of time without experiencing pain or discomfort (Azma et al., 2015).

Hypermobility has been associated to poor knee performance, including impaired proprioception, isokinetic and isometric knee strength (Fatoye et al., 2009). However, there is a lack of research on muscle activation in hypermobile people, leaving it unclear if functional deficits and the need for joint stabilisation in hypermobility are related to muscle activity (Jensen et al., 2013). Hypermobility is more frequent in women than in men, and it is widely recognised as one of the primary risk factors for knee ligament injuries (Junge et al., 2019). A recent study found that athletes with knee hypermobility have lower hamstring strength, resulting in a lower hamstring-to-strength ratio at lower angular velocities (Bascevan et al., 2024).

Research has shown that athletes from contact and non-contact sports exhibit differences in knee mobility. Athletes, particularly those in contact sports, have been found to have superior knee function and dynamic knee control, as well as different movement strategies during certain athletic activities (Markström et al., 2019). These differences in knee mechanics are particularly evident in the sagittal and frontal planes, with athletes exhibiting lower peak flexion angles and higher peak extension moments in certain activities (Tanikawa et al., 2013). Athletes participating in contact sports are also at a higher risk for the development of knee osteoarthritis (Vad & Bhat, 2000). Therefore, it is expected that athletes from contact and athletes from non-contact sports would differ in knee mobility and strength parameters.

There is a lack of studies which investigated knee mobility and strength parameters in athletes from different types of sports. This paper aimed to investigate the differences in knee mobility and strength parameters in healthy athletes from contact and non-contact sports.

Methods

The sample consisted of 47 healthy athletes without knee injuries aged 23.48±3.54 years. Athletes from various sports were included and were categorized as contact (mostly football, handball and volleyball) or non-contact sports (track and field, rowing, swimming) athletes.

The variables included the degree of knee hypermobility, isokinetic parameters of hamstrings and quadriceps muscles, and anthropometric indices (body height, body mass). The degree of hypermobility was measured using the goniometer Pasco Xplorer GLX while sitting on the floor. The isokinetic muscle testing was done using a Biodex System 4 isokinetic device. The isokinetic variables included hamstring to quadriceps ratio (H/Q) at 60°/s, and at 180°/s for both legs. The H/Q strength ratio was calculated by dividing the greatest moment of strength of the hamstrings by that of the quadriceps.

Statistical analyses included descriptive statistics (means and standard deviations). Moreover, differences between contact and non-contact athletes have been determined using the t-test for independent samples. Additionally, the differences were graphically confirmed by the one-way ANOVA. The statistical package Statistica v13 was used, and a p level of 0.05 was applied for all analyses.

Results

Descriptive statistics and differences between contact and non-contact athletes are displayed in Table 1. Significant differences were noted in the degree of knee hypermobility of both legs, with non-contact athletes having a higher degree. No significant differences were found in any other variable.

Table 1: Descriptive statistics and differences between contact and non-contact athletes

	Non-contact (n=17)		Contact (n=30)		t-test	
Variable	Mean	Std.Dev.	Mean	Std.Dev.	t-value	p
Body mass	80.89	10.51	79.28	11.01	0.49	0.63
Body height	182.06	6.54	181.37	7.37	0.32	0.75
Body mass index	24.36	2.53	24.00	1.92	0.55	0.58
HdegR	10.64	3.95	8.02	3.74	2.26	0.03
HdegL	11.22	3.44	8.69	3.74	2.29	0.03
H/Q60R	0.55	0.08	0.59	0.10	-1.33	0.19
H/Q60L	0.53	0.08	0.57	0.09	-1.50	0.14
H/Q180R	0.62	0.09	0.66	0.11	-1.17	0.25
H/Q180L	0.63	0.11	0.67	0.11	-1.11	0.27

Note:Hdeg - Degree of knee hypermobility, R – right leg, L – left leg, H/Q60 – hamstrings-to-quadriceps ratio at an angular velocity of 60°/s, H/Q180 - hamstrings-to-quadriceps ratio at an angular velocity of 180°/s

Additionally, the graphical presentation of the significant differences is shown in Figure 1, which shows that non-contact athletes have a higher degree of knee hypermobility than contact athletes.

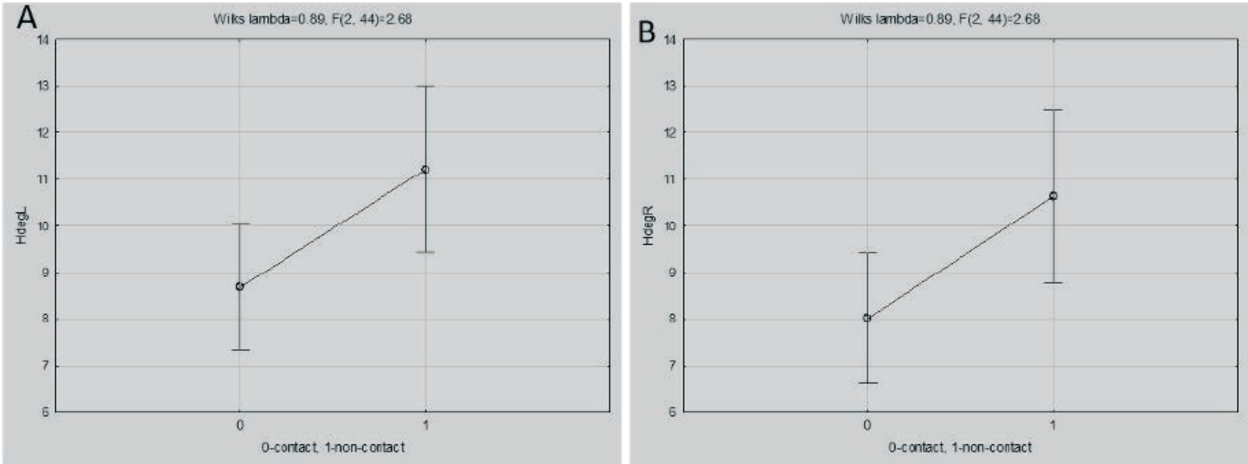

Figure 1: Graphical presentation of differences between contact and non-contact athletes in knee hypermobility. Hdeg – Degree of knee mobility.

Discussion

The finding that non-contact athletes have a higher degree of knee hypermobility than contact athletes is not confirmed in previous studies as this issue has not been investigated so far. The possible reason for this could be that athletes from contact sports have more rigid joint movements due to forces and higher demands on the joints. For example, it is expected that one football player will suffer higher forces in the knee joint than one swimmer. The high-impact, weight-bearing, and contact nature of football means that players experience higher forces on their knee joints compared to swimmers, whose sport involves low-impact, non-weight-bearing activities. Therefore, it's reasonable to expect that football players will suffer from higher knee joint forces (Lopezosa-Reca et al., 2018). However, this assumption is not jet proven on the larger sample and on the targeted athletes from different nature of the sports.

Research that differentiates respondents into the category of contact and non-contact athletes based on isokinetic indicators does not exist, while the data indicate that in this mixed sample of respondents from contact and non-contact sports, there is no statistically significant difference between the two groups in the isokinetic indicators of the H/Q strength ratio at 60°/s and 180°/s on the right and left sides. However, previous research has confirmed that there is a difference in isokinetic indicators in indoor sports (basketball and volleyball) versus outdoor sports such as football (Cheung et al., 2012; Magalhães et al., 2004)., but in no paper has the difference between contact and non-contact sports in isokinetic indicators been investigated. Individually, studies of certain sports branches in isokinetic indicators indicate some specificities. Thus, the research of Andrade et al. (2012) compares men and women from contact sports (judo, football and handball) at angular speeds of 60°/s and 300°/s on an isokinetic device with a primary focus on the strength ratio of hamstrings and quadriceps (Andrade Mdos et al., 2012). The data indicate that judokas achieve lower H/Q values at an angular speed of 60°/s than soccer and handball players, while at a speed of 300°/s, there are no differences in H/Q ratios. Research on Kenyan long-distance athletes records higher values of the H/Q ratio at all tested angular velocities in contrast to the average values. The authors emphasize that without a more detailed comparison with athletes from other sports, but with the same genetics as the sample in this research, they cannot determine with certainty the reason for the higher isokinetic values of the H/Q ratio, i.e., whether it is genetic, training or because these athletes did not suffer more severe knee injury (Kong & de Heer, 2008).

Conclusion

Significant differences were noted in the degree of knee hypermobility of both legs, with non-contact athletes having a higher degree. A probable explanation for this is that athletes in contact sports have more stiff joint motions due to pressures and increased demands on the joints. However, without a more detailed comparison with athletes from other sports, we cannot determine with certainty the reason for the finding that there is no difference in isokinetic values of the H/Q ratio while there is a difference in knee hypermobility, i.e., whether it is genetic, training, or because these athletes did not suffer a more severe knee injury. Therefore, future research should include a larger sample size and more targeted athletes from contact and non-contact sports as this research included a large number of sports.

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ASSOCIATION OF HAND GRIP STRENGTH DEFICIT AND SPATIOTEMPORAL GAIT ASYMMETRIES IN OLDER YOUTH: A CROSS-SECTIONAL STUDY IN A SPECIAL SPORT POPULATION OF STUDENTS

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Abstract
The mail purpose of this study was to investigate the association between hand grip strength deficit and spatiotemporal asymmetries in sport population of students. In this cross-sectional study, we recruited 91 male (age: 19,34±0,60 years; height: 182,08±6,47 cm; weight: 77,68±8,78kg) and 38 female students (age: 19,42±0,72 years; height: 165,18±6,35 cm; weight: 58,26±6,68 kg) from Faculty of Kinesiology at the University of Zagreb, Croatia. We used Zebris pressure platform to measure gait parameters and K-force dynamometer to measure hand grip strength. Among all participants, a weak positive correlation was found between maximum Handgrip strength deficit (HGSD) and step length asymmetry ($r=0.19$, $p=0.03$). However, in females, gender-specific analyses revealed more significant associations between HGSD and step length symmetry index ($r=0.34$, $p=0.04$), as well as moderate negative correlations with stance phase ($r=-0.39$, $p=0.02$), swing phase ($r=-0.39$, $p=0.02$), and step time ($r=-0.41$, $p=0.01$) asymmetry. These findings suggest that greater HGSD may be associated with compromised gait patterns and decreased symmetry in various gait parameters, particularly in females. Further research is warranted to explore interventions to address asymmetries and optimize musculoskeletal health.

Keywords: *hand grip strength, spatiotemporal gait, asymmetry*

Introduction

Handgrip dynamometers are widely used in various clinical settings, translational research, and population-based studies to assess handgrip strength (HGS) (Chen, Ho & Chau, 2022; Lee & Gong, 2020). Recent evidence suggests that the presence of strength deficit may serve as an early indicator of muscle dysfunction before noticeable deficiencies in overall strength capacity (Chen et al., 2022). Furthermore, studies have revealed that individuals with hand strength deficit (HGSD) tend to experience compromised health and a shortened lifespan (McGrath et al., 2021).

Considering the positive association between upper and lower extremity strength (Bohannon, 2012), it becomes imperative to expand HGS assessments by incorporating measurements from both hands. This expansion enables a more comprehensive understanding of bilateral deficit, which can limit an individual's physical performance. Additionally, disparities in strength between limbs have been linked to an increased risk of prospective injuries (Brumitt et al., 2013), emphasizing the importance of minimizing inter-limb imbalances. To address potential issues associated with strength deficit, it is widely acknowledged that imbalances of 10-15% or more can be problematic (Kyritsis et al., 2016).

In the domain of human locomotion, healthy individuals typically exhibit a symmetrical gait pattern, with minimal deviation between the left and right sides of the body (Seeley et al., 2008). However, a certain degree of asymmetry within the range of 5% to 15% is considered normal between the two sides of the body (Lanshammar & Ribom, 2011). Understanding and quantifying these asymmetries are crucial for gaining insights into the complexities of human locomotion and its potential implications (Sadeghi et al., 2000).

Despite the widespread use of handgrip dynamometers in clinical and research settings to assess HGS, there's a noticeable gap in understanding bilateral deficits in HGS and their implications. We hypothesized a significant association between HGSD and spatiotemporal asymmetries in older youth, where greater HGSD correlates with pronounced gait parameter deviations. This cross-sectional study aims to fill this gap by investigating the association between HGSD and spatiotemporal asymmetries in older youth.

Methods

Study participants

In this cross-sectional study, the participants were convenient sample of first-year students. The selection criteria for the participants required them to be in a healthy state without any locomotor injury in the past 12 months. The study included 91 male (age: 19,34±0,60 years; height: 182,08±6,47 cm; weight: 77,68±8,78kg) and 38 female students (age: 19,42±0,72 years; height: 165,18±6,35 cm; weight: 58,26±6,68 kg). The students were asked to complete a questionnaire during a lecture, where they were also informed about the purpose and objectives of the study. Participation in the research was voluntary, and students had the option to withdraw at any time. This research was conducted in accordance with the principles outlined in the Declaration of Helsinki. The Faculty of Kinesiology at the University of Zagreb, Croatia granted ethical approval to carry out the study within its facilities (Ethical code: 82/2023).

Hand grip strength assessment

Participants' maximum isometric hand grip strength was assessed using the K-ForceGrip@ dynamometer (Kinvent, Monpellier, France). Prior to measurements, participants underwent brief familiarization with the dynamometer. During assessment, participants stood with their elbow extended, following Sousa-Santos and Amaral's protocol (2017). Each trial comprised a 5-second grip repetition, followed by a 3-second rest period, with three repetitions per hand.

Spatiotemporal gait parameters

The Zebris plantar pressure platform (FDM; GmbH, Munich, Germany) was used to assess various spatiotemporal gait parameters. The platform covered an area of 149 cm x 54.2 cm and was integrated into a 10.5 m walkway. Participants were instructed to walk straight without targeting the platform directly, followed by a 180° turn at the end of the walkway. This process was repeated four times per participant to enhance inter-reliability. The platform facilitated measurement of spatial parameters like step length, width, foot rotation, stride length, position, and symmetry, along with temporal parameters including stance, load response, mid stance, pre-swing, swing, double stance, step and stride time, cadence, velocity, gait line length, single support line, and maximum velocity.

Symmetry index calculation

The symmetry index (SI) was calculated using the formula by Robinson, Herzog and Nigg (1987): (Xright – Xleft) / 0.5 * (Xright + Xleft) * 100%. This index evaluates symmetry between the right and left sides of the body, yielding a result of 0 for perfect symmetry. Positive or negative values indicate deviations from perfect symmetry, with larger absolute values indicating greater asymmetry. For hand grip strength deficit assessment, we utilized the strength deficit parameter from the K-force pro app report.

Statistical Analysis

Basic descriptive statistics for all participants and divided according to gender are presented in Table 1. Shapiro Wilk W test was used to test normality. Since the data did not follow a normal distribution based on the results of the Shapiro-Wilk W tests, non-parametric statistics were used for subsequent analyses. Differences between male and female students were examined with Mann-Whitney U test. Spearman rank correlation coefficient was used to assess the relationship between spatiotemporal gait asymmetry parameters and hand grip strength deficit, with correlations categorized as weak ($r < 0.29$), moderate ($0.30 < r < 0.69$), or strong ($0.70 < r < 1$) (Dancey & Reidy, 2007). Associations were tested collectively for all participants and separately by gender. The significance was set at $p<0.05$. All analyses were held using Tibco Statistica Enterprise (version 14.0.1.25).

Results

Descriptive statistics for spatiotemporal gait and HGSD parameters are presented in Table 1. In the comparison between men and women, men exhibited significantly larger pre-swing phase SI, greater length of gait line SI, and higher values of midfoot pressure SI. However, no significant differences were observed in other parameters.

Table 1. Descriptive statistics of spatiotemporal gait asymmetries and handgrip strength deficit

Variables	ALL (N=129) Median (25th-75th)	Male (N=91) Median (25th-75th)	Female (N=38) Median (25th-75th)	p-value
Foot rotation_SI	0,06 (-0,11-0,25)	0,06 (-0,07-0,21)	0,09 (-0,37-0,41)	0,72
Step length_SI	0,03 (0,02-0,06)	0,03 (0,02-0,07)	0,03 (0,01-0,06)	0,59
Stance phase_SI	0,00 (0,00-0,01)	0,00 (0,00-0,01)	0,00 (0,00-0,01)	0,08
Load response_SI	0,02 (0,01-0,02)	0,02 (0,01-0,03)	0,01 (0,00-0,02)	0,31
single limb support_SI	0,01 (0,01-0,01)	0,01 (0,01-0,01)	0,01 (0,00-0,01)	0,23
Pre-swing_SI	0,01 (0,00-0,02)	0,01 (0,00-0,02)	0,01 (0,00-0,02)	0,57
Swing phase_SI	0,01 (0,00-0,01)	0,01 (0,00-0,01)	0,01 (0,00-0,01)	0,04
Step time_SI	0,00 (0,00-0,01)	0,00 (0,00-0,01)	0,00 (0,00-0,01)	0,25
Length of gait line_SI	0,00 (0,00-0,01)	0,01 (0,00-0,01)	0,00 (0,00-0,01)	0,03
Single limb support line_SI	0,01 (0,01-0,02)	0,01 (0,01-0,03)	0,01 (0,00-0,02)	0,08
HGSD	7,50 (4,50-13,00)	7,50 (4,40-12,60)	7,75 (4,70-16,20)	0,45

The associations between HGSD and spatiotemporal gait asymmetries are presented in Table 2. Among all participants, a statistically significant weak positive correlation was observed between maximum HGSD and step length SI (r = 0.19, p = 0.03). However, in male participants, no statistically significant correlation was found. In contrast, among female participants, several statistically significant correlations were identified. Specifically, a statistically significant moderate positive correlation was observed between HGSD and step length SI (r = 0.34, p = 0.04). Furthermore, statistically significant moderate negative correlations were established between HGSD and stance phase SI (r = -0.39, p = 0.02), swing phase SI (r = -0.39, p = 0.02), and step time SI (r = -0.41, p = 0.01).

Table 2. Association between maximum handgrip strength deficit and spatiotemporal asymmetries

	ALL (N=129)		Male (N=91)		Female (N=38)	
Pair of Variables	**Spearman**	**p-value**	**Spearman**	**p-value**	**Spearman**	**p-value**
HGSD & Foot rotation_SI	0,13	0,13	0,08	0,45	0,25	0,13
HGSD & Step length_SI	0,19	0,03	0,12	0,27	0,34	0,04
HGSD & Stance phase_SI	-0,15	0,08	-0,01	0,90	-0,39	0,02
HGSD & Load response_SI	0,02	0,84	-0,01	0,90	0,10	0,56
HGSD & single limb support_SI	0,00	0,97	0,09	0,37	-0,16	0,34
HGSD & Pre-swing_SI	0,10	0,28	0,03	0,77	0,27	0,11
HGSD & Swing phase_SI	-0,15	0,09	0,00	0,97	-0,39	0,02
HGSD & step time_SI	-0,09	0,30	0,05	0,65	-0,41	0,01
HGSD & Length of gait line_SI	-0,07	0,40	-0,08	0,44	0,04	0,83
HGSD & Single limb support line_SI	0,00	0,96	0,04	0,70	0,05	0,75

Discussion

Our study revealed statistically significant weak positive correlations between HGSD and step length SI (r=0.19, p=0.03) for all participants. These findings support the notion that greater HGSD is associated with increased asymmetry in step length, potentially indicating impairments in gait mechanics. Those findings are expected because HGSD (Chen et al., 2022; McGrath et al., 2021) and step length asymmetry are associated with numerous locomotor problems.

Statistically significant correlations were found only among female participants when analyzing male and female participants separately. This discrepancy could be attributed to variations in body size and shape between genders. Women typically have a pelvis tilted more anteriorly, exhibit more up-and-down oblique motion, and demonstrate a faster cadence, smaller step length, and shorter step time compared to men (Cho, Park & Kwon, 2004). These anatomical differences, including a wider pelvis, shorter height, and lighter weight, may contribute to the observed associations between HGSD and specific gait parameters, unique to female participants in this study. Moderate positive correlations were observed between

HGSD and step length SI (r=0.34, p=0.04), indicating that greater HGSD is associated with more asymmetrical step lengths among female participants. Moreover, moderate negative correlations were found between HGSD and stance phase asymmetry (r=-0.39, p=0.02), swing phase (r=-0.39, p=0.02), and step time (r=-0.41, p=0.01) among female participants. These findings suggest that greater HGSD is associated with decreased symmetry in stance phase, swing phase, and step time, potentially indicating disruptions in gait coordination and stability.

Klawitter et al. (2022) demonstrated a significant association between HGSD and weakness, revealing 1.46 times greater odds for the accumulation of future morbidities. The study also identified HGSD as a potential indicator of impaired muscle function, highlighting its clinical relevance.

Our study has several limitations. Firstly, the cross-sectional design warrants caution in interpreting the association between HGSD and spatiotemporal gait asymmetries. Secondly, the study population comprising first-year kinesiology students might yield different results if including individuals with varying physical activity levels and sports participation history. Future research should consider increasing sample size, including inactive populations, and employing multiple formulas to assess asymmetry.

Conclusion

In conclusion, our study provides novel insights into the association between HGSD and spatiotemporal gait asymmetries in older youth. The findings suggest that greater HGSD may be related to increased asymmetry in step length and stance phase, swing phase, and step time among female participants. These results highlight the importance of HGSD and its potential implications for musculoskeletal function and gait mechanics. Future research should continue to investigate the longitudinal effects of HGSD on gait parameters and explore interventions aimed at reducing asymmetries and optimizing musculoskeletal health.

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ANALYSIS OF MUSCLE ACTIVITY DURING CROSS-COUNTRY SKIING IN SKIERS WITH DIFFERENT QUALITY OF TECHNIQUE

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Abstract
The purpose of this study was to analyse and compare EMG signal of the four muscles during the cross country (XC) skiing by classical technique represented by diagonal stride. The data were collected by surface electromyography method (SEMG), and by synchronized pressure insoles for motion cycle determination. Acquired data were processed by software MATLAB.The study was focused at comparing muscle activity in two groups of cross-country skiers, the first group with a very good quality of diagonal stride technique, the second with deficiencies in technique. From the upper body, the muscles measured were the triceps brachii long head and the latissimus dorsi and two lower limb muscles, rectus femoris, biceps femoris, which are important for cross-country skiing throughout the movement cycle, were monitored. Differences in muscle activation between groups were found. Larger differences were found for the upper body muscles. The differences were found in total muscle activity time in the cycle.

Keywords: *cross country skiing, diagonal stride, movement cycle, muscle activity, SEMG*

Introduction
Performing the correct movement structures is determined by the quality of the neuromuscular system, allowing for the correct timing of muscle activity stimuli, which can be evaluated by EMG (Hermens et.al. 2000). For both research and practice, invasive and non-invasive techniques are used for monitoring and recording of EMG signal. During active movement activities, it is more convenient to use surface EMG (SEMG). SEMG is also suitable for use outside the laboratory during terrain research (Hermens et. al. 2000). The correct temporal involvement of muscles and muscle groups during specific movements is an important research topic that also applies to cross-country skiing. Several studies have demonstrated good opportunities to conduct research in natural conditions with valid results to evaluate the involvement of important muscles during the movement cycle. These studies include Chrastkova et.al. (2014) and Lindinger et. al. (2009). The classical style of XC skiing mainly includes diagonal stride (DS), double poling (DP), double poling with kick and herringbone run (Nilsson, Tveit, & Eikrehagen, 2004). This study is focused only to diagonal stride (DS). The movement cycle in DS is divided into take off, gliding and swing. Several relevant studies have been carried out describing the classical cross-country skiing technique from different perspectives, including kinematics, kinetics, physiology and muscular activity (Nilsson, Tveit, & Eikrehagen, 2004; Lindinger et al. 2009; Göpfert et al. 2016).

The aim of the research was to analyse the segmentation of the muscle activation of selected muscles during the movement cycle in two groups of XC skiers with different quality of diagonal stride technique.

Methods
Four XC skiers volunteered to participate in this study were divided into the two Pairs of skiers as "technically more proficient" (Pair 1) and "technically less proficient" (Pair 2), based on the quality of their XC ski technique. The first Pair (n=2, age 44±7 y, height 179±5 cm, weight 80±4 kg) demonstrated good DS techniques. The second Pair (n=2, 23±1 y, 181±6 cm, 81±5 kg) showed some coordination deficiencies. All participants provided written informed consent prior to measurements. The experimental protocol and all methods used in this study were approved by the Ethics Committee of the Brno University of Technology, Centre of Sports Activities.

Procedures
Muscle activity was measured for one classical style techniques: diagonal stride (DS). Measurements was made on flat and 60 m long section. Each participant completed this section 3 times. The speeds for DS were set at 12 km/h on the flat. The speed was controlled with a speedometer. The highest quality test record was selected for data processing. From this record, the best 10 cycles were selected for data processing.

Data collection

Muscle activity was assessed on both sides of the body using surface electromyography (SEMG) with a wireless SEMG system featuring built-in accelerometers (Miniwave, Cometa, Milan, Italy; EMG software and MotionsTools 8.7.6.0). The sampling rate was set at 2000 Hz with 16-bit resolution. SEMG sensors were placed and the skin under the electrodes was treated according to Hermens et.al. (2000). Data acquisition utilized Kendall™ ECG electrodes (diameter 24 mm, USA). The inter-electrode distance between each pair was set at 20 mm. The muscles analysed in this study included the rectus femoris (RF), biceps femoris (BF), latissimus dorsi (LD) and biceps brachii long head (BB). The peak dynamic method (PDM) were used for express EMG data from a muscle as a ratio of the peak value acquired from the same muscle during skiing (Crimswell, 2012). To determine the kinematic variables of the movement cycle, the Medilogic mobile pressure insole system (fy. Medilogic, Germany) was employed.

Variables

Time intervals of muscle activity and their segmentation in the movement cycle. The magnitude of muscle activity area under the curve in the movement cycle.

Data Processing

Electromyographic signals were saved in digital form and processed with a data acquisition frequency of 2000 Hz. Raw signals were passed through a high pass filter (20 Hz) and a Butterworth filter with an order 4. Subsequently, they were passed through a low pass filter (500 Hz) and another Butterworth filter with an order 4. The signals were then rectified. Signal smoothing was performed using the root mean square method (RMS, left range 25, right range 25). Parts of the EMG envelope exceeding 15 % of the maximum reached during a movement cycle were marked as muscle activity intervals (Spulak, 2014). The movement cycle in the DS was starting from the first touch of the ski with snow after the end of the swing phase to the touch after the next swing phase with the same ski. This cycle consists of three phases: gliding, take-off and swing. The MATLAB programme version R2022 was used for processing the signals and statistical analysis.

Statistical Analysis

Descriptive statistics were calculated including mean, standard deviation, percentage for phase. The Cohen's d effect size was used to compare the two groups. The Cohen's d effect size was calculated to indicate the size of the difference, with d = 0.2 – 0.50 indicate weak, d = 0.5 – 0.80 moderate and d ≥ 0.8 large size differences.

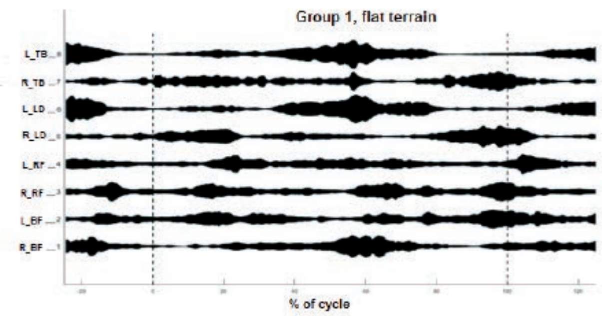
Results

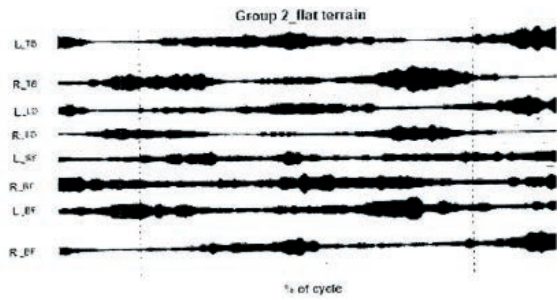
The analysis of the activity of all muscles is based on movement cycles that start with a gliding phase, continue with a take off, and end with a swing. The results are interpreted based on the temporal shifts of muscle activation and deactivation of selected muscles during the movement cycle, as well as the magnitude of activation of these muscles throughout the cycle (Tab.1). All intervals that exceeded 15% of the PDM and were longer than 8% of the cycle, with a magnitude greater than 5%, were counted. Acute non-systemic muscle activities of short duration and magnitude were not counted. Muscle activation magnitude was calculated by integrating the area under the activity curve of each muscle.

Table 1. Segmentation of muscle activity in the cycle and the magnitude of muscle activity

	Group of technicaly good XC skiers, run on flat							Group of recreational XC skiers, run on flat						
	1st interval		2nd interval		3rd interval		Size of activity	1st interval		2nd interval		3rd interval		Size of activity
	Act	Deac	Act	Deac	Act	Deact		Act	Deac	Act	Deac	Act	Deact	
TB (R)	10	21	88	100			538	1	22	66	99			1547
TB (L)	37	68					877	15	57					608
LD (R)	1	21	82	100			679	71	93					409
LD (L)	38	79					1029	38	63					211
RF (R)	11	21	57	70	92	100	106	42	87					746
RF (L)	18	30	46	61			243	9	23	40	50			289
BF (R)	11	21	57	70			629	29	55					979
BF (L)	9	21	29	39	90	100	106	0	15	63	95			359

Legend: Act-percentage of muscle activation onset, Deac-percentage of muscle activation end, TB(R)-triceps brachii, right side, TB(L)-triceps brachii left side, LD(R)- latissimus dorsi, right side, LD(L)-latissimus dorsi, left side, RF(R)-rectus femoris, right side, RF(L) rectus femoris, left side, BF(R)-biceps femoris, right side, biceps femoris, left side.





Picture 1. Muscle activation intervals of Pair 1   Picture 2. Muscle activation intervals of Pair 2

TB(R): Two intervals of muscle activity were recorded in both pairs, one at the beginning and one at the end of the cycle, which partially overlapped. In Pair 1, this muscle was active for 24% of the movement cycle time, while in Pair 2 it was active for 54% (large effect size, d=2.36). The magnitude difference of muscle activity was a large effect size (d=2.53).

TB(L): One longer interval was found in the middle part of the cycle in both Pairs. The interval time was 31% of the cycle time in Pair 1 and 42% in Pair 2 (medium size effect, d=0.6). The magnitude difference of muscle activation a large effect size (d=1.14)

LD(R): Two intervals of muscle activity were found in Pair 1, at the beginning and at the end of the cycle (38%), and one at the end of the cycle in Pair 2 (22%) of the cycle (large effect size, d= 0.85). The magnitude difference of muscle activity was a large effect size difference (d=1.54).

LD(L): A single interval of muscle activity was found in both pairs. Muscle activity was longer in Pair 1 (41%) than in Pair 2 (25%), suggesting a large effect size difference (d=0.89). The magnitude difference of muscle activity was significant (large effect size, d=3.17).

RF(R): In Pair 1 we found 3 intervals of muscle activity in a cycle (31%), while in Pair 2 we found one longer activity in the middle part (45%). The difference was medium effect size (d=0,72). The magnitude difference of the activity was medium effect size (d=0,56).

RF(L): There were two intervals of muscle activity in both groups; at the beginning and in the middle part. Intervals of activation was 27% in Pair 1 and 22% in Pair 2 (small effect size, d=0.28). The magnitude difference of muscle activation was a small effect size (d=0.38).

BF(R): In Pair 1, two intervals of muscle activation were found at the beginning and in the middle part of the cycle (23%), while in Pair 2, one interval was found in the middle part (26%). The difference in muscle activation time was not significant (small effect size, d=0.15). The magnitude of muscle activation was significantly different (large effect size, d=1.21).

BF(L), In Pair 1, three muscle activations were found; two in the first half of the cycle and the last one at the end of the cycle (32%). In Pair 2, two activations were found; at the beginning and at the end of the cycle (47%). The difference was a large effect size (d=0.94). The magnitude difference of activation a large effect size (d=1.74).

Discussion

Skiing on flat terrain is less demanding in terms of loading intensity, so we expected fewer and smaller differences between Pairs, despite a significant difference in technique. In fact, for individual muscles, mostly large differences were found between groups, but there was a difference between upper and lower body muscles. Almost all of the differences were significant (large) for the upper body muscles, with only one being medium, while for the lower body muscles, most were small or medium. The pictures 1,2 shows that the muscle activities intervals of the right and left sides alternate in relatively regular cycles in Pair 1, indicating good coordination of the selected muscles. In Pair 2, the involvement of the muscles of the right and left sides also alternates, but visually, it is possible to identify some deficiencies, especially in the timing of and magnitude of muscle activation. Differences in the segmentation of upper body muscle activation between groups were mostly observed at the beginning of the cycle, when recreational skiers typically exhibited little or no activity (Tab.1). Pair 2 used most of these muscles in the middle and end of the cycle. In terms of muscle activation time required to engage the upper body muscles in poling, an important finding was that beginners used TB more than LD (both sides), whereas the opposite was true for more proficient skiers. For Pair 2, this is a consequence of both poorer basic trunk position, hanging on to the poles, more flexed arms during the swing and a limited range of motion in which LD is underutilized. The imbalanced involvement of TB in recreational skiers is also evidenced by the tendency to favour their preferred arm, whereas in technically proficient skiers, the temporal use of TB and LD is very balanced. The greater muscle activity in LD is indicative of better muscle involvement in the poling in Pair 1, which is crucial for generating propulsive forces. In recreational runners, the lower LD involvement at the beginning of the cycle is evident. For Pair 1, the upper body muscle activities within the cycle (TB, LD) are well defined; the opposing muscles are coordinated in the countermovement, so the timing of the cycle for both muscle pairs is relatively good. For Pair 2, it is evident that the movements are based on a bipedal gait, where upper body involvement is lower, hence the lower use of LD and the inefficient use of TB results from poorer poling. Although the coordination visually resembles quadrupedal activity, muscle activation does not confirm the effective involvement of the selected muscles in producing propulsive forces.

For the lower limbs, we found more similar muscle activity results for both groups in terms of both total time of activity in the cycle and the magnitude of muscle activity. For lower limb muscles, small and medium size effect differences predominated. Comparing the RF activation time with Chrastkova's (2014) value of 26%, the mean RF activation time for the left and right leg muscles in our groups was 29% and 33.5% (Pair 1 and Pair 2, respectively). We consider this to be a similar result, especially for Pair 1, although for recreational skiers, this comparison is also favourable as Chrastkova (2014) tested a high-quality skier. Also, the magnitudes of muscle activity for RF were more balanced between our Pairs than for the upper body muscles. For BF, differences in activation time between the Pairs were significant for the left leg, while the difference for the right leg was negligible. The size of difference in activation time was large and medium for both legs between Pairs. When compared with Chrastkova (2014), similar activation time was found only for the BF of the left leg in recreational skiers. For the right leg in Pair 2 the values were smaller, even in technically better skiers for both legs. The difference resulted from both the higher technical quality of the skier in Chrastkova's (2014) study and the higher running speed in her study, in which muscle activation time of the selected muscles was prolonged and increased. Another fact is that recreational skiers do not typically engage the calf muscles vigorously in take-off, primarily due to the shorter take-off and greater use of the anterior thigh muscles. Similar to Chrastkova (2014), better skiers performed two intervals of activity during take-off, whereas recreational skiers performed only one. In Pair 2, this deficiency is due to short take-off, poorer weight transfer and the generation of less pressure applied to the ski during take-off. In recreational skiers, it was always possible to observe multiple peaks and dips during the activation period, indicating an imbalance in the loading of the upper and lower body muscles, their worse coordination, or even a lack of balance. Technically proficient skiers exhibited very good orthogonal coordination of muscle activity, which built on each other and did not overlap. They showed a clear rise and fall in muscle activity over the course of the activation period.

Conclusion

Despite the relatively good visual coordination during the diagonal stride in recreational skiers, deficiencies in the temporal distribution of muscle activation during the movement cycle were found. Recreational skiers demonstrated little muscle activity at the beginning of the cycle.

Larger differences between pairs were found for the upper body muscles. These differences can be associated with poorer ski technique, the ability to dynamically implement all phases of the movement cycle as well as the ability to build on each other in recreational runners.

The authors are aware that a small sample size is limiting the discussion and the conclusions.

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THE IMMEDIATE EFFECT OF KINESIO TAPE ON STATIC POSTURAL STABILITY IN HEALTHY INDIVIDUALS: A RANDOMIZED CONTROLLED STUDY

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Abstract
Kinesio Tape (KT), recognized for its elasticity, enables unrestricted movement and is claimed to offer various physiological benefits, including possible improvements in postural stability through proprioceptive activation via mechanoreceptor stimulation. This study aimed to assess the acute effect of KT application on static postural stability in healthy individuals. Forty participants (16 male, 24 female) were randomly allocated to either the KT group (n=20) or control group (n=20). Using a FootWork Pro portable baropodometry platform, measurements were taken in three positions (bipedal, monopedal-left, monopedal-right) pre- and post-tape application. Statistical analysis revealed significant improvements in the KT group during bipedal and monopedal-left standing for center of pressure, frontal, and sagittal planes ($P<0.05$). Conversely, no significant differences were observed in the control group ($P>0.05$) or for monopedal-right standing in the KT group ($P>0.05$). These findings suggest that KT application may enhance static postural stability, particularly during bipedal standing. However, this study focused solely on acute effects, highlighting the need for investigations into long-term effects or duration of observed benefits.

Keywords: *taping, posture, center of pressure, healthy population*

Introduction

Postural stability is an important characteristic of human movement, and maintaining a stable posture is essential for activities of daily living and physical performance. It relies on proprioceptive feedback and intricate sensorimotor processes to control the body's center of mass (COM) within a specific base of support against internal and external forces (Ghai et al., 2017). Measuring the center of pressure (COP) is often used to assess postural stability, indicating where all applied forces converge on the ground surface (Ruhe et al., 2011). This metric offers insight into force distribution and reflects the motor mechanisms involved in maintaining balance and aligning the COM vertically within the base of support (Schubert et al., 2012).

The use of Kinesio Tape (KT) has been proposed to enhance proprioception and potentially improve postural stability by activating neurological and circulatory systems with its special elastic therapeutic tapes characterised by flexibility and extensibility (Ogrodzka-Ciechanowicz et al., 2021; Pourmomeny et al., 2016; Toprak Celenay & Ozer Kaya, 2019). Various theories propose mechanisms through which KT may influence stability, including its potential impact on joint stiffness (Pourmomeny et al., 2016), as well as its ability to stimulate cutaneous mechanoreceptors in the skin throughout a constant stretch to the skin. These mechanoreceptors transmit information about joint position and movement to the central nervous system. KT may enhance proprioceptive feedback by stimulating these receptors, enabling improved standing posture and postural control (Ogrodzka-Ciechanowicz et al., 2021; Pourmomeny et al., 2016).

Despite differing opinions on its effectiveness, there is consensus that external skin stimulation could enhance proprioceptive function and postural stability rather than solely providing joint support (Gök et al., 2019; Ogrodzka-Ciechanowicz et al., 2021; Toprak Celenay & Ozer Kaya, 2019). This study investigates the effect of KT application to the plantar surface on static postural stability compared to sham application among healthy individuals.

Methods

Participants

A total of 43 healthy participants were initially involved in the study, but three did not meet the inclusion criteria and were subsequently excluded. The final cohort consisted of 40 participants (16 male, 24 female) with an age range of 18 to 60 (mean age: 37.5 ±12.7) who took part in this single-blind, randomised, sham-controlled trial that received approval from the Ethical Committee (EKV-2021-009). Inclusion criteria precluded individuals with lower limb injuries, fractures, ligament injuries, balance disorders, polyneuropathy or neurological deficits within the past three months. Written informed consent was obtained from all participants before their involvement in the trial. They were then randomly allocated into either the KT (kinesiotape) group or the sham (control) group at a ratio of 1:1 while maintaining blinding throughout the study process.

Design

The procedure involved two postural stability measurements: one without tape and the other following KT or sham tape application. Participants underwent static postural stability tests in both double-leg (bipedal) and single-leg (monopedal) standing positions with eyes open. Each measurement comprised four 30-second trials, with a short rest period between each trial. Participants were instructed to stand barefoot with their feet shoulder-width apart, arms alongside their body, and to look straight ahead on a pressure platform. A certified KT researcher performed tape application to maintain blinding regarding the type of tape used.

Equipment

Measurements were taken using a FootWork Pro portable baropodometry platform (AM CUBE, Inc., France). The platform measures 645 x 520 x 25 mm in total size with active dimensions of 490 x 490 x 5 mm. The platform has an accuracy of approximately 5%, with sensors sized at 7.6 x 7.6 mm, providing two sensors per square centimeter on the pressure plate and a pressure range of 10 Kpa/1200 Kpa. This device efficiently captures mean pressure, peak pressure, and foot contact area with high speed and resolution to measure pressure and force distribution in the plantar region. For taping applications, KINESIO® TEX CLASSIC 5 cm x 4 m tape measuring cm was used across all applications.

Taping application

The experimental group (KT group) received therapeutic KT application on both feet, with the subject's ankle at 90 degrees (Figure 2 – A, B, C). The first strip covered the sole without stretch, and the second strip, with a 50–60% stretch, pulled the bent part toward the inside of the foot. The KT edges (3–4 cm) were applied without stretching, with the length ranging from 14–18 cm based on foot size (Figure 2-F). The control group received a sham application (Figure 2-D, E). The ankle position was not fixed at 90 degrees, and a strip was placed on the sole without stretching (Figure 2-E).

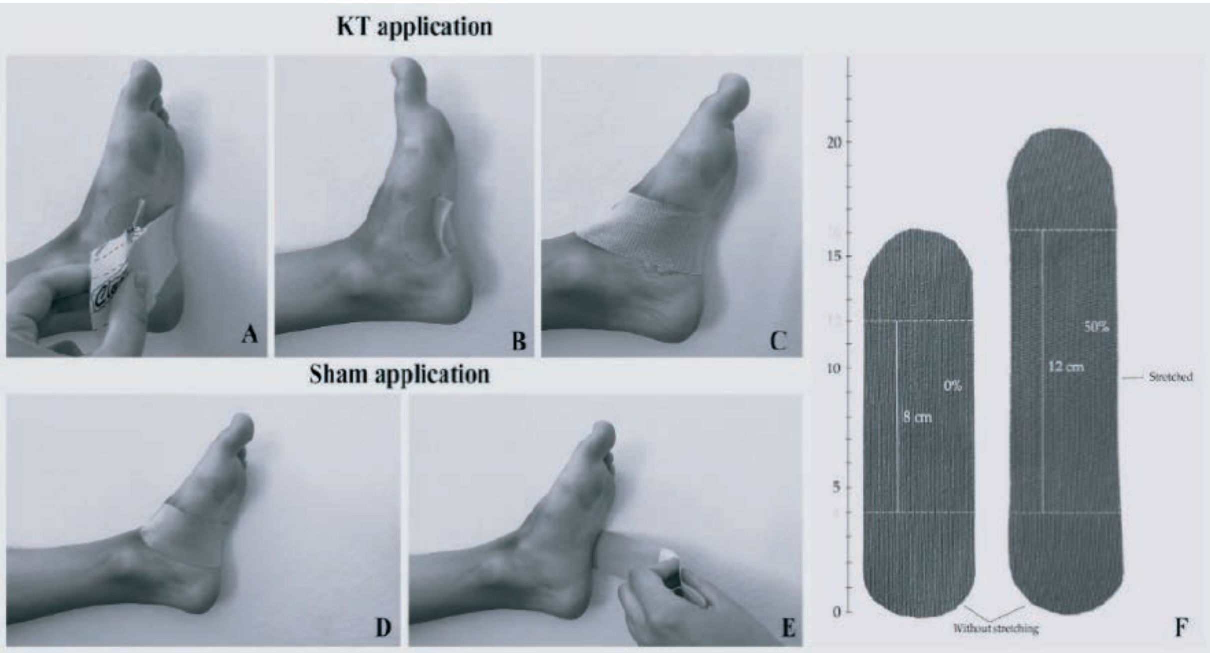

Figure 2: Application of therapeutic KT divided into three steps (A, B, C) and sham taping (D, E), KT stretching (F)

Data Processing

All parameters, including COP area (cm²), lateral oscillations (frontal plane, [cm]), and anterior-posterior movements (sagittal plane, [cm]), were obtained using Footwork Pro software. The COP area represents the confidence ellipse area (in cm²) with a selected point of 90%, essential for assessing postural stability while standing. This standardised evaluation involves analysing the area that covers the COP trace (Schubert et al., 2012). The COP serves as a reliable index of postural stability; test reliability is influenced by factors like the number of trial recordings and duration rather than specific COP parameter selection (Ruhe et al., 2010).

Statistical Analysis

Statistical analysis involved Statistica Statsoft 14, employing Shapiro-Wilk's Normality Test to assess data distribution normality. Unpaired Student's t-tests compared demographic characteristics, presenting data as mean ± SD, median, and min-max. Paired sample t-tests compared postural stability with and without KT application in both groups due to normal data distribution. Unpaired t-tests assessed gender differences. Significance was set at $P < 0.05$. Cohen's d-value effect size (ES) determined differences in magnitude, categorised as small (d = 0.2), medium (d = 0.5), and large (d = 0.8) (Lakens, 2013).

Results

The basic demographic characteristics of the participants can be found in Table 1. These two groups had no significant differences ($P > 0.05$).

Table 1: Demographic characteristics of the participants

	n	Age (year)	Weight (kg)	Height (cm)
KT group	20	39.1±13	68.8±13.5	170.4±10.6
Control group	20	36.0±12.4	74±3	76.7±11.1
P (<0.05)		0.453	0.083	0.226

Gender differences in postural stability variables were not statistically significant ($P > 0.05$). Thus, analysis was conducted collectively for both female and male participants. Significant differences ($P < 0.05$) were observed in bipedal and monopedal standing on the left foot after KT application (Table 3). Conversely, in the control group, no significant differences were noted between pre-test and post-test measures ($P > 0.05$) across all standing positions.

Table 2: Results of the t-test for both groups between the pre-test and post-test

<table>
<tr><td colspan="2" rowspan="2">Dominant leg (right), n (%)</td><td colspan="3">KT group (n = 20; 12 F, 8 M)</td><td colspan="3">Control group (n = 20; 12 F, 8 M)</td></tr>
<tr><td colspan="3">18 (90 %)</td><td colspan="3">19 (95 %)</td></tr>
<tr><td colspan="2"></td><td>Pre-test (mean±SD)</td><td>Post-test (mean±SD)</td><td>p</td><td>Pre-test (mean±SD)</td><td>Post-test (mean±SD)</td><td>p</td></tr>
<tr><td rowspan="3">Bipedal</td><td>COP (cm2)</td><td>3.137±1.977</td><td>1.930±1.080</td><td>*0.002</td><td>2.934±1.516</td><td>2.847±1.284</td><td>0.689</td></tr>
<tr><td>Frontal (cm)</td><td>1.707±0.512</td><td>1.381±0.366</td><td>*0.008</td><td>1.570±0.489</td><td>1.534±0.482</td><td>0.736</td></tr>
<tr><td>Sagittal (cm)</td><td>2.141±0.823</td><td>1.675±0.587</td><td>*0.001</td><td>2.247±0.758</td><td>2.202±0.552</td><td>0.655</td></tr>
<tr><td rowspan="3">Monopedal-left</td><td>COP (cm2)</td><td>7.513±3.644</td><td>6.179±3.242</td><td>*0.009</td><td>7.393±4.034</td><td>7.899±3.572</td><td>0.408</td></tr>
<tr><td>Frontal (cm)</td><td>2.842±0.939</td><td>2.545±0.852</td><td>*0.049</td><td>2.587±0.978</td><td>2.590±0.851</td><td>0.980</td></tr>
<tr><td>Sagittal (cm)</td><td>3.576±0.935</td><td>3.193±1.043</td><td>*0.013</td><td>3.584±1.220</td><td>3.899±1.209</td><td>0.265</td></tr>
<tr><td rowspan="3">Monopedal-right</td><td>COP (cm2)</td><td>7.561±3.457</td><td>6.800±3.805</td><td>0.150</td><td>7.318±3.630</td><td>6.627±4.309</td><td>0.253</td></tr>
<tr><td>Frontal (cm)</td><td>2.712±0.725</td><td>2.584±0.865</td><td>0.364</td><td>2.717±0.791</td><td>2.468±0.801</td><td>0.093</td></tr>
<tr><td>Sagittal (cm)</td><td>3.457±1.041</td><td>3.394±1.190</td><td>0.711</td><td>3.282±0.895</td><td>3.023±1.340</td><td>0.259</td></tr>
</table>

Cohen's d values indicated a large effect size for the COP and sagittal plane in bipedal standing after KT application (COP: ES = 0.811, Sagittal: ES = 0.933), with a medium effect size for the frontal plane (Frontal: ES = 0.467). In the left monopedal standing post-KT, medium effect sizes were found for all variables (COP: ES = 0.650, Sagittal: ES = 0.617, Frontal: ES = 0.470).

Discussion

This study aimed to evaluate the acute effects of KT applied to the plantar surface of the foot on static postural stability compared to sham taping among healthy participants. Our findings revealed a significant enhancement in postural stability during bipedal and monopedal-left standing after KT application, as evidenced by changes in variables such as COP, frontal, and sagittal planes. However, no improvement was observed during monopedal-right standing, despite 90% of participants identifying their right foot as dominant.

These results are consistent with previous studies by Gök et al. (2019), indicating that KT application to the ankle improved mediolateral stability in standing balance. Ogrodzka-Ciechanowicz et al. (2021) demonstrated immediate enhancements after ACL rupture, showing a decrease in total path length and improvements in parameters related to the frontal and sagittal planes. Furthermore, Toprak Celenay & Ozer Kaya's (2019) findings suggested improved postural stability and reduced pain among patients with chronic low back pain after KT application. Contrary to these findings, Silva et al. (2015)) found no significant enhancement in postural control in healthy individuals with KT application under eyes-open conditions. However, they observed an interesting interaction between taping and visual conditions, where KT significantly reduced postural sway area and distance only when participants had their eyes closed. This suggests that the participant's visual condition may influence the impact of KT on postural control.

The lack of improvement observed during monopedal-right standing following KT application may be attributed to factors such as biomechanical differences between the legs or variations in muscle activation patterns. While it's commonly assumed that the left foot may be more stable due to factors like leg preference, these differences alone may not fully account for the lack of improvement. However further research is needed for a comprehensive understanding.

Our study's limitations include focusing on acute effects only, without investigation into long-term effects, and the absence of subjective feedback from participants. Additionally, individual responses to KT application may vary, and caution should be exercised when applying this technique.

Conclusion

In conclusion, our study demonstrates that KT application to the plantar surface can immediately affect static postural stability, particularly in bipedal and monopedal-left standing positions. These findings support the theory that skin stimulation via KT may enhance proprioceptive function and improve postural stability. Nonetheless, further research with larger sample sizes and including healthy and unhealthy populations is warranted to validate these findings and inform clinical practice. Additionally, future studies should consider incorporating subjective feedback from participants to provide a more comprehensive understanding of the effects of KT applications.

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THE ROLE OF BODY MASS IN ADOLESCENT BALANCE: INVESTIGATING ASSOCIATIONS

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Abstract
This study aimed to explore balance parameters and their association with body weight among adolescents. Forty high school adolescents participated in the study, undergoing measurements of body height and weight using validated instruments. Balance was assessed using the Single Leg Stance (SLS) Test, which evaluates static postural and balance control. Gyroscopic devices captured equilibrium parameters, including ellipse area, trajectory length, mean velocity, mediolateral length, and anteroposterior length. The findings revealed statistically significant associations among adolescents performing the single stance test with closed eyes on their left leg. Despite their youth and relatively active lifestyles, participants found the task challenging, particularly those with dominant right-handedness and non-dominant left legs. Body weight and balance parameters showed a negligible association, indicating that body weight may not significantly impact balance in adolescents. Nevertheless, additional research with larger sample sizes is required to validate these discoveries and investigate potential gender disparities.

Keywords: *asymmetry, balance, high school students, single stance test*

Introduction
Adolescence encompasses the phase of life marking the transition from childhood to adulthood. Adolescence is usually considered to begin around the age of 10 or 11 and can last until the early 20s. It is a time of intense physical, emotional, social, and cognitive changes (Kuzman, Pavić-Šimetin & Pejnović Franelić, 2012).

Balance refers to the capacity to sustain a particular body posture with minimal motion, whether in static or dynamic circumstances (Zemková & Hamar, 2010). Static balance denotes the capacity to uphold body posture with minimal sway while positioned on a stable surface, whereas dynamic balance refers to the adeptness in preserving body position amidst movement or on an unstable surface (Nardone & Schieppati, 2010; Davlin, 2004).

Recognizing the correlation between correct body posture and balance in children and adolescents holds growing significance in contemporary times, owing to lifestyle alterations and their association with various musculoskeletal disorders (Azevedo et al., 2022; Szita et al., 2018). This study aims to explore potential correlations between body weight and balance parameters in adolescents.

Methods
Participants
The research included 40 adolescents (29 females, 11 males) aged 15.53 ± 0.5 years, height 169.22 ± 8.30 cm and weight 62.54 ± 10.95 kg. All are attending one high school in Osijek-Baranja County, Croatia. The testing took place over 3 weeks in March, during regular physical education classes. Before participating in the study, the participants' parents had to authorize participation in the research, individuals were required to sign a written consent form. The study was approved by the Ethics Committee of the Faculty of Kinesiology in Osijek (classification code 029-01/24-01/05 and registration number 2158-110-01-24-3) and was conducted following the current Helsinki Declaration.

Measurement Instruments
The body height was measured using a validated anthropometer (Seca 217 Stadiometer Mobile Height Measurement Scale), body weight was measured to the nearest 0.1 kg using a BIA device's body weight scale, with the participant standing in the center of the scale platform, barefoot (Omron BF-511, Kyoto, Japan). A gyroscopic device GYKO (Microgate, Bolzano, Italy) was used to test the balance of the participants.

Variables
From the equilibrium parameters obtained by the Gyko device, the following variables were taken (Gyko, 2022): Ellipse area (EA) - The area of the ellipse encompassing approximately 95% of the trajectory points is expressed in square millimeters (mm^2). Length (D_L) - The total length of the trajectory, expressed in millimeters (mm), is the sum of distances from one point to the next. Mean velocity (D_V) - represents the average velocity of trajectory movement. Medio-lateral length (ML_L)

- the medio-lateral length is the total distance in the medio-lateral plane, calculated as the sum of absolute distances between two points in the medio-lateral direction. Mean velocity ML (ML_V) - represents the average velocity of trajectory movement in the mediolateral plane. Antero-posterior length (AP_L) - the antero-posterior length is the total distance in the antero-posterior plane, calculated as the sum of absolute distances between two points in the antero-posterior direction.

Mean velocity AP (AP_V) - represents the average velocity of trajectory movement in the anteroposterior plane.

Protocol
The participants performed all measurements barefoot. They measured their body height at the first station, followed by measuring their body weight on an Omron scale. The final test was the single stance test on both legs. The Gyko device was secured onto a special belt and placed on the T1 vertebrae, which was located manually through palpation, following the manufacturer's instructions (Gyko, 2022). After device placement, the height was measured, and the obtained values were inputted into the GykoRePower program. Participants were instructed to close their eyes and, upon the signal, lift their left leg and maintain a steady position until a new signal was given. The GykoRePower program selected the Sway test with a stabilization time of 1 second, which was not included in the measurement results to allow participants to establish a balanced posture. The effective duration of the test itself was 30 seconds. After one participant completed the test with the left leg raised, they proceeded to perform the test with the right leg raised.
The Tibco Statistica Enterprise program (version 14.0.1.25) was utilized for testing purposes. The Shapiro-Wilk W test was employed to assess the normality of distribution, revealing that the variable "body height" follows a normal distribution. However, all variables related to equilibrium parameters did not exhibit normal distribution and were further analyzed using non-parametric tests. The Wilcoxon signed-rank test was employed to determine differences between equilibrium parameters of the left and right legs in the closed-eyes test. Spearman correlation test was used to ascertain the association between body mass and equilibrium parameters. The level of association was defined as negligible. Specifically, the level of association is described as negligible when the correlation coefficient is less than 0.29, low when it falls within the range of 0.30 to 0.50, moderate when between 0.50 and 0.70, high when between 0.70 and 0.90, and very high when between 0.90 and 1.00 (Mukaka, 2012). Statistical significance was set at $p < 0.05$.

Results
Table 1: Results of the Wilcoxon signed-rank test for paired samples between the left and right legs in equilibrium parameters.

Variables	Number	T	Z	p
3-EA & 4-EA	39	390,00	0,00	1,00
3-D_L & 4-D_L	39	349,00	0,57	0,57
3-D_V & 4-D_V	39	349,00	0,57	0,57
3-ML_L & 4-ML_L	39	353,00	0,52	0,61
3-ML_V & 4-ML_V	39	353,00	0,52	0,61
3-AP_L & 4-AP_L	39	286,00	1,45	0,15
3-AP_V & 4-AP_V	39	286,00	1,45	0,15

Legend: * $p < 0.05$; r - Spearman correlation coefficient, BM-body mass, 3-EA- Ellipse area right leg, 3-D_L- Length right leg, 3-D_V- Mean velocity right leg, 3-ML_L-Medio-lateral length right leg, 3-ML_V- Mean velocity ML right leg, 3-AP_L -Antero-posterior length right leg, 3-AP_V- Mean velocity AP right leg, 4-EA- Ellipse area left leg, 4-D_L- Length left leg, 4-D_V- Mean velocity left leg, 4-ML_L-Medio-lateral length left leg, 4-ML_V- Mean velocity ML left leg, 4-AP_L -Antero-posterior length left leg, 4-AP_V- Mean velocity AP left leg

In Table 2, the association of body mass with body balance parameters is presented. Statistically significant correlation coefficients were found in the variables BM & 4-ML_L (p=0.04) and BM & 4-ML_V (p=0.04). Although not significant, low correlation exist in the variables BM & 4-EA (p=0.05), BM & 4-D_L (p=0.07), BM & 4-D_V (p=0.07), BM & 4-AP_L (p=0.07), and BM & 4-AP_V (p=0.07).

Discussion
Mediolateral movement can be associated with body weight in several ways. Primarily, greater body weight can create increased pressure on the feet and legs, which can affect stability and control during mediolateral movement (Walsh et al., 2017). Additionally, greater body weight can influence the body's center of gravity, resulting in a greater need for balance adjustments during mediolateral motions (Greve et al., 2013). Ultimately, body mass can affect muscle strength and the

ability to control movement, which can also influence mediolateral stability (Prasetiowati, Kusumaningtyas & Tamin, 2017). The Single Leg Stance (SLS) Test is used to assess static postural and balance control.

Parameters of single-leg body sway can be utilized to analyze the static performance of stabilization under conditions of unilateral distribution of body weight (Trajković et al., 2022). In this study, a statistically significant correlation was observed among adolescents who performed the test in one stance with eyes closed on the left leg (BM & 4-ML_L p=0.04, r=0.32 and BM & 4-ML_V p=0, 04, r = 0.32). Although there is a statistically significant correlation, it is weak, probably because in our study the participants were neither obese nor excessively high in body mass. For other balance parameters, there is no significant relationship with body mass. We can say that the test of one stance with eyes closed probably slightly disturbs the length of the poster and the speed of movement, but it would be good to examine the relationship between these variables on a larger sample of subjects. Therefore, we can understand the lower correlation between body mass and balance parameters, especially considering previous research showing that higher body mass tends to disrupt balance trajectories (Greve et al., 2013).

The participants are relatively young, do not have excess weight, and are relatively active, the single stance test with closed eyes remains a challenging task for them. This result is consistent, given that the majority of participants are right-handed, and their left leg is non-dominant. The act of standing on one leg poses a significant challenge in human movement as it necessitates maintaining the body's center of mass within a smaller support area compared to standing on both legs (Lee & Lin, 2007). When a participant shuts their eyes, it disturbs their balance, resulting in heightened corrective actions by the postural control system to sustain equilibrium (Hertel, Olmsted-Kramer & Challis, 2006). From certain authors, the analysis indicated superior balance performance among adolescents compared to children regarding static steady-state, dynamic steady-state, and proactive balance. It is inferred that the maturation of balance might not be finalized during childhood but could potentially extend into adolescence among healthy individuals (Schedler, Kiss & Muehlbauer, 2019).

According to the authors who tested 31 elementary school students, there was no notable distinction observed in the upper and lower limbs between physically active and inactive groups in terms of balance, as evaluated through a closed-eye single stance test (Cho & Kim, 2017). Some researchers examined balance on various surfaces and concluded that during recordings on a hard surface, closing the eyes led to a more pronounced increase in sway among obese individuals compared to lean and overweight individuals, particularly concerning sway length and area (Cruz-Gómez et al., 2011).

Conclusion

Although the results in this study show that there is an association between body mass and some balance parameter variables, this association is small. This implies that body mass may not significantly affect balance parameters in non-obese adolescents, but if body mass is greater, it could potentially affect these balance parameters.Despite their youth, absence of excess body weight, and relative activity levels, the single-leg stance test with closed eyes remains challenging. These results could serve as a basis for future research aimed at better understanding the relationship between body weight and balance parameters in adolescents. Also, future research should consider increasing the sample size and investigating potential differences between genders and age groups of participants.

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INFLUENCE OF THE BODY MASS INDEX ON THE MOTOR PATTERNS OF WALKING IN CHILDREN OF AN EARLY AND PRESCHOOL AGE

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Abstract
The goal of this research was to perform a kinematic analysis of the motor structure of walking in children of an early and preschool age in order to determine the inter-individual differences of children and their connection with the body mass index. The research was conducted on 174 children of an early and preschool age, of the average age of 71 months, attending the regular full-day programme of the Rijeka Kindergarten in the Primorje-Gorski Kotar County. Four motor tasks of walking were realized, which were recorded with a video camera, and the recordings were processed in the Kinovea program. The basic descriptive parameters of the variables were calculated. The connection between the variables was tested with the Pearson correlation coefficient, while the t-test for an independent sample was used to test inter-individual differences, i.e., to test the reference constant. The results show that children who have a higher BMI take a significantly shorter step when walking backwards and on the Swedish bench, that is, they need significantly more time to complete the task and the average duration of contact with the ground is significantly longer. Obtained statistically significant interindividual differences between children, there is no unique kinematic pattern of movement when it comes to step length and duration of contact with the surface. The body mass index has a significant negative impact on the execution of some more complex motor patterns of children's walking and prevents the development of their motor potential. Walking with children of early and preschool age needs to be improved with kinesiology interventions, in order to make motor patterns uniform.

Keywords: *body mass index, motor pattern, walking, children*

Introduction
Walking belongs to the basic biotic motor skills (Petrić, 2022). A child in the first year of life does everything to strengthen their muscles, so that they can stand on their own feet and take their first steps. Walking appears in a child as early as the seventh month of life, it is coordinated on average up to the 12th month, and it is perfected almost until the child's 3rd year of life (Petrić, 2019). After children take their first steps, they gradually become more confident and their steps become longer, thus adopting adult-like motor walking patterns (Looper et al., 2006). During training, they also adopt different stopping behaviours, especially while walking down a slope (Gill et al., 2009). Children's mastery of walking skills is directly related to the frequency and quality of experiences they have playing with their peers (Adolph et al., 2003).

Many famous world scientists were fascinated by the human body and in some of their writings, they described exactly the biomechanics of the motor pattern of walking (Petrić, 2021). Here Aristotle and Leonardo da Vinci can be highlighted. Aristotle (384-322 B.C.), an ancient Greek philosopher and naturalist, was the first to analyse and describe the principles of walking as a rotatory movement that turns into a translational one and that subjects muscular action to geometric analyses. Aristotle formulated the meaning of movement and connected life and movement in a very simple way and briefly defined: "Movement is life". Movement is life, and physical activity and creativity, regardless of its nature (whether productive, professional, artistic, sports), always manifests itself through movement. Leonardo da Vinci (1452-1519) described the mechanics of the body when standing, walking up and down a hill, when getting up from a sitting position, when jumping, and he studied the relationships between the centre of gravity and balance, and the centres of resistance. Furthermore, the problem of excessive body weight and obesity is increasingly present in early preschool age. Contemporary research indicates a constant increase in the body mass index in a large sample of children aged two to eight (Jovancevic et al., 2019). The World Health Organization states that there are currently 42 million overweight and obese children between the ages of 0 and 5 in the world. Today, obesity is considered a disease and is not a condition that a child outgrows, but in 80 % of cases it happens that they remain obese in adulthood (Rojnić Putarek, 2018). Research focused on the kinematics of movement in children of early and preschool age confirms deviations in the optimal development with regard to obesity, linking the adaptation of the body, that is, muscle and bone tissue to pressure and tendency to injuries (Lerner et al., 2014; Dufek et al., 2012).

The question arises as to whether and to what extent excessive body mass and obesity can affect the complete motor development of a child, that is, his motor walking patterns, as one of the basic biotic motor skills in early and preschool age. This is precisely why the goal of this research is to perform a kinematic analysis of the motor structure of walking in children of an early and preschool age in order to determine the inter-individual differences of children and their connection with the body mass index.

Methods
Participants
The research was conducted with children of early and preschool age, i.e., a total of 174 children (97 girls and 77 boys). The children attended the regular all-day programme of the Rijeka Kindergarten in the Primorje-Gorski Kotar County and their average age was 71 months (min = 29, max = 85). The average body height of children was 107.95 cm, body weight 19.63 kg and body mass index 16.62 m/kg².

Sample of variables
The morphological variables of this research are: body height (cm), body mass (kg) and body mass index (kg/m²). Body height was measured with an anthropometer. Body mass was measured with a digital scale placed on a horizontal surface. The body mass index was obtained according to the formula describing it as the ratio of the value of body mass expressed in kilograms to the square of the value of body mass expressed in meters. Kinematic variables were obtained by processing video recordings in the Kinovea program, namely: total duration of the task, length of steps and time of contact with the surface.

Research protocol description
The research was conducted in accordance with the Code of Ethics for children and was approved by the Faculty of Teacher Education and the Council of Educators. Also, a parents' meeting was organized where parents obtained all the necessary information related to the research and recording of their children. Consents for the participation of their children in this research were collected at the same meeting. The research lasted for three days, and activities were performed, i.e., three motor tasks from the domain of mastering space - running. On the first day, the children's body mass and height were measured. On the second day, children from the nursery group were filmed, and on the third day, the same was done with children from the kindergarten group. All children, or tasks, were recorded with two video cameras. One was placed frontally, and the other laterally. The first motor task was forward walking. The children were given the task of walking a marked part of the field (5 meters). The second motor task was walking backwards on the same ground of 5 meters. The task was first demonstrated by the teacher and then performed by the children. The third task was walking on the Swedish bench.

Statistical data processing
The data were analysed in the Statistica 14.0.1.25 program. Basic descriptive parameters were calculated for all variables: arithmetic mean and standard deviation. The association was tested with the Pearson correlation coefficient, while the t-test for an independent sample was used to test inter-individual differences, i.e., to test the reference constant. Statistical significance was tested at the $p<0.05$ % level.

RESULTS
Table 1 shows the descriptive parameters and the results of the significance of inter-individual differences in the kinematic structure of children's walking when performing four motor tasks. The children performed the tasks of walking backwards and on the Swedish bench the slowest, i.e. they had the shortest step and the longest contact with the ground. Contrary to the above, they performed the task of walking forward the fastest, with the longest steps and the least contact with the ground.

Table 1. Inter-individual differences among children in the kinematic structure of walking

	Variables	M	SD	SE.	RC	t	df	p
BACKWARD	Total duration	9813.15	3341.45	747.17	0.00	13.13	173	0.00*
	Length of steps	28.14	5.79	1.29	0.00	21.71	173	0.00*
	Contact with the ground	691.63	181.52	40.58	0.00	17.03	173	0.00*
FORWARD	Total duration	5195.00	935.93	209.28	0.00	24.82	173	0.00*
	Length of steps	44.05	8.06	1.80	0.00	24.42	173	0.00*
	Contact with the ground	550.51	97.71	21.84	0.00	25.19	173	0.00*
SWEDISH BENCH	Total duration	6952.52	3042.41	697.97	0.00	9.96	173	0.00*
	Length of steps	36.79	8.83	1.97	0.00	18.63	173	0.00*
	Contact with the ground	629.67	172.34	38.53	0.00	16.33	173	0.00*

M- mean; SD- standard deviation; SE- standard error; RC- Reference Constant; t-value; df- degrees of freedom; p- value

The analysis of interindividual differences (Table 1) shows statistically significant (p=0.00) differences in all variables and in all tasks. It can be said that in this sample of subjects there is no unique kinematic movement pattern when it comes to the number and length of steps, the duration of contact with the ground and the overall duration of the task.

Table 2. Correlation of kinematic parameters of children when walking with BMI

	BACKWARD	FORWARD	BENCH
Total duration	0,54*	-0,25	0,65*
Length of steps	-0,65*	0,22	-0,68*
Contact with the ground	0,59*	-0,02	0,59*

*statistical significance P<0.05

Table 2 shows the results of the correlation of kinematic variables that define walking with the body mass index. Children who have a higher BMI take a significantly shorter step when walking backwards and on the Swedish bench, that is, they need significantly more time to complete the task, and the average duration of contact with the ground is significantly longer. It can be said that the aforementioned children are less skilled in motor skills and are significantly more careful when performing some more complex patterns of movement when walking.

Discussion

Each child deviates statistically significantly from the average, and in this sample of participants there is no unique kinematic pattern of movement when it comes to the number and length of steps, the duration of contact with the ground and the overall duration of the task. The investigation of inter-individual differences in children provides insight into the processes essential for motor control and learning, and is especially important for the optimal adaptation of necessary interventions (Anderson et al., 2021).

The results indicate a relatively large heterogeneity in the performance of all realized walking tasks in children of early and preschool age, that is, there are significant interindividual differences in all measured variables. Exactly similar results were obtained in almost all recent research (Ogawa et al., 2021; Axeti et al., 2017). Children's motor patterns are significantly impaired and it can be assumed that they will not improve satisfactorily on their own, while the fact that the same thing happens with simple structures such as walking is especially worrying. It is walking that is easy to develop, and is a prerequisite for the development of more complex skills. Children develop them naturally, and increased walking levels, their intensity and proper development can serve as prevention in cases of impaired health status and lack of physical activities (Logan et al., 2012; Carlin et al., 2016; Huang L., 2014). In preschool children, it is necessary to constantly improve biotic motor skills, so that their motor potential can be fully realized over the years (Petrić, 2022). As a rule, interventional kinesiology programmes can significantly contribute to the quality of motor patterns and properly direct their motor abilities during growth and development (Wdovskog et al., 2020). Today, there really is a need for intervention training programmes to improve motor skills and movement quality in children (Axeti et al., 2017). All of the above indicates how important it is to encourage proper walking movement in children from an early age and to apply it in organized physical activities. Such research with included interventions is more common with slightly older children, which leads to highlighting the importance of intervention research with children of an early and preschool age, made possible today by modern technology, the possibility of monitoring, and the simplicity of the display that today's technologically modern measuring instruments bring (Steinberg et al., 2017).

Children with a higher BMI take a significantly shorter step when walking backwards and on the Swedish bench, that is, they need significantly more time to complete the task, and the average duration of contact with the ground is significantly longer. In other words, BMI has a significant negative impact on the execution of somewhat more complex motor patterns of children's walking. By reviewing previous research, it is possible to connect the obtained results with pressure on the foot and joint, which can lead to degenerative diseases (Hung et al., 2013). As a rule, deviations are manifested in the width of the gait, stance and angles in the joints and knees due to muscle weakness, as well as stronger pressure on the foot and lower extremities due to increased force under the influence of excessive body mass. Through such force action, the child's body adapts to the different stages of walking, compensating for deficiencies and reducing force. Muscle weakness and the decline of cartilage health significantly affect walking speed, arm swings when walking, and, accordingly, the posture of the whole body. From all this, it can be concluded that in addition to deviations in the development of walking, the burdens due to obesity limit the ability to exercise and worsen the general health status (Adamo et al., 2016). Body mass is one of the main causes of stress on the joints, which consequently causes damage to the joint cartilages, pain and degenerative diseases. Such symptoms are increasingly present in children, and the described problem occurs daily in clinical treatments with children of preschool age (Horsak et al., 2015). An increased body mass index negatively affects the development of children's motor potential and represents a significant risk for locomotor injuries in children.

Conclusion

It can be concluded that children who have a higher BMI take a significantly shorter step when walking backwards and on the Swedish bench, that is, they need significantly more time to complete the task and the average duration of contact with the ground is significantly longer. Every child deviates statistically significantly from the average and in this sample of participants there is no unique kinematic pattern of movement when it comes to the length of steps and the duration of contact with the ground. There is a need for intervention training programmes to improve motor skills and movement quality in children. The body mass index has a significant negative impact on the execution of some more complex motor patterns of children's walking and prevents the development of their motor potential. Walking with children of early and preschool age needs to be improved with kinesiology interventions, in order to make motor patterns uniform.

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CURRENT TRENDS AND INNOVATIONS IN KINESIOLOGY RESEARCH: PROCEEDINGS

MANAGEMENT OF SPORT

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THE CONNECTION OF ECONOMIC FACTORS WITH THE INTERRUPTION OF A SPORTS CAREER

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Abstract
The aim of this study was to determine the influence of financial aspects as well as other possible reasons on the premature career termination of young sailors. The research involved 73 male sailors and 28 female sailors who prematurely ended their sports careers. For the purposes of the research, an online questionnaire in Croatian language consisting of 14 items was utilized, designed for the implementation of this study. The questionnaire was divided into a general section concerning the respondent's general information and a specific section regarding the reasons for discontinuing sailing. The results indicate that the participants most commonly discontinued sailing between the ages of 19 to 22 years old and between 16 to 18 years old. The main reason cited for discontinuation is the lack of time due to academic or school obligations, with as much as 27.7% of respondents indicating this factor. Additionally, insufficient financial resources are the second most important reason for discontinuing sailing, cited by 18.8% of respondents. Consequently, finances represent a direct economic factor leading to discontinuation, while education represents a financial and existential necessity that subsequently influences decisions to withdraw.
Keywords: sport, sailing, career break

Introduction
Since Croatia's independence, Croatian sailors have achieved top honors in various sailing classes, including Olympic classes. By discontinuing their sailing careers, the state not only loses athletes but also ambassadors for the country. Athletes who compete in major competitions are, in fact, the best promoters of their own country, regardless of whether the sport belongs to team or individual categories. Usain Bolt made an immeasurable contribution to the promotion of Jamaica, Novak Đoković to the promotion of Serbia, and athletes such as the Sinković brothers, and the Fantela brothers have undoubtedly influenced the promotion of Croatia. An excellent indicator of the promotional value of sports and athletes is Luka Modrić and the successes of the Croatian national football team in 2018, which saw a tremendous surge in searches for these terms (Lacković et al., 2023), placing Croatia on the world map of renowned countries. Croatia finances athletes through the Croatian Olympic Committee through 4 key programs, 3 of which relate to athletes and 1 to coaches. There are also agreements that enable athletes to be employed in the Croatian Army Reserve, but they cover a small number of athletes.

By participating in sports, young people attain numerous benefits from physical activity. Physically active adults have a lower likelihood of developing diseases such as obesity, diabetes, depression, cancer, heart diseases, and osteoporosis (Berger & Owen, 1988). Healthcare costs in the Republic of Croatia increased by 66% from 2002 to 2016, emphasizing the importance of organized physical activity. Additionally, it is estimated globally that physical inactivity contributes to a 1-4% increase in total healthcare costs (Obadić et al., 2017). Despite everything, research indicates that a significant portion of youth temporarily or permanently quits sports in the short term, before entering adolescence (Armentrout & Kamphoff, 2011), thereby reducing the likelihood of achieving physical, psychosocial, and motor benefits.

The reasons for discontinuing sports are numerous, often involving a combination of factors leading to withdrawal. To enhance the quality of sports, it is essential to have as many participants as possible in all categories of competitors, thereby fostering the emergence of more elite-level athletes. To achieve this, it is necessary to understand why children, youth, and athletes in general abandon sports before reaching or during their professional sports careers.

Gender and age are important factors in the decision to discontinue sports participation. The most significant decline in the number of young athletes is associated with the onset of adolescence (Eime et al., 2016). A characteristic period for this is career selection when enrolling in high school and when applying for college, during which athletes predominantly choose professions to pursue.

The causes of sports dropout can generally be categorized into three domains: personal limitations, social limitations, and structural limitations (Crane & Temple, 2015). Measuring and monitoring youth participation and dropout from sports are important for understanding specific factors that aid in continued participation and reducing dropout rates. Furthermore, long-term monitoring can evaluate achieved results and create strategies at the national level to increase the number of active participants in sports. In line with all the aforementioned points, it is necessary to find a model that will provide support to athletes in developing themselves throughout their careers and preparing them for the period after their athletic careers. The problem addressed in this study is the premature termination of the sports careers of young sailors, and it is necessary to identify the factors that lead to such decisions by athletes. The aim of this research was to determine at what age sailors most commonly cease training in sailing and what are the most common reasons that lead them to make such a decision.

Methods

This study involved 101 participants, including 28 former female sailors and 73 former male sailors. The participants completed the questionnaire online, and it was completely anonymous. Each participant voluntarily agreed to participate in the study. A questionnaire in the Croatian language, consisting of 14 items, was used to collect data on the reasons for discontinuing sailing. The questionnaire was divided into a general section concerning the respondents' demographic information and a specific section addressing the reasons for discontinuing sailing. Participants were provided with response options for the statements received, from which they selected only one that they considered most accurate. Each question constituted a separate variable. For statements such as "How long have you been training in sailing," participants were provided with response options grouped by years, such as "1-2 years," "3-4 years," or "5-6 years." In the second part of the questionnaire, questions were formulated so that participants indicated the extent to which a specific reason influenced their cessation of sailing training. For statements like "How much did school or academic obligations influence your decision to stop sailing training," response options included "did not influence," "minimally influenced," "somewhat influenced," "considered one of the main reasons," and "it is the main reason for discontinuation." The results were processed using the statistical software Statistica 14.0. The results display the frequencies of response items, along with the percentage distribution of each response.

Results

In the sample of participants, a larger proportion consists of males (n=73; 72.3%), while females account for 27.7% (n=28) of the total number of participants. The majority of participants are aged between 15 and 25 years old, comprising 52.5%, followed by those aged between 26 and 35 years old, constituting 36.7%. Regarding sailing experience, the largest proportion of participants trained in sailing for 11 to 15 years, comprising 31.7%. They are followed by those who trained for 9 to 10 years, accounting for 25.7% of the total participant share, while 15.8% trained in sailing for 7 to 8 years. Just over 7% of participants trained in sailing for more than 15 years.

The majority of respondents (41.6%) ceased sailing training between the ages of 19 and 22. Between the ages of 16 and 18, 32.7% of respondents stopped sailing, while 13.9% discontinued between the ages of 23 and 29. Four respondents quit between the ages of 6 and 12. The three primary reasons cited for discontinuing sailing training are lack of time due to school or academic obligations (27,7%), insufficient financial resources (18,8%), and incompetence of coaching staff (10,9%). Other reasons include injury/illness (7,9%), lack of interest (6,9%), unfavorable morphological characteristics (4,0%), adverse weather conditions (3,0%), and miscellaneous factors.

The lack of time, insufficient financial resources, lack of interest, and incompetence of coaching staff are the most common reasons for quitting sailing among men, while the most common reasons for women are lack of time, incompetence of coaching staff, and insufficient financial resources (Table 1).

Table 1. Most common reasons for quitting sailing by gender

Men (n, %)	Women (n, %)
Lack of time (n=20; 27.40%)	Lack of time (n=7; 25.00%)
Financial resources (n=15; 20.55%)	Incompetence of coaching staff (n=5; 17.86%)
Lack of interest / incompetence of coaching staff (n=6; 8.22%)	Financial resources (n=4; 14.29%)

Figure 1. The most common reasons for quitting sports and the percentage representation of their impact on quitting

Academic and school-related reasons

When asked to choose the most significant reason for discontinuing active sailing training, lack of free time due to school or academic obligations stands out as the primary reason (Figure 1), with 28 respondents selecting it as the most crucial factor. In response to the subsequent question regarding education, "How much did school or academic obligations influence your decision to stop sailing training," respondents had the option to choose from five possible answers. Eighteen respondents considered it the main reason for discontinuation, while 25 respondents believed it was one of the main reasons, totaling almost 45% together. 13,9% felt that these obligations somewhat influenced their decision to quit, while 14.9% believed they had minimal influence. Twenty-eight respondents, believed that academic or school obligations had no impact on their decision to stop training.

Financial reasons

Additionally, insufficient financial resources emerge as the second most significant reason for discontinuing sailing (Figure 1). When asked about the correlation between financial reasons and discontinuation of sailing, most of respondents emphasized that the lack of financial resources was not a reason for quitting. Among 24 respondents think that this reason only had a partial impact. Twenty respondents considered it one of the main reasons, while 15 respondents stated that the lack of funds had minimal influence. Ten respondents highlighted it as the main reason.

Incompetent coaching staff

Due to incompetent coaching staff, 11 respondents discontinued their sailing careers, making it the third most common reason influencing their decision to quit (Figure 1). In response to the question regarding the impact of incompetent coaching staff on their decision to quit, most of respondents believe that the incompetence of coaches did not affect their decision to stop sailing training, but part of them think it had minimal influence, while 20.8% consider it one of the main reasons for discontinuing training. 18.8% of respondents believe that coaching staff had a partial impact on their decision to quit, while 1% of respondents believe it was the main reason for quitting.

Other reasons

In addition to the aforementioned reasons, respondents also answered questions regarding the following career discontinuation factors. Severe and demanding weather conditions did not affect the cessation of sailing training for 68.3% of respondents. 15.8% considered them to have minimal influence, while 10.9% believed they had some influence. Lack of motivation and disinterest did not lead to the cessation of sailing training for 44% of respondents, had minimal influence for 28%, and somewhat influenced the decision for 14%. Injury or illness did not lead to discontinuation of sailing for 74.3% of respondents, had minimal influence for 10.9%, and was the main reason for quitting training for 5.9% of respondents.

Insufficient family support did not lead to the cessation of sailing for 87.1% of respondents, had some influence for 5.9%, and minimal influence for 5%. Changing classes did not lead to quitting sailing for 60.4% of respondents, while it had minimal or some influence for 15.8% of respondents. Morphological characteristics did not lead to quitting sailing for 69.3% of respondents, had some influence for 12.9%, and minimal influence for 10.9% of respondents.

Discussion
The results indicate that the lack of free time due to school or academic obligations is cited as the most common reason for discontinuing sailing training. The individual's endeavour to pursue a successful sports career can be a demanding task that consumes a significant amount of time. A considerable body of research shows that the lack of time due to school or academic obligations is a significant limiting factor for continued participation in sports, which aligns with the findings of this study (Butcher et al., 2002; Gatouillat et al., 2019; Persson et al., 2019). Further education and financial reasons interrupt the career of more than 50% of respondents. More than 70% of the respondents studied at university, but their sports careers were interrupted, which leads to the conclusion that there is mistrust and mismatch between educational opportunities and an active sports career. Balancing one's own sports training and competition with education poses a major challenge; therefore, athletes often prioritize education over sports to achieve livelihood and financial independence. An optimal environment for young athletes is exemplified by sports schools where academic education and competitive sports are complemented and supported. Based on practical insights, it is considered that there is a lack of programmatic and political initiatives for the implementation of a dual career, as well as a lack of communication in coordinating sports and educational policies (Ćužić, 2021). After mastering time management, it is necessary to teach athletes how to establish a balanced relationship between sports training, family, friends, and academic demands (Aquilina, 2013). Quality education gives athletes greater opportunities after the end of their careers. In addition, a higher level of education usually gives people a greater spectrum of specific abilities, so it is common for people with a higher level of education to have better salaries and work in better jobs (Psacharopoulos, 2009), which consequently leads to easier realization of existential security. In addition to a lack of time, insufficient financial resources have emerged as the second most common reason for discontinuing sailing training. It has been shown that individuals from lower socioeconomic backgrounds are more likely to drop out of sports because it is too expensive compared to those from higher socioeconomic backgrounds (Espedalen and Seippel, 2022). It can be assumed that amateur athletes, compared to those with professional contracts, are more likely to anticipate having to quit sports due to lack of funds for independent living. Sailing is a sport in which financial requirements are a crucial factor in achieving a successful sports career, often without adequate support from state institutions. To enable sailors to continue their sports career, it is necessary to provide funding for travel, equipment maintenance, and participation in competitions. Clubs that primarily focus on younger age groups tend to have a slightly worse financial situation, which undoubtedly leads to the withdrawal of better athletes due to the inability to finance their participation at higher levels of competition. These clubs represent the foundation of sports sailing in Croatia, so greater financial and organizational support is needed to increase the number of seniors in later stages. Since sailing is classified as an Olympic sport, it is important to address the entire issue at higher levels such as the Croatian Olympic Committee (HOO) or ultimately with the administrations of individual cities.

As the third most common reason for discontinuing sailing training, the incompetence of coaching staff is highlighted. Armentrout and Kamphoff (2011) suggest that nearly a third of athletes decide to quit sports due to the influence of coaches. Sometimes, inadequate coach education may limit the content of training sessions, resulting in repetitive exercises. Very often, coaching roles are taken by former sailors who have quit the sport but have not obtained the targeted education needed to be adequate for the coaching position. The dropout rate in sports is significantly higher among athletes who train under coaches without adequate education compared to athletes whose coaches have formal education (Barnett et al., 1992). Coaches are often volunteers or undertake coaching as a secondary job for minimal compensation, especially when dealing with younger age groups. Any form of coach learning and education will surely contribute to the development of athletes in the desired direction. These 3 reasons can be linked to the desire for financial independence and livelihood security, which they assume cannot be achieved in sports. A characteristic period of sports career break is when enrolling in high school and when applying for college, during which athletes predominantly choose professions to pursue. In a country with developed nautical tourism, young sailors but also the coaches are aware that if they implement their knowledge for commercial nautical purposes, they are almost certain to achieve an easier livelihood.

A certain proportion of sailors have discontinued their athletic careers due to injuries. Injuries are a frequent occurrence among elite athletes, and the health problems that arise after injuries are partly responsible for the cessation of sports careers. The decision to end a career is often not solely the result of the injury itself but also a combination of factors associated with it. However, an injury typically serves as the trigger for career discontinuation. Sports injuries are frequently negatively correlated with life satisfaction both during and after athletic careers (Park et al., 2013). Lack of interest in sports is cited as another common reason for discontinuation. It is commonly assumed that the primary motive for children to participate in sports is enjoyment and experiencing pleasant experiences (Green, 2005). It appears that not all those considered talented wish to participate in sports at a level where it becomes more professional (Persson et al., 2019). Insufficient family support affected the cessation of sailing training for only one participant, while nearly 90% of respondents stated that insufficient family support did not influence their decision to discontinue sailing training. In most cases, parents and family have a positive impact on the sports careers of young athletes. Family support is essential for achieving top results, as parents significantly influence children's motivation to engage in sports (Brustad, 1992). Research indicates that strong social support (family, friends, and partners) helps athletes overcome challenges during their careers, as well as after the end of their sports career. Creating conditions for life after sports is crucial for making decisions about career cessation. Sometimes unexpected problems arise that are beyond the control of the athletes and significant others. Coaches can excel in their job and provide support to athletes, yet athletes may still ultimately quit sports. For this reason, it is crucial to understand that quitting sports is a normal occurrence, especially among young athletes who often explore different activities during adolescence. It is also important to emphasize that young athletes may quit sports because they have redirected their interests elsewhere, not necessarily due to negative experiences in the sports field.

Conclusion

The results indicate that the most common reasons for discontinuing sailing training are lack of time due to school or academic obligations, insufficient financial resources, and incompetence of coaching staff. Balancing sports training with school or academic commitments represents a complex organizational task for athletes. Therefore, athletes need to be provided with flexibility in meeting their school or academic obligations to ensure uninterrupted progress in their sports careers. Athletes need to be financially supported by clubs or sponsors to finance the acquisition and maintenance of equipment and participation in competitions. By supporting young sailors from multiple angles, they are enabled to continue participating in the sport and achieve not only sports but also other goals. In the future, young sailors should be enabled to pursue a sports career while continuing their regular education instead of the common practice where sailors must choose one and completely abandon the other. Career counseling by experts or mentors promoting and supporting dual careers must be available to athletes, especially during the transition from high school to college. It is necessary to provide greater support to all athletes during their careers, but after the end of the career, prepare them for functioning outside the sports family. Continuous education of coaches would improve the quality of training and consequently lead to better results for sailors at sports competitions.

This study provides insights into the reasons why young sailors quit sailing training. However, there are certain limitations to this research. The sample size of participants is relatively small, and the responses to questions were predetermined. Future research should be qualitative in nature and encompass a larger sample of participants.

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STRUCTURE AND COMPARISON OF CROATIAN AND DANISH GENERAL GOVERNMENT EXPENDITURES WITHIN EU SPORT SYSTEM CONTEXT

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Abstract
Public financing of national sport (for Croatian Sport, see Škorić et al. 2012 and Bronić et al. 2012; for Danish see Pfister, 2011) may be regarded as a certain measure of success at top level competitions, and “various research has shown connection between the development of a society and the level of expenditure for sport” (ibid), although it is far from the rule. Opposite, almost mirror perspective of sport engagements through public sport policies is directly related to health (see Szczepaniak, 2020). Main goal of the research was to compare and correlate Croatian and Danish general government expenditures within EU context – through data time series in period 2012-2021, among financing of general/central/local state. Secondary goal was to upgrade perspective of sport financing in Croatia within EU context (within cumulative EU statistics), and to open discussion on possibilities of horizontal transfers of financial framework of model member state, i.e. Denmark. Results have shown that Danish general government expenditures within 2012-2021 period are highly correlated to general government expenditures of EU27 and Croatian general government expenditures within 2012-2021 period are not only significantly but moreover negatively correlated to general government expenditures of EU27 and Danish as well. Those findings direct focus towards individual and ‘general’ EU policies. With regard to specificities within correlations among financing of general / central / local state, it is symptomatic that Danish local state financing apparatus is in positive correlation to general and central state, whilst Croatian local state financing apparatus correlates highly and positively with general state, but negatively to central state.

Keywords: *COFOG, Croatia, Denmark, EU, Sport*

Introduction
According to Szczepaniak (2020) general government expenditures on sport and recreation in Denmark (in 2022 population near 6 million, cca 376-billion-euro GDP) compared to other EU countries in 2001, 2005, 2010, 2015, 2017 and the average rate of change in the period 2001-2017 were significant – ranking from 1st to 4th place (EUR per capita), whilst Croatian (in 2022 population near 4 million, cca 67-billion-euro GDP) ranking varied from 25th to 28th – in absolute values.

The most difficult part of any comparison of national economies on any basis is to precisely justify the choice of that particular economy as a ‘benchmark’. That is why, in the attempt to set the Danish economy as a benchmark for this report, sociological and cognitive-behavioural patterns of understanding similarities and differences were 'grounded' with numbers. Within established 'public space and communications' an indirect comparison of Denmark and Croatia was possible. E.g., while in Denmark the 'yellow card' is well-known and recognized, in Croatia there is the quasi-equivalent ‘eGrađanin’ ('eCitizen') system. In the ‘second layer’ of the argument for DEN-HR comparison, there are counter-argumentations with regard to position and role of the ‘sport system’ in public administration - in HR, in the observed period, Sport was under the Ministry of Science, Education, and Sports, whilst in DEN, it was under the Ministry of Culture, Sports and Media. It furthermore entails a 'third layer' - a direct transfer of different perceptions to perpetually generated differences in educational systems.

When ‘sport’ as a phenomenon is perceived, understood, processed and governed differently – as analysed within this research - implications on formal educational system, as well on non-formal and informal learning frameworks produces different behavioural and social patterns, with measurable health-related and top-level-sport-results-related outcomes within economic and policies-making/political frameworks. This is mostly due to a fact that sport is a rather complex social phenomenon and depending on its’ “level of quality, number of participants and aimed population” (Milanović, 2013, p. 27) it encompasses several different areas (Bartoluci and Škorić, 2009). According to European Sports Charter sport “means all forms of physical activity which, through casual or organised participation, are aimed at maintaining or improving physical fitness and mental well-being, forming social relationships or obtaining results in competition at all levels.” (©COE) Therefore, playing and achieving top sport results at different championships is as much as a sport as exercising at a local fitness centre three times a week. However, when it comes to financing matters, not all areas and activities inside these areas are financed the same way. Public funding is reserved only for activities considered to be public goods, and it is a task of each government on both local and central level to determine what exactly that is.

One of most prominent argumentations with regard to differences stem from establishment of “Team Denmark”- an independent public institution, responsible exclusively for the distribution of the financial resources provided by the Danish state for top-level sport (Trangbaek et al. 1995 and Storm&Brandt 2008 in Pfister, 2011). The role of Team Denmark was to protect ‘borders’ and differences between “Sport for All” and top-level sport. Danish parliament passed the legislation on elite sport which strengthened the link between “Team Denmark” and Ministry responsible for sport, the Ministry of Culture. Thus, attempt made by DIF (i.e., Danish Olympic Committee) to take over leading role in Team Denmark was thwarted (Nielsen, 2003 in Pfister 2011). Comparatively, Croatian Olympic Committee has almost exclusive privilege to govern public financing of top-level sport in Croatia.

According to Ibsen (2017), the Danish sports system differs from that of most European countries in terms of six distinctive characteristics: 1) three independent umbrella organisations 2) stronger organisational separation between the organisation of elite sports and the organisation of ‘Sport for All’, 3) semi-governmental institutions for sports, 4) particularly decentralised sport policy, 5) two separate support systems (local/state), 6) both sports organisations and sports clubs have a high degree of autonomy (the level of public support is among the highest in Europe). This argumentation is very interesting due to semi-governmental approach - which in Croatia and EU countries is either diverged into specific national organisation of sport or as part of the state department responsible for sport.

In general, Sport is often understood with regard to sport clubs, national teams, Olympics, world, continental and national competitions. Public financing of national sport (for Croatian Sport, see Škorić et al., 2012, Bronić et al., 2012) may be regarded as a certain measure of success at top level competitions, and “various research has shown connection between the development of a society and the level of expenditure for sport” (ibid), although it is far from the rule. Opposite, almost mirror perspective of sport engagements through public sport policies is directly related to health (see Szczepaniak, 2020).

When it comes to public financing, most common understanding of Sport financing in EU countries is related to money coming from games of chances/lotteries. Comparison of content of Croatian ‘Decree on the criteria for determining the beneficiaries and the method of distribution of part of the income from games of chance for the year 2023’ (NN 31/2023, 16/03/2023) and Danish ‘Act on distribution of profits and dividends from lotteries’ - reveal differences within policies (ACT no. 1532 of 19/12/2017).

Further and specific comparisons of elite sport policies of nations may be assessed, e.g. by a mixed methods approach (De Bosscher, 2018, followed by De Bosscher et al, 2006, De Bosscher et al, 2009., De Bosscher et al, 2010, De Bosscher et al, 2015, De Bosscher et al, 2019.) covering composite indicators within 9 ‘pillars’ as success factors 1: Financial support, 2: Governance, organisation & structure, 3: Sports participation 4: Talent identification & development, 5: Athletic and post athletic career support, 6: Training facilities, 7: Coach provision & development, 8: (Inter)national competition, 9: Scientific research & innovation.

When it comes to defining sport for economic purposes and measurement of its value, countries officially use NACE (R93.1) classification and sport encompasses operation of sports facilities, activities of sport clubs, fitness facilities, and other sports activities. However, this is the “core” of sport activities since, as previously explained, sport encompasses a number of other that are found under different NACE codes. Therefore, in 2006 European Commission set up a Working Group “Sport and Economics” whose first task was to “identify economic activities in goods and services associated with sport” (EC, 2018, p. 9) and develop “a common European approach for measuring the economic importance of sport” (Statistics Netherlands, 2012, p. 4). Their activities resulted in so called Vilnius definition of sport (Definition of Sport) encompassing: 1) Statistical definition of sport: Corresponds with the current CPA 2008 category 93.1 ("sporting services"), 2) Narrow definition of sport: All products and services which are necessary as inputs for (doing) sport ("to produce sport as an output"), and 3) Broad definition of sport: Statistical definition + narrow definition + all products and services which have a (direct or indirect) relation to any sport activity but without being necessary to do sport ("which draw upon sport as an input").

This definition of sport represents the basis for EUROSTAT data used in this paper. Within following statistical representation it is confined within strict Eurostat frame and categories: ‘Employment in sport’ - in general, categorized by sex, age and by educational attainment level, ‘Enterprises in sport sectors’ - annual detailed enterprise statistics for industry, business demography by size class, ‘International trade in sporting goods’ - Intra and extra-EU trade in sporting goods by product and partner, ‘Sport participation’ - Attending sport events, Physical activity, Time spent on sport and physical activity, Sport in cities, ‘Private households expenditure on sport’ - Mean consumption expenditure of private households on sporting goods and services by COICOP (Classification of individual consumption by purpose) consumption purpose and by income quintile, HICP (harmonised index of consumer prices) - annual data (average index and rate of change), HICP - monthly data (index), ‘Public expenditure on recreation and sport’- General government expenditure by function (COFOG).

Main goal of the research was to compare and correlate Croatian and Danish general government expenditures within EU context – through data time series in period 2012-2021, among financing of general/central/local state.

Secondary goal was to upgrade perspective of sport financing in Croatia within EU context (within cumulative EU statistics), and to open discussion on possibilities of horizontal transfers of financial framework of model member state, i.e. Denmark.

Methodology

All data within category 'Sport' were collected from Eurostat - extracted on 12/06/2023 16:23:43 from [ESTAT], last updated: 02/06/2023 23:00. This base covers years from 2004 onwards, NACE Rev. 2 - for the goals of the research – for EU27, EA20, Croatia and Denmark within time frame between 2010-2021. Absolute values were followed and presented by derivatives – percentages and discrete growth rates (Δ). Descriptive parameters (mean, standard deviation), normality tests (Kolmogorov-Smirnov test), and correlation (Pearson) analyses were assessed by Statistica (Tibco, Inc).

Results and discussion

General government expenditure by function (COFOG) are presented in Table 1. as part of public expenditure on recreation and sport. Although in Croatia there was (and is) a 'common narrative' of continuous disharmonious government expenditure within and for Croatian sport&recreation-oriented institutions and individuals, dichotomous arguments are supported in relative parameters, i.e. percentages of gross domestic product. Within year 2017 revisions of GDP brought down public expenditures on recreation and sport to greatest extent, as a main pillar for argumentation for forthcoming period of increase (2018-2021).

Table 1. Total general government expenditure - National accounts indicator (ESA 2010)

Million euro	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
EU27*	42.658,50	43.576,40	44.131,00	44.991,40	45.606,60	47.903,50	50.987,00	54.049,30	52.916,00	55.973,80
Δ		2,11	1,26	1,91	1,35	4,79	6,05 ↑	5,67	-2,14 ↓	5,46
EA20**	36.106,10	37.225,00	37.027,20	37.953,70	38.040,90	39.584,30	41.964,40	44.403,70	42.990,90	46.162,20
Δ		3,01	-0,53	2,44	0,23	3,90	5,67	5,49	-3,29 ↓	6,87 ↑
Denmark	1.025,60	1.029,40	1.017,30	1.083,40	1.099,00	1.108,30	1.166,20	1.214,30	1.235,40	1.238,50
Δ		0,37	-1,19↓	6,10 ↑	1,42	0,84	4,96	3,96	1,71	0,25
Croatia	218,3	213,6	223,9	214,6	200,2	150,4	159,5	175,6	185,2	212,6
Δ		-2,20	4,60	-4,33	-7,19	-33,11↓	5,71	9,17	5,18	12,89 ↑
% of GDP***	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
EU27*	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4
EA20**	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4
Denmark	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4
Croatia	0,5	0,5	0,5	0,5	0,4	0,3	0,3	0,3	0,4	0,4

*European Union - 27 countries (from 2020); **Euro area – 20 countries (from 2023); ***Percentage of gross domestic product (GDP); ↑-greatest increase; ↓- greatest decrease

Context for presented data follows. According to official Eurostat statistics, there is structural inconsistency within basic statistics related to 'Employment in sport' – in general, and specifically - categorized by sex, by age, and by educational attainment level. However, initial data for EU27*/Denmark/Croatia in thousand persons for 2011 is 1.118,6/25,7/4,1u, i.e. 0,60%/0,97%/0,25%u, and in 2021 is 1.364,7b/27,9b/7,6bu, i.e. 0,70%b/0,99%b/0,46%bu (b-break in time series, u - low reliability; *- European Union 27 countries from 2020). This info should serve only as an 'orientation point' for analyses of imprint of general government. Further categories may reveal more differentiating layers - 'Enterprises in sport sectors'. 'International trade in sporting goods', 'Private households' expenditure on sport'. Those could indirectly offer insights in 'sport identities' and 'sport identity transfer' – usually described through Sport participation (Attending sport events, Physical activity, Time spent on sport and physical activity, Sport in cities), or likewise (not part of analyses).

Correlation analyses

When general government expenditures of EU and individual states are 'correlated' (table 2.), although those commonly regulated through Directives (not often with Regulations), those may reveal individual patterns – ones closer to, and ones more distant from 'general' EU policies (which are not part of the analysis, therefore not discussed).

Table 2. Correlations among general government expenditures

Variable	Means	Std.Dev.	EU27*	EA20**	Denmark	Croatia
EU27*	48279,35	4834,40	1,00	†1,00	†0,97	-0,45
EA20**	40145,84	3493,74	†1,00	1,00	†0,96	-0,41
Denmark	1121,74	86,88	†0,97	†0,96	1,00	-0,47
Croatia	195,39	26,17	-0,45	-0,41	-0,47	1,00

*European Union - 27 countries (from 2020); **Euro area – 20 countries (from 2023), †-significant at p < ,05

Individual patterns may be described by numerous governmental policies and interventions, national and central bank interventions, market situations and barriers, but final introspection of correlations among financing of general, central and local state in Croatia and Denmark comparatively – may bring broader, individual conclusion among EU member states – as a pattern, but not as conclusive perspective of any national, herby Croatian or Danish, finances in sport in EU context.

Table 3. Correlations among financing of general / central / local state - for Croatia and Denmark

CROATIA	Means	Std.Dev.	general	central	local	Means	Std.Dev.	DENMARK
general	195,39	26,17		†0,77	†0,96	1121,7	86,88	general
central	8,37	11,20	0,12		0,55	141,0	30,63	central
local	187,02	27,20	†0,91	-0,30		981,3	66,75	local
CROATIA	Means	Std.Dev.	general	central	local	Means	Std.Dev.	DENMARK

†-significant at p < ,05

Limitations

Time series analysis usually should include stationarity tests, causality test, etc. Presented time series are not long enough for these procedures. Research didn't cover categories - 'Employment in sport', Enterprises in sport sectors', 'International trade in sporting goods', 'Private households' expenditure on sport'. 'Attending sport events', 'Physical activity', 'Time spent on sport and physical activity', 'Sport in cities'.

There were also breaks in time series, low reliability of certain reports, etc. Finally, all correlations include numerous covariates, therefore no conclusive generalizations are possible. Without acknowledgement and calculation of exact covariate, followed by 'partializations' of results in observed variables, conclusions would lead to well-known falsely confirmed 'spurious' correlations. All analyses of data were not within 'Vilnius definition of sport' (Eurostat, n. d.).

Finally, as a recommendation for future research, for the purposes of a more precise comparison of these two systems and their effectiveness, an inclusion of variables such as sporting success and other sources of financing should be included.

Conclusions

Danish general government expenditures within 2012-2021 period are highly correlated to general government expenditures of EU27 and Croatian general government expenditures within 2012-2021 period are not only significantly but moreover negatively correlated to general government expenditures of EU27 and Danish as well. Those findings direct focus towards individual and 'general' EU policies.

With regard to specificities within correlations among financing of general / central / local state, it is symptomatic that Danish local state financing apparatus is in positive correlation to general and central state, whilst Croatian local state financing apparatus correlates highly and positively with general state, but negatively to central state.

Without further argumentations, just informatively - for correlations among financing of general / central / local state with export extra EU27, findings also reveal differences between Croatian and Danish sport systems. In Croatian case, there is statistically significant correlation between central state and export extra EU27, while in Danish case, statistically significant correlation exists between general&local state and export extra EU27 (possibly in line with argumentation of Ibsen, 2017). Which brings conclusions back to different social and behavioural patterns reproduced within definition of sport – culturally, economically, politically etc.

Sport as a phenomenon is quite divergent. Amalgamation of definitions predominantly converge sport to idea of competition (amateur, professional etc.) or health (via recreational or even medical engagements or likewise). 'Sport medicine' or 'medicine in sport' bring two main features of sport upfront – success (result) and health (harmony). Therefore, for the introspection purposes - different categorizations of sport bring different time series of data depicting state of sport in different organizational, intellectual, communication, even cultural and identity-related frameworks for analysis of impacts of sport phenomena within anthroposphere. Individual and institutional dedication for continuous demystification of sport phenomena often reveal 'marriage' between sport and politics, with economic/financial imprint. Mirror effect of same actions reveal undeniable power of individual action to achieve highest representation of human capacity to grow above his/her limits – both with regard to success in particular sport, and in achieving lateral impact of sport within in everyday ordinary life.

Future research with deeper introspections of all these 'horizontal transfers' should spread onto those national sport systems in which public financing also differs from Croatian model of governmental support – aside from dual governance by Ministry of Culture and Ministry of Education in Denmark - e.g. like in Italy where leading role is shared by Ministry of Culture and Ministry of Economy and Finances, or in Sweden where leading role is held by Ministry of the Interior, or in Austria where Office of the Federal Chancellor holds leading role – all comparative to e.g. data from research project from 2012, done by Institute for Public Finance from Zagreb, ordered by Croatian Ministry of science, education and sport, with title 'Financing sports in the Republic of Croatia with a comparative view of financing in the European union'.

Final observation of this report is that methodology intertwined with limitations should support future regulation of 'social leverages'. Standards should be built by exclusion of subjectivity and 'occasional providence' of actual sport or political actor, and by inclusion of reliable, dedicated 'hubs' of public interest - like Eurostat, the statistical office of the European Union, along with e.g. United Nations Statistics Division, Croatian Financial Agency (CFA) , or National Classification of Economic Activities (NACE), (e.g. under division 93 "Sports activities and amusement and recreation activities").

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THE CORRELATION BETWEEN DEMOGRAPHIC AND ECONOMIC FACTORS AND THE MEDALS WON IN SAILING AT WORLD CHAMPIONSHIPS AND THE OLYMPIC GAMES

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Abstract
The aim of this study was to determine the correlation between a country's land area (expressed in km^2), GDP (expressed in \$), total population, water area (expressed in km^2), and the total number of medals won by countries at World championships and the Olympic Games from 1992 to 2023. The sample consisted of 41 countries that won one of the top 3 places in the observed period from 1992 to 2023. It was found that there is a slight correlation between the number of medals won variable, with population size, the total land and water area of the country. No correlation was found between success in sailing and the wealth of the countries, leading to the conclusion that countries with lower economic power can also achieve significant success in world competitions.

Keywords: *sailing, numbers of medals, demographic factors*

Introduction

Sailing is a sport influenced by a multitude of factors. It represents an activity that cannot be conducted in controlled 'indoor' conditions due to the natural conditions on which sailing depends. A large number of environmental factors are unpredictable and variable, especially in the context of competitions, making sailing unique but also complicating data collection for scientists. Such sports often require a multidisciplinary, and even interdisciplinary, approach to research (Sjøgaard, Inglés, & Narici, 2015). Sailing has historically been considered a sport of the wealthy (Mihelić, 2018), and even today, it requires significant financial investments, particularly in technological development aimed at enhancing competitiveness (Pezelj, 2019). Given the financial demands of this sport, we can assume that countries with greater financial resources will also have greater investments in sailing (Škorić and Hodak, 2011), which can consequently lead to greater success. As Forrest reports, sailing is one of the sports in which poor countries find it very difficult to win medals (Anderson, 2012). Sailing comprises numerous classes, each of which has the right to organize its own championships, including world championships. Only since 2003 has World Sailing—the International Sailing Federation (WS)—introduced world championships for classes included in the Olympic program, while other classes can still independently organize their own world championships. Over the past 20 years, numerous classes have been added to the Olympic program to increase the attractiveness of sailing. Technological advancements make sailing a very dynamic and changeable sport, and for this reason, this research encompasses Olympic classes from 1992 to 2023. Frequent changes in the Olympic program, travel, and preparation require resources that can sometimes be difficult to secure, raising the question of the relation between GDP and sporting success. The hypothesis is that countries with higher GDPs will provide sailors with better conditions for training and achieving success. Furthermore, the assumption is that larger countries will have greater water areas, which are essential for training sailors. There is also a possibility that a larger population contributes to a higher number of sailors, thereby increasing the chances of selecting higher-quality athletes. Although success in sailing largely depends on a spectrum of different skills and attributes, as well as technical and tactical requirements and knowledge (Oreb, Prlenda, & Kolega, 2013), such research can offer insights into potential factors contributing to development or achieving success at the highest level. Several authors have addressed this topic, and Krističević et al. (2018) did not prove a correlation between GDP, population size, and the area of the country with success in bowling. However, they emphasize that bowling is a sport with lower financial demands, so there is a possibility that these results could be disproven in sailing. Gotal (2017) established a correlation between population size and the total number of medals based on a sample of football championships. Some authors confirm the correlation between GDP as a measure of a country's wealth and success in sports (Andreff, 2010; Forrest et al., 2016). Lui & Suen (2008) argue that a higher GDP consequently leads to better results. The reason for this is the ability to send a larger number of athletes to competitions. The creation of a high-quality sailor is a continuous and long-term process (Callevaert et al., 2015), so the gradual development of young athletes is essential for them to become medal contenders. Maglov, Milanović, and Prlenda (2023) conducted research on sailors in the Optimist class, which is numerous but not an Olympic class, and found no statistically significant correlation between achieved results and geographical and socioeconomic factors. This study aims to determine the correlation between the land area of countries, water area, population size, GDP, and the number of sailing medals won. The research includes Olympic classes from 1992 to 2023, evaluating their results in the Olympic Games and World Championships. This study also includes results from the Olympic windsurfing class, as it is an integral part of sailing sports in the Olympics. The objective of this study was to determine the correlation between a country's land area (expressed in km^2), GDP (expressed in $), total population, water area (expressed in km^2), and the total number of medals won by countries at world championships and the Olympic Games from 1992 to 2023.

Based on the objective of the study, the following hypotheses were proposed:
H1 – There is a statistically significant correlation between the land area and the number of medals won.
H2 – There is a statistically significant correlation between the population size and the number of medals won.
H3 – There is a statistically significant correlation between GDP and the number of medals won.
H4 – There is a statistically significant correlation between the water area and the number of medals won.
H5 – There is a statistically significant correlation between the total land area, population size, water area, and GDP of medal-winning countries.

Methodology
Sample of Entities
The sample consists of 41 countries that achieved one of the top three positions in the observed period from 1992 to 2023. The results from all Olympic classes that were included in the Olympic Games program during this period and held world championships were considered. Some classes did not hold world championships every year, or appeared in only some Olympic Games, but they had certain significance in the sailing world and were therefore included in the study. It is important to note that some classes have only changed their names over time, while the standards of these classes have remained the same. Despite the number and type of classes in the Olympic program changing over the years, all countries had equal chances of winning medals in all championships.

The study includes sailing and windsurfing classes. Windsurfing classes: RS:X women, RS:X men, Board Mistral – women, Mistral – Windsurfer men, Board Lechner Women, Lechner – Windsurfer men. Sailing classes: 470 men, 470 women, 49er men, 49erFx women, Finn men, Laser men, Laser Radial women (formerly Europe), Nacra17 mixed, Elliott 6m – Match racing women, Star – Keelboat men, Tornado – Multihull mixed, Yngling – Keelboat women, Fleetmatch Race Keelboat Open Soling mixed, Flying Dutchman.

Sample of Variables
The observed variables are country area (km^2), GDP (Gross Domestic Product - nominal per capita), population size, water area (km^2), and the total number of medals won. GDP (nominal) represents the market value of goods and services of a country, and per capita (per head) is calculated by relating GDP to the population size to obtain the nominal GDP per capita (Grlić, 2020). GDP was calculated and presented as average value for the observed period (1992 – 2023) for each country. The country area (total) represents the total area of a country, while the water area refers only to the water regions of a country, both expressed in square kilometres. The total number of medals refers to the number of medals won by each country in the Olympic Games and world championships during the observed period in the aforementioned classes.

Predictor variables are country area (km^2), population size, GDP (nominal – per capita; expressed in dollars), water area (km^2). The criterion variable is total number of medals won – representing the number of medals won by each country in the Olympic Games and world championships.

Table 1. Countries with medals won at the Olympic Games and/or World Championships in all Olympic sailing classes from 1992 to 2023

No.	Country	Medals won	Total area	Population	GDP (nominal)	Water area
1.	Argentina	27	2.780.400	45.036.032	9.603	43.710
2.	Australia	96	7.692.024	25.670.051	41.849	58.920
3.	Austria	23	83.871	8.907.777	40.231	1.426
6.	Belarus	1	207.600	9.633.741	43.16	4.700
4.	Belgium	11	30.528	11.561.717	37.688	250
5.	Bermuda	2	54	63.893	67.787	144
7.	Brazil	65	8.515.767	213.196.304	7.304	157.630
23.	China	26	9.706.961	1.424.949.781	37.403	270.550
16.	Croatia	21	56.594	4.096.870	4.658	620
8.	Cyprus	6	9.251	1.237.537	15.206	10
9.	Czech Republic	9	78.865	10.530.954	23.943	1.620
10.	Denmark	56	43.094	5.825.641	16.434	660
11.	Estonia	2	45.227	1.329.444	49.369	2.840
12.	Finland	16	338.424	5.529.468	13.708	34.330
13.	France	100	551.695	64.480.053	39.163	3.374
30.	Germany	84	357.114	83.328.988	35.703	8.350
14.	Greece	31	131.990	10.512.232	37.954	1.310
15.	Hong Kong	9	1.104	7.500.958	19.076	35
25.	Hungary	35	93.028	9.750.573	33.191	3.420
17.	Ireland	5	70.273	4.946.119	11.027	1.390
19.	Israel	27	20.770	8.757.490	50.536	440
18.	Italy	60	301.336	59.500.579	29.852	264.129
20.	Japan	12	377.930	125.244.761	29.940	13.430
22.	Kanada	25	9.984.670	37.888.705	38.501	891.163
24.	Lithuania	3	65.300	1.897.052	11.971	2.620
26.	Mexico	2	1.964.375	125.998.302	8.576	20.430
27.	Netherland	89	41.850	17.434.558	42.542	7.650
29.	New Zeland	73	270.467	5.061.134	29.517	4.301
28.	Norway	13	323.802	5.379.839	66.463	19.520
31.	Poland	33	312.679	38.428.367	9.996	8.430
32.	Portugal	9	92.090	10.298.192	18.365	620
33.	Russia	7	17.098.242	145.617.329	7.763	720.500
35.	Singapore	1	710	5.909.870	42.823	10
36.	Slovenia	10	20.273	2.117.641	19.175	122
21.	South Africa	1	1.221.037	58.801.927	5.572	4.620
37.	Spain	65	505.992	47.363.807	24.357	6.390
38.	Sweden	37	450.295	10.368.970	44.708	39.960
39.	Switzerland	10	41.284	8.638.613	66.433	1.280
41.	Ukraine	16	603.500	43.909.667	2.332	24.220
40.	United Kingdom	118	242.900	67.059.474	37.193	1.680
34.	USA	75	9.372.610	335.942.004	47.509	685.924

Legend: Medals – number of medals won; Total area. – country size in sq. km; Population – number of citizens; GDP – Gross Domestic Product, Water area – total water surface in sq. km

Data processing methods

Descriptive parameters were calculated, including the arithmetic mean, minimum value, maximum value, and standard deviation. Normality of distribution was assessed using the Shapiro-Wilk W test, while Spearman's correlation coefficient was employed to calculate the correlation.

Results

Table 1 displays the list of countries that have won medals in Olympic classes at the Olympics and/or World Championships from 1992 to 2023.

Table 2. Descriptive parameters

	Descriptive Statistics (Spreadsheet2)					
Variable	**Valid N**	**Mean**	**Minimum**	**Maximum**	**Std.Dev.**	**Normality**
Medals	41	32	1	118	32	0,00004
Total area	41	1807463	54	17098242	3830753	0,00000
Population	41	75846498	63893	1424949781	225810693	0,00000
GDP	41	28774	2332	67787	18084	0,03549
Water area	41	81902	10	891163	205469	0,00000

Table 2 presents the descriptive parameters of the observed sample, including the arithmetic mean, minimum value, maximum value, standard deviation, and distribution normality. A total of 41 entities participated in this study, with 1311 placements analyzed. Among the medal winners, the United Kingdom stands out the most, having collectively won 118 medals in Olympic classes at the Olympics and World Championships from 1992 to 2023, followed by France with 100 medals and Australia with 96. The fewest number of medals (1) were won by Belarus, South Africa, and Singapore. Among the 41 countries, the smallest in terms of area is Bermuda, with only 54 km², and it also has the fewest inhabitants (63,893), while Russia is the largest in terms of area, covering 17,098,242 km². The most populous country among all medal winners is China, with 1,424,949,781 inhabitants. Average GDP values for the observed period was from 2,332 dollars (Ukraine) to 67,787 dollars (Bermuda). Cyprus has the smallest water surface area (10 km²), while Canada has the largest (891,163 km²).

Table 3. Spearman correlation coefficient

	Spearman Rank Order Correlations (Spreadsheet1) MD pairwise deleted Marked correlations are significant at p <,05000				
Variable	**Medals**	**Total area.**	**Population**	**GDP (nominal)**	**Water area**
Medals	1,00	0,36	0,43	0,20	0,29
Total area		1,00	0,77	-0,32	0,80
Population			1,00	-0,29	0,57
GDP (nominal)				1,00	-0,10
Water area					1,00

*Statistical significance was determined by the correlation coefficient ($p < 0.05$).

From Table 3, the values of the Spearman correlation coefficient can be discerned. By comparing the number of medals won with other variables, it can be observed that there is a statistically significant correlation with the total land area (0.36), population size (0.43), while no correlation was found with the GDP of countries (0.20) and the water surface area (0,29). The total land area of countries significantly correlates with the population size (0.77), GDP (-0.32), and water surface area (0.80). The variable of population size is significantly correlated only with water surface area (0.57). The achieved GDP values do not significantly correlate with the water surface area (-0.10).

Discussion

The assumption of this study was that countries with greater economic wealth (measured by average nominal GDP values), larger total land and water areas, and larger populations would achieve more successful results than other countries. Based on these results and the predefined research goal, it can be determined that hypotheses 1 and 2 have been confirmed, while hypothesis 5 is partially confirmed. Hypotheses 3 and 4 are not confirmed. Although a mild correlation between the total land area and the number of medals won has been established, it can be concluded that larger countries have greater opportunities to win medals at the Olympics and World Championships in the observed classes. Although the correlation coefficient shows a relationship, the example of the United Kingdom, which has the most medals, suggests that the size of the country and population is not a decisive factor. The United Kingdom ranks only in the middle of all the observed countries in terms of country size value. A slightly stronger correlation has been found between the population size and the number of medals won. As previously noted, a larger population can lead to a greater number of sailors. A larger number of sailors enables coaches to make better athlete selections. Additionally, over the years, changes in classes have occurred, so a larger population likely results in a greater number of sailors. Consequently, there is a possibility of having more sailors from a given country participating in individual classes. A greater number of children involved in sailing can lead to higher membership revenues, which are then reinvested in club activities and operations. Often, sailing clubs are supported by parents who secure private sponsors and investors. Alongside these conclusions, we can also take into consideration the quality of coaching staff, which is crucial for attracting and retaining youth in sailing. There is no statistically significant correlation between a country's wealth and the number of medals won, indicating that GDP does not influence success in the observed classes in sailing which is contrary to some of the results of previous research (Lui & Suen, 2008; Roberts, 2006). These data suggest that countries with different economic capabilities reach minimum standards necessary for success, regardless of GDP, and increasing a country's wealth does not guarantee improved performance. Supporting these claims is the fact that Bermuda has the highest GDP but has won only 2 medals. Similar conclusions regarding the correlation between GDP and success were reached by Maglov et al. (2023) in a study on optimist class competition. This finding is positive for countries with lower GDP values, suggesting that they too have the potential to achieve significant results. De Bosscher et al. (2019) highlight the issue of sports budget allocation, noting that countries generally achieve the most success in sports they invest the most in. Therefore, information on government budget allocations for sailing as a sport would provide a clearer picture of the relations between success and economic factors. According to the results, there is no correlation between the number of medals won and the water surface area. It can be assumed that this correlation related to water surfaces would be significantly stronger if data on, for example, only the size of the coastal area were included in the study, as most training sessions predominantly take place in that area. Hypothesis number 5 is partially confirmed because statistically significant correlations have not been found between all predictor variables. The total land area significantly correlates with population, GDP, and water area. Water area significantly correlates with population. A significant correlation between GDP and the water surface area (-0.10), and population (-0,29) was not found. The highest correlation related to winning medals was established between the total area and the population size. These facts lead to the conclusion that predominantly larger countries generally have larger populations and they are winning more medals than others. Interestingly, the GDP of countries negatively correlates with total area, water area, and population variable, meaning that larger and more populous countries generally have lower GDPs. There is only a mild correlation when comparing the number of medals won with other variables, so area smaller countries like Croatia also have the opportunity to win medals (21). Sailing is inherently a dynamic sport, so proper education and guidance of children by coaches are extremely important for later success. A limiting factor of this research could be the diversity of the Olympic program. In this regard, a larger number of competitors in a given country can lead to participation in a greater number of classes, thereby increasing the chances of winning a medal. Future research should include other variables, such as the number of participants in the observed competitions, weather conditions, infrastructural development, investment in sailing, the number of clubs, competitors, and similar factors. It is also necessary to note the possible influence of tradition (Bartoluci and Škorić, 2009), which is certainly greater in different world parts.

Conclusion

This study has identified a mild correlation between the number of medals won, population size, and the land (total and water) area of a country. Organizing water surfaces and adapting them for sailing and windsurfing would undoubtedly contribute to the quality and opportunities of the training process, which consequently could lead to better results. A larger population may also signify a greater number of sailors, giving coaches a better chance to select quality candidates. Sailing is a sport where having quality environmental working conditions is important, thus natural working conditions such as water surfaces are necessary. There was no correlation found between success in sailing and the wealth of countries, indicating that even countries with lower economic power can achieve success if they have reached minimum standards for success.

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THE CONNECTION BETWEEN PUBLIC FUNDING OF SPORTS PROGRAMS AND SPORTS QUALITY OF ATHLETES IN TEAM SPORTS IN THE LARGEST CROATIAN CITIES TOGETHER

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Abstract
Financing of team sports in larger cities from city budgets is significant. The aim of this research is to determine the relationship between financial investments of public funds of the largest Croatian cities and sports achievements of athletes in five Team Olympic sports, through: costs of using sports facilities, professional work of coaches, competition costs, development programs for young athletes and the number of active athletes and sports quality. According to their sports achievements, athletes classified into 3 quality categories. The research covered the allocation of financial resources from 2016-2019. which were awarded to clubs of selected sports in each of the cities: Zagreb, Split, Rijeka and Osijek, and the number of active and quality athletes. The Spearman correlation coefficient was used to test the correlations between the observed variables, and the Quasi-canonical correlation was used to test the correlation between the two sets of variables. The results show that there is a statistically significant correlation between the allocation of public funds especially for the professional work of coaches, competition of athletes and youth development programs, with the active number of athletes and of two levels of sports quality. There is no correlation between financial investments and sport quality of 2nd category of top athletes.

Keywords: *sports financing, sports programs, local sports, top sports*

Introduction
In pursuit of their country's international (Olympic) success, many governments and national sports organizations spend considerable resources (Houlihan and Green 2008; De Bosscher et al. 2015; De Bosscher et al. 2017). According to De Bosscher et al. (2018a), there are several factors that influence the decision of each country sport's governing structures when prioritizing the funding of some sports over other sports. In most countries, the focus is on funding on a smaller number of sports in which country has the best chance of winning medals (Bostock, Crowther, Ridley-Duff, & Breese, 2017). According to Sotiriadou and Shilbury (2009) the factors that influence the top sports result are having enough high-quality facilities with priority access for athletes, qualified coaches, and a good structure of national competition with opportunities for athletes to participate at international levels of competition. These finding were later confirmed by De Bosscher (2015) as well. The importance of the competition is threefold because it helps to retain and develop abilities and to advance the athlete to a higher level of performance.

Nevertheless, only a handful of researchers investigate the connection between achieved sport results and assistance from local authorities. Soares et al. (2015) in their study investigating the strengthening of the power of regional governments in the development of sports policies, pointed out the great financial dependence of clubs on regional public administration, for example in supporting the financing of national sports competitions, which cost a lot and for many of them there is no interest of sponsors (Barross, 2005). The influence of the local community (cities) on the activities of clubs in Germany was investigated by Breur and Wicker (2011), Wicker and Breur (2015), and concluded that it is not only internal, but also external factors that affect the resources of sports clubs and their effective functioning, especially in periods of crisis. One of the reasons for the small amount of research on the topic of local sports concerns the difficulties in obtaining the data necessary for the implementation of the research. Therefore, it seems that top sport is only taken care of by the state, but financial indicators at local levels, Ricov (2021a) and Ricov (2022), show that two-thirds of public financial resources are allocated by local self-government and only one-third by the state.

To what extent does the financing of sports at the local level affect the overall success of top sports at the national level, i.e. whether the systematic inclusion of that level of financing can contribute to greater success of the state at international competitions, is certainly a topic that needs to be addressed. This topic is covered in detail in the paper by Ricov (2022). In this paper focus is on a group of five Olympic team sports observed in the four largest Croatian cities together. The main goal of this paper is to determine the results of the investments of all four cities together in the mentioned sports programs for selected Olympic team sports, as well as their connection with the level of sports quality including number of athletes.

Sample and research methodology
The research covers the allocation of public financial resources from 2016 until 2019 awarded to clubs from the summer Olympic sports of basketball, football, volleyball, handball, water polo (Table 1). Independent variables are financial resources for certain types of costs: for the use of sports facilities, for professional work of coaches, for competitions and development programs for young athletes. Dependent variables are the number of top athletes I. to III. categories and number of registered active athletes in competition systems.

The basic statistical parameters of all variables for each city for team sports on the manifest data are shown in table 1. Amounts of money are in kuna, (1 EUR = HRK (kuna) 7.5 approximately).

Table 1. Average allocation of funds per city in the period 2016-2019 (in kuna)

CITY	Sport facilities	Coaches' salaries	Competition	Youth development programs	Total cost per year	Cost per club	Cost per athlete	Cost per categorized athlete
ZAGREB	29.035.478	20.652.280	32.330.535	21.784.712	103.803.005	1.000.511	4.417	487.338
SPLIT	7.590.658	6.919.310	9.890.200	597.663	24.997.831	781.182	6.770	221.220
RIJEKA	15.794.108	2.007.515	1.129.494	709.591	19.640.708	569.296	7.403	365.409
OSIJEK	2.580.892	566.112	4.081.596	1.128.693	8.357.293	224.357	2.326	157.685
Total	55.001.135	30.145.217	47.431.826	24.220.660				

Both univariate and multivariate analyses were used (SPSS software package), basic statistical parameters (arithmetic means, standard deviations) were calculated, the normality of frequency distributions (Shapiro-Wilk test) was tested for all variables. The Spearman correlation coefficient was used to test the correlations between the variables that define financial investments in sports, the number of active athletes and top athletes. Quasi-canonical correlation was used to calculate the connection between groups of variables within the observed cities, given that the data are not normally distributed, significance levels are less than 5% (p=0.05) and the data sample is small.

Research results
Based on data presented in table 1, it is evident that the City of Zagreb allocates the highest amounts of money to all programmes which is expected since the largest number of clubs, active athletes and quality athletes are situated in Zagreb. Nevertheless, Rijeka and Split are the cities allocating the most funds by athlete, but not when it comes to categorized athlete. In this case, Zagreb takes the lead.

To test the connection, basic statistical parameters were calculated and presented, and normality testing of the frequency distributions of independent and dependent variables was performed (Table 2). Frequency distributions are not normal, because the significance is less than 5% (p=0.000), so Spearman's correlation coefficient was used to test the connection between independent and dependent variables.

Table 2. Basic statistical parameters and testing the normality of the frequency distribution with the Shapiro-Wilk test for all independent and dependent variables of all four cities for team sports together

Variables	N	Arithmetic means	Standard deviations	Lowest results	The greatest results	Shapiro-Wilkov test
1.FACILITIES	80	2.750.056,76	3.123.041,74	388.839,29	14.256.825,30	,000
2.COACHES	80	1.507.260,86	2.235.717,15	4.883,38	10.209.890,93	,000
3.COMPETITIONS	80	2.371.591,28	3.007.179,80	3.012,07	11.820.851,36	,000
4.YOUTH PROGR.	80	1.211.032,98	2.169.041,58	29.300,29	8.860.823,19	,000
5.ATHLETES	80	1.671,82	3.737,65	78,00	19.638,00	,000
6. I. Category	80	1,19	2,414	0	13	,000
7. II. Category	80	1,46	3,778	0	20	,000
8. III. Category	80	18,99	19,176	0	80	,000

Correlations between financing variables and quality variables are presented in Tables 3 and 4.

Table 3. Spearman's correlation coefficients between the financing of sports facilities, coaches, international and domestic competitions, youth development programs and number of athletes (by categorization as well) in team sports

VARIABLES	Facility	Coaches	Competitions	Youth program	Athletes	I. Category	II. Category	III. Category
Facility	1,000	,560	,260	,432	,270	,537	,293	,440
P-value	-	**,000**	**,020**	**,000**	**,015**	**,000**	**,008**	**,000**
Coaches	,560	1,000	,744	,432	,649	,387	,162	,681
P-value	**,000**	-	**,000**	**,000**	**,000**	**,000**	**,150**	**,000**
Competitions	,260	,744	1,000	,646	,726	,392	,120	,728
P-value	**,020**	**,000**	-	**,000**	**,000**	**,000**	**,288**	**,000**
Youth program	,432	,432	,646	1,000	,658	,357	-,037	,545
P-value	**,000**	**,000**	**,000**	-	**,000**	**,001**	**,745**	**,000**

High correlation coefficients between the variables that define financial investments in team sports indicate that the system of independent variables is interrelated and as such are significantly related to the number of active and elite athletes as well.

Table 4. Spearman's correlation coefficients between the number of active athletes, the number of top athletes of category I, II. category and III. categories in team sports

VARIABLES	ATHLETES	I. Category	II. Category	III. Category
ATHLETES	1,000	,027	-,199	,635
p-value	-	**,811**	**,077**	**,000**
I. Category	,027	1,000	,617	,480
p-value	**,811**	.	**,000**	**,000**
II. Category	-,199	,617	1,000	,214
p-value	**,077**	**,000**	-	**,057**
III. Category	,635	,480	,214	1,000
p-value	**,000**	**,000**	**,057**	-

Table 4 shows that the variable number of active athletes (ATHLETES) significantly correlates only with the variable top athletes III. categories, with a correlation coefficient of 0.635 ($p=0.005$).

Top athletes of category I. are related to the variable top athletes II. categories through the correlation coefficient, which is 0.617, and with the variable top athletes III. categories with a correlation coefficient of 0.480 ($p=0.000$).

Since none of the observed variables was normally distributed, in order to determine the connection between the independent set of variables (financing of team sports) and the dependent set of variables (active and top athletes of categories I, II and III), a spectral decomposition of the covariance matrix between the above sets of variables was performed. One significant quasi-canonical component (factor) was extracted (Table 5). The table shows that the quasi-canonical correlation is 0.847 and the quasi-canonical determination is 0.717 ($p<0.05$) pointing to conclusion that there is a connection between the financing of team sports and the number of active and top athletes I., II. and III. categories via the first quasi-canonical factor.

Table 5. Quasi-canonical correlation significance testing

Quasi-canonical			F test	Degrees freedom		Significance
components	correlation	determination		df1	df2	Sig.
1.	**0,847**	**0,717**	**602,389**	**1**	**238**	**0,000**

Since a statistically significant association was obtained between the mentioned sets of variables through the first quasi-canonical component, it is necessary to analyse the structure of this association (Tables 6 and 7).

Table 6. Quasi-canonical coefficients and matrix of the structure or correlation of team sports financing variables on the quasi-canonical component extracted from the 1st and 2nd set of variables

Variables	Quasi-canonical coefficients (weight values)	Correlations of the variables of the 1st set to the factors from the 1st set	Correlations of the variables of the 1st set to the factors of the 2nd set
FACILITY	**-0,487**	**-0,837**	**-0,802 (3.)**
COACHES	**-0,481**	**-0,937**	**-0,794 (4.)**
COMPETITION	**-0,504**	**-0,926**	**-0,832 (2.)**
YOUTH PROGRAM	**-0,526**	**-0,935**	**-0,868 (1.)**

Table 7. Quasi-canonical coefficients and matrix of structure or correlation of variables from the 2nd set - number of active and top athletes of all categories on quasi-canonical components extracted from the 1st and 2nd set of variables

Variables	Quasi-canonical coefficients (weight values)	Correlations of the variables of the 1st set to the factors from the 1st set	Correlations of the variables of the 1st set to the factors of the 2nd set
ATHLETES	**-0,707**	**-0,722**	**-0,804**
I. Category	**-0,366**	**-0,545**	**-0,416**
II. Category	-0,137	-0,320	-0,156
III. Category	**-0,589**	**-0,846**	**-0,669**

All variables of the 1st set significantly participate in the connection with the 2nd set of variables.

The most responsible variable for connecting these two groups is ATHLETES - active athletes, then III. Category - top athletes of the third category and finally with the first category - top athletes of the first category. Top athletes II. categories do not participate in the association with team sports financing variables.

Three significant canonical factors have been extracted through which the financing of team sports relates to the number of active and top athletes of all categories using the QCCR program. By examining the structure of the 1st and 2nd set of variables, the connections contained in the first canonical factor fully correspond to the first quasi-canonical factor. This makes it possible to conclude that more precise correlation results were obtained using Canonical Covariance Analysis or Quasi-Canonical Analysis than using Canonical Correlation Analysis.

Discussion

Financing of youth development programs, international and domestic competitions, sports facilities, and the professional work of coaches significantly participates in connecting with the number of active and top athletes I. to III. categories, according to the first quasi-canonical factor because the quasi-canonical correlation is 0.847 and the quasi-canonical determination is 0.717 (table 5). The variables that describe the connection between the number of active and top athletes of all categories with the area of team sports financing in Table 7 are according to the strength of the relationship as follows: active athletes with a quasi-canonical coefficient of -0.707, then top athletes III. category whose quasi-canonical coefficient is -0.589, followed by top athletes of category I whose quasi-canonical coefficient is -0.366 and top athletes of II. categories that participate very little in the connection with the financing of team sports.

All mentioned correlations of sports quality are negative, with the same direction of determination, as for variables related to financing, which may mean that better financing of team sports relates to a larger number of active and top athletes I. and III. categories for all four cities together. Connection with II. category is very small. Based on the results from table 3, decision-makers on financial investments in sports programs in cities can conclude that if they want to increase the number of active athletes in team sports, they should invest more in all four types of expenses (coaches' salaries, competitions, development of young athletes and facilities). And if they want to increase the number of top athletes of category I (high international level of sports results) and category III. result categories (national level of sports results) should invest more in coaches' salaries, competitions and development programs for young athletes. However, to increase athletes II. category requires additional investment in sports facilities. From the results in table 4, shows that many active athletes are not associated with high quality international sports results, but only with the national level. Which means that if we increase the number of active athletes, we can expect a larger number of national-level athletes, but not high or medium international level results, i.e. I. and II. categories of top athletes. A broad base does not automatically mean a high international quality of results. If you want to increase the number of category I athletes, you need to increase the number of category II athletes and III. categories.

The structure of investments in other groups of sports (individual, martial arts, etc) is visible in the work of Ricov (2022), where we can see the fact that the programs with the largest investments are precisely in team sports, and the support model for top sports in cities contributes significantly to these types of expenses. Many scientific studies at the state level (allocation of public funds for the costs of facilities, coaches, competitions) have shown exactly these key factors for the success of athletes at international competitions (De Boscher, 2015, 2017, 2018a). At local city levels (except for Ricov, 2021, 2021a, 2022), no research of this type has been observed. The results of Croatian athletes, almost all of whom came from one of the cities that are the subject of this research, further indicate why it is important to research this level of funding.

Conclusion

The results in this paper show a statistically significant connection (quasi-canonical correlation = 0.847) between the financing of certain basic sports programs and sports quality in the largest Croatian cities together, in the most popular Olympic team sports. These results can indicate in which direction public funds should be invested both at the level of general and sports policies at the state and city level.

The process of creating a top athlete takes a long time, and in the Croatian sports system, it rests largely on the clubs. A sports club that is financed with the funds of local sports communities, i.e. cities, recognizes the athlete, selects them, and brings them to the appropriate level of sports quality, becomes recognized and the object of interest of national selectors, and the care of the further development of that athlete is taken over by national sports federations and national teams. Elucidation of the facts related to the importance of sports financing at the local level in creating a base of active athletes and increasing the number of top athletes, as well as its connection with sports financing at the state level, is especially necessary in countries that have a smaller population and are less wealthy. This could be the difference that makes the country more successful compared to other competitive countries (Matros & Namoro, 2004).

Team sports are more interesting in the media, they attract great interest from the public, sponsors, but also children and young people, and according to many studies, they have a wider social significance. According to the work of Ricov (2022), 2/3 of public city funds are invested in these sports in comparison to other popular Olympic sports, as well as in the group of selected Olympic individual and martial sports. By working on the seventeen best sports in Zagreb (Ricov, 2021), research was conducted on a larger group of different sports where the connections were only at the national level of the quality of athletes.

This research covered the allocation of funds only for certain groups of sports programs from the public funds of cities, and for only one group of sports (five team sports), which is one of its limitations. To more precisely determine the impact of sports financing at the local level and in what way and to what extent such financing affects the success of Croatian athletes, it would be necessary to obtain all sources of financing (public and private) at all levels (national, regional and local) and other factors.

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KNOWLEDGE, SKILLS AND COMPETENCIES OF SPORT MANAGERS: COMPARATIVE VIEWS OF BUSINESS AND KINESIOLOGY STUDENTS

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Abstract
Sport management has recently gained an enormous importance and is becoming increasingly internationalized and complex, requiring specific skills, knowledge and capabilities from sport managers. As the performance of organizations in sport is directly influenced by the people in the management positions, developing their managerial capabilities consequentially gained significant importance. This paper examines the desirability of different skills, knowledge and competencies of sport managers, as perceived by students of kinesiology and business. Having such insights into students' attitudes helps to understand their acceptance of different learning programs. Results suggest that students of kinesiology and business have divergent views on the knowledge and skills that managers in sports organizations should possess. Both group of students agreed that managers should have the abilities and competencies to coordinate activities of other people and be willing to take risks, while the general education and managerial experience is not as important for the job performance. The study results indicate that students rated high the professional competences that can be learned through the educational process, while general knowledge and education or previous experience were not found as important.

Keywords: *sport managers, students of kinesiology, students of business*

Introduction
Sport is a labour intense activity (Bartoluci & Škorić, 2009) which accounts for 2.72% of total employment in EU (EC, 2018). According to EOSE (2021), more than 60% of people working in sport organizations have a "non-sport specific occupation", meaning they are managers, secretaries, receptionists, cleaners, or occupy other administrative positions. When it comes to managerial staff, some estimates state that managers account for 8.8% of all positions in sports organizations (EOSE, 2019). Considering such a high proportion of managerial positions in sport organizations, it is not surprising that sport managers' activities and competencies needed to conduct those activities have been a topic of interest for researchers for more than three decades (e.g. see Jamieson, 1987). Ensuring a high-quality and interdisciplinary sport management education is thus becoming a necessity for the successful operation of sport organizations. The quality of sport management education is determined by several features: (1) the background and characteristics of students and of sport management educators; (2) course length and course structures; (3) course content and delivery modes; (4) course assessment and evaluation of procedures; (5) the nature and length of professional experience; and (6) the nature and strength of partnerships among different sport management stakeholders (Skinner & Gilbert, 2007). Still, as found by Ratten (2018), educational programs in sports focus mostly on the fitness or physical activity component rather than the business perspective, which makes a gap between sport management education and the needs of sports managers in the sports sector (De Schepper & Sotiriadou, 2018). Improving the higher education institutions curriculums by implementing more management/business topics in curriculums thus becomes essential for the successful educational process (Gerdin & Pringle, 2017). The learning outcomes should therefore be structured to develop knowledge, skills and competencies relevant to the new challenges found within sports industry (Miragaia & Soares, 2017).

The development of the appropriate competencies of managers in sports organizations should be supported with the appropriate curriculum and pedagogy used by higher education institutions (Skinner & Gilbert, 2007). Competencies generally "cover a broad range of higher order skills and behaviours that represent the ability to cope with complex, unpredictable situations" (Westera, 2001, p. 80) that are so often found in the changing sport industry. It is a "proven ability to use knowledge, skills and personal, social and/or methodological abilities, in work or study situations and in professional and personal development" (Council of the European Union, 2017, p. 14). An impressive number of research addressing the issue of sport managers' competencies signals the importance of this topic (e.g. Barcelona & Ross, 2004; Cingiene et al., 2006; DeSensi, Kelley & Beitel, 1990; EOSE, 2019; Farner & Schüttoff, 2020; Horch & Schütte, 2003; Jamieson, 1987; Ko, Henry & Kao, 2011; Lambrecht, 1987; Retar, Plevnik & Kolar, 2013; Škorić, 2008, 2009, 2018). These studies were conducted in different settings (private vs public), with different participants (practitioners, academia and students), and covered a broad range of employment opportunities (both recreational and competitive sport). This paper further contributes to the topic, as it aims to examine the attitudes towards the desirable knowledge and skills of sports managers from a stakeholder perspective – potential future sports managers, students of business and kinesiology, taking in consideration their educational background (business or kinesiology related). The literature covering students' attitudes with respect to sports management education is limited. In that vein, this paper aims to analyse students' expectations, to assist the development of effective interdisciplinary sports management educational programs (Ratten & Jones, 2018). Such insights are the requirement for the successful implementation of educational programs for future sport managers.

Theoretical background

According to systematic review on sport management relevant knowledge, competencies, and skills (K/C/S) conducted by Guidotti et al. (2023), a list of 61 K/C/S was extracted from 682 recorded citations published between 2012 and 2022. Effective interpersonal communication skills (internal/external) and leadership skills were found to be the most mentioned ones with 65% and 54% of occurrences respectively. The list was followed by communication skills (written/oral), technological/digital/social media skills, teamwork, finance and administration skills, networking and ethical commitment and behaviour/integrity with representations in between 40% and 50% analysed papers. Another contribution by EOSE (2019) reports that for senior management staff, decision-making and problem-solving skills seem to be the most important skills since those were rated as essential by more than 90% of interviewees. These were followed by leadership, team working, organisational and planning skills, strategical thinking, verbal communication, ethics, motivational and business development skills (all rated as essential by 80-90% of interviewees). Middle management list of skills is slightly different, with team working being the only skill chosen by more than 90% of interviewees as essential, and organisational and planning skills together with verbal communication by 80.7% interviewees.

A study by Cingiene et al. (2006) found will to succeed (motivation), leadership, capacity for planning and organising, marketing (commercialization), capacity to adapt to new situations (internationalisation), creativity (demand, commercialization), production (commercialization), teamwork, oral communication, computing skills, and interest in following the developments in the field (life-long-learning) to be core competencies for sport managers. However, they state that this list is somewhat different when fitness managers are excluded from it, and only sport club, national sport federations and local sport managers are analysed. Their core competencies include strategic planning and management, project design and management, financial management, language skills, ability to work in international context, research skills, problem solving skills, capacity for analysis and synthesis, information management skills, written communication, and capacity for applying knowledge in practise. Other studies showed the importance of other skills, including entrepreneurial skills (González-Serrano, Moreno & Hervás, 2021), some personality traits-related trainings (e.g. self-confidence, stress resistance (see Tomino, 2020)), but also the importance of new pedagogical approaches that allow the improvement of critical thinking by the inclusion of internship, new technologies, and e-learning (Miragaia & Soares, 2017).

Previous studies indicate a comprehensive need for managerial competencies training, as the required competencies are not unanimous among sectors or positions. For example, differences in terms of perceived importance of different competencies were observed between sport club managers and coaches (Eksteen, Malan & Lotriet, 2013), depending on the gender and position (Bravo, Won & Shonk, 2012; Fahrner & Schüttoff, 2020), age and type of organization (Fahrner & Schüttoff, 2020). Although required competencies are context specific, some competencies such as communication and organising skills have been seen as the most important ones by several researches (Cingiene et al., 2006; DeSensi, Kelley & Beitel, 1990; Farner & Schüttoff, 2020; Horch & Schütte, 2003; Lambrecht, 1987; Škorić, 2009, 2018).

Students have previously been a part of research in sports management education (e.g. González-Serrano et al., 2021), but not in the sense that they were considered relevant stakeholders whose inputs would be considered when developing educational programs. Since sport management professions in Europe are educated in two main ways: "the first way is to get the basic education from "Sport Sciences" and then in the end of the studies specialize on more or less sport management related management, financing, economics etc. or special sport management subjects; the second is to start with general management, economics, financing etc. and then specialize in the end on sport management or closely sport management related subjects" (Cingiene et al., 2006 p. 173), we find this line of research important to discuss. Building on the premises that students of business have through their studies been focused on different set of competencies than students of kinesiology, differences in their opinions regarding expected competencies for sport managers are to be expected,. Gabrić (2021) in his research on specifics of management in kinesiology recreation in relation to the management in other sectors confirmed that expert knowledge was found to be more important for managers working in recreation than for managers in other service sector activities. Expert knowledge refers to so called technical group of knowledge and skills, since it is based on methods and techniques used at work, i.e. in this case knowledge about sport and kinesiology in general. Based on all previously discussed, and considering that both students of kinesiology and business can be suitable candidates to take on the roles of sports managers in the future, this paper is based on the following research questions:
RQ1: What skills and competencies do students of sports and business find important for sports managers?

RQ2: Are there any differences in the desirable skills and competencies of sports managers when comparing perceptions of students of kinesiology and business?

The answers to these research questions are important in the context of understanding the changes that need to be made in an international learning and higher education, as sports management education must be responsive to sport innovations and stakeholder demands.

Methodology

The sample consisted of students at University of Zagreb, at Faculty of Kinesiology (FK; 78 students enrolled into 7th semester subject Economics and Management of Sport), and Faculty of Economics & Business (FEB; 63 students enrolled into 7th semester of major Management). Business students were selected from major "management" as they get general education in management (e.g. in the field of human resources management, strategic management, leadership and organization design) and are being prepared to undertake managerial positions in the future, including managerial positions in sport. On the other hand, kinesiology students acquire two competencies: first for becoming Physical Education teachers and second depending on module they choose they can work in sports, sports recreation, kinesitherapy and sports management (University of Zagreb Faculty of Kinesiology, 2024). They are involved in the work of different sport organizations by being sportsmen/women and coaches, but later climb the organizational ladder and become managers at different levels.

Questions analysed in this paper are a part of a broader research questionnaire developed by Sikavica and Bahtijarević-Šiber (2004). FK sample consisted of 38 males and 40 females which were 22 years of age (M=22,16; SD =±1,14). FEB sample was on average 23 years old (M=22,97; SD =±2,09) with 18 female and 45 male students. Non-probability sampling was used to select participants for this research. Questionnaire consisted of 13 questions, and two are of interest for this paper. Students were asked to state their opinions about: 1) needed knowledge and skills for sport managers, and 2) how important they find different competencies, knowledge, and skills for sport managers.

Results and discussion

Sport management education has been recognized as a tool to improve management and leadership skills of those in managerial positions in sports. In order to answer the first research question, this research first examined which groups of basic knowledge and skills are found to be important for sport managers. Specifically, students were asked to assess the importance of technical knowledge and skills, people skills or conceptual knowledge (Table 1). Both groups agree that people skills are dominantly needed by sport managers, which is aligned with previous research suggesting that communication skills are most important ones. For FK students conceptual skills are also dominantly needed, which is not the case with FEB students which place medium importance to both technical and conceptual knowledge and skills. Possible explanation for this might be the one of educational background since FEB students have already gained an insight into how organizations function, and FK students did not.

Table 1. Types of knowledge and skills necessary for the job of sport managers

	Slightly needed		**Medium level importance**		**Dominantly needed**	
	FK	**FEB**	**FK**	**FEB**	**FK**	**FEB**
Technical knowledge and skills	6.41%	19.05%	47.44%	61.90%	46.15%	19.05%
People skills	2.56%	0.00%	23.08%	12.70%	74.36%	87.30%
Conceptual knowledge and skills	2.56%	3.17%	24.36%	55.56%	73.08%	36.51%

In the second question students were asked to rate on a Likert type scale (1-highly unimportant to 5-highly important) the importance of 12 different sets of competencies for sport manager's job. The overview of descriptive statistics for all 12 sets of competencies and results of Man-Whitney U test are presented in Table 2.

Table 2. Descriptive statistics for 12 competencies and skills of sports managers and results of Man-Whitney U test

Variable	Mean		Mode		St.Dev.		Z-adjusted	p-value
	FK	FEB	FK	FEB	FK	FEB		
Organising work	4.56	4.33	5.0	5.0	0.57	0.78	1.68343	0.092293
Willingness to take risks	4.44	4.38	5.0	5.0	0.65	0.85	-0.18117	0.856236
Entrepreneurship	4.41	3.81	5.0	4.0	0.67	0.96	3.85567	0.000115
Coordination of activities	4.32	4.41	4.0	5.0	0.65	0.77	-1.24526	0.213038
Anticipation abilities	4.29	4.24	5.0	5.0	0.82	0.96	0.04528	0.963885
Expertise	4.26	4.06	4.0	4.0	0.65	0.85	1.05780	0.290149
Foreign language	4.26	4.02	4.0	4.0	0.79	0.94	1.53763	0.124141
Expediency of decision making	4.10	4.48	4.0	5.0	0.84	0.80	-2.93723	0.003312
Innovation	4.01	3.87	4.0	4.0	0.81	0.99	0.62825	0.529843
High level of general education	3.64	3.35	4.0	Multiple	0.73	0.91	2.01984	0.043401
Great managerial experience	3.67	3.54	4.0	4.0	0.81	0.93	0.64793	0.517033
Ability to transfer knowledge to others	3.42	3.98	Multiple	5.0	0.90	1.03	-3.56786	0.000360

Valid N for FK is 78, and for FEB 63

Table 2 shows several differences in perceptions of skills, knowledge and competencies required for the job of manager in sports industry, and thus provides answers to the second research question. Both FK and FEB students agree that willingness to take risks is one of the most important competencies needed by sport managers, and that high level of general education as well as great managerial experience are not as important. However, according to FK students, two other “top three” skills/competencies by importance are good organizing skills and entrepreneurial skills, and for FEB students those are fast decision-making capabilities and high ability to coordinate activities. Interestingly, entrepreneurship skills are found the be one of the least important for FEB students, and one of the most important for FK students. Man-Whitney U test confirmed statistically significant differences for the examined set of competencies (p=0.01). Since FK students have greater knowledge about kinesiology and sport industry, they might “see” greater opportunities for entrepreneurial projects than FEB students, and therefore find these competencies important. Although high level of general education was found least important in both groups of students, statistically significant differences were found (more important for FK than FEB students; p=0.05). Opposite was found for ability to transfer knowledge to others, since FEB students find it more important than FK students (p=0.01), although, interestingly, transferring knowledge to others is what FK students are primarily educated for. After completing their studies, they acquire necessary competencies for teaching Physical Education classes at all levels, and therefore might look at this competency in a different way than FEB students. For FK students it is about teaching others (mostly children) some sport specific skills, and not teaching employees to do some business specific tasks. The study results indicate that students rated high the professional competences that can be learned through the educational process, while general knowledge and education or previous experience were not found as important.

Previous findings indicate that sports managers can receive training in different fields (see e.g. Guidotti et al., 2023) to increase their level of competencies (e.g. Retar, Plevnik & Kolar, 2013; Škorić, 2018). The present research seeks to contribute to the literature from another point of view – it analyses student perceptions, as possible future sports managers, about the importance of different competences. Results obtained on a student sample confirm that students find important exactly those skills that can be learned through the educational process (Cingiene et al., 2006), such as entrepreneurial ability, conceptual skills or effective decision making (e.g. Tomino, 2020). Sport management studies should develop students’ professional competencies and managerial skills, that should enable individuals in managerial positions to face the daily challenges in their work. Since there are differences in how students from different educational backgrounds perceive the importance of different sets of competencies, future educational programmes should consider these differences and implement them in their curriculums. More emphasis should be placed on managerial knowledge and skills, but it would also be useful to develop knowledge about sport industry among business students, for example through elective courses. These skills are essential to ensure that future sports managers take actions at the right time and to maximize the collective performance of the group. Higher education policies that combine formal and informal learning environments (De Schepper & Sotiriadou, 2018) will most likely be the most efficient in increasing efficiency of managers in sports.

Conclusion

This research indicates that students have different expectations regarding the knowledge and skills necessary to perform the job of sports managers, depending upon their field of study. Most of the professional competencies and skills that students find important are being taught as a part of the higher education curriculums, which proves the relevance and accuracy of sport management education. Also, the implication of this study is for faculties to have a reference point with respect to sport management study programs, i.e. the attitudes about current practices and possible improvements in the future. Additionally, sports management educational programmes could benefit from collaboration between educational institutions, as research results show that sports managers are expected to have a broad array of skills and competencies, both business and kinesiology related. This research also has several limitations. The small and convenience sample is non-representative of the whole student population. Furthermore, students of business are majoring in management so they might have a better understanding of managerial responsibilities compared to students of kinesiology. Questionnaire included closed-end questions, so there could be more paramount skills, knowledge and competencies important for sports managers that were not identified with this research. As a part of future research, in addition to increasing sample size, it would be advisable to revise the list of researched competencies and conduct similar research on operating managers in sports.

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CURRENT TRENDS AND INNOVATIONS IN KINESIOLOGY RESEARCH: PROCEEDINGS

MEDICINE OF SPORT & EXERCISE

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IMPACT OF MENSTRUAL SYMPTOMS ON DAILY LIFE: DOES CHRONOTYPE PLAY A ROLE IN YOUNG WOMEN'S EXPERIENCES?

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Abstract
This study examined the prevalence of menstrual symptoms and their impact on young women's daily lives and sports activities. It also investigated the relationship between chronotype and the expression of these symptoms. 76 young women participated in an online survey covering questions about their menstrual cycle, symptoms, daily life impacts, circadian preferences, and anthropometric data. The Morningness–Eveningness Questionnaire (MEQ) was used to classify participants' chronotypes. The findings reveal that a significant portion of participants experience heavy menstrual bleeding (46.1%) and regular pain during menstruation (72.4%), along with other symptoms such as headaches (25%), lumbar spine pain (57.9%), lower abdominal pain (78.9%), and increased fatigue (63.2%). Evening chronotypes reported a higher prevalence of pain (81.8%) during menstruation, while intermediate types experienced more fatigue. Restrictions in daily and sports activities during menstruation were common; evening types exhibited the highest levels of activity limitation (36.4% of sports and 45.5% of daily activities). The statistical analysis of the study suggests that individuals with evening chronotypes may experience certain symptoms, such as heavy menstrual bleeding and a higher prevalence of lower abdominal pain, more significantly than those with intermediate and morning types ($p<0.05$). However, no statistically significant correlations were found between other menstrual symptoms or limitations in physical activity in relation to MEQ scores. Overall, this study reveals how circadian rhythms impact the expression of menstrual symptoms, highlighting the need for further research to explore underlying mechanisms and potential interventions to address this issue among young women.

Keywords: *menstrual cycle, dysmenorrhea, pain, fatigue, circadian rhythm, circadian preference*

Introduction
The menstrual cycle is a natural physiological process that women experience monthly. During this time, women may have symptoms such as pain (dysmenorrhea), fatigue, mood changes, and heavy bleeding. These symptoms can lead to decreased quality of life and restrictions in daily and sports activities (McKenna & Fogleman, 2021).

Moreover, one factor contributing to these symptoms could be an individual's circadian rhythm or chronotype, which determines their sleep-wake patterns and energy levels throughout the day (Postolache et al., 2020). For instance, bedtime may influence the experience of menstrual symptoms based on one's chronotype. Individuals with later bedtimes show a notably higher prevalence of menstrual pain compared to those with earlier bedtimes (Mitsuhashi et al., 2022). Additionally, morning chronotypes are less sensitive to pain than evening ones (Jankowski, 2013), which might result in a higher tolerance for menstrual pain and less disruption of daily life activities for morning chronotypes. Understanding the prevalence and impact of menstrual symptoms on daily life is crucial for addressing the challenges faced by young women. This study aimed to (i) investigate the prevalence of menstrual symptoms, such as pain and fatigue, in young women, (ii) the impact of menstruation on their daily lives and participation in sports activities, and (iii) explore the relationship between chronotype and the expression of menstrual symptoms.

Methods
Participants: This study included 76 young women between the ages of 18 and 35 from the Czech Republic. Participants were recruited through university advertisements and social media platforms. They were eligible for the study if they reported having regular menstrual cycles without using hormonal contraceptives.

Experimental design: Participants completed an online survey that included questions about primary anthropometric data, their menstrual cycle, menstrual symptoms, the impact of menstruation on their daily life, and circadian preferences. By participating in the online survey, participants agreed to take part in research conducted as part of a Specific Research (MUNI/A/1455/2022) at the Faculty of Sport Studies, Masaryk University (MU), which The Research Ethics Committee of MU approved.

Survey questions and data collection: The online survey included four standardized surveys and additional questions explicitly created for this research. The study utilized a standardized Morningness–eveningness questionnaire (MEQ) by Horne & Ostberg (1976) to classify chronotype along with specific queries related to the menstrual cycle, pain and symptoms during menstruation, limitations in daily activities, and physical activity during menstruation. Anthropometric data (age, height, weight) and information on physical activity levels (performance tier assessments by McKay et al. (2022)) were gathered through a questionnaire to encompass the essential participant characteristics. To detect symptoms during menstruation, we asked: Have you ever had a problem with heavy menstrual bleeding?; Do you suffer from pain during menstruation?; Do you get a headache during menstruation?; Do you experience pain in the lumbar spine during menstruation?; Do you have pain in your lower abdomen during menstruation?; Does your fatigue level increase during menstruation?; Do you limit the activities of your daily life during menstruation (housework, shopping, walking, ...)?; Do you limit sports activities during menstruation?; Have you ever missed school or work because of your menstruation?. Participants' menstrual cycle-related data were collected through self-reported responses to specific questions regarding symptoms and limitations during menstruation.

Statistical analysis: The prevalence of menstrual symptoms, the limitation of daily activities, and participation in sports activities is shown using percentages for all subjects as well as separately for individual chronotypes. Non-parametric Spearman correlation was used to assess the relationship between menstrual symptoms, limitations in daily activities, sports participation, and MEQ scores, with a significance level set at $p<0.05$.

Results

Participants characteristics: Of the 76 participants in this study, 29 were morning, 36 intermediate, and 11 evening chronotypes. Descriptive statistics in Table 1 present the evaluated anthropological data, general information about the menstrual cycle (including cycle length and bleeding), performance class, and MEQ score for individual chronotypes.

Table 1. Participant characteristics, data are summarized using the mean ± standard deviation.

	Total	Morning types	Intermediate types	Evening types
Age [years]	23.19 ± 4.31	23.41 ± 3.49	22.69 ± 4.8	24.82 ± 4.38
Height [cm]	168.11 ± 5.9	168.52 ± 6.2	167.81 ± 5.59	167.73 ± 5.71
Weight [kg]	62.62 ± 9.16	63.91 ± 10.48	61.77 ± 8.38	61.91 ± 8.95
Length of MC [days]	28.73 ± 2.8	28.62 ± 2.27	28.99 ± 3.46	28.09 ± 1.81
Length of bleeding [days]	5.44 ± 1.09	5.21 ± 0.99	5.61 ± 1.19	5.55 ± 1.04
Tier of PA	1.58 ± 1.03	1.83 ± 1.04	1.44 ± 1.03	1.55 ± 1.13
MEQ score	54.28 ± 10.74	64.24 ± 4.72	51.31 ± 4.12	35.27 ± 5.62

Menstrual symptoms: The study on menstrual symptoms revealed that a significant percentage of participants experienced heavy bleeding (46.1%) and regular pain during menstruation (72.4%). In addition, 6.6% suffered from occasional pain. Lower abdominal pain was the most frequently occurring symptom, with 78.9% experiencing it regularly, while few reported it infrequently (5.3%) or exceptionally (1.3%). Moreover, headaches were regularly experienced by 25% of the participants and infrequently by 5%. Similarly, lumbar spine pain was reported regularly by 57.9%, and occasionally by only 2.6%. During menstruation, many participants experienced increased fatigue regularly, with 63% reporting this. Only a small number reported occasional occurrences (2.6%).

Additionally, 25% of the participants regularly limited their daily activities during menstruation, while 1.32% reported occasional limitations. Also, 28.9% regularly restricted their sports activities during menstruation, with 2.6% indicating it happened sometimes. Furthermore, 34.2% had missed school or work due to menstruation.

Menstrual symptoms in chronotypes: When we examine the occurrence of symptoms in different chronotypes, for example, evening types have a higher prevalence of regular pain during menstruation (81.8%) compared to morning types (65.5%) and intermediate types (75%). Moreover, increased levels of regular fatigue were more prevalent in intermediate types (72.2%) compared to both morning (55.2%) and evening types (54.5%). Additionally, regular restrictions in daily activities during menstruation were more common among evening types (45.5%) than in the morning (24.1%) and intermediate types (19.4%). On the other hand, an interesting finding reveals that missing school or work due to menstruation was most common among intermediate types at 44.4%, followed by morning types at 31% and then evening types at only 9.1%. Table 2 displays the precise percentage prevalence of menstrual symptoms within different chronotypes.

Table 2. Prevalence of menstrual symptoms and limitation of daily/sport activities in individual chronotypes, as summarized by percentages.

	Morning types [%]			Intermediate types [%]				Evening types [%]		
	R/Y	N	S	R/Y	N	S	E	R/Y	N	S
heavy menstrual bleeding	31	69	–	55.6	44.4	–	–	54.5	45.5	–
pain during menstruation	65.5	27.6	3.4	75	13.9	11.1	0	81.8	18.2	0
headage during menstruation	31	65.5	3.4	22.2	72.2	5.6	0	18.2	72.7	9.1
lumbar spine pain during menstruation	58.6	41.4	3.4	55.6	38.9	0	5.6	63.6	27.3	9.1
lower abdominal pain during menstruation	65.5	27.6	6.9	88.9	5.6	2.8	2.8	81.8	9.1	9.1
increase of fatigue level during menstruation	55.2	44.8	0	72.2	25	2.8	0	54.5	36.4	9.1
limitation the activities of daily life during menstruation	24.1	72.4	3.4	19.4	80.6	0	0	45.5	54.5	0
limitation sports activities during menstruation	20.7	75.9	3.4	33.3	63.9	2.8	0	36.4	63.6	0
missed school or work because of period	31	65.5	–	44.4	55.6	–	–	9.1	90.9	–

Abbreviations: R, Regularly; Y, Yes; N, Never; S, Sometimes; E, Exceptionally

The uncovered a statistically significant, yet weak to moderate positive correlation between heavy menstrual bleeding and MEQ scores ($\rho=0.231$, $p=0.044$), as well as the prevalence of lower abdominal pain and MEQ scores ($\rho=0.283$, $p=0.013$). This suggests that individuals with a morning chronotype might experience a slightly lower prevalence of heavy menstrual bleeding and lower abdominal pain compared to those with an evening chronotype. Conversely, although the correlation between pain during menstruation and MEQ scores was positive, it did not reach statistical significance ($\rho=0.140$, $p=0.229$). Similarly, no statistically significant correlations were observed for other menstrual symptoms such as headaches, lumbar spine pain, or increased fatigue during menstruation, nor limitations in daily life activities or sports activities due to menstruation.

Discussion

The research aimed to examine the prevalence of symptoms related to menstruation, such as pain and fatigue, among young women. It also sought to evaluate the impact of menstruation on their daily activities and participation in sports. Additionally, it investigated how chronotype influences the expression of menstrual symptoms.

Prevalence of the menstrual symptoms: Our study found that lower abdominal pain is the most common symptom of menstruation, with a prevalence of about 79%. This aligns with previous research reporting a high prevalence (27.4–85.9%) of abdominal pain during menstruation (Mitsuhashi et al., 2022). Fatigue is another prevalent menstrual symptom, occurring in ranges from 42.9% to 78.8% (Mitsuhashi et al., 2022), which is consistent with our study's finding of 63.2%. These symptoms, including lower abdominal pain and fatigue, may significantly impact a woman's daily life by limiting activities such as sports or work due to menstruation, an issue prevalent in our study at rates ranging from 25% to 34.2%. The effect of menstrual symptoms varies widely among individuals; for example, approximately 54.5–92.4% of women reported an impact on their daily lives due to menstrual pain and between 4.5–37.3% on sports activities (Mitsuhashi et al., 2022).

Prevalence of the menstrual symptoms in chronotypes: Our study revealed that approximately 82% of evening chronotypes experienced menstrual pain, compared to 65.5% of morning chronotypes. This could be attributed to a higher sensitivity to pain among evening chronotypes (Jankowski, 2013). Additionally, statistically significant, weak to moderate, correlations were found only for lower abdominal pain ($p<0.05$) and heavy menstrual bleeding ($p<0.05$), which were more strongly linked with eveningness. This finding is in line with previous research indicating that among adolescents, a preference for eveningness is associated with higher prevalence of menstrual abdominal pain ($p<0.01$) and also, for instance, levels of fatigue ($p<0.01$) compared to those with a morning preference (Negriff & Dorn, 2009).

This study provides insights into how chronotype affects menstrual symptoms among young women. However, it is limited by a small, regionally specific sample from the Czech Republic, which may impact the generalizability of the findings. Additionally, relying on self-reported data introduces the potential for subjective bias. Further research with larger and more diverse populations and objective measures is necessary to enhance our understanding of the relationship between circadian rhythms and menstrual symptoms.

This finding contributes an additional dimension to our comprehension of how circadian rhythms might impact menstrual symptoms; however, further research is necessary to clarify the underlying mechanisms associated with this connection.

Conclusion

This study highlights the significant impact of menstrual symptoms on young women's daily lives and sports activities. It suggests that chronotype may play a role in the manifestation of these symptoms. Findings indicate that evening chronotypes more frequently report pain during menstruation, while intermediate types experience higher levels of fatigue. Statistically significant correlations between heavy menstrual bleeding, prevalence of lower abdominal pain, and MEQ scores suggest that evening types may experience these symptoms more intensely. However, the relationships between other menstrual symptoms and chronotype remain less clear. This study provides an important overview of the influence of circadian rhythms on menstrual symptoms and calls for further exploration of potential intervention strategies to improve affected women's quality of life.

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EFFECT OF MENSTRUAL CYCLE PHASE AND PERCEPTUAL RESPONSES IN BRAZILIAN FOOTBALL 7 PLAYERS: A PILOT STUDY

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Abstract
This pilot study aimed to describe the possible effect of the menstrual cycle phase on perceptual responses to recovery, wellbeing and motivation in Brazilian Football 7 players. Data from sixteen female players (age: 30.19 ± 5.11 yrs) belonging to the same team were collected three months before each match. Perceive of recovery was collected by the Total Recovery Quality scale; wellbeing by the 5-point Likert scale on the domain of fatigue, sleep, soreness, stress and mood; and motivation to compete by a 7-point Likert scale. The menstrual cycle phase was self-determined by the menstruation, day 7, day 14, or day 21 after the menstruation. Data were grouped according to the phases and compared by the Friedman test, with a significance set of $p<0.05$. Players did not significantly differ in their perception of recovery, wellbeing domains and motivation to compete across the menstrual cycle phases ($p> 0.05$). However, specifically, a significant impairment in perception of soreness at day 7 ($p=0.013$) and stress on menstruation ($p=0.028$) compared to day 21 were found. Therefore, it appears that female players in this cohort maintain relatively consistent perceptions of recovery, wellbeing and motivation throughout their menstrual cycles. However, further investigation with long-term monitoring is necessary to confirm these findings definitively and explore potential individual differences in response to menstrual cycle variations in the Football 7 players.

Keywords: *menstruation, sport, female, wellbeing, fatigue*

Introduction
Recent evidence has been reported that perceptual responses to recovery, wellbeing and motivation to compete among athletes can vary significantly depending on the menstrual cycle phase (Crewther & Cook, 2018; Paludo et al., 2022). For instance, during the ovulation phase, athletes can experience heightened motivation and competitiveness and improved wellbeing, compared to the luteal or follicular phase, potentially leading to enhanced performance. In contrast, negative perceptual responses may be exacerbated during pre-menstruation (e.g., mood disturbance) and menstruation period (e.g., menstrual symptoms and drop in vigour) compared to the luteal and ovulation phases (Paludo et al., 2022). These perceptual discrepancies could significantly impact training approaches and athletic performance. However, conflicting findings exist, with some studies suggesting no significant variance in athletes' perceptual responses across menstrual cycle phases (Graja et al., 2022; Paludo et al., 2022). Such inconsistencies may be attributed to limited research on female athletes and menstrual cycle effects, including the specific phases examined (e.g., bi-phasic model or multiple subphases) (Elliott-Sale et al., 2021). Inconclusive evidence might also stem from the scarcity of longitudinal, particularly in team sports.

Amongst sports modalities enrolled by female athletes, the Football 7 stands out in South America. Originating as an amateur pursuit, Football 7 is a recent sport modality that has gained attention, particularly in Football 7, also known as seven-a-side football, is a variation of traditional football that is played with seven players (6 players on the field and one goalkeeper on each team, played on a reduced court (30 x 50 m in the synthetic field) during two periods (25 min separated by 5 min break) and with similar rules (Batista et al., 2019). Despite its rising popularity, there remains a lack of information about this modality, especially among female players. Therefore, this study aims to fill this gap by exploring the relationship between the menstrual cycle phase and perceptual responses, while also contributing to the literature on Football 7. The main aim is to describe how players perceived recovery, wellbeing and motivation according to the menstrual cycle phase over a three-month competition period. We hypothesized that players will report better recovery, enhanced wellbeing domains and increased motivation to play the matches during the phases with higher concentrations of ovarian hormones, such as ovulatory (day 14) and mid-luteal (day 21) phases compared to phases with lower concentration (menstruation and day 7).

Methods
Participants
Eighteen Brazilian female Football 7 players (age: 30.19 ± 5.11 yrs) belonging to the same team were evaluated during a tournament lasting 14 weekends (2022). The inclusion criteria were to be a natural menstrual cycle, participate in the

matches and to agree to take part in the study. Two players were excluded due to the use of oral contraception and menstrual irregularities. This study is part of an international project, approved by the Ethics Committee (EKV-2022-054) hosted by a University in the Czech Republic. Players were instructed in their native language (Portuguese) about the study's objectives and an informed consent form was completed before the beginning of the study.

Study design
Football 7 players from a Brazilian team were monitored during 14 weekend matches, in Brazil from March to May 2022. Data collection was performed before each match. Players reported their perception of recovery by Total Quality of Recovery scale- TQR, wellbeing by a 5-point Likert scale of fatigue, sleep, soreness, stress and humor domains, and motivation by a 7-point Likert scale. Also, the players were asked to report on each menstrual phase she was in the moment: menstruation, day 7, day 14 or day 21.
Descriptive data on age and menstrual cycle information were collected via an online survey.

Recovery
Total Quality of Recovery (TQR) was used to evaluate the players' recovery. TQR, proposed by (Kenttä & Hassmén, 1998), is a Likert scale ranging from 6 to 20, representing 'not at all recovered' to 'fully recovered' respectively.

Wellbeing
Wellbeing was measured using a wellness questionnaire, adapted from (McLean et al., 2010). The questionnaire comprised the domains of fatigue, perceived sleep quality, stress, muscle soreness and mood. Each domain has a 5-point Likert Scale, in which 1 corresponds to the lowest response to wellbeing and 5 highest response to wellbeing.

Competition Motivation
Competition motivation was evaluated by the question "How would you rate your motivation to compete right now? " The motivational ratings ranged 0 to 7 points (0= extremely low to 7= extremely high). Rating methods have been used previously in female athletes (Crewther & Cook, 2018).

Menstrual cycle phase
The menstrual cycle phase was separated by: the menstruation, day 7 after first day of menstruation (middle follicular phase), day 14 (ovulation) and day 21 (middle luteal). The players were asked a question "In which day of your menstrual cycle you are today?" The answers were: "I am in my period", "I am close to day 7 after the first day of my period", "I am close to day 14 after the first day of my period" and "I am close to day 21 after the first day of my period. "

Statistical analysis
Data presented a non-parametric distribution by the Shapiro-Wilk test, therefore the recovery, wellbeing and motivation were displayed in mean and minimum and maximum as a central tendency and dispersion, respectively. To compare perception during the menstrual cycle phase, the Friedman test was used, along with a Durbin-Conover post hoc test, to identify possible differences. Data were analyzed using the JAMOVI statistical software package, with a significance set at $p<0.05$.

Results
The players presented non-significant changes in recovery, wellbeing and motivation across the menstrual cycle phases ($p<0.05$). Analyzing the single comparison, significant differences were found solely in some parameters, as the players reported a significant impairment in perception of soreness at day 7 ($p=0.013$) and stress on menstruation ($p=0.028$) compared to day 21.

Table 1. Perception variables across the menstrual cycle phases, described in mean (minimum-maximum)

	Menstruation (n=19)	Day 7 (n=37)	Day 14 (n=29)	Day 21 (n=28)	p-value
Recovery	15.3 (9-20)	15.00 (9-20)	14.8 (11-19)	16.1 (9-20)	0.459
Fatigue	3.47 (2-5)	3.46 (2-5)	3.55 (2-5)	3.68 (2-5)	0.274
Sleep	4.00 (3-5)	3.97 (1-5)	3.59 (1-5)	4.00 (1-5)	0.420
Soreness	3.63 (2-5)	3.46 (1-5)a	3.17 (1-5)	4.04 (3-5)	0.078
Stress	3.37 (2-5)b	3.78 (2-5)	3.66 (2-5)	3.93 (3-5)	0.180
Mood	3.95 (3-5)	4.03 (1-5)	4.00 (3-5)	4.21 (3-5)	0.256
Motivation	6.26 (4-7)	6.32 (3-7)	6.52 (4-7)	6.54 (5-7)	0.913

[a] day 7 – day 21= p= 0.013; [b] menstruation – day 21= p= 0.028.

Discussion

The primary objective of this study was to explore how menstrual cycle phases influence the perceptual responses to recovery, wellbeing and motivation among Brazilian Football 7 players. The main finding demonstrated that the phases of menstrual cycle had a non-significant effect on most perceptual parameters, contradicting the initial hypothesis. An exception, there was a significant decrease in the perception of stress during menstruation and soreness on day 7, compared to day 21 and decrease in soreness and better/worse mood at day 7 compared to day 21.

The non-significant changes observed in perceptual responses across menstrual cycle phases among Football 7 players underscore the complexity and individual variability in how hormonal fluctuations may manifest in athletes' experiences. While some studies have reported associations between menstrual cycle phases and perceptual responses in athletes (Carmichael et al., 2021; Cook et al., 2018; Crewther & Cook, 2018), the inconsistency in findings highlights the multifactorial nature of this relationship. Factors such as variations in hormone sensitivity, training status and psychological factors likely interact with menstrual cycle phases, contributing to diverse perceptual outcomes among athletes.

Comparisons can be made with recent studies investigating similar parameters in other sports modalities. For instance, a study on futsal players during a congested tournament found no significant changes in perception of recovery between players in the early luteal phase (menstruation) and players in days 10-15 after menstruation (Dal'Maz et al., 2023). Although the results were similar, it is important to note that the mentioned study was conducted over a four-day tournament, whereas our study lasted three months. However, it can be a potential consistency in the perception of recovery across the menstrual cycle.

Similarly, a study examining wellbeing domains and menstrual cycle phases in Australian Football players during a competition season reported differences in fatigue and sleep quality, indicating impairments during the follicular phase compared to the luteal phase (Carmichael et al., 2021). In contrast, our study identified differences in soreness and stress, with significant impairments during menstruation and day 7 (follicular phase) compared to day 21 (luteal phase). Although the Australian Football study utilized a bi-phasic model, distinguishing between follicular and luteal, and our study on Brazilian Football 7 players extended beyond these phases, encompassing multiple sub-phases. Upon analyzing the findings, it becomes apparent that in both studies, wellbeing domains experienced impairment during the follicular phase, which comprehends the pre-ovulatory menstruation period characterized by lower ovarian hormone concentrations compared to the mid-luteal phase (day 21).

Identifying changes in soreness and stress across menstrual cycle phases has practical implications for coaches and sports scientists. These findings suggest the need for tailored interventions to address muscle soreness perception during menstruation and day 7, potentially enhancing athletes' readiness for competition. Lastly, as previous research has indicated a positive correlation between motivation and ovulation in elite athletes from various sports disciplines (Cook et al., 2018; Crewther & Cook, 2018), our study did not find significant changes in motivation perception before matches. This disparity may be attributed to methodological differences, such as data collection timing, which could be influenced by factors like opponents and match location.

Limitations of this study include its small sample size and aggregated results. Long-term monitoring across menstrual phases could provide a more comprehensive understanding of potential effects. Additionally, self-reported menstrual cycle phases may lack precision, suggesting the need for additional methods such as ovulation tests or hormone concentration assessments to reinforce phase identification. Nonetheless, this study represents the first investigation of menstrual cycle phase effects in Football 7 players, contributing valuable insights to a sport modality with limited existing evidence. By adding information on the menstrual cycle's influence on perceptual responses in this unique cohort, this study informs training and competition strategies tailored to the specific needs of female athletes in Football 7.

Conclusion

In summary, this pilot study investigated the potential influence of menstrual cycle phases on perceptual responses to recovery, wellbeing and motivation among Brazilian Football 7 players. While there were isolated instances of significantly increased perception of soreness on day 7 and higher stress levels during menstruation compared to day 21, overall, the perceptual responses did not reach statistical significance. Therefore, female players in this cohort appear to maintain relatively consistent perceptions of recovery, wellbeing and motivation throughout their menstrual cycles. However, further investigation with individual long-term monitoring is necessary to confirm these findings definitively and explore potential individual differences in response to menstrual cycle variations in the Football 7 players.

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THE RISK OF LOW ENERGY AVAILABILITY, BODY IMAGE, AND MENSTRUAL CYCLE PERCEPTION IN FEMALE DANCERS

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Abstract
Introduction: Based on the Relative Energy Deficiency in Dance (RED-D) consensus statement recommendation, the aim of this study was to screen the prevalence of low energy availability in dancers from different dance genres. Furthermore, this study aimed to analyze the menstrual cycle perception, symptoms, and communication; and assess the relationship between body image, dancer identity, orthorexia nervosa tendencies, and the risk of low energy availability in dancers. Materials and Methods: A total of 29 female dancers on the competitive level completed the survey. The survey consisted of several questionnaires: LEAF-Q, DIMS, ORTO-R, PFRS, actual-ideal weight discrepancy, and questions on menstrual cycle perception. Results: The observed prevalence of menstrual cycle disorders was 31% to 65.5%, the prevalence of menstruation-related symptoms was up to 97%, and the prevalence of risk score of LEAF-Q was 24%. Conclusions: These results highlight the need for open communication about the menstrual cycle between dancers and coaches/choreographers. Furthermore, the tendency to prefer lower body weight/BMI and the observed prevalence of risk score of LEAF-Q in dancers highlight the need for education about RED-D.

Keywords: *LEAF-Q, dancer identity, menstrual disorders, dance, RED-D*

Introduction
Dance combines both physical and artistic demands. In terms of demands and environment, dance training can be a significant factor in the development of low energy availability (LEA) (Keay et al., 2020). In elite ballet dancers, the reported prevalence of menstrual cycle disorders and female athlete triad was 47% and 40%, respectively (Doyle-Lucas et al., 2010).
In the year 2024, the Relative Energy Deficiency in Dance (RED-D) was described by Allen et al. (2024). RED-D was based on a broad-spectrum syndrome of Relative energy deficiency in Sport (REDs), which was previously acknowledged as the Female Athlete Triad. Chronic LEA might lead to serious health-related issues affecting menstrual function, bone health, immunity, metabolic rate, cardiovascular health, and psychological health (Mountjoy et al., 2014). Dancers, similarly to athletes, were observed to have an increased incidence of eating disorders compared to the general population and to perceive the advantage of weight loss making them suspected of LEA. However, the reported awareness of RED-S among dancers was only 29% (Keay et al., 2020).

The aim of this study was to (i) to screen the prevalence of low energy availability; (ii) analyze the menstrual cycle perception, symptoms, and communication; and (iii) assess the relationship between body image, dancer identity, orthorexia nervosa tendencies, and the risk of low energy availability in dancers.

Methods
Participants
A total of 29 female dancers at the competitive level completed the survey. Their age, body height, and body mass are shown in Table 1. Of these, 14 were ballet dancers, 8 were contemporary dancers, 3 were sport dancers, and 4 identified as urban dancers. The average number of years participants had been dancing was 12.31 ± 6.31 years. The reported number of training hours per week was less than 8 hours in 15 dancers, 8 to 12 hours in 5 dancers, 13 to 20 hours in 5 dancers, and more than 20 hours in 4 dancers. Informed consent to participation in the study was given online before filing out the questionnaire. The study was approved by the Research Ethics Committee of Masaryk University (EKV-2021-109).

Table 1. Dancers' characteristics.

	Mean ± SD
Age (years)	23.38 ± 4.49
Body height (cm)	162.72 ± 5.11
Body mass (kg)	55.76 ± 6.56

Menstrual cycle perception
This part of the survey focused on perceived changes in performance across the menstrual cycle, the prevalence of menstrual symptoms and their management, the history of menstrual cycle disorders, communication about menstrual cycle symptoms with the coach/choreographer, and the perceived importance of this communication.

Low energy availability in the female questionnaire (LEAF-Q)
LEAF-Q was introduced by Melin et al. (2014) as a screening tool assessing the risk of low energy availability. The questionnaire consists of 25 items focused on injuries, gastrointestinal function, and reproductive function. The score ≥8 indicates the risk of low energy availability and female athlete triad (Melin et al., 2014). The consensus statement by Allan et al. (2024) states, that LEAF-Q is an appropriate tool for routine screening of LEA in female dancers.

Dancer Identity Measurement Scale (DIMS)
DIMS was introduced by Langdon & Petracca (2010) and it was based on the Athletic Identity Measurement Scale. Words “athletics” and “athlete” were replaced by “dance” and “dancer” in DIMS. The scale consists of 10 items and a higher score indicates that the person identifies more as a dancer (Langdon & Petracca, 2010).

Orthorexia nervosa questionnaire (ORTO-R)
ORTO-R is a refined measure of orthorexia nervosa based on the previous questionnaire ORTO-15. ORTO-R consists of six questions assessing orthorexic thoughts and behaviors. A higher score in ORTO-R indicates more orthorexia nervosa tendencies (Rogoza & Donini, 2021).

Female Photographic Figure Rating Scale (PFRS)
PFRS consists of 10 photographic images of real women with BMI ranging from emaciated to obese. Participants rate their current body size on PFRS. Furthermore, participants were asked to select the image they considered their ideal body size (Swami et al., 2008).

Actual-ideal weight discrepancy
The actual and ideal weight discrepancy was measured as the difference between reported actual body mass and reported body mass on a question “On average, over the past month what weight have you wanted to be?” as used previously by Lantz Lesser et al. (2021).

Statistical analysis
The prevalence of menstrual cycle characteristics and its perception was shown in percentages. Non-parametric Spearman correlation was used to assess the relationship between LEA and other analyzed factors. The statistical analyzes were conducted using JASP (JASP Teams, version 0.18.3, University of Amsterdam, Netherlands).

Results
A history of secondary amenorrhea was reported by 31% (9 women), and the reported prevalence of the history of oligomenorrhea was 65.5% (19 women). 59% (17 women) stated that it is important to talk about the menstrual cycle with a coach/choreographer; however, only 7% (2 women) communicate about the menstrual cycle with them. Menstruation was reported to affect dance performance by 45% (13 women) who stated that their performance was worse during menstruation. On the other hand, 3.5% (1 woman) stated that her performance was better during menstruation. The ideal phase of the cycle for dance performance was in the mid to late follicular phase (72%, 21 women), late luteal phase (3.5%, 1 woman), and during menstruation (3.5%, 1 woman). 21% (6 women) did not perceive menstrual cycle-related changes in their performance. Regular use of painkillers to alleviate menstruation-related pain was reported by 24% (7 women). The prevalence of menstruation-related symptoms is shown in Table 2.

Table 2. The prevalence of menstruation-related symptoms.

	Depressed mood	Anxiety	Confusion	Irritability	Isolation	Breast tenderness	Cramps	Headache	Bloating
Prevalence (%)	38	52	31	86	48	45	97	55	52

Median, lower and upper quartiles of final scores from analyzed questionnaires are shown in Table 3. The risk score of LEAF-Q was observed in 24% of participants (7 women). Both PFRS and actual-ideal weight discrepancy show the tendency to prefer lower body weight/BMI compared to actual body size.

Table 3. Descriptive characteristics of analyzed questionnaires results.

	Median	Lower Quartile	Upper Quartile
BMI	21.09	19.14	22.89
LEAF-Q score	6.00	5.00	7.00
PFRS	1.00	0.00	2.00
Actual-ideal weight	2.00	0.00	3.00
ORTO-R score	18.00	15.00	22.00
DIMS score	37.00	33.00	39.00

Figure 1 shows the associations between analyzed questionnaires. A statistically significant association was observed between LEAF-Q score and ORTO-R score (p=0.048), and DIMS score (p=0.025). A statistically significant correlation was observed between PFRS and actual-ideal weight discrepancy (p<0.001), and between PFRS and ORTO-R score (p=0.017). Age was associated with BMI (p=0.008), PFRS (p=0.014), and actual-ideal weight discrepancy (p=0.015). Similarly, BMI showed a statistically significant correlation with PFRS (p<0.001), and actual-ideal weight discrepancy (p<0.001).

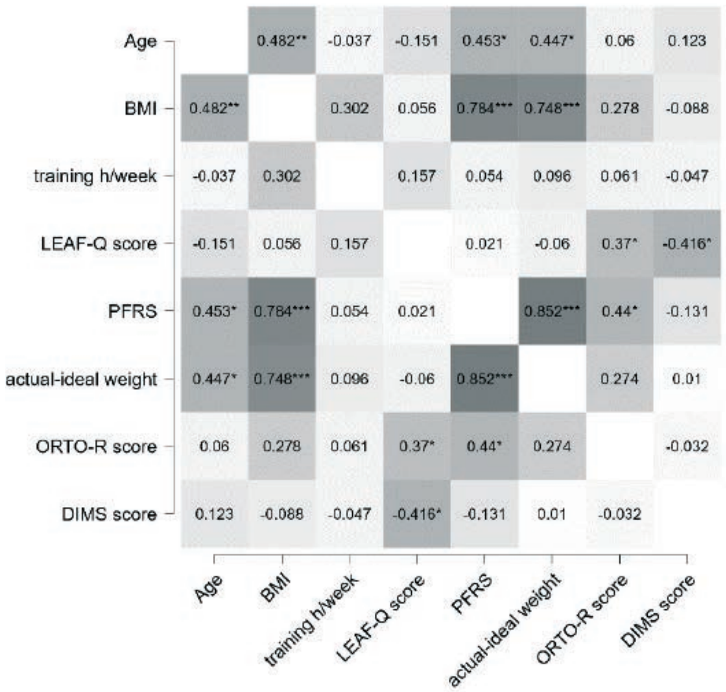

Figure 1. Heatmap showing the results of Spearman's rho assessing the relationship between LEA and other analyzed factors. * highlights the statistical significance at 0,05; ** highlights the statistical significance at 0,01; *** highlights the statistical significance at 0,001

Discussion

This study aimed to screen the prevalence of LEA in dancers from different dance genres. The observed risk score of LEAF-Q among dancers from different dance genres in this study (24%) was lower compared with previous literature showing the prevalence of LEA in female ballet dancers between 40 to 57% (Doyle-Lucas et al., 2010; Keay et al., 2020).

This study also aimed to analyze the menstrual cycle perception, symptoms, and communication. The prevalence of a history of oligomenorrhea (65.5%) and secondary amenorrhea (31%) is similar to the prevalence of these menstrual cycle disorders in sports (Gimunová et al., 2022). Also, the prevalence of menstruation-related symptoms among dancers is similar to the general population and athletes. The regular adverse menstrual symptoms were reported by 90% of women from the general population (Doohan et al., 2023) and by 93% of athletes (Findlay et al., 2020). Similarly to the dancers in this study, abdominal cramps, and bloating are among the most common symptoms reported by women during menstruation (Doohan et al., 2023; Findlay et al., 2020). Compared to female athletes (up to 67% in Findlay et al., 2020), fewer dancers (24%) use self-medication to alleviate menstrual symptoms. However, both athletes and dancers seem to lack communication, openness, and awareness about the menstrual cycle from sport/dance-related personnel (Findlay et al., 2020).

Orthorexia nervosa tendencies are highly prevalent among eating disorders patients (Rogoza & Donini, 2021). Similarly, in this study, a higher ORTO-R score was associated with a higher LEAF-Q score and the preference for smaller body sizes assessed by PFRS. Similarly to the study by Swami et al. (2008), a significant correlation between PFRS and BMI was observed in dancers. With age, the actual-ideal weight discrepancy was observed to increase and in accordance with the study by Lantz Lesser et al. (2020), the actual-ideal weight discrepancy was not significantly related to LEA.

A stronger identity as a dancer assessed by the DIMS score was related to a lower risk of LEA. Higher dancer identity may be reflected in more knowledge about sports nutrition and regeneration. Future studies could explore the relationship between the identity as a dancer, knowledge about sports nutrition and RED-D, and the prevalence of LEA in dancers.

Several limitations of this study including a low number of dancers from analyzed dance genres, and the design of this study based on survey make the generalization of the results difficult. Long-term monitoring of energy availability, menstrual cycle disorders, and symptoms in dancers would bring more detailed insight into RED-D.

Conclusion

The high prevalence of menstrual cycle disorders, menstruation-related symptoms, and its perceived effect on performance highlight the need for open communication about the menstrual cycle between dancers and coaches/choreographers which was reported to be rare. Furthermore, the tendency to prefer lower body weight/BMI by dancers highlights the need for education about low energy availability, female athlete triad, and RED-D.

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INJURY FREQUENCY AND MOST COMMON INJURIES AMONG PROFESSIONAL FOOTBALL PLAYERS IN CROATIA

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Abstract
Football is the most popular sport worldwide. In recent times, football players have been subjected to significantly higher training loads and competitive matches, resulting in an increase in the number of injuries. The aim of this research was to determine the frequency and most common sports injuries among professional football players in the Republic of Croatia.The study involved 440 participants, professional football players in Croatia, including Croatian national team players. All participants were personally provided with an online questionnaire via online platform, which they were required to complete according to instructions. Data analysis aimed to analyze basic descriptive parameters. The results showed that 91% of the participants had an injury that kept them off the sports field for 2 weeks or longer. Sixty-two percent of the participants had a muscle injury that required treatment for more than 2 weeks, and 75% had a joint injury. Joint injuries were more common among participants in this study than muscle injuries. The most common joint injury was ankle joint injury, and the most common muscle injury was damage to the m. suadriceps femoris in addition to adductors muscles. These results suggest that almost every professional football player experiences an injury during their career that prevents them from training normally for 2 or more weeks. Additionally, the results of this study can be used for preventive activities within the training process.

Keywords: *injury frequency, common injuries, professional football players, football injuries, soccer*

Introduction
Professional football, both in Croatia and worldwide, is the most popular sport. It holds significant importance for various societal aspects, including marketing, finances, and emotional engagement of the masses who follow the sport. Therefore, understanding the frequency and types of sports injuries is of utmost importance to enable preventive measures. When an injury occurs, it not only affects the professional footballer but also their team, sports club, and all entities involved in the competition.

A comprehensive systematic review and meta-analysis of football injuries in Europe revealed an injury frequency of 8.1 injuries per 1000 hours of exposure to training or competition (López-Valenciano et al., 2020). Research conducted on a sample of 23 professional football teams showed a higher frequency of sports injuries during competitive matches compared to training (27.5 vs. 4.1, $p < 0.0001$) (Ekstrand et al., 2011). In Croatia, there has not been a broad study examining the frequency and specific types of sports injuries among professional footballers, thus lacking adequate results to shape preventive training processes aimed at reducing the frequency of certain injuries in professional footballers. One of the larger studies conducted on a sample of 24 professional football teams followed over 11 years showed that the frequency of sports injuries among professional footballers and their consequent absence from competitive matches resulted in poorer rankings of their teams in the competition (Hägglund et al., 2013). The aim of the research was to obtain precise data on the frequency of sports injuries, types of sports injuries, recurrence of injuries, and whether all treatments for injuries are administered by qualified personnel, using a large sample that includes all professional football clubs in Croatia, as well as the Croatian national football team.

Methods
The research was conducted from 2020 until the end of 2023 in the area of the Republic of Croatia. The study was conducted on a sample of 440 participants. All participants were adult male and professional soccer players competing in professional ranks of Croatian soccer and Croatian national team players competing in the mentioned competition ranks. All participants provided their personal consent to participate in the study. The frequency of injuries and the most common injuries among professional soccer players in Croatia (this study) is part of a broader research project that included 6 sports and over 1150 participants. The participants were personally provided with questionnaires via online platform, to which they responded according to the previously provided instructions. The questionnaire consisted of 13 questions and it was developed for the purpose of this research. The questionnaire was completely anonymous, and participants were informed that the obtained results would be used for the development of research and its publication. The questions were related to the frequency, type, and location of sports injuries, the recurrence of injuries after recovery, the professional supervision and treatment of sports injuries by medical staff or individuals, the frequency of surgical procedures after sports injuries, and athletes' habits

in the context of preventive measures, i.e., exercising the area of previous injury. To specify the responses to the questions, it was possible to answer with only one response, except in two questions where there was the possibility of providing two or more responses.

Results

The study involved 440 participants. All participants were male and professional football players competing in the professional leagues of Croatian football. Additionally, Croatian national football team members competing in the aforementioned leagues were also included in the study. All participants were adults. The distribution by age is shown in Figure1.

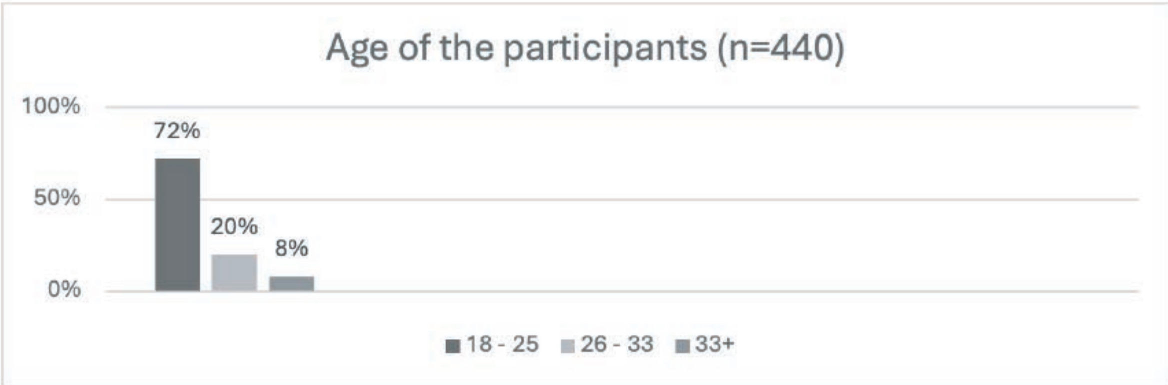

Figure 1. Age of the participants

In Table 1, results, i.e., the responses to questions related to the frequency and type of sports injuries among the participants, as well as their treatment and habits after recovery, are presented. From the obtained results, it is evident that 91% of the participants had an injury that prevented them from training and competing for two weeks or longer. The proportion of joint injuries is higher compared to muscle injuries (75% versus 62% of participants). Forty-four percent of the participants had muscle ruptures occurring without contact with another person. The percentage of participants who experienced bone fractures is 46%, while the percentage of participants who underwent surgical treatment is 32%. Participants who received treatment under the constant supervision of a medical professional constituted 74% of the total number of respondents. The percentage of participants who experienced a repeated injury within six months after complete recovery is 30%, and the percentage of participants who engage in preventive exercises for the injured segment after complete recovery is 72%.

Table 1. Frequency and type of sports injuries (n=440)

Answer	Yes	No
Have you ever had an injury that kept you out of training for 2 weeks or longer?	401 (91 %)	39 (9 %)
Have you ever had a muscle rupture (tear) that occurred without contact (strike)?	195 (44 %)	245 (56 %)
Have you ever had a muscle injury that kept you out of training for 2 weeks or longer?	273 (62 %)	167 (38 %)
Have you ever had an injury to any joint in your body that kept you out of training for 2 weeks or longer?	328 (75 %)	112 (25 %)
Have you ever had a fracture (broken bone) in any part of your body?	202 (46 %)	238 (54 %)
Have you received treatment after any of the injuries mentioned above under the control and constant supervision of a professional (physiotherapist or doctor)?	324 (74 %)	116 (26 %)
Have you ever had an athletic injury that required surgical intervention?	143 (32 %)	297 (68 %)
Have you had a reoccurrence of injury (within 6 months of healing) that previously kept you out of training for 2 weeks or more?	134 (30 %)	306 (70 %)
Do you perform preventive exercises for the part of the body that was injured before training?	316 (72 %)	124 (28 %)

In Table 2, the prevalence of joint injuries, which was experienced by 75% of the participants, was analyzed regarding their location. According to the obtained results, the most common joint injury was ankle sprain, accounting for 45% of the participants. The least represented locations of joint injuries in this study were spine, elbow, and hip joints, each comprising less than 1% of the total.

Shoulder joint injuries were slightly more prevalent, accounting for 2% of the total joint injuries, while small foot joints were represented at 3%. Wrist joint or hand small joints injuries accounted for 4% of the total. Additionally, 31% of the participants reported having injuries in two or more joints. Individually, the second most commonly injured joint was the knee joint, with a prevalence of 15% among the participants.

Table 2. Joint injuries by location (n=330)

Share of participants who answered "yes" to the question: have you ever had an injury to any joint in your body that caused you to be absent from training for 2 weeks or longer?	**N/%)**
Sspinal joints	1 (<1 %)
Shoulder joint	7 (2 %)
Elbow joint	1 (<1 %)
Wrist joint or small hand joints	13 (4 %)
Hip joint	1 (<1 %)
Knee joint	48 (15 %)
Ankle joint	147 (45 %)
Small foot joints	11 (3 %)
Two or more joint injuries (location)	101 (31 %)

In Table 3, the prevalence of muscle injuries among participants, which accounted for 62% of them, is analyzed by muscle group. The most common muscle injury in this study is the injury to the muscles of the front of the thigh and adductors, accounting for 25% of participants, followed closely by injuries to the muscles of the back of the thigh and abductors, with a share of 23%. Twenty-seven percent of participants reported having two or more muscle injuries. The third most common individual muscle injury, with a share of 9%, is the injury to the muscles of the lower leg and foot. Muscles of the front of the trunk and hip flexors (m. iliopsoas), as well as muscles of the back of the trunk and m. gluteus maximus, each had an equal share of 6%. Injuries to the muscles of the neck, shoulder, upper arm, forearm, and hand had small shares ranging from 0 to 2%.

Table 3. Muscle injuries by location (n=273)

Share of participants who responded "yes" to the question: have you ever had a muscle injury that kept you out of training for 2 weeks or longer?	**N/%)**
Neck muscles	2 (<1%)
Shoulder muscles	6 (2%)
Upper arm muscles	0 (0 %)
Forearm and hand muscles	3 (1 %)
Muscles of the front of the trunk + hip flexors	15 (6 %)
Muscles of the back of the trunk + gluteus maximus	15 (6 %)
Muscles of the front of the thigh + adductors (groin)	71 (25 %)
Muscles of the back of the thigh + abductors (outer thigh)	64 (23 %)
Muscles of the lower leg and foot	24 (9 %)
Two or more muscle injuries (location)	73 (27 %)

Discussion

The conducted research aimed to determine the most common sports injuries among professional football players in Croatia. This is one of the largest studies examining the frequency and specific types of sports injuries among professional footballers in Croatia. The obtained results in the study can greatly contribute to the development of more effective preventive activities within the training process, which could lead to a reduction in the incidence of injuries. From the results, it is easily discernible that the most common joint injuries are indeed ankle and knee injuries, with a significant percentage of respondents having suffered injuries to multiple joints in the body. Interestingly, a small percentage of respondents had hip joint injuries (less than 1% of respondents). Furthermore, it is evident that muscles responsible for movements in the hip joint in the sagittal plane (each 6%, m. iliopsoas and m. gluteus maximus) are less frequently injured compared to muscles responsible for movements in the knee joint through the same sagittal plane (48%), specifically the m. quadriceps femoris and adductors (25% incidence), and the muscles of the hamstrings group and abductors (23% incidence), while the knee joint itself was injured by 15% of respondents. From this, it can be concluded that preventive activities should focus on muscles responsible for movements in the knee joint through the sagittal plane. Furthermore, the results show a large percentage of respondents who have injured two or more joints in the body (31%), as well as two or more muscles (27%). This indicates the need for not only partial but also comprehensive preventive measures aimed at reducing the number of injuries. The high percentage of respondents who had to take a longer break due to injury (91%) is certainly concerning but it is in line with results from studies conducted at the European level (López-Valenciano et al., 2020). When comparing the type of sports injury, a difference is noticeable compared to studies conducted in Western European countries. In contrast to this study, which had a higher incidence of joint injuries compared to muscle injuries, other previously mentioned studies have obtained opposite results (Ekstrand et al., 2011). The conducted research opens up possibilities for conducting new studies based on the obtained results, which could contribute to reducing the number of sports injuries.

Conclusion

The results indicate a high number of participants who experienced a sports injury, with 91% of respondents reporting such incidents, out of which 75% suffered from joint injuries, and 62% from muscle injuries. Forty-six percent of the participants experienced bone fractures, while 30% reported a recurrence of the same injury within 6 months of completing treatment for the initial injury. It is concerning that only 74% of respondents received treatment under the supervision of a healthcare professional. It is of utmost importance to educate professional football players, as well as coaching staff, about the importance of high-quality and precise rehabilitation processes following a sports injury to prevent recurrence. Equally important is to emphasize the significance of implementing preventive activities to avoid injuries altogether. The obtained results can be utilized to develop more precise preventive training programs.

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PHYSIOLOGICAL RESPONSES TO REPEATED SPRINT TRAINING WITH HYPOVENTILATION INTERVENTION

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Abstract
Hypoventilation training is a non-traditional training method, which consists in performing intense physical activity while holding the breath. The purpose of the study was to compare the acute physiological responses during hypoventilation training in comparison with non-restricted breathing. A randomised experimental trail was used to assess differences in acute physiological responses on training load with and without application of hypoventilation. The research group consisted of 21 semi-professional soccer players. All players performed a training protocol, which consisted of 6 repetitions of 50 m sprints (departure each 45 s) in separate days, under two breathing conditions – natural breathing pattern (NB) and breath-holding after exhalation during sprint (BH). After each sprint, following physiological variables were monitored: peak heart rate (HR) and drop of blood oxygen saturation (SpO2). To assess normality of data distribution Kolmogorov-Smirnov test was used. Wilcoxon T-test was used to assess significance of differences in HR and SpO2 between NB and BH conditions. To assess effect size, coefficient r interpreted by Cohen was used. Results: Under BH condition, participants reached significantly lower SpO2 (79.67 ± 7.80 vs 94.83 ± 1.52; $p < 0.01$, $r = 0.87$) in compared to NB. BH also led to significantly higher HR (164.04 ± 10.57 vs 157.91 ± 8.48; $p < 0.01$; $r = 0.40$) in compared to NB. Hypoventilation training causing significantly lower SpO2 and higher HR in compared to NB. Hypoventilation training is effective training method for creating significant hypoxia and higher cardiac activity.

Keywords: *voluntary hypoventilation training, breathing, heart rate, blood oxygen saturation, repeated sprint ability*

Introduction
High-altitude hypoxic training or intermittent hypoxic training requires a significant amount of time and financial resources, contributing to the fact that these training methods are not readily available to a wide range of athletes (Woorons et al., 2014). Therefore, scientists continuously seek ways to simulate hypoxic conditions without traveling to high-altitude environments or employing financially demanding and less accessible procedures (such as hypoxic chambers). In the last few decades, scientists have been validating the concept of hypoventilation training (HYT), which consists of short bouts of end-expiratory breath-holding (BH) during physical activity (Woorons et al., 2020). The advantages of this non-traditional and modern method are that it is costless and applicable to all athletes whose health status allows it and who want to benefit from hypoxic intervention even at sea level without modern technology (Woorons et al., 2020). Hypoxic training is predominantly used by endurance athletes who seek hypoxic conditions for its positive effects on aerobic endurance performance (Feng et al., 2023). HYT is effective in terms of creating hypoxic conditions, but maintaining the same level and volume of hypoxia compared to classical high-altitude training is practically impossible (Imai et al., 2022; Woorons et al., 2014). Nevertheless, HYT should not be condemned outright, as it demonstrates benefits compared to conventional training without the use of respiratory interventions in both swimming and running training (Braham et al., 2024; Brocherie et al., 2023; Fornasier-Santos et al., 2018; Kapus et al., 2013; Karaula et al., 2016; Lapointe et al., 2020; Lavin et al., 2015; Stavrou et al., 2015; Trincat et al., 2017; Woorons et al., 2008, 2014, 2016, 2019). It is well established that the application of HYT can improve repeated sprint ability (Braham et al., 2024; Brocherie et al., 2023; Fornasier-Santos et al., 2018; Lapointe et al., 2020; Trincat et al., 2017; Woorons et al., 2019), however, its positive effects on aerobic endurance performance was not clearly confirmed (Holfelder et al., 2018).

Acute and long-term effects of HYT in various types of athletes and physical activities are still scientifically explored. However, it has already been proven that HYT is effective in both reducing end-tidal oxygen pressure and increasing carbon dioxide pressure in the human body (Toubekis et al., 2017; Trincat et al., 2017; Woorons et al., 2007, 2008, 2010, 2011, 2014, 2021, 2023). Increased anaerobic glycolysis, leading to higher lactate concentrations, has also been noted (Toubekis et al., 2017; Woorons et al., 2010, 2011, 2014; Zając et al., 2020) as a consequence of HYT. Increased activity of the cardiovascular system (Woorons et al., 2008, 2011), and elevated EMG activity (Kume et al., 2016) compared to non-restricted breathing were also noted.

Various breathing interventions have potential to affect sport performance (Lörinczi et al. 2023, 2024a, 2024b, yet are still overlooked in sport practice (Lörinczi 2023b). In recent years, HYT has gained attention in the realm of exercise physiology abroad, but for most conditioning coaches around the world, it remains unknown. Our goal is to contribute to the increasing awareness of this modern and non-traditional training method as well as verify the acute effects of HYT on the physiological response of semi-professional soccer players during a training protocol commonly used in sports practice.

Methods

Participants

The research group comprised 21 semi-professional male soccer players (mean age: 24.9 ± 4.0 years; mean body height: 178.7 ± 4.8 cm; mean body weight: 76.8 ± 7.8 kg). All participants were from Slovakia and resided at approximately 160 meters above sea level. They were screened for respiratory diseases, were non-smokers, and had not been exposed to altitudes exceeding 600 meters prior to or during the study. The regular training program included 4 to 5 sessions per week. Participation in the study was voluntary, and all participants provided written informed consent before commencement. The study was approved by the ethics commission of the Faculty of Physical Education and Sport, Comenius University in Bratislava (approval number: 6/2022) and adhered to the ethical principles outlined in the Declaration of Helsinki (2000).

Study design

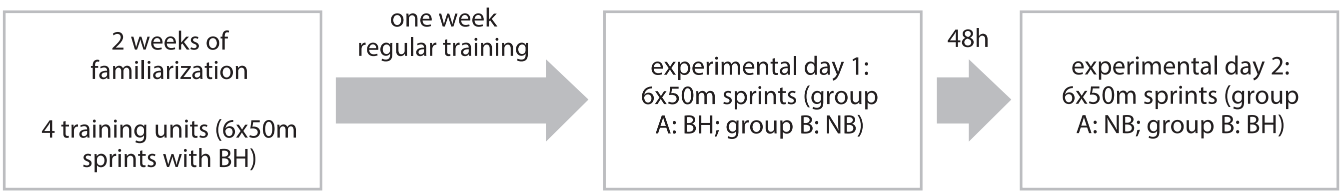

Figure 1 Study design

All participants underwent a familiarization period with the experimental protocol, consisting of 4 training sessions over 2 weeks. Prior to the experiment, a week of classical training without hypoventilation intervention was implemented. The experimental procedure was divided into two separate days with a 48-hour interval between them. Before the experimental procedure, participants refrained from training for 24 hours. The experimental training protocol commenced after a consistent 15-minute warm-up, comprising dynamic stretch exercises and running alphabet exercises. The experimental protocol consisted of one round of 6 repetitions of 50-meter sprints with submaximal intensity (defined as at least 90% of one repetition maximum, monitored by FiTRO Light Gates). Repeated sprints were initiated at 45-second intervals, with passive recovery between repetitions. For the experimental procedure, participants were randomly assigned into two groups. Each group underwent the testing protocol under two breathing conditions: non-restricted breathing pattern (natural breathing - NB) and breath-holding after exhalation during sprints (BH), on separate days. If a participant was unable to hold the breath for the entire duration of the 50-meter sprint, he was instructed to inhale and complete the sprint with breath-holding.

Measurements

Following each sprint of the testing protocol (6 x 50 m), peak heart rate (HR) and the drop of blood oxygen saturation (SpO2) were measured at 30-second intervals. HR was monitored using a chest strap heart rate monitor (Polar system), while SpO2 was measured using a Viatom pulse Oximeter PC-60FW.

Statistical Analysis

The Kolmogorov-Smirnov test was utilized to assess the normality of data distribution. Since the data did not conform to normal distribution, the Wilcoxon T-test was employed to determine the significance of differences in HR and SpO2 between NB and BH conditions after each repetition, both individually and cumulatively. The significance level was set at $p < 0.05$ and $p < 0.01$. Effect size was assessed using the coefficient r as interpreted by Cohen (1998).

Results

SpO2

Implementation of hypoventilation intervention in repeated sprint training induces significant hypoxia. Following each 50-meter sprint with BH, a substantial drop in SpO2 was observed (79.67 ± 7.80%). Conversely, after sprints with NB, SpO2 remained at low normoxic levels on average (94.83 ± 1.52%), with only rare instances of mild hypoxia recorded. The disparities in SpO2 between BH and NB conditions were statistically significant ($p < 0.01$) with a large effect size ($r = 0.87$) (refer to Table 1).

Table 1. Results of SpO2

SpO2 (%)	sprint nr.					
	1	**2**	**3**	**4**	**5**	**6**
BH (x ± SD)	79.3 ± 8.1	80.1 ± 7.6	79.9 ± 7.1	80.5 ± 7.8	78.7 ± 8.9	79.6 ± 8.0
NB (x ± SD)	94.6 ± 1.8	95.0 ± 1.3	95.0 ± 1.0	95.0 ± 1.2	94.6 ± 1.9	94.8 ± 1.8
T-test (p)	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
significance	**	**	**	**	**	**
in summary	BH < NB; 79.67 ± 7.80 vs 94.83 ± 1.52; p < 0.01; r = 0.87					

In both BH and NB conditions, a mild upward trend in HR was observed after each sprint in the series. Overall, the incorporation of BH resulted in significantly higher HR following repeated 50-meter sprints (164.04 ± 10.57 vs 157.91 ± 8.48; $p < 0.01$) (refer to Table 2). Effect size analysis indicated that the breathing condition could moderately influence HR. However, this trend was not consistently observed after each repetition, as no significant differences in HR between BH and NB were recorded after the second, fourth, and fifth sprints.

Table 2. Results of HR

HR (bpm)	sprint nr.					
	1	**2**	**3**	**4**	**5**	**6**
BH (x ± SD)	159.8 ± 10.3	162.6 ± 10.7	164.1 ± 11.5	164.0 ± 10.1	165.6 ± 9.4	168.2 ± 10.7
NB (x ± SD)	149.3 ± 7.4	156.6 ± 7.2	157.9 ± 6.7	160.9 ± 5.0	162.2 ± 8.9	160.7 ± 8.9
T-test (p)	0.005	0.089	0.038	0.219	0.373	0.048
significance	**	n.s.	*	n.s.	n.s.	*
in summary	164.04 ± 10.57 vs 157.91 ± 8.48; BH > NB; p < 0.01; r = 0.40					

Discussion

The conclusions of this experiment align with previous studies, which have consistently shown significantly lower SpO2 and higher HR as a result of hypoventilation intervention during physical exercise compared to non-restricted breathing conditions body (Toubekis et al., 2017; Trincat et al., 2017; Woorons et al., 2007, 2008, 2010, 2011, 2014, 2021, 2023). The novelty of this study lies in the application of HYT to the typical workload of semi-professional soccer players during preseason. Given the financial and time constraints associated with hypoxic training in team sports, HYT presents itself as a feasible alternative. However, it is important to note that the degree of hypoxia induced by HYT is significantly lower compared to traditional hypoxic training, potentially limiting the extent of expected adaptations.

While SpO2 was significantly lower and HR significantly higher after sprints with BH compared to NB, both physiological variables were mostly comparable between conditions at the end of the recovery periods. Despite achieving hypoxia levels akin to exercise performed at simulated altitudes around 4000 meters (Bowtell et al., 2014; Willis et al. 2017), the hypoxic effect during HYT is transient, lasting only a few seconds per repetition. Nonetheless, the potential negative consequences of this training method, both acute and long-term, remain insufficiently explored, warranting further investigation in future studies.

One limitation of this study is the use of pulse oximeters, which indirectly diagnose SpO2 in the periphery, potentially resulting in delayed and distorted values compared to real-time values in working muscles. Additionally, the conclusions drawn from this study may not be generalized to other athletes or types of physical activities that can be conducted during hypoventilation interventions. While significant hypoxia can be rapidly induced during intensive sprints, it may take longer to achieve similar hypoxic states in activities with lower intensity.

Conclusion

Hypoventilation training, employing breath-holding after exhalation during intensive physical activity, proves to be an effective method for inducing significant hypoxia and higher peak heart rates during training sessions. BH resulted in significantly lower SpO2, and higher HR compared to NB.

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IMPACT OF REPEATED COUNTERMOVEMENT JUMPS TO FAILURE ON CONTRACTILE PROPERTIES OF VASTUS MEDIALIS MUSCLE: A PILOT STUDY

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Abstract
The purpose of this study was to determine the effect of repeated countermovement jumps to failure on the contractile properties of the vastus medialis muscle. Twenty-seven students whose mean age was 19.22 years, height 176.07cm and weight 72.48kg, participated in this study. Participants completed three sets of repeated countermovement jumps to failure. Contractile properties of the vastus medialis were assessed before, after, and between the sets. The variables analyzed in this study included muscle contraction time, delayed muscle contraction time, muscle relaxation time, duration of contraction, and maximal vertical muscle displacement. The results indicate that repeated countermovement jumps to failure led to a decrease in contraction time ($p=0.02$) and an increase in delay contraction time ($p=0.00$) in the right vastus medialis as the sessions progressed. Meanwhile, maximal vertical muscle displacement showed significantly lower values ($p=0.00$) as the sessions progressed in the left vastus medialis. Our findings reveal that repeated countermovement jumps to failure affect the contractile properties of the vastus medialis muscle differently in the left and right leg, suggesting a need for further research on sport-specific fatiguing protocols across various muscles.

Keywords: *Fatigue, Tensiomyography, Vertical jump*

Introduction
Fatigue, a complex phenomenon influenced by numerous factors (Fitts, 2006; Smajla et al., 2024), is defined as a decline in muscular performance leading to reductions in strength and power generation (Ditroilo et al., 2011), which can impact athletic performance and increase the risk of injury (Ditroilo et al., 2011; Liederbach et al., 2014). Therefore, it is essential to study fatigue in different activities that closely resemble competitive scenarios (García-Manson et al., 2012; Hunter et al., 2003). Due to the complexity of fatigue, there has been a need to measure fatigue in various ways to determine how different activities affect different physiological mechanisms. Tensiomyography has emerged as a method that allows the measurement of peripheral and central fatigue without additional voluntary efforts (García-Manson et al., 2011). Numerous studies have examined different fatiguing protocols using tensiomyography (Buoite Stella et al., 2023; Cuba-Dorado et al., 2023; Šimunič et al., 2023; Weakley et al., 2024; Willberg et al., 2022), but to our knowledge, no studies have examined the fatiguing protocol involving repeated countermovement jumps, activity frequently present in various physical activities. Therefore, the purpose of this study was to determine the effect of repeated countermovement jumps to failure on the contractile properties of the vastus medialis muscle. We hypothesized that there would be significant changes in the contractile properties of the vastus medialis muscle following the implementation of repeated countermovement jumps to failure and that these changes would increase as the series progressed.

Methods
Subjects
The pilot study sample comprised 27 students (age:19.22±1.01 years, height:176.07±8.66cm, weight: 72.48±11.27kg). The inclusion criteria were the absence of any musculoskeletal injuries. Inclusion criteria required participants to have no musculoskeletal injuries. Participants were informed of their right to withdraw from the study at any time and were required to provide written consent before participation. The study protocol received approval from the Ethics Committee of the Faculty of Kinesiology at the University of Osijek (Classification mark:029-01/24-01/05 and register number: 2158-110-01-24-13) and adhered to the principles outlined in the current Declaration of Helsinki.

Tensiomyography
The neuromechanical contractile properties of the left and right vastus medialis were assessed using the tensiomyography method (TMG-BMC, Ljubljana, Slovenia). Šimunič (2012) demonstrated that tensiomyography is a valid and reliable method for evaluating neuromechanical contractile muscle properties. To ensure maximal reliability and validity of the measurements, we adhered to the manufacturer's recommendations. Neuromechanical contractile properties were assessed with the sensor (GK40, Panoptik, Ljubljana, Slovenia) that detects changes and collect data after the application of an electrical pulse through two self-adhesive electrodes placed proximal and distal of the sensor. The variables analyzed in

this study included muscle contraction time (Tc), delayed muscle contraction time (Td), muscle relaxation time (Tr), duration of contraction (Ts), and maximal vertical muscle displacement (Dm). Tc and Dm have been identified as the most reliable variables for assessing muscle fatigue (Martín-Rodríguez et al., 2017), thus, we primarily focused on these parameters in our study.

Fatiguing protocol
Repeated countermovement jumps to failure were used to induce fatigue. Participants were instructed to perform the maximal number of countermovement jumps upon the signal from the measurer and to continue until they could no longer perform any more jumps. This protocol was repeated two more times.

Experimental procedure
Potential participants in this study were given a brief presentation outlining the objectives and potential risks associated with participation. All interested individuals who met the necessary criteria proceeded to the study. Each participant was assessed using a TMG device to determine their initial condition, followed by a 5-minute self-directed warm-up. Subsequently, they performed the first series of repeated countermovement jumps to failure, continuing until the participant was unable to execute any further countermovement jumps. Following the initial series, testing of the contractile properties of the left and right vastus medialis muscles was conducted. This procedure was repeated two more times, and after the final TMG measurement, the testing concluded.

Statistical analysis
For this study, we employed the Tibco Statistica Enterprise software (version 13.4.0.14) for data analysis. Shapiro-Wilk W test was utilized to assess the normality of the data distribution. Mean (M) and standard deviation (SD) were used as descriptive statistics for all participants. To assess differences between sessions, repeated measures analysis of variance (ANOVA) was utilized for normally distributed variables, while the Friedman test was applied for non-normally distributed variables. In the event of significant differences, a Bonferroni post hoc test was conducted for normally distributed variables, and the Wilcoxon signed-rank test was employed for non-normally distributed variables. Alpha was set at $p<0.05$.

Results
Descriptive parameters for all participants, along with statistically significant differences between testing sessions, are presented in Table 1. Significant differences were observed in VM_Td ($p=0.00$) and VM_Tc ($p=0.02$) of the right leg, whereas in the left leg, significant differences were observed only in VM_Dm ($p=0.00$). The right vastus medialis muscle exhibited a delayed contraction time as sessions progressed, whereas the contraction time decreased. Conversely, in the left leg, maximal vertical muscle displacement showed significantly lower values as sessions progressed.

Table 1. Descriptive parameters and differences between initial and final Vertical jumps

Variable	Right				p	Left				p
	1. session	2. session	3. session	4. session		1. session	2. session	3. session	4. session	
	M (SD)	M (SD)	M (SD)	M (SD)		M (SD)	M (SD)	M (SD)	M (SD)	
TMG_VM_Td	22,95‡†Ţ (1,93)	23,80 Ґ†Ţ (2,09)	24,12 Ґ‡ (2,20)	24,76 Ґ‡ (3,06)	0.00#	22,55 (2,04)	22,28 (1,72)	22,75 (2,54)	22,18 (1,98)	0.87#
TMG_VM_Tc	23,32 Ґ†Ţ (2,99)	22,77 Ґ (2,39)	22,26 Ґ (2,17)	22,33 Ґ (2,28)	0,02#	24,21 (3,06)	25,28 (2,32)	24,42 (3,14)	24,61 (3,12)	0,09#
TMG_VM_Ts	170,50 (29,98)	172,29 (25,42)	175,72 (28,45)	165,05 (22,62)	0,31#	167,61 (31,62)	158,87 (24,78)	165,54 (30,63)	158,03 (25,29)	0,14#
TMG_VM_Tr	47,63 (31,17)	64,84 (48,31)	68,68 (52,94)	66,37 (48,17)	0,52#	41,95 (23,04)	43,13 (24,68)	51,49 (40,49)	60,47 (49,15)	0,09#
TMG_VM_Dm	6,71 (1,30)	6,82 (1,65)	6,63 (1,73)	6,29 (1,68)	0.16	7,25†Ţ (1,44)	6,64 (1,60)	6,28 Ґ (1,82)	6,01 Ґ (1,82)	0,00
TMG_VM_Am	63,66 (10,40)	67,70 (11,26)	63,82 (12,07)	65,32 (9,66)	0.47	61,78 (8,31)	60,94 (14,46)	57,28 (14,14)	60,77 (10,79)	0,26#

Legend: # - Friedman ANOVA; Ґ - significant difference with first set; ‡ - significant difference with second set; † - significant difference with third set; Ţ - significant difference with forth set; M – indicating mean value; SD – indicating standard deviation; p – p value from repeated measurement ANOVA

Discussion

There are several important findings from the results of this study. First, we found that repeated countermovement jumps to failure affect the contractile properties of the vastus medialis muscle. Second, significant differences were observed in different parameters for the left and right vastus medialis muscles, possibly due to differing loading on each leg during the performance of repeated countermovement jumps to failure.

These results align with previous studies by BuoiteStella et al. (2023), Cuba-Dorado et al. (2023), Weakley et al. (2024), and Willberg et al. (2022), which similarly demonstrated the impact of sport-specific fatiguing protocols on muscle contractile properties. Understanding the effects of sport-specific fatiguing protocols on diverse muscles and populations is crucial, as fatigue is a multifaceted phenomenon governed by various physiological mechanisms across different activities. Insights derived from such research are invaluable to both scientific inquiry and practical application, informing the development of targeted recovery strategies and reducing injury risk.

In the present study, our investigation focused on the vastus medialis muscle, a muscle frequently studied due to its essential role in various activities (Kakavas et al., 2024; Paravlic et al., 2022). Consistent with our findings, Paravlic et al. (2022) reported significant inter-limb differences in female soccer players concerning the vastus medialis muscle, particularly in delayed muscle contraction time and contraction time, suggesting that different activities can lead to varying contraction properties in the vastus medialis muscle. Their results indicate that differences emerge following long-term engagement in specific activities, while our research suggests that distinct changes are also present acutely.

In addition to the influence of various activities on inter-limb differences in the contractile properties of the vastus medialis, different injuries can also result in significant changes in these properties. Kakavas et al. (2024) observed that female collegiate footballers who had suffered concussions exhibited significantly lower maximal vertical muscle displacement and increased contraction time compared to a healthy cohort, indicating that concussions can affect neuromuscular control manifesting in alterations of the vastus medialis muscle.

However, despite these strengths, certain limitations must also be acknowledged. In this study, we did not separate subjects by gender, physical status, or abilities. It is possible that different outcomes could be observed within these groupings. Additionally, our focus was solely on the vastus medialis muscle; thus, these findings may not be generalizable to other muscles. Future research is needed to gain a deeper understanding of the various physiological mechanisms of fatigue and how different recovery methods may influence changes in the contractile properties of various muscles.

Conclusion

We found that repeated countermovement jumps to failure influence the contractile properties of the vastus medialis muscle. Those effects were found in both the left and the right leg but in different parameters. Future studies are needed to further investigate the impact of various sport-specific fatiguing protocols on the contractile properties of different muscles.

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EFFECTS OF NORDIC WALKING IN WATER ON MUSCLE ACTIVATION

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Abstract
The Water Nordic Walking (Water NW) was established in Japan, it was performed Nordic Walking (NW) in water pool. The aim of this study was to evaluate the physiological effects of Water NW compared to ground NW. 12 healthy volunteers performed 20-minute treadmill trials of Walking (W), NW, and Water NW. Seven electromyogram (EMG) activities were recorded using bipolar surface methods in the biceps brachii, triceps brachii, deltoideus, tibialis anterior, medial gastrocnemius, rectus femoris and biceps femoris muscles. Oxygen uptake (VO2) was recorded on each trial. Water NW significantly decreased oxygen uptake compared to W and NW ($p<0.05$). Water NW significantly decreased lower limb muscle activity compared to the other two ground conditions due to body weight relief, buoyancy ($p<0.05$). Our results were showed that NW in water for 20 minutes resulted in decreased VO2 and lower limb muscle activity. Based on these results, it could be considered that it was an effective movement as an exercise program for the elderly who could walk by upper limb muscle activities without requiring lower limb muscle activities as much as on ground, thus reducing the burden on cardiopulmonary function.

Keywords: *Nordic Walking, Water Nordic Walking, Electromyography activity, oxygen uptake*

Introduction
Physical inactivity has been a major factor in the development of human disease. In modern society, opportunities for physical activity in daily life have been reduced. Walking (W), was considered to be a simple and safe form of exercise and easy to implement even for beginners in endurance sports (Lee & Buchner, 2008). It has been observed that growth hormone (GH) and lactic acid levels increase after about 20 minutes of aerobic exercise (Vanhelder et al., 1984). This was a possible form of exercise for the elderly, obese and those with lower limb joint disabilities.

Walking with poles, called Nordic Walking (NW), has been an established aerobic sport for 30 years (Church TS & Earnest CP, 2002). Several scientific papers demonstrated health-related effects of NW (Tschentscher et al., 2013). NW has been shown to induce higher work intensities as well as significantly increased upper muscular activities (Figard-Fabre et al., 2010). Therefore, NW has not only been used for the rehabilitation of athletes. It was found that the increased energy expenditure during NW compared to W was due to increased muscle activation during the forward swing of the poles. Oxygen uptake (VO2) for W has been related to hand bearing loads (Soule & Goldman, 1969).

An aquatic environment was a different exercise environment to land and had clinical benefits for patients with motor dysfunction due to the known physical characteristics of water (Becker, 2009). It has been suggested that aquatic exercise, like land-based exercise, appears to be effective in promoting health, while having characteristics that allow people to perform exercises that cannot be performed on land (Silva et al, 2008). It was important to measure physiological indicators of muscle activity and cardiopulmonary response when evaluating aquatic exercise (Katsura et al, 2010). Water Nordic Walking (Water NW, Figure 1) was performed in water. It was a new exercise that combined the characteristics of the water environment with the effect of NW. It was performed in Japan as rehabilitation for patients with lower limb arthroplasty. However, there were many not clear points at the point of view of the kinesiology about underwater NW. It was not revealed whether there was what kind of difference in Water NW than ground normal walk, NW.

Figure 1. Practical example of Water NW for hip osteoarthritis

It was not clear what the exercise load and muscle activity were during this time. The purpose of this study was to evaluate and investigate water NW compared to ground NW.

Methods

Subjects

12 physically active and healthy male and female volunteered to take part in the present study (male: age 23.00 ± 1.00 years, weight 70.00 ± 8.63 kg, height 1.74 ± 0.05 m, female: age 20.78 ± 0.92 years, weight 51.44 ± 5.83 kg, height 1.59 ± 0.05 m). They had no movement disorders.

They were giving written informed consent and participated in this study, which was approved by the Ethics Committee at the Jissen Women's University (2018-15).

Experimental procedure and protocols

The walking speed was assumed to be the comfortable speed of each subject in all conditions. Subjects walked at 4.72 ± 0.50 km/h on the land treadmill (W, NW) and 0.92 ± 0.23 km/h on the underwater treadmill (Water NW). They walked continuously at the same speed along the same route, and all participants completed three 20-minute trials. W and NW were performed on a treadmill at a speed comfortable for each subject. The water NW was performed in water at a temperature of 27-29°C at a depth of about 1.2 m. They walked around the 25 m pool for 20 minutes. Experimental settings were following conditions:

W: Normal Walk, Walking without poles

NW: Nordic Walking with normal poles (API-202A, 240g/pole, Kizaki Co. Ltd, Japan)

Water NW: Water Nordic Walking with pole (APAF-AQ101, 720g/pole, Kizaki Co. Ltd, Japan)

Measurements and analysis

Surface electromyography (EMG) was recorded using the DataLOG model of the P3X8 system (Biometrics, Gwent, UK). EMG activity was recorded from 7 sites: deltoid, triceps brachii, biceps brachii, rectus femoris, biceps femoris, tibialis anterior and medial gastrocnemius on the right side of the body. After skin preparation, pairs of conventional surface electrodes (SX230 preamplifier) were placed along the muscle fibres. The distance between the electrodes was 3 cm. For EMG recordings in water, the electrodes were securely covered with water-resistant adhesive microfilms (model Tegaderm, 3M; St. Paul, MN, USA). EMG signals were sampled at 1 kHz. Integrated EMG (iEMG) was the best method to measure total muscle effort. All experimental data were calculated from the absolute values of the EMG time series. The iEMG was obtained by calculating the sum of the absolute value of the EMG signal. iEMG normalised the subject's "W" as 1. A gas analyser (VO2000, Med-Graphics; Ann Arbor, USA), previously calibrated according to the manufacturer's specific cations, was used to evaluate the ventilatory data collected during the experimental protocol. The sampling rate used to collect values was 10 s (Aerograph software). The data obtained in each experiment were calculated as the average value during 3 min between 12 min and 15 min, when a plateau state was reached.

Statistical analysis

Data for each dependent variable (iEMG, VO2) were expressed as mean ± SD. Repeated measures ANOVA was used to determine the significance of the comparison between W, NW and Water NW. Statistical analysis was performed using SAS University Edition (SAS Institute, USA). Where significant differences were identified using ANOVA, post-hoc comparisons using paired t-tests with Bonferroni adjustment were used to identify the specific effects of pole conditions. The significance level was set at P < 0.05 for all analyses.

Results

Electromyography

It was showed the Figure 2 that there was a significant difference in the iEMG of the lower limb muscles (P < 0.05). The significant effect of environment on iEMG values for all lower limb muscles. It was significantly lower values of water NW compared to W and NW. Mean iEMG values at BB, which was one of the upper limb muscles, for W, NW and Water NW were 1, 4.4 ± 1.0 and 1.8 ± 1.6, respectively. This analysis showed that the upper limb muscle activation of Water NW was significantly increased (P < 0.05) compared to W (Figure 3).

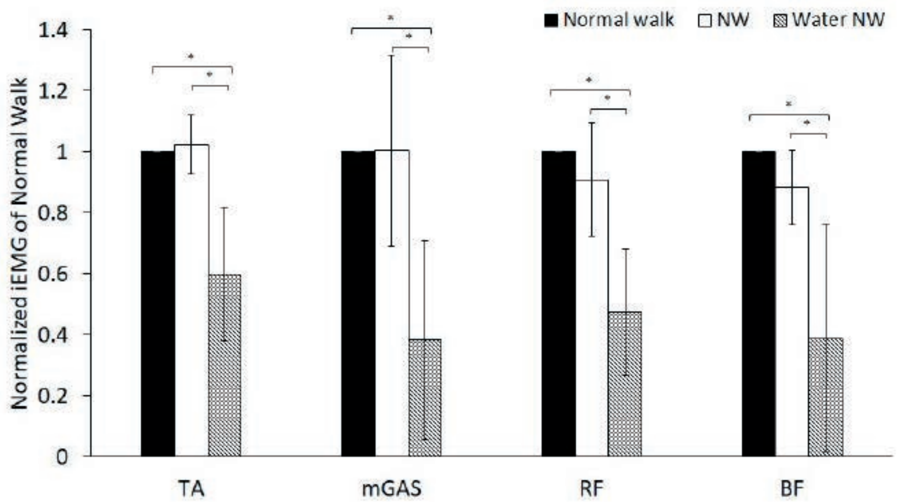

Figure 2. Normalized iEMG of lower limbs muscles by each participant's (*p<0.05)

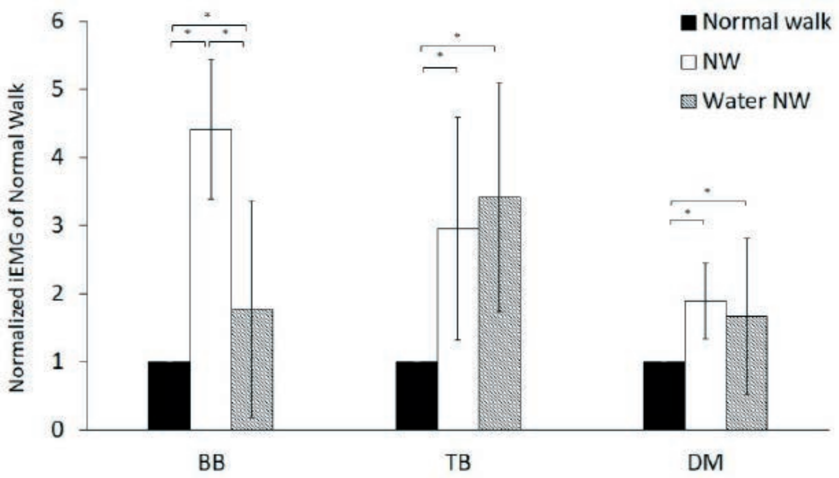

Figure 3. Normalized iEMG of upper limbs muscles by each participant's (*p<0.05)

Oxygen uptake

The mean VO2 values for W, NW and water NW were 13.3 ± 2.8, 18.0 ± 5.4 and 7.4 ± 1.2 ml/min/kg, respectively. A significantly lower value for VO2 (Figure 4) was measured for water NW compared to W and NW (P < 0.05). VO2 (Figure 4) was higher for NW compared to W.

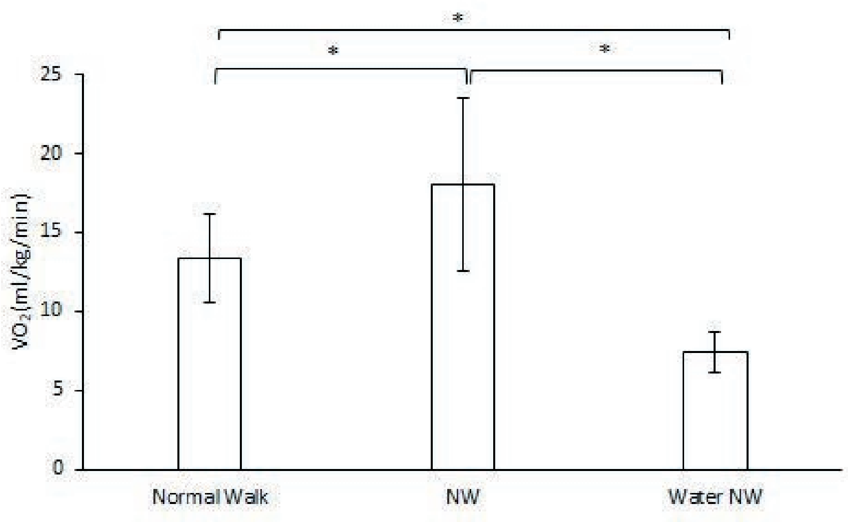

Figure 4. Compared with VO2(ml/kg/min) by each participant's (*p<0.05)

Discussion
The current study provided the physiological response of Water NW such as muscle activities, cardiopulmonary response, walking stability. The results of this study showed that oxygen uptake and lower limb muscle activity decreased in Water NW compared to W and NW. Muscle activity in the upper limbs was found to be higher than on ground.

The data obtained in the present study indicate that iEMG was lower in water NW than in NW. Different EMG activation patterns were observed during walking in water compared to walking on ground for most of the lower limb muscles (Barela et al., 2006). In our study, the EMG activation patterns of the lower limb muscles showed a phasic pattern during walking on ground, and instead a tonic pattern of EMG activations was observed in the water NW. Those were different that ground, underwater walking speeds in the precedent study. The result of iEMG of this lower limbs showed the tendency like the precedent study (Barela et al., 2006) .This was not the tendency in the activity of the upper limb muscles, but activities like NW were seen in the water NW (Figure 2, 3). Recently, it has been known that the underwater treadmill was used as a gait training tool for gait disorders. However, it was difficult for most facilities to have the resources for treadmill training in water. Water NW could make it easier to maintain balance compared to water walking without pole, maintained the standing posture, and created limb muscle movement as a rhythmic exercise. It reduced the bias and spasticity of muscle tone caused by the ground of gravity, resulting in fewer dyskinesias. As a young subjects result, Water NW was recommended for osteoarthritis patients who found it difficult to walk or exercise on ground.

Conclusion
In conclusion, we have shown that Water NW has good benefits for cardiopulmonary function. The most likely candidate for this effect was an increase in upper limb muscles. We suggested that this new walking training has many benefits for gait disorders.

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EFFECTIVENESS OF DIFFERENT MANUAL TECHNIQUES ON THE TIGHTNESS OF THE ILIOTIBIAL BAND IN ATHLETES

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Abstract
In the case of sports injuries, manual therapy is increasingly entering the standard rehabilitation procedure and the first step in pain relief. Limited flexibility in the human population increasingly affects the pelvis and lower extremities. The aim of this research was to determine whether there are differences in flexibility in the ITB after the EMMETT and ART technique. For the purposes of the study, it was necessary to measure the range of motion of the ITB using the Ober test of the dominant leg. By applying the EMMETT and ART techniques with movements on certain parts of the body, therapy was performed, after which the range of movements was re-measured with a modified Ober test. 65 physically active young football athletes participated in the research itself. Therefore, the presented results indicate that EMMETT and ART has an acute effect in the increase of flexibility in the ITB which indicates that in the future we should look at proving how EMMETT and ART or other manual techniques have a long-term effect on soft tissue and how different manual techniques can contribute to faster rehabilitation and as a prevention of overuse syndromes and possible pelvic and lower extremities injuries.
Keywords: Emmett technique, ART technique, range of motion, rehabilitation

Introduction
In the world of kinesiology, especially kinesitherapy, the presence of manual therapy is increasingly popular. Manual therapy (MT) is defined as "a broad group of passive interventions in which manual therapists use the hands to apply skilled movements designed to modulate pain, increase joint range of motion, reduce or eliminate soft tissue swelling, inflammation or restriction, relaxation, improve contractile and -contractile tissue extensibility and lung function improvement" (Sheldon, 2022). Some of the manual techniques that are often used recently to increase the range of motion (ROM), relax the muscles and increase their flexibility are the EMMETT technique and the Active Release Technique (ART). The EMMETT technique is a newer manual technique that was first used in Australia and in the last few years has also been used in Europe. The founder of this technique is called Ross Emmett, who described it as a corrective technique that acts on the junction of sensory and muscle receptors. Those spots he called EMMETT points. It is a method where, by applying light pressure on a person's body, muscle relaxation, flexibility and ROM are improved. Light pressure is applied 3 times in the same place for 5-20 seconds, where the purpose of the first pressure is to check/assess the tissue itself, the second is its correction, and the third serves as a confirmation to make a change on the body. The result is often an immediate physical change where new movement patterns are created on the spot, without pain and with better balance (Emmett, 2012). Active Release Technique (ART) is a soft tissue manipulation therapy used to treat various musculoskeletal conditions and injuries by Leahy (2021), in the late 1980s. The primary goal of ART is to diagnose and treat soft tissue problems that may result from overuse, trauma, or repetitive stress. ART practitioners use the hands to assess the texture, tension and movement of these tissues to identify abnormalities and areas of dysfunction (Leahy, 2021). The goal of treatment is to break adhesions, release trapped nerves, improve blood flow and restore normal tissue function. The ITB is the longest thick tendon which, proximally in the hip area, is formed by the gluteus maximus, gluteus medius and TFL, where they attach to the lateral side of the tibia with a common tendon (Evans, 1979). Due to its anatomical structure, it is mostly tight and limited flexibility in the pelvis and lower extremities. With all the above, it is one of the most common injuries among runners, including football players. This research aimed to determine if there is any significant increasing in flexibility of the ITB after applying two different manual techniques in comparison to the control group.

Methods
The sample was conducted of 65 asymptomatic young athletes from the football (17,21±1,99 years old), randomly divided into three groups. Control group (n=22), experimental group on which was applied EMMETT technique (n=21) and second experimental group (n=22) on which was applied ART manual protocol. Three measurement of the range of motion (ROM) were measured on dominant leg before and after applying manual therapy techniques in both experimental groups, while in the control group measurements are performed before and after resting for one minute in side lying position. The ROM of the right and left leg was measured with the EasyAngle® goniometer through the Ober test position. The Ober test is used to assess the tension of the ITB. (Figure 1).

Figure 1. Testing position for ITB flexibility (OBER test) with EasyAngle® goniometer

The goniometer used for measurement was a digital goniometer EasyAngle® (Meloqe devices) that allows therapists to measure any joint in any direction. Measurements are accurate to within 1 degree and require only one hand to use, leaving the therapist a free hand to support the patient. Intrarater and interrater reliability for this digital goniometer is good to excellent for all hip ROM measurements (0.81-0.97 intrarater; 0.77- 0.91 interrater) (Duffy et al., 2024). After applying initial measurement of ITB flexibility through the Ober test position and with the EasyAngle®, for both experimental group subjects was performed manual therapy protocol, while subjects from control group stay in the side laying position for one minute long. After those protocols the second measurement of ITB flexibility was measured. All measurements were done by the same evaluator and it is measured three times for calculation of reliability of the measurement protocol. The ART protocol contains four gradual steps in order to obtain the most accurate result. The subjects remained in the same lying position as during the measurement with the goniometer. The first step is precise palpation of the ITB, from which the tension of the tensor muscle is read fascia latae and ITB tendons. The second step is to place one palm on the proximal part of the upper leg anteriorly, while the other palm performs palpation on the TFL muscle and at the same time performs a movement distally , automatically holding the lower leg with the palm, moving the hip and knee into extension and slight adduction (Figure 2).

Figure 2. Applying ART manual technique

The EMMETT protocol contains the application of 2 corrections (ITB and ITB/Sartorius). Both corrections were performed with the subjects lying on their backs in a relaxed position, and the technique was applied on the dominant leg. ITB correction is applied by finding the proximal and distal part of the ITB and applying light pressure to the tissue perpendicular to the body with the middle finger. ITB/Sartorius correction is applied by finding the middle of the ITB and Sartorius muscles and applying light pressure to the tissue perpendicular to the body with the middle finger. The pressure for both corrections is held for 5-15 seconds, or until the "first jump" is felt. The application of each correction lasted 1.5 minutes per person. It is important to note that both corrections were applied 3 times in the same place, and the pause between each repetition was 5 - 10 seconds. After the last repetition, the subjects would lock the movement through the activities by making certain movements with the treated muscle group (bend and extend the leg from the hip and knee, sit down and stand up, walking around the room).

Data analysis performed with IBM SPSS Statistics software version 23.0 for Windows. Distribution fitting was tested with Kolmogorov-Sminrov test of normality where for all variables (every measurement, mean of three measurements, differences between post-treatment and post-treatment variable) is determinate a normal distribution fitting. The descriptive statistics were computed for all variables and expressed as an arithmetic mean and standard deviation (SD).

Figure 3. Applying EMMETT manual technique

Differences between measurement of pre-treatment and post-treatment were tested by one-way ANOVA for repeated measures with Bonferroni post-hoc test to determinate and the significant difference between control and two experimental groups. Itraclass correlation coefficient (ICC (3,1)) was calculated for all cases for three pre-treatment measurements, as well as for three post-treatment measurements.

Results

Reliability of all three measurements with same evaluator was calculated with ICC (3,1). Used digital goniometer (EasyAngle®) established excellent reliability (range: 0,913 to 9,381) the values were interpreted according to the classification of Koo and Li (2016).

Table 1. Descriptive statistics with number of cases in each group (n), arithmetic mean (Mean) and Standard deviation (SD)

Variables	n_E	$Mean_E$	SD_E	n_K	$Mean_K$	SD_K	n_A	$Mean_A$	SD_A
ITB_PRE-TREATMENT	21	28,43	2,49	22	30,36	5,32	22	31,41	3,92
ITB_POST-TREATMENT	21	31,89	2,34	22	30,45	5,10	22	35,36	3,80
DIFFERENCES PRE-POST	21	3,46	1,33	22	0,09	1,91	22	3,96	1,94

Descriptive statistics of measured ITB flexibility variables are presented in Table 1. In pre-treatment ROM measurement in all three groups means where in range of 28,42 degrees to the 31,41 degrees, while in post-treatment means where in rang of 30,45 degrees to the 25,36 degrees. In experimental groups we can notice that pre and post ROM measurements are increase for in average of 3,46 degrees for EMMETT technique to 3,96 degrees for ART technique group, while in control group we can notice very small changes of 0,09 increase of ROM of ITB flexibility. The results form repeated measurements ANOVA are presented in Table 2. According to the univariate results for each variable we can notice that in pre-treatment variable there is a not significant difference between all three groups (p=0,0621), and there is a significant difference in post-treatment measurement as well as in variable of obtained differences between pre and post-treatment ROM of ITB flexibility (p=0,0004, p=0,0000). Multivariate results according to the WIlks'λ test in repeated measurement ANOVA indicate that control and experimental groups are significant different (p=0,000).

Table 2. Repeated measurements ANOVA; univariate results and multivariate results between control and experimental groups in three variables

Variables	F	p	Wilks'λ	0,369
ITB_PRE-TREATMENT	2,912	0,0621	F	19,708
ITB_POST-TREATMENT	9,053	0,0004	df1,df2	4,122
DIFFERENCES PRE-POST	41,871	0,0000	p	0,000

As we find a statistically significant result we need to determine where our differences truly came from. Bonferroni's post hoc test was performed to determine significant differences between groups. As we conclude in Table 2., there is a not significant difference in pre-treatment ROM of ITB. In post-treatment ROM of ITB flexibility results we can see the significant difference in amount of ROM's after applying both manual techniques. This significant difference is not important because it is dependent on starting ROM in pre-treatment measurement. How we can test our main goal in this research most important are results from the variable of obtained differences from pre to post-treatment ROM measurements. In that variable, we got a significant difference between the control groups and experimental groups (EMMETT p=0,000; ART p=0,000) and we didn't get a significant difference between the two experimental groups (p=0,872).

Discussion

The area of the ITB has always been an interesting field of research when it comes to tissue tension. Also, many studies have investigated the influence of various manual techniques and stretching techniques on the flexibility of soft tissues. In this research, a significant influence of two manual techniques on the flexibility of ITB was obtained. Today, many forms of manual techniques that include a soft tissue manipulation exist; ART, Bowen therapy, Emmett technique, deep tissue massage, neuromuscular techniques (NMT), Muscle Energy Techniques (MET), very easy to do foam rolling and many others. The results from the previous researches confirm that the manipulation of soft tissues has a significant impact on their flexibility (George et al., 2006; Ercole et al., 2010). But also in the research of Sharp et al.'s (2013) was found that the EMMETT technique was more effective than foam rolling in reducing ITB tension and increasing hip ROM which leads us to the conclusion that manual techniques have more impact on soft tissue relaxation according to the well used foam rolling technique.

Conclusion

The research confirmed that after EMMETT and ART treatment, an acute effect was obtained in the flexibility of the ITB. In the future, it is very important to start using manual techniques in sports that have effects on the flexibility of the ITB and not only on them, but also on other soft tissues that are subject to changes. Different manual techniques can contribute to faster rehabilitation and as a prevention of overuse syndromes and possible pelvic and lower extremities injuries. As with any manual therapy, including EMMETT and ART, its long-term effect should be determined in a larger sample, following the effect of a single treatment over a period of 7-15 days to see the real effect. Also the inclusion of symptomatic populations in the future researches would give more information's about effectiveness of different manual techniques in rehabilitation process of athletes.

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WOMEN IN SPORTS: LONG-TERM BIOLOGICAL VARIATION OF HEMATOLOGICAL AND COAGULATION PARAMETERS

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Introduction

Biological variation (BV), the underlying science of the athlete biological passport (APB), had been previously studied, but predominantly in male athletes. As a high level of physical exercise most probably influences BV (1), and because the menstrual cycle influences acute physical exertion, the studies performed on male athletes cannot be transferred to females. Therefore, the study aimed to define the long-term BV in hematological and coagulation parameters in female athletes.

Methods

Blood samples from 29 female athletes (handball N=22, waterpolo N=5), median age 21 years (range 18 – 31), were drawn between 8 and 10 am monthly for four months, and were analyzed using Siemens Advia 2120i hematological and Siemens BCS XP coagulation analyzer (Siemens; Marburg, Germany). All samples were collected after an overnight fast and before any light or intense physical activity. The obtained data were assessed for normality and log-transformed if necessary. According to an open-source R script published by Winden et al. (2), BV estimates were calculated (within-subject (CVi) and between-subjects (CVg)) and compared with the general population provided in the EFLM database (3).

Results

Out of 16 measured hematological parameters, 5 differed in CVi and CVg from the general population, mostly in leukocyte differential count (lymphocytes, monocytes, eosinophils, and basophils). However, a significant number of parameters showed changed CVi values in comparison to the EFLM database (leukocytes, erythrocytes, and erythrocyte indices (MCV, MCH, MCHC, RDW) and MPV). The standard coagulation tests showed intraindividual variability, while APTT and fibrinogen also differed in athletes compared to the general population. Interestingly, most athlete CVis were higher than the CVis derived from the general population (except monocytes). However, athletes' CVg was lower than the general population's CVg, thus emphasizing the homogeneous nature of the studied group.

Conclusions

As the reference change value (RCV), defined as a clinically significant change in longitudinal observance of laboratory results is calculated from CVi, a special care must be taken in case a female athlete would be in need for specialized medical care. The significant changes in laboratory results could be overseen due to their changed metabolism and different within-subject biological variation estimates.

Keywords: *biological variation, athletes, hematology, coagulation*

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THE LINEARITY CHANGES IN ERECTOR SPINAE MUSCLE OXYGEN SATURATION HAVE HIGHER AGREEMENT WITH SYSTEMIC THRESHOLDS THAN BREAKPOINTS IN VASTUS LATERALIS DURING INCREMENTAL CYCLING EXERCISE

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Abstract
The purpose of this study was to analyse the agreement between ventilator thresholds and local muscle oxygen saturation (SmO2) breakpoints of the Vastus Lateralis and Erector Spinae muscles. 13 male U19 competitive cyclists (19.5±6.3 y.; 1.81±0.08 m; 73.1±7.7 kg; 61.4±6.5 mL/min/kg) performed incremental cycling exercise (3 min steps and 30W increment). First (VT1) and second (VT2) Ventilatory Thresholds were evaluated through the pulmonary gas exchange, and changes in the linearity of the Vastus Lateralis (VL) and Erector Spinae (ES) muscles SmO2 signals were determined as first (BP1) and second breakpoints (BP2). The agreement between relative power (Pkg) values at VT1 and BP1, and VT2 and BP2 was evaluated by repeated measures ANOVA, Bland-Altman (Limits of Agreement – LOA) and correlation analyses. There were no statistical differences ($p>0.05$) between methods at the first threshold, but ES BP1 demonstrated narrower LOA (-0.42 to 0.43 W/kg) and higher correlations ($r=0.87$) with VT1 than VL BP1 (LOA: -0.43 to 0.70; $r=0.77$). At the second threshold, the Pkg at ES BP2 was higher ($p<0.05$) than that at VL BP2 and VT2. LOA was narrower (-0.61 to 0.11) and correlation stronger ($r=0.91$) between Pkg at ES BP2 and VT2, compared to agreement between VT2 and VL BP2 (LOA: -0.5 to 0.81; $r=0.77$) Conclusion: during incremental cycling exercise the SmO2 BP-s of ES had higher agreement with systemic thresholds than BP-s in VL muscles, but occurrence of ES BP2 tended to be delayed compared to VT2.

Keywords: *NIRS, SmO2, Breakpoints, Ventilatory threshold*

Introduction
Road cyclists' competition and training process sets excellent demands on athletes' aerobic abilities, and exercising at a metabolically optimal intensity, separated by two thresholds, is crucial for improving different physiological systems behind high aerobic performance (Seiler, 2010). The changes in dynamics of systemic reactions, mainly in pulmonary gas or blood lactate measures, have been Gold Standard assessing methods for the first (Aerobic) and second (Anaerobic) thresholds, separating different training intensities (Pooly et al., 2021; Seiler, 2010). The technological evolution and need for real-time monitoring of exercise intensity has increased the development and usage of different wearable sensors, where non-invasive measurement of muscle oxygen saturation (SmO2) in the working muscle by portable near-infrared spectroscopy (NIRS) is one of the promising methods (Perrey & Ferrari, 2018; Perrey, 2022). Similarly to systemic reactions, the muscle SmO2 signal from working muscles has demonstrated distinctive linearity changes or breakpoints (BP) during exercises with graded workload increase, and several studies have validated SmO2 BP against systemic thresholds (Sendra-Pérez et al., 2023). In the majority of cycling-related SmO2 BP validation studies, only primary locomotory muscles, like Vastus Lateralis (VL), of one body side are analysed and mainly strong group level, but low to moderate individual level agreement was reported (Yogev et al., 2022; Sendra-Pérez et al., 2023). A recent study by Reinpõld et al. (2024) has demonstrated that the average value of contralateral VL SmO2 BP measures is in higher agreement with Ventilatory Thresholds (VT) than bilateral BP measures separately, and agreement between contralateral BP values is even lower. Additionally, there are some studies demonstrating that SmO2 BP of main non-locomotory muscles, like the deltoid (Yogev et al., 2022) or intercostal muscles (Contreras-Briceño et al., 2022), can reflect systemic thresholds at the same level or even more precisely than SmO2 dynamics in primary power producers. Furthermore, fewer results are presented about SmO2 dynamics of postural stabilising muscles, having a high proportion of type I muscle fibres, during incremental cycling exercise for competitive cyclists. Therefore, this study aimed to analyse the agreement between ventilator thresholds and local muscle oxygen saturation breakpoints of the Vastus Lateralis and Erector Spinae muscles.

Methods
Participants of the study were 13 trained U19 class male road cyclists (Age: 17.5±0.6 years, Height: 1.85±0.04 m, Body Mass: 75.0±4.7 kg, and VO2max: 63.1±5.9) who had at least four years of cycling training experience and seasonal cycling distance during last season above 12000 km. The local ethical committee approved the study.

The study design included incremental cycling exercise with a target cadence of 90±5 rpm with an initial load of 100 W and 30 W increment every 3 minutes until exhaustion on a Cyclus 2 cycling ergometer (Avantronic, Cyclus 2, Leipzig, Germany).

Respiratory gas exchange variables (Oxygen uptake (VO2), carbon dioxide output (VCO2), and minute ventilation (VE)) were continuously measured with Cosmed Quark CPET metabolic analyser (Rome, Italy) using a breath-by-breath mode. The first (VT1) and the second Ventilatory Threshold (VT2) were assessed using Cosmed Omnia 2.1 software by methods of Wasserman (2005). The maximal oxygen uptake (VO2max [ml/min/kg]) was determined as the highest 30 s average value during the exercise test. The corresponding power values at VT1 and VT2 time points were computed proportionally (Reinpõld et al., 2024), and body mass normalised power values (Pkg@VT1 and Pkg@VT2 [W/kg]), as mainly used cycling performance measures, were incorporated to future analysis.

The continuous recording (at 0.5Hz) of muscle oxygen saturation (SmO2) from the Right and Left Vastus Lateralis (VL) and Erector Spinae (ES) muscles was performed using the mobile NIRS device Moxy Monitor (Fortiori Design LLC, Hutchinson, USA) (Feldmann et al., 2019) connected to Garmin Edge 1040 head unit. The Moxy Monitor probes were placed on VL approximately two-thirds of the distance between the anterior superior iliac spine and the lateral side of the patella (Reinpõld et al., 2024) and on the right ES muscle approximately in the height of L2/L3. All participants had adipose tissue thickness (ATT) lower than 10mm in all NIRS sensor placement regions, measured as half skinfold thickness by Skinfold Caliper.

The signal processing and BP analyses for SmO2 signals were performed in an R-programming environment with the automated segmented (piecewise) regression analysis with a maximum of two breakpoints (more detailed described by Reinpõld et al., 2024). The first change point in the SmO2 signal slope was defined as BP1, and the second change as BP2. The power values at BP1 (Pkg@BP1) and BP2 (Pkg@BP2) for all three muscles were computed proportionally from the time points where those BP were detected and normalised with body mass (like VT). For the VL muscle, the left and right BP values were average for single VL BP1 and VL BP2 values because bilaterally averaged values have demonstrated higher agreement between systemic thresholds than single body side measures separately (Reinpõld et al., 2024). Pkg values at BP1 and BP2 for VL and ES were incorporated into future analysis.

Data analysis was performed with JASP 0.18.3 computer software (JASP Team, 2024). The descriptive statistics were computed for all variables and expressed as a mean±Standard Deviation (SD). The one-way ANOVA for repeated measures with the Bonferroni post-hoc test was used to evaluate differences in Pkg values between methods. If Mauchly's test indicated a violation in the assumption of sphericity, then the Greenhouse-Geisser correction was used. The Bland Altman plots with Limits of Agreement (LOA) at ±1.96 SD level were established to evaluate the individual level agreement between corresponding VT and BP values. A correlation analysis was conducted to evaluate group-level agreement between VT and BP-related Pkg values. The significance level was set at $p<0.05$.

Results
The BP evaluation with segmented regression demonstrated different sloping patterns in SmO2 signals from VL and ES. After BP1, the SmO2 signal downward slope steepened for both muscles, but after BP2, the signal slope in VL muscle decreased or levelled off, but for ES, it steepened and decreased rapidly. The descriptive statistics of cyclists' VT and BP values at the first and second thresholds are presented in Table 1. There were no significant differences between VT and BP values at the first threshold ($F(2, 22)=2.40$, $p=0.114$, $\eta^2=0.179$). However, at the second threshold, the ANOVA indicated within subject's effect between methods ($F(1.3, 13.7)=2.40$, $p=0.005$, $\eta^2=0.472$), and post-hoc test revealed significantly higher Pkg values (later occurrence) for ES BP2, compared to two other threshold evaluation methods.

Table 1. The descriptive statistics of relative power values at first and second thresholds

First threshold	N	Mean	±	SD	Second threshold	N	Mean	±	SD
Pkg@VT1 (W/kg)	13	2.91	±	0.42	Pkg@VT2 (W/kg)	13	4.15	±	0.41
Pkg@VL BP1 (W/kg)	13	2.77	±	0.44	Pkg@VL BP2 (W/kg)	13	3.99	±	0.52
Pkg@ES BP1 (W/kg)	12	2.89	±	0.40	Pkg@ES BP2 (W/kg)	12	4.40	±	0.43 *, #

* - significantly different from VT; # - significantly different from VL BP (p<0.05)

The Bland Altman analysis (Figure 1) demonstrated remarkably lower LOA between Pkg values at ES BP and VT at both thresholds than between VL BP and VT. The correlation analysis also demonstrated higher common variability between Pkg at ES BP and VT on the first (r=0.87, p<0.05) and second (r=0.91, p<0.05) threshold, than between Pkg at VL BP and VT (r=0.77, p<0.05; r=0.77, p<0.05 for first and second threshold respectively).

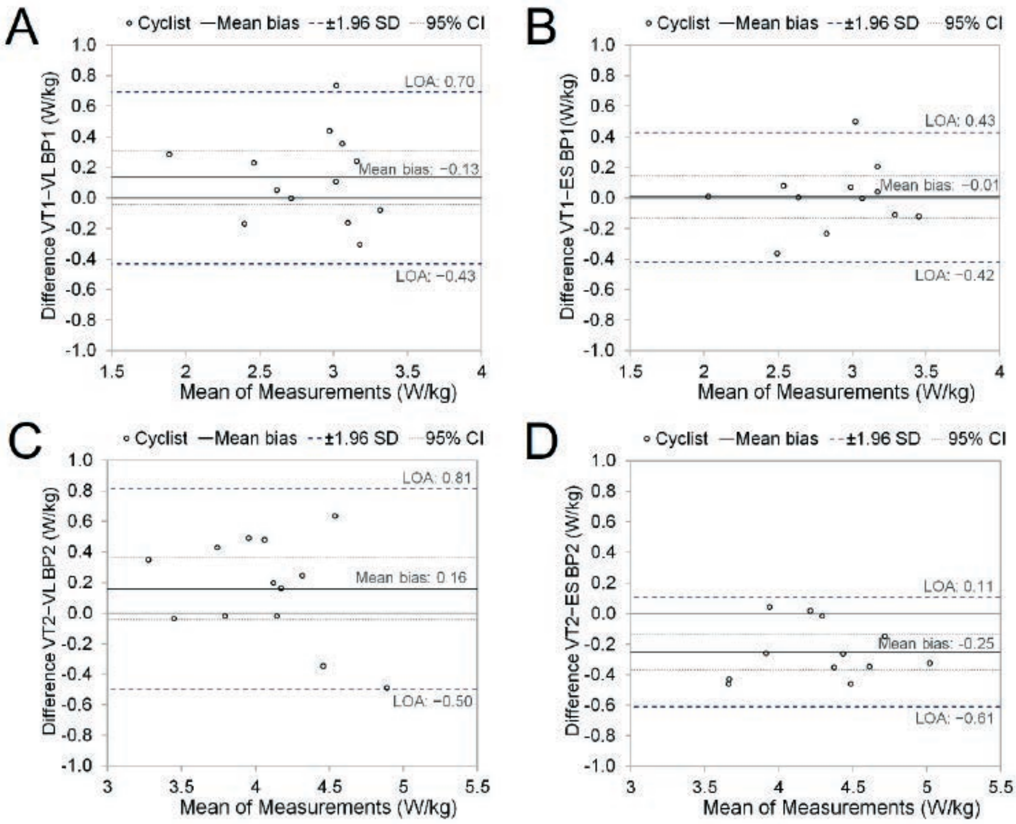

Figure 1. Agreement between Pkg values (W/kg) at VT1 and VL BP1 (Panel A); VT1 and ES BP1 (B); VT2 and VL BP2 (Panel C); VT2 and ES BP2 (D)

Discussion

The results of the current study demonstrated that at the first metabolic threshold, the ES BP1 is in higher agreement with VT1 compared to VL BP1, at both within and between individual levels. The linearity changes in the SmO2 signal steepened after BP1 for both muscle groups, as also described previously (Reinpõld et al., 2024; Yogev et al., 2022), but in most cases, the SmO2 signal downward slope was relatively flat in ES compared to VL before the BP1. The steepening of SmO2 signal slope in working muscle (VL) indicates an increased O2 consumption rate per unit of work and increased glycolysis, signalling the cardiovascular and respiratory centres to cause systemic reactions measured as markers of VT1 (Poole et al., 2021). The results of our study qualitatively indicated the earlier occurrence of VL BP1 compared to VT1 (Figure 1), following the local threshold concept attributed to the first threshold (Poole et al., 2021), but due to the small sample size, the current study laced statistical power to show significance. The differences between local and systemic thresholds incorporate several methodological limitations and may also depend on athletic phenotype (Reinpõld et al., 2024). The BP1 in postural stabilising muscle (ES) may be associated with increased demands to control the upper body stability. However, it can be hypotise that increased metabolic demands are more likely related to lactate utilisation, leaked from muscles producing external mechanical work, during "isocapnic buffering region" (Poole et al., 2021).

The results at the second metabolic threshold also demonstrated narrower LOA and higher correlations between ES BP2 and VT2-related Pkg values compared to VL BP2, but significantly higher Pkg at ES BP2 indicated relatively later occurrence of ES BP2 in time compared to VT2 and VL BP2. After BP2, the SmO2 signal slope of VL usually levelled off, indicating exhaustion of the potential of aerobic processes and increased glycolysis (Poole et al., 2021), but the signal slope for ES muscle steepened downward at a high rate, described previously by Yogev et al. (2022), which may indicate increased needs for lactate buffering to maintain the homeostasis (Poole et al., 2021). It can be hypnotised that the mechanical work-related changes in metabolic activity are sensitive to load sharing between muscle groups or regions of the same muscle. However, muscle activity triggered by disturbance of homeostasis is probably more uniform, which could explain better agreement between VT and ES BP. Our results demonstrate the potentially new ways to monitor the endurance training process and indicate the importance of aerobic abilities of non-locomotory muscles on endurance performance, especially in terms of the work performed above the second threshold or "critical power ".

Conclusion

The results of the current study demonstrate that during incremental cycling exercise, the linearity changes in mainly postural stabilising Erector Spinae muscle SmO2 signal had higher within the subject's and group level agreement with systemic thresholds than breakpoints in primary power-producing Vastus Lateralis muscles but the occurrence of Erector Spinae second breakpoint tended to be delayed compared to second Ventilatory Threshold.

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PREVALENCE OF LOW ENERGY AVAILABILITY AMONG FEMALE ATHLETES: A TIER-BASED PERSPECTIVE FROM RECREATIONAL TO PROFESSIONAL LEVELS

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Abstract
This study assesses the prevalence of Low Energy Availability (LEA) among female athletes across four performance tiers, exploring its association with health and physiological metrics, including body weight, injury prevalence, gastrointestinal symptoms, and menstrual function. Surprisingly, the risk of LEA did not significantly vary across performance levels, challenging the expectation that elite athletes would exhibit a higher risk. This suggests that other factors, such as nutritional knowledge, substantially influence LEA risk among athletes of all tiers. The significant link between high performance and menstrual dysfunction further illustrates the complex effects of LEA on female athlete health. The study's reliance on self-reported data indicates the need for further objective research to validate these findings.

Keywords: *Energy Deficiency; Sports Women; Reproductive Health*

Introduction
Energy availability is crucial for the optimal health and performance of athletes. Low energy availability (LEA), which occurs when an athlete's dietary energy intake is insufficient to support the energy expenditure required for health and performance, has been recognized as a concern, particularly among female athletes (Mountjoy et al., 2014). LEA impairs athletic performance and adversely affects an athlete's physiological functions, including reproductive and bone health (De Souza et al., 2014).

The prevalence of LEA has been documented variably across different sports and performance levels, with high-performance athletes often at greater risk due to intense training and pressure to maintain certain body weights or aesthetics (Sundgot-Borgen & Torstveit, 2004). Performance tiering in sports can influence the risk and incidence of LEA due to varying training loads and competitive stressors (Roberts et al., 2016).

Furthermore, specific health parameters, such as menstrual function, are affected by LEA, with menstrual dysfunction reported as a common issue in female athletes, often associated with the Female Athlete Triad and Relative Energy Deficiency in Sport (RED-S) (Joy et al., 2016). This study examines the prevalence of Low Energy Availability among a cohort of female athletes categorized into four performance tiers. The objective is to identify significant differences in LEA prevalence across these tiers and evaluate its association with essential health and physiological metrics, including body weight parameters, injury prevalence, gastrointestinal symptoms, and menstrual function.

Methods
Participants
The research involved 191 female individuals from the Czech Republic, recruited explicitly through university promotions, targeted outreach on social media platforms such as Instagram and Facebook, and the faculty's official website.

Data collection
Participants completed the LEAF-Q questionnaire to assess the risk of LEA and provided demographic and anthropometric data, including age, height, weight, and information on physical activity levels. Performance tier assessments by McKay et al. (2022) were gathered through a questionnaire to encompass essential participant characteristics. By engaging in the web-based questionnaire, respondents agreed to participate in a study carried out as part of an identified research project (MUNI/A/1455/2022) at the Faculty of Sport Studies, Masaryk University, for which approval was granted by the Research Ethics Committee of MU

Statistical Analysis
The Shapiro-Wilk test and the Kolmogorov-Smirnov test with Lilliefors correction were utilized to determine the normal distribution of the data. Depending on the distribution, appropriate statistical tests were applied. For normally distributed data, one-way ANOVA was utilized to discern mean differences across performance tiers. For non-normally distributed data, non-parametric tests were employed, including the Chi-Square test for independence and the Kruskal-Wallis H test for comparing median scores across independent groups.

Post-hoc analyses followed significant findings. In cases where the ANOVA was significant, we applied Tukey's HSD test to control for Type I error across multiple comparisons. We used pairwise comparisons with Bonferroni correction for non-parametric tests with significant Kruskal-Wallis H results to identify specific group differences.
Effect sizes were computed to quantify the magnitude of observed phenomena. For the Chi-Square test, Cramer's V was calculated to assess the strength of association. For ANOVA, partial eta-squared values were derived from the ANOVA output, providing a measure of effect size relative to the variance explained by the independent variable within the model.
Statistical significance was set at $p < 0.05$, and all analyses were conducted using the statistical software Statistica version 14.

Results
Our study investigated the prevalence of low energy availability (LEA) across different performance tiers in female athletes. The number of participants in each tier varied, with the highest percentage of athletes at risk of LEA found in Tier 3 (47%). However, the risk of LEA was not significantly different across the tiers, as indicated by a p-value of 0.50 and an effect size of 0.11, suggesting a small practical significance.

Regarding anthropometric characteristics, the average age of participants ranged narrowly between 22.4 ± 3.7 years in Tier 2 and 24.3 ± 7.1 years in Tier 4. Heights and weights were also similar across tiers, with no statistically significant differences noted. The variability within tiers was minimal, suggesting a homogenous sample in terms of age, height, and weight.

Interestingly, the highest weight with current height showed a statistically significant difference between performance tiers ($p = 0.04$; effect size = 0.11), with Tier 1 athletes having the highest average highest weight.

The Total LEAF-Q score, a composite score reflecting the risk of LEA, revealed significant differences among performance categories ($p = 0.01$; effect size = 0.13). Post-hoc analysis indicated significant differences, particularly between Tier 1, Tier 2 and Tier 4 ($p = 0.01$), suggesting that Tier 4 athletes may be at a greater risk of LEA than those in Tier 1 and Tier 2.

Injury scores and gastrointestinal symptom scores did not differ significantly across tiers. However, menstrual cycle/contraception scores showed significant differences in the post-hoc comparisons between Tier 1 and Tier 4 ($p = 0.01$) and between Tier 2 and Tier 4 ($p = 0.02$), with Tier 4 athletes displaying higher scores, indicating potential menstrual dysfunction in higher performance tiers.

Table 1 Participant Characteristics and comparison between performance tiers in LEAF-Q score and related parameters

	Tier 1 LEA risk	Tier 2 LEA risk	Tier 3 LEA risk	Tier 4 LEA risk	p-value	Effect size
Number of participants (n)	35 (34 %)	11 (34 %)	18 (47 %)	6 (35 %)	0.50	0.11
Age	23.7 ± 4.6	22.4 ± 3.7	23 ± 4.2	24.3 ± 7.1	0.78	0.02
Height	168.6 ± 6.1	168 ± 4.5	170.4 ± 6.9	167.5 ± 2.3	0.67	0.02
Weight	65 ± 10.2	60.9 ± 9.6	67.7 ± 8.8	56.6 ± 8.7	0.06	0.1
Your highest weight with your present height:	69.7 ± 11.3	63.8 ± 9,9	72 ± 9.8	59.8 ± 9	0.04*	0.11
Your lowest weight with your present height:	55.7 ± 8	55.1 ± 5,9	60.3 ± 10	52.8 ± 6.9	0.15	0.07
Total LEAF-Q score	10.5 ± 2.3	9.4 ± 2,7	10.3 ± 1,8	12.8 ± 2,6	0.01*	0.13
Injury score	3,7 ± 2,7	4,5 ± 2,2	4,8 ± 2,2	2,7 ± 2	0,17	0,07
Gastro-intestinal symptom score	3,3 ± 2,2	1,7 ± 1,4	1,7 ± 1,4	3 ± 1,1	0,02*	0,13
Menstrual cycle/contraception score	3,5 ± 2,3	3,2 ± 2,6	3,8 ± 2,1	7,2 ± 1,7	0,01*	0,13

Discussion
This study aimed to investigate the prevalence of Low Energy Availability (LEA) among female athletes across different performance tiers and its association with various health and physiological metrics. Contrary to our hypothesis, the risk of LEA did not significantly differ across the performance tiers, as indicated by a p-value of 0.50. This finding is particularly intriguing, suggesting that factors other than performance level, such as nutritional knowledge and dietary habits, may play a critical role in influencing LEA risk among athletes.

The absence of significant differences in LEA risk across tiers may reflect a broader, systemic nutritional education issue within the athletic community. Logue et al. (2020) provided an updated narrative review, emphasizing that the risk of LEA remains a prevalent issue among athletes, influenced significantly by a lack of sports nutrition knowledge. Recent findings by Magee et al. (2023) further support this notion, demonstrating that amateur athletes are at risk for LEA partly due to poor sports nutrition knowledge, underscoring the critical need for improved education.

Our research identified a significant association between higher performance levels and menstrual dysfunction, a condition often exacerbated by Relative Energy Deficiency in Sport (RED-S). This correlation is reinforced by recent findings from Quesnel, Hefner, and colleagues (2022) and Coelho et al. (2021), who explore the detrimental effects of LEA on athlete health, specifically menstrual dysfunction. Further, the comprehensive analysis by Mountjoy et al. (2023) on RED-S provides pivotal insights into the complex repercussions of energy deficiency, including its impact on menstrual health, underscoring the critical need for an integrated approach to athlete care. This multifaceted strategy should encompass nutritional, physiological, and psychological support to effectively address the intertwined issues of energy availability and menstrual health in female athletes.

The statistical significance found in the highest weight with current height across tiers ($p = 0.04$) might indicate a nuanced aspect of athlete management. Weight fluctuations can be a physical manifestation of LEA, reflecting its impact on an athlete's body composition and potentially influencing performance and health (De Souza et al., 2014). This highlights the necessity of individualized nutritional and training plans that consider the unique physiological needs of each athlete, thereby minimizing the risk of LEA and its adverse effects.

Conclusion

This study examined the prevalence of Low Energy Availability (LEA) among female athletes at different performance levels and its correlation with key health and physiological measures. Our results indicate that the risk of LEA does not vary significantly across performance tiers, emphasizing the impact of factors beyond performance level, such as nutritional knowledge and dietary habits, on LEA risk in athletes. The notable link between higher performance levels and menstrual dysfunction highlights the intricate relationship between energy availability, menstrual health, and overall well-being in female athletes. While offering valuable insights, this study is constrained by its reliance on self-reported questionnaire data; hence further research using more objective measurements is necessary to validate these findings.

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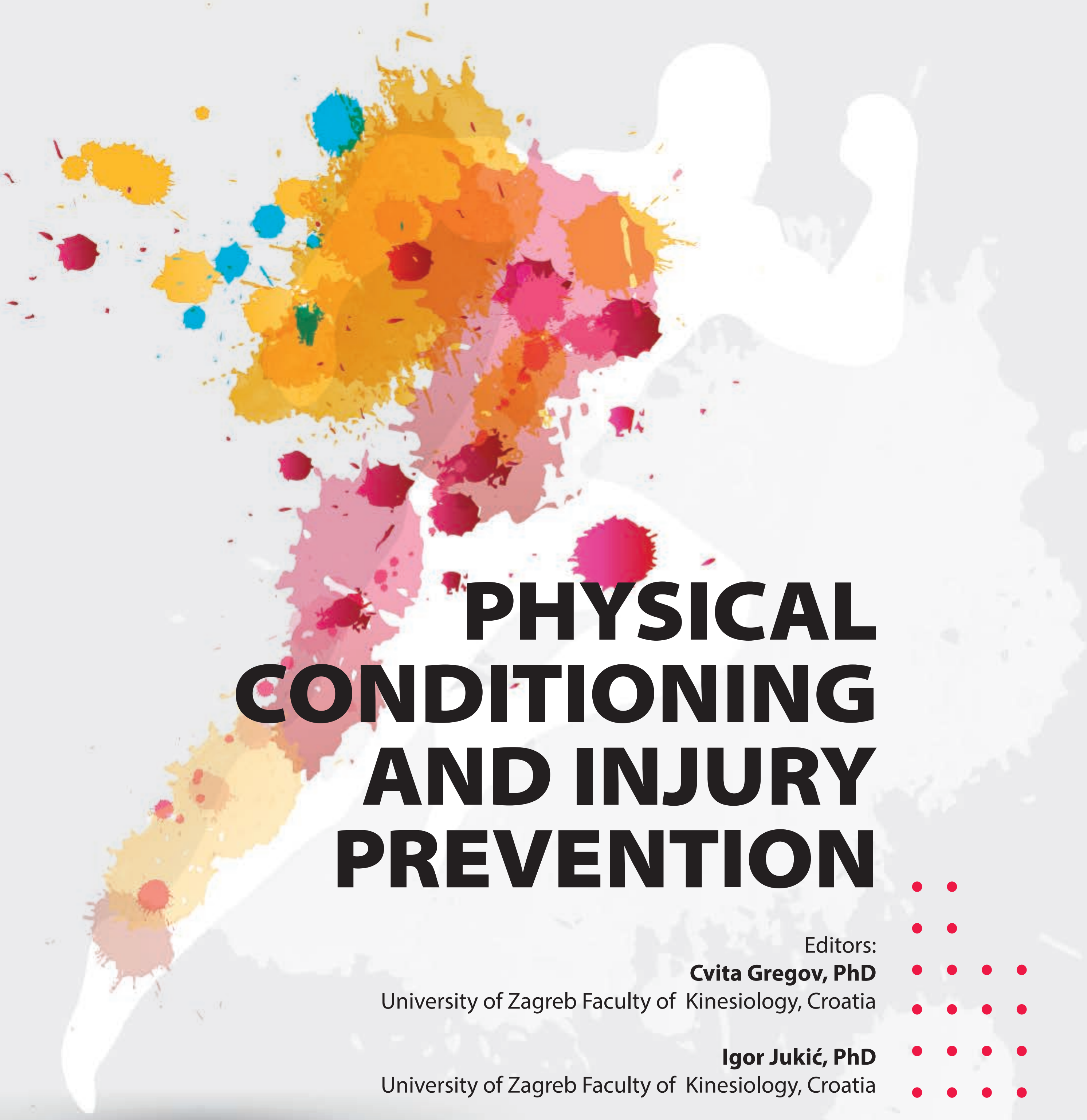
CURRENT TRENDS AND INNOVATIONS IN KINESIOLOGY RESEARCH: PROCEEDINGS



PHYSICAL CONDITIONING AND INJURY PREVENTION

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DIFFERENCES IN FUNCTIONAL MOVEMENT CAPABILITIES BETWEEN JUNIOR CADET AND CADET BOXERS

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Abstract
Boxing, as a polystructural acyclic activity, requires a high level of psychomotor development and capabilities. To ensure a boxer's sports career is both long-lasting and healthy, athletes should be physically and functionally prepared for the high demands of training and competitive cycles. This research aimed to assess the functional movement capabilities of young boxers, prevent injuries, and correct imbalances and asymmetries in their bodies, using an expanded battery of FMS tests. The research was attended by younger cadets and cadets who are also active members of the "Gladijator" boxing club in Zagreb, Croatia. The research results were described in detail and analyzed using the t-test for independent samples. Differences in the results were found through the analysis, with a statistically significant difference identified in only one of the variables. However, it is important to note that in the final result of the extended battery of FMS tests, no statistically significant difference was observed between the examined groups.

Keywords: *boxing, expanded battery of FMS tests, movement assessment, injury prevention, sports career*

Introduction

Polyscstructural activities involve acyclic actions with the aim of symbolically dismantling the opponent, and movement is executed and constrained in contact with the partner (Jurko et al., 2015). As a polystructural acyclic activity, boxing necessitates the development of both motor and mental abilities. It is crucial to foster these abilities from an early age; however, Bompa, in his book, delineates age limits and guidelines for engaging in boxing. According to Bompa, the suitable age for initiating boxing is between 13-15 years, the age for commencing specialization in boxing is between 16-17 years, and the age conducive to achieving high results in boxing is between 22-26 years (Bompa, 2009).

The development of abilities significantly impacts an athlete's sports career. A more capable athlete tends to have a more prolonged and healthier career, although exceptions exist. In some athletes, abilities are not fully developed, leading to injuries and an early termination of their sports career. To prevent undesirable health consequences, Gray Cook and Lee Burton devised the Functional Movement Screen (FMS) test, aimed at diagnosing movement functionality. Tests like FMS, utilizing modest instrumentation, can be valuable in assessing movement functionality, maintaining a healthy body throughout a sports career, and reducing the risk of injuries (Cook, 2010).

In the research, utilizing an expanded battery of Functional Movement Screen (FMS) tests, the functionality of movements was analyzed, and issues related to asymmetry, imbalance, and poor movement structures were examined among younger age categories of boxers.

Methods

Entities

The participant sample for the test battery consisted of 20 boxers from the "Gladijator" boxing club in Zagreb, Croatia, aged between 11 and 14.

Variables

The battery included fundamental Functional Movement Screen (FMS) tests and supplementary tests assessing ankle mobility (dorsiflexion), hip flexor mobility (Thomas test), thoracic spine rotational mobility, and thoracic spine extension. This comprehensive evaluation aimed to analyze the movement functionality of the actively engaged boxers, providing insights into their fundamental movement patterns and overall physical capabilities. The testing occurred in mid-March 2023 at the "Gladijator" boxing club.

Statistical analysis

The research results were described in detail and analyzed using the t-test for independent sample and data processing was implemented by applying the statistical software package Statistica for Windows, ver. 14.0.

Results and discussion

Table 1. Arithmetic means of extended battery FMS tests in cadets and junior cadets in the boxing discipline

	Test		AM-cadets	AM-younger cadets
1.	DS		1,70	2,00
2.	HS	R	2,00	1,80
		L	2,00	1,80
3.	HS		2,00	1,80
4.	INL	R	2,10	2,40
		L	2,40	2,30
5.	INL		2,25	2,35
6.	SM	R	2,70	2,90
		L	2,20	2,50
7.	SM		2,45	2,70
8.	ARS	R	2,30	2,50
		L	2,00	2,50
9.	ARS		2,15	2,50
10.	PU		2,60	2,80
11.	RS	R	2,00	2,00
		L	2,00	2,00
12.	RS		2,00	2,00
13.	DORS		2,20	2,20
14.	THOMAS		1,80	2,00
15.	TSE		2,40	2,80
16.	TSRM	R	2,20	2,30
		L	2,40	2,30
17.	TSRM		2,30	2,30

Legend: DS(deep squat), HS(hurdle step), INL(inline lunge), SM(shoulder mobility), ASR(active straight-leg raise), PU(trunk stabilitiy push up), RS(rotary stability), DORS(ankle mobility (dorsiflexion)), THOMAS(hip flexor mobility (Thomas test)), TSE(thoracic spine extension), TSRM(thoracic spine rotational mobility), AM- arithmetic mean

In Table 1, the results of average scores in tests assessing stability and mobility in younger cadets and cadets in boxing using the expanded battery of FMS tests are presented. The arithmetic mean for each individual test is highlighted in the results. After processing and analyzing the data in the Statistica 14.0 program, a statistically significant difference was observed only in the test assessing the mobility of the right shoulder, where younger cadets showed better results than cadets. Other tests did not show statistically significant differences, as clearly evident from Table 1. A more detailed analysis of Table 1 reveals that cadets perform better than younger cadets in some tests, while the reverse is also true. However, these differences are not statistically significant.

Table 2. Difference in the final scores of extended battery FMS testing between cadets and junior cadets in boxing

	Cadets	Younger cadets	t-value	p- value
	AM ± SD	AM ± SD		
FMS (final scores)	2,18 ± 0,73	2,30 ± 0,69	-1,60	0,40

Legend: FMS- Functional movement screen; AM- arithmetic mean ; SD- standard deviation

Following the analysis of Table 2, encompassing the comprehensive results of the extended battery of FMS tests, it is noted that the disparity in the final results between cadets and younger cadets is not statistically significant. This distinction was subjected to a t-test for independent samples at a significance level of $p < 0.05$, revealing that the participant groups do not exhibit statistically significant differences.

In a similar study by Popović (2015), it was found that there are statistically significant differences among karate practitioners engaging in kata and sparring disciplines. Fighters achieved better results than karate practitioners focusing on katas. The results suggest a significant potential for improvement among kata practitioners in their motor skills and movement functionality (Popović, 2015). Additionally, differences were observed between these two studies. In the study involving karate practitioners, a statistically significant difference in results was determined, while such a difference was not observed in boxers. The potential reason for the disparity in results lies in the fact that the karate study was conducted on juniors and younger seniors who are more developed and already have their professional imbalances, whereas cadets still possess a full range of motion and a functionally sound body without professional imbalances.

Many scientists monitor sports injuries and associate them with various factors such as movement dysfunction (Lehance et al., 2009; Chorba et al., 2010; Butler et al., 2010), range of motion, anatomical asymmetries, and insufficient trunk stability (Leetun et al., 2004; Kiesel et al., 2008; Magnus and Farthing, 2008; Sorenson, 2009), reduced neuromuscular control (Williams et al., 2001; Hagglund et al., 2006; Chorba et al., 2010), and many other factors.

Thanks to the research of these scientists, it can be concluded that timely and precise muscle activation during movement is a fundamental concept of functional motion. Therefore, for a successful sports career, the supervision of a professional staff that will appropriately develop motor skills is necessary, resulting in healthy and proper functional movements in athletes.

One possible reason for the similarity in results between younger cadets and cadets in boxing may be the lack of a conditioning coach at the "Gladijator" boxing club. Focusing on the development of motor skills in the introductory part of training could significantly alter the assessment and performance quality of young boxers. Therefore, to prevent potential injuries and improve the functional abilities of participants, it is necessary to include a conditioning coach in the "Gladijator" boxing club who will systematically and purposefully guide them towards their progress.

Conclusion

The aim of the study was to determine if there is a statistically significant difference in movement functionality among boxers in the younger cadet and cadet age groups. Based on the conducted analyses, it can be concluded that there are no statistically significant differences between the two examined groups. An independent samples t-test was employed to assess the difference in the final results of the extended battery of Functional Movement Screen (FMS) tests between boxers in the younger cadet and cadet age groups, with a set significance level of $p<0.05$. Data processing utilized the Statistica 14.0 program, revealing a statistically significant difference only in the test assessing the mobility of the right shoulder, where the younger cadets demonstrated better results than the cadets. On the other hand, no statistically significant differences were observed in other variables. Considering their age, it is important to emphasize that continuous development and improvement of movement functionality are crucial under professional supervision. Through collaboration with a conditioning coach, boxers in the cadet age group can enhance and develop their motor and functional abilities. Simultaneously, the proper execution of functional movements will be crucial as a prerequisite for the further development of other motor skills such as strength, speed, and endurance.

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RELATIONSHIP BETWEEN JUMPING HEIGHT, LOWER LIMB VERTICAL TAPPING FREQUENCY AND ANAEROBIC ENDURANCE AMONG YOUNG ATHLETES OF VARIOUS TEAM SPORTS

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Abstract
The current study aims to find possible relationships between vertical jumping ability, characteristics of lower limbs vertical stride frequency and indicators of continuous jumps performed for 30 seconds among young athletes of different sports games. The importance of lower limbs' explosive power and its positive impact on agility in team sports is widely known. In scientific research, much attention is paid to indicators of anaerobic endurance among athletes of sports games. Much less is known about the characteristics of lower limbs vertical stride frequency performance. The indicators characterising the foot tapping frequency and the methodology of conducting the tests in many studies vary in terms of test duration and body position. A total of 87 athletes participated in the study. To determine the physical abilities of the subjects, the countermovement jump (CMJ), countermovement jump with arm swing (CMJAS), 15 seconds vertical foot tapping test (FT15) and a 30-sec continuous jump test (CJ30) were carried out. Data were collected using Optojump Next and processed using the freeware data processing program JASP. A partial correlation method was used to determine relationships. The main results of the correlation analysis showed that the height of CMJ and CMJAS has a moderate relationship with the vertical foot tapping frequency indicators and anaerobic endurance.

Keywords: *young athletes, physical abilities, quickness of movement*

Introduction
A successful sports game player is distinguished not only by good anthropometric indicators and technical-tactical activity but also by specific physical ability, including, among others, lower limbs explosive power, agility, and anaerobic endurance. Several scientific studies have confirmed the great importance of maximal dynamic strength and explosive power of the lower limbs and their positive effect on agility among athletes participating in sports games. Explosive power is a significant characteristic of basketball players, and it is one of the most critical factors for achieving top sports results (Aksović et al., 2020). Results of a study conducted by Chaouachi et al. (2009) showed a positive relationship between maximal dynamic lifting ability and short sprinting in elite basketball. Short sprints are strongly associated with the height of the countermovement jump (CMJ) (Young et al., 2011). Elite volleyball players showed significantly better performances in the CMJ and countermovement jump with arm swing (CMJas) when compared to basketball and handball elite players (Peña et al., 2018). Results of investigations conducted by Köklü et al. (2015) among young soccer players and by Asadi (2016) among elite young basketball players showed that CMJ height was highly correlated with agility performance. Along with explosive power, anaerobic capacity is equally important among team sports. Elite junior basketball players spent 19.3 ± 3.5 and 56.0 ± 6.3% of total time in the maximal- and high-intensity zones (Abdelkrim et al., 2010). In most offences, the heart rate value of junior basketball players varies between 168 – 184 BPM, highlighting the high physiological intensity of offensive activity in basketball (Bazanov & Rannama, 2017). Until now, the frequency of movements of the limbs, especially the lower ones, has been much less studied. Most studies highlight the importance and utility of foot and finger-tapping tests in medicine (Enoki et al., 2019; Jobbágy et al., 2005). Few rehabilitation and sports performance investigations have focused on vertical foot-tapping characteristics (Chaabouni et al., 2022; Kurz et al., 2022). However, in these studies, the testing methodology varies in test duration (4-15 s) and FT frequency indicators. In addition, the goals set in the previous scientific studies are not directly related to explaining the relationship between lower extremity performance, vertical movement frequency and anaerobic endurance among different team sport male and female athletes. Based on the problems mentioned above, the current study aimed to find relationships between vertical jumping height, anaerobic endurance and lower limb vertical tapping frequency indicators among young athletes of different sports games.

Methods
Subjects
A total of 87 team sport (Handball, Basketball, Volleyball) athletes voluntarily participated in the study. Of these, 44 men (aged 18±1.5 years, weight 77.2±11.1 kg, height 184.9±9.4 cm) and 43 women (aged 17.7±1.8 years, weight 68.9±10.8 kg, height 175.2±7.1cm). All young athletes were the Tallinn Sports School members, and data were collected during systematic annual testing of sports school athletes. All players were familiar with the testing procedure used before the start of this study. All young athletes and their parents were informed about the needs of the research, possible risks and the benefits

that the research should provide. The study was conducted according to the Declaration of Helsinki 1975. All participants provided their written informed consent.

Testing procedures
Before starting the tests, the subjects were asked to carry out a self-administered warm-up consisting of 5 minutes of jogging, 5 minutes of dynamic stretching and submaximal vertical jumps. The athlete's vertical jump height was determined during countermovement (CMJ) and countermovement jump with arm swing (CMJAS). Each type of jump was performed three times, and the best result was included in the future analysis. A 15-second vertical foot tapping test (FT 15) was used to determine the vertical movement frequency of the lower extremities. A 30-second continuous jump test (CJ30) was carried out to find indicators characterising athletes' anaerobic endurance. Players continuously performed vertical jumps. The subjects were encouraged to exert maximum effort when performing all the tests. The continuous jumps performed for 30 s is a reliable test that can adequately detect athletes' anaerobic capacity level (Dal Pupo et al., 2014). Optojump Next (Microgate, Bolzano, Italy) was used for testing and data collection. The Optojump photocell system is a valid and reliable tool for assessing vertical jump height (Glatthorn et al., 2011). Further processing of the collected data was carried out using the freeware statistical analysis program JASP 0.17.10.

Statistical Analyses
Descriptive statistics (Mean ± SD, Min, Max) and partial correlation (controlling variables: gender and age) were used to determine between variables relationships. The level of statistical significance was set at $p < 0.05$.

Results
Table 1 presents descriptive statistics of the main indicators. Results showed that the Mean ± SD values of CMJ and CMJAS jump height were 31.5 ±7.37 cm and 36.2 ±9.21 cm, respectively. The stride frequency of the FT15 test was 582.7±68.3 (Steps/min) with the duration of ground contact time 0.12 ±0.02 s and flight phase 0.09 ±0.02 s on average. The Mean value of CJ30 height was 24.2 ±6.7 cm, ranged from 17 cm to 30.1 cm.

Table 1. Descriptive statistics of the tests performance*

N= 87	CMJAS Height (cm)	CMJ Height (cm)	Average flight phase FT15(s)	Average ground contact time FT15(s)	Average stride frequency FT15(Steps/min)	Average CJ30 height (cm)	Max CJ30 height (cm)	Min CJ30 height (cm)
Mean	36.2	31.5	0.09	0.12	582.7	24.2	30.1	17
SD	9.21	7.37	0.02	0.02	68.3	6.7	7.1	7.3
Min	17.7	14.8	0.06	0.08	438.6	10.2	14.9	0.1
Max	59.2	52	0.15	0.18	740.2	39.7	47	32

* CMJ = Countermovement jump; CMJ AS=Countermovement jump Arm swing; FT15= Foot tapping test; CJ30= 30-sec continuous jumps

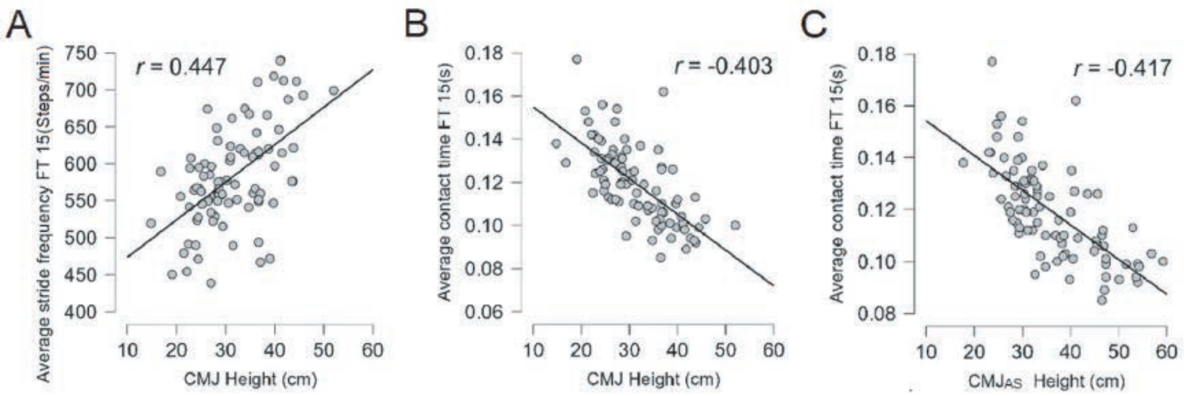

Figure 1. Relationship between legs explosive power and vertical FT characteristics for CMJ Height and stride frequency (panel A); CMJ Height and Average contact time (B); CMJAS Height and Average contact time (C)

The results of the correlation analysis showed a moderate relationship between the height of CMJ and lower limbs vertical stride frequency (r= 0.447; p<.001) (Figure 1A). CMJ and CMJAS height indicators were significantly correlated with the duration of the ground contact phase of FT 15 test (r= -0.403; p<.001 r= -0.417; p<.001) respectively (Figure 1, panels B and C). CMJ height was also positively correlated with the average performance of the 30-second continuous jump test (r= 0.534; p< .001) (Figure 2A). Figure 2 (panels B and C) also demonstrates the relationships between lower limbs stride frequency (r= 0.426; p< .001) and ground contact time (r= 0.430; p< .001) indicators and the average of 30 seconds of continuous jumping performance.

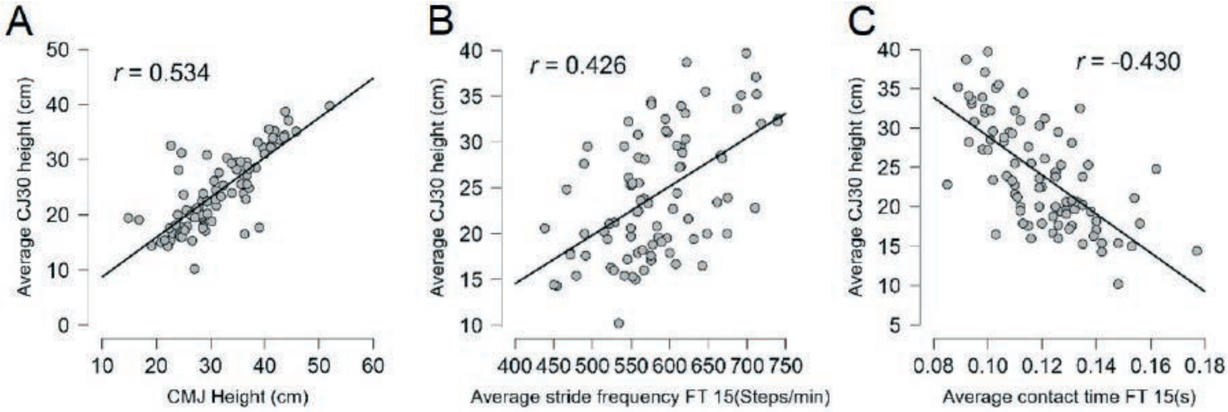

Figure 2. Relationship between anaerobic endurance, legs explosive power and vertical FT characteristics for CMJ Height and CJ30 Average height (panel A); stride frequency and and CJ30 Average height (B); Average contact time and CJ30 Average height

Discussion

The present study examined the relationships between vertical jumping height, anaerobic endurance and lower limb vertical tapping frequency indicators among young male and female team sports athletes. Kurz et al. (2022) found that the foot-tapping indicators are independent of power characteristics. The same assumption is shared by Chaabouni et al. (2022), suggesting that except for motor neuromuscular abilities, the tapping test does not appear to be influenced by soccer players' physical abilities, such as muscle strength and power or even speed. However, key findings of the current study show moderate relationships between lower limbs' vertical tapping indicators, reflecting speed qualities and coordination of movement, CMJ and CMJAS height, which primarily characterise the explosive power of the lower extremities and the average height of 30 seconds continuous jumps, which can represent anaerobic endurance. The relationship between indicators of explosive power and characteristics of lower limbs' vertical movement frequency was revealed for the first time. Furthermore, there is a positive transfer of strength qualities to anaerobic endurance, which in turn is interconnected with the frequency of movements of the lower extremities and the ground contact time. In light of the results of the current study, it can be stated that strength qualities, particularly explosive power, have a beneficial effect on increasing the frequency of vertical movements of the lower extremities and indicators of anaerobic endurance among adolescent athletes.

Conclusion

The faster vertical lower limb stride frequency, especially by the shorter ground contact time, can be partly (~20%) described by the higher lower limb's explosive power characteristics among young male and female team sports athletes. At the same time, higher indicators of vertical jumping ability is positively reflected in characteristics of anaerobic endurance.

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EFFECT OF WEIGHT CYCLING ON THE FEMALE MUAYTHAI FIGHTER – A CASE STUDY

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Abstract
Weight cutting is a common practice among athletes in combat sports, including female Muay Thai fighters, however, it can have detrimental effects on both short-term performance and long-term health. This study aimed to investigate the impact of weight cycling on the body composition and metabolic parameters of a female Muay Thai fighter, with a focus on moving up a weight category. The athlete, aged 24, underwent two assessments with a 5-month interval between them, timed approximately 1-2 weeks after a fight/tournament. Measurements included body composition analysis using dual X-ray absorptiometry (DXA) and basal metabolic rate (BMR) assessment using indirect calorimetry. Results showed an increase in fat-free mass +1,4kg (FFM) without a corresponding increase in body fat percentage. During the study period, the fighter successfully implemented rapid weight loss strategies, resulting in a significant reduction in body weight during the fight week. The calculated average energy availability throughout the study period was within the recommended levels for maintaining overall health and supporting optimal physiological function in female athletes. These findings highlight the importance of tailored nutritional and training interventions to optimize performance and minimize the negative effects of weight cycling in female combat athletes. Further research is warranted to explore the long-term implications of weight cycling and to develop evidence-based strategies for promoting the health and well-being of athletes in combat sports.

Keywords: *combat sports; female; weight cycling; weight class; weight cutting.*

Introduction

Weight cutting is a common practice among athletes, including female Muay Thai fighters, in combat sports such as boxing and mixed martial arts. This practice involves rapidly losing a significant amount of weight in a short period before a fight. Losing body weight (BW) can be divided into chronic weight loss (CVL) and rapid weight loss (RWL). Chronic weight loss is based on caloric deficit. In a combat environment, a "3, 2, 1" diet is often used, where fighters have the following macronutrient distribution: carbohydrates 3g/kg BW, protein 2g/kg BW, fat 1g/k BW and fiber 30g/day (O. R. Barley et al., 2018; Langan-Evans et al., 2022). Weight loss using RWL strategies is based on manipulating body water, gut content, and glycogen stores. The RWL strategies include a low carbohydrate diet, water manipulation, low sodium intake, low fiber intake, and active and passive sweating (Artioli et al., 2016; Brechney et al., 2022).

Weight cutting can have both immediate and long-term effects on the female Muay Thai fighter. The immediate effects of weight cutting on female Muay Thai fighters may include dehydration, acute kidney injury, fatigue, decreased muscle strength and power, impaired cognitive function, and increased risk of injury (O. Barley et al., 2019; Cengiz, 2015; Lakicevic et al., 2021). Long-term effects of weight cutting can include hormonal imbalances, menstrual irregularities, reproductive dysfunction, and bone density loss. Additionally, there is an increased risk of injury and disordered eating behaviors. These effects can impact the overall health and performance of fighters. Additionally, they may contribute to the development of Relative Energy Deficiency in Sport (RED-s), which is a condition that occurs when energy intake is insufficient to support the body's needs, leading to numerous physiological and psychological impairments. which is a condition that occurs when energy intake is insufficient to support the body's needs, leading to numerous physiological and psychological impairments. (Cabre et al., 2022). In addition, weight cycling, which refers to repeatedly gaining and losing weight, can further exacerbate the negative effects on a female Muay Thai fighter's body and health. Overall, weight cutting can have significant negative effects on the female fighter's physical and mental well-being (Franchini et al., 2012; Langan-Evans et al., 2021).

Methods

Athlete overview and case report design

The female Muay Thai fighter, aged 24, with a height of 1.68m and competing in the 60kg weight category, is an international-level muaythai competitor who typically participates in 3-5 fights per year. In the 60kg weight category, she typically undergoes a weight loss of 3-5kg. This involves a 4-week energy deficit regimen followed by the final use of rapid weight loss strategies, including a low-carb diet, low sodium intake, water manipulation, and active/passive sweating. She is a member of the Czech national team and fights under amateur and professional rules. She has been practicing Thai boxing for 7 years and has competed in a total of 23 fights. She falls into the Tier 4 classification based on training and performance caliber (McKay et al., 2022). In this case study, the plan was to monitor the effect of body weight cycling (due to fights) on the female athlete's body. In the case of this case study, the plan was to monitor the effect of body weight manipulation (due to fights) on the female athlete's body. The athlete underwent two measurements, spaced 5 months apart, during which she had to reduce her body weight for a fight. She attended one amateur tournament (weigh-in on the same day as the fight), where she reduced her body weight to 63,5kg, body weight at the beginning of a fight week (5 days) before the first weigh-in 65,6kg (weigh-in two days in a row). The given weight class was 3,5kg higher than she had been fighting so far. The description of the measurements will be provided later in the text. The athlete gave written informed consent, and this case report was approved by the Research Ethics Committee of Masaryk University.

Athlete assessment

All measurements were conducted at midday, following a day of rest. The athlete underwent two assessments with a 5-month interval between them, timed approximately 1-2 weeks after a fight/tournament. Body composition was determined using dual X-ray absorptiometry (DXA) equipment (QDR Series Horizon; Hologic Inc., Bedford, MA). The data obtained from DXA assessments were later utilized for calculating energy availability. The measured basal metabolic rate (BMR) was determined through indirect calorimetry using the Cortex Metalyzer 3B-R3, which was calibrated before usage. The application of measurements and subsequent analyses adhered to the recommended protocols (Compher et al., 2006), and the predicted BMR (BMRpred) was computed using the Cunningham equation (Cunningham, 1980).

Results

In Table 1 you can see the value measured by indirect calorimetry, where the BMRratio (BMR/Cunningham) value remained almost unchanged. There was a change in substrate utilization, with a decrease from 359g/day to 230g/day for carbohydrates, an increase from 29g/day to 90g/day for fats, and an increase from 20g/day to 26g/day for proteins.

Table 1 – Indirect calorimetry. BW – body weight, FFM – fat free mass, RQ – respirátory quotient, BMR – basal metabolic rate, BMR/BW – basal metabolic rate/body weight, BMR/FFM – basal metabolic rate / fat free mass,

Date of measurement	25.05.2023	29.10.2023	difference
BM (kg)	65,9	67,7	3%
FFM (kg)	49,4	50,8	3%
V'O2 (l/min)	0,256	0,298	16%
V'CO2 (l/min)	0,242	0,254	5%
RQ	0,94	0,85	-10%
BMR (kcal/d)	1 829	1 872	2%
BMR/BW (kcal/kg/d)	27,8	27,7	0%
BMR/FFM (kcal/kg/d)	40,0	36,9	-8%
Cunningham (kcal/d)	1 587	1 618	2%
RMR/Cunningham (%)	115	116	1%
Carbs (g/d)	359	230	-36%
Fats (g/d)	29	90	210%
Proteins (g/d)	20	26	28%

In Table 2 we can see the results of DXA measurements. When there was an increase in body weight of +1.8kg. Furthermore, we can observe an increase in the amount of fat-free body mass (FFM) +1.4kg. There was a slight increase in fat mass +0.4kg, but the percentage of adipose tissue remained the same, 24.9%. The T-score increased from 0.8 to 1.0 and the Z-score increased from 0.9 to 1.0.

Table 2 – Dual X-ray absorptiometry. Est. VAT Mass - Estimated Value-Added Tax mass

Date of measurement	25.05.2023	29.10.2023	difference
Total Mass (g)	65 855	67 677	3%
Total Lean Mass (g)	49 435	50 833	3%
Total Fat Mass (g)	16 421	16 844	3%
% Fat	24,9	24,9	0
Est. VAT Mass (g)	160	176	10%
BMD (g/cm2)	1.174	1.189	1%
T-score	0.8	1.0	25%
Z-score	0.9	1.0	11%

Discussion

The main aim of this study was to investigate the effect of body weight manipulation in the context of weight loss on the body of a female Muay Thai fighter. The female fighter was expected to undergo several bouts in the weight class in which she fought during the study period. However, the female fighter fought in one tournament during the study period at a higher weight class than she reported as her fighting weight class when she entered the study.

No negative changes in the results are evident within the study period. On the contrary, there was an improvement where we can see an increase in muscle mass while leaving the same percentage of body fat (PBF). This change in body composition may be beneficial because most of the time, the lower the weight class, the lower the PBF the fighters have.

For amateur fights where there is a 3-12hours period between weigh-ins and fight, it is recommended to reduce body weight by 3% BW during the fight week (Sullivan & Lennon, 2023). The female Muay Thai fighter lost weight in the fight week using RWL strategies from 65.6kg to 63.5kg, a reduction of -2.1kg (3.2% BW).

According to the energy availability - energy balance method (Tarnowski et al., 2023) the average energy availability during the study period was calculated to be 43.5kcal/kg FFM. An energy availability in women of around 45 kcal/kg FFM is suitable for maintaining body weight and providing sufficient energy for all physiological functions (Melin et al., 2019).

The observed increase in muscle mass without a corresponding increase in body fat percentage is particularly noteworthy, as it indicates a potentially advantageous shift in body composition. This may confer benefits in terms of strength, power, and overall athletic performance, which are crucial factors in combat sports such as Muay Thai (Burke et al., 2021).

The fighter's ability to successfully implement rapid weight loss strategies during the fight week, resulting in a significant reduction in body weight, underscores the importance of effective weight management strategies in combat sports (O. Barley et al., 2019). Moreover, the calculated average energy availability throughout the study period aligns with recommendations for maintaining overall health and supporting optimal physiological function in female athletes (Melin et al., 2019).

Conclusion

In conclusion, this study provides valuable insights into the effects of weight cycling on the body composition and metabolic parameters of a female Muay Thai fighter. Despite the unexpected change in weight class during the study period, the fighter demonstrated improvements in muscle mass while maintaining the same percentage of body fat. These findings suggest that careful management of weight cycling, coupled with appropriate dietary and training interventions, can mitigate negative impacts on body composition and metabolic health in female combat athletes.

Overall, this study highlights the importance of tailored nutritional and training interventions to optimize performance and minimize the negative effects of weight cycling in female Muay Thai fighters. However, it is important to note the limitations of this research, particularly the fact that it was conducted on only one female fighter. Therefore, caution should be exercised in generalizing the findings to broader populations of female combat athletes. Further research involving larger and more diverse samples is warranted to validate these findings and explore potential variations across different athlete profiles and weight categories. Additionally, future studies should aim to investigate the long-term implications of weight cycling and develop evidence-based strategies for promoting the health and well-being of athletes in combat sports. By addressing these key areas and building upon the findings of this study, researchers and practitioners can work towards enhancing the overall health, performance, and longevity of female Muay Thai fighters and combat athletes alike.

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ORIGIN, APPLICATION, AND MECHANISM OF SAND TRAINING: A REVIEW

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Abstract
In recent years, Sand Training (ST) has been widely applied in the fields of competitive sports and rehabilitation medicine. However, its application effects and mechanisms of action remain unclear. This paper systematically reviews the relevant literature, both domestic and international, regarding the historical origin, application effects, and scientific mechanisms of ST. The study finds that sand training originated from military training. Compared to hard surfaces, ST is an effective training method for enhancing muscle strength, agility, balance, and aerobic capacity, making it widely used in the field of competitive sports. However, related studies indicate that ST may negatively impact eccentric utilization ratio. The mechanisms of ST may involve the elongation of the eccentric-concentric contraction process and the transition phase between eccentric and concentric contractions, greater energy expenditure, and enhanced muscle fiber recruitment capacity. Furthermore, ST not only offers athletes an alternative approach to improve their athletic performance but also provides an idea for enhancing muscle strength and preventing secondary injuries in injury patients. To conclude, ST is an important training method that can enhance athletic performance while preventing sports injuries. Future practical applications and scientific research need to further explore the differential effects of ST in different populations, dose-response effects, and training adaptations.

Keywords: *sand training; athletic performance; adaptation mechanisms; injury prevention*

Introduction

Joint and muscle injuries are common in many sports. According to a survey by the National Collegiate Athletic Association (NCAA), over 50% of sports injuries occur in the lower extremities[1]. The risk of sports injuries in football ranks among the highest. Common injuries in football include knee injuries such as anterior cruciate ligament (ACL) tears and meniscal injuries[2]. Additionally, prolonged high-intensity training can lead to overtraining in athletes, which is a significant factor contributing to muscle injuries. Frequent sports injuries can shorten an athlete's career and negatively impact their performance.

Sand Training (ST) has garnered significant attention due to its ability to enhance muscle strength while reducing the risk of muscle and joint injuries. Compared to traditional hard surfaces such as grass or wooden floors, sand presents different stressors[3, 4] and adaptations[5-8] due to its unique material properties. Specifically, sand offers cushioning that can reduce ground reaction forces[9], and running or jumping on sand causes foot sinking[10], which means that skeletal muscles must exert greater mechanical effort to perform movements. Extensive research has demonstrated that ST can have positive effects on athletes[5, 8, 11-13], general adults[7], adolescents[14, 15], chronic disease patients[16-18], and individuals with ACL injuries[11]. However, there is currently a lack of research on the application effects and mechanisms of ST, both domestically and internationally. This gap in knowledge may hinder a comprehensive and objective understanding of ST and limit its application. Therefore, this study aims to review the application effects and underlying mechanisms of ST.

Application Effects

During sand training, plyometric exercises are typically employed. This training method is based on the Stretching-Shorten Cycle (SSC). Performing plyometric exercises on sand can effectively develop maximum strength, explosive power, aerobic capacity, balance, and agility, while also effectively preventing and reducing joint and muscle injuries, as detailed in Table 1.

The Impact of Sand Training on Athletic Performance

The Impact of Sand Training on Maximum Strength and Explosive Power

Muscle strength is closely associated with daily life activities, enhancing athletic performance while reducing the risk of sports injuries for athletes[25]. For untrained individuals and chronic disease patients, improved muscle strength contributes to enhancing quality of life[26, 27]. The enhancement of neuromuscular recruitment capacity is a primary factor underlying strength gains from ST. Compared to plyometric training on hard surfaces, ST has been shown to significantly increase maximal lower limb strength. Amrinder et al. (2014) randomly assigned 40 national male field hockey players to ST and Grass Training (GT) groups, both undergoing similar plyometric jump training. Isokinetic dynamometer testing of quadriceps eccentric strength revealed significant increases in the ST group (65.90±26.76 N.m to 73.25±24.29 N.m) compared to the GT group (52.90±16.15 N.m to 57.20±20.29 N.m), with significant between-group differences ($p<0.05$)[28]. Additionally, studies indicate significant improvements in leg press 1RM following ST[5]. During plyometric training on sand, SSC is prolonged, requiring greater eccentric force during the eccentric phase to maintain balance. Similarly, the longer eccentric phase necessitates greater torque during the concentric phase, resulting in increased loads on both eccentric and concentric contractions during ST, thereby promoting greater muscle strength gains.

SSC is a critical determinant of running and jumping performance, and practicing SSC exercises on sand can effectively enhance sprinting performance[29]. Bonavolontà et al. (2021) randomly assigned 16 male soccer players into ST group (n=8) and GT group (n=8), both undergoing identical plyometric training sessions three times per week for 8 weeks[13]. After the 8-week intervention, the ST group demonstrated significant improvements ($p<0.05$) in 5m, 10m, and 20m sprint times, whereas the GT group also showed improvements but without statistical significance.

Similarly, increases in maximal strength lead to enhancements in peak power output[30], thereby improving jumping ability. However, ST can affect the adaptability of jumping performance[31], as evidenced by the decrease in Eccentric Utilization Ratio (EUR), depicted in Figure 1. EUR reflects the efficiency of energy and power transfer during the eccentric phase and can be calculated as the ratio of countermovement jump to squat jump heights[32], effectively indicating the body's ability to utilize elastic potential energy during SSC. Research by Impellizzeri et al. (2008) found that after 4 weeks of intervention, the increase in vertical jump height was significantly smaller in the ST group (37.2±3.6 cm to 39.6±5.5 cm) compared to the GT group (37.8±3.6 cm to 43.3±5.9 cm). However, trends in squat jump height differed from those of vertical jumps[13]. The ST group exhibited a greater increase in squat jump height (34.3±4.5 cm to 37.8±4.0 cm) compared to the GT group. Consequently, the EUR was higher in the GT group (1.21±0.03) than in the ST group (1.05±0.03), showing significant statistical differences between the two groups ($p=0.005$)[13]. However, differences in study populations may influence results. Ahmadi et al. (2021) found that volleyball players exhibited a larger improvement in countermovement jump height after ST (16%) compared to hard surface training (11%)[5]. This could be attributed to the high demand for elastic energy utilization in volleyball, indicating better eccentric-concentric transition capabilities among players, potentially mitigating adverse effects of ST on countermovement jumps.

Table 1. The effect of Sand training for different populations

Subjects	Sand Training		Firm Surface Training			
	Sample size (n)	Results	Sample size (n)	Results	Duration (weeks)	Frequency (time per week)
Volleyball player (Female, 21-25yrs)	8	Dump jump |, CMJ↑*, 20m sprint↑*, T agility test↑**, Leg press 1RM↑**	9	Dump jump |, CMJ↑*, 20m sprint↑*, T agility test↑**, Leg press 1RM↑**	8	2
National hockey athlete (Male, 19-22yrs)	20	Flexor strength↑, Extensor strength↑, Muscle endurance ↑, Static balance↑, T agility test↑, Muscle soreness↓*	20	Flexor strength↑, Extensor strength↑, Muscle endurance↑, Static balance↑, T agility test↑, Muscle soreness↓*	4	3
Team event athletes (Female, 19-25yrs)	12	Leg press 1RM↑, Dynamic balance↑*, Squat jump↑, CMJ ↑, T agility test ↑, 20m sprint ↑*, Repeated sprint ability↑*, Blood lactate↓*, Exhaustion time↑*, Maximum oxygen uptake↑*, Running economy ↑, Heart rate↓, Lactic acid↓	12	Leg press 1RM↑, Dynamic balance↑*, Squat jump↑, CMJ↑, T agility test↑, 20m sprint↑*, Repeated sprint ability↑*, Blood lactate↓*, Exhaustion time↑*, Maximum oxygen uptake↑*, Running economy↑, Heart rate↓, Lactic acid↑	8	3
Football athletes (Male, 19-28yrs)	8	5m sprint↑*, 10m sprint↑*, 20m sprint↑ *, CMJ↑, Standing long jump distance↑*, T agility test↑, Static balance↑	8	5m sprint↑*, 10m sprint↑*, 20m sprint↑*, CMJ↑, Standing long jump distance↑*, T agility test↑, Static balance↑	8	3

Handball athletes (Female and Male, 18-27yrs)	15	CMJ↑*, Dump jump↑,20m sprint↑, Handball special agility test↑	14	CMJ↑*, Dump jump↑,20m sprint↑, Handball special agility test↑	8	2
Young handball player (Male, 16-17yrs)	11	20m sprint↑**, Modified T agility test↑**, Modified Illinois agility test↑**, Squat jump↑*, CMJ↑**, Five level jump test↑, Repeated sprint ability↑*, Static balance↑**, Dynamic balance↑*	10	20m sprint↑**, Modified T agility test↑**, Modified Illinois agility test↑**, Squat jump↑*, CMJ↑**, Five level jump test↑, Repeated sprint ability↑*, Static balance↑**, Dynamic balance↑*	7	3
Football player (Male, 21-28yrs)	19	CMJ↑*, Squat jump↑*,20m sprint↑, Muscle soreness↓*	18	CMJ↑*, Squat jump↑*,20m sprint↑, Muscle soreness↓*	4	3
Young basketball players (Male, 17-18yrs)	6	Standing long jump distance ↑, CMJ↑, T agility test↑,30m sprint↑	6	Standing long jump distance↑, ↑CMJ , T agility test , 30m sprint↑	6	3
Healthy adults (Male, 19-21yrs)	8	CMJ↑*, Standing long jump distance↑,20m sprint↑,40m sprint↑, T agility test↑**, Leg press 1RM↑*	8	CMJ↑*, Standing long jump distance↑,20m sprint↑,40m sprint↑, T agility test↑**, Leg press 1RM↑*	6	2
Healthy adults (Male, 22-25yrs)	8	CMJ↑*, After intervention, 24-hour CK↑*, LDH↑*, Mb↑*	8	CMJ↑*, After intervention, 24-hour CK↑*, LDH↑*, Mb↑*	6	3
Children (Female, 9-11yrs)	20	20m sprint↑, Squat jump↑, Standing long jump distance ↑, Maximum oxygen uptake ↑ Dynamic balance↑, T agility test↑	20	20m sprint↑, Squat jump↑, Standing long jump distance↑, Maximum oxygen uptake↑, Dynamic balance↑, T agility test ↑	4	2
Children (Male, 9-11yrs)	20	20m sprint↑, Squat jump↑, Standing long jump distance ↑, Maximum oxygen uptake↑, Dynamic balance↑, T agility test↑	20	20m sprint↑, Squat jump↑, Standing long jump distance↑, Maximum oxygen uptake↑, Dynamic balance↑, T agility test↑	4	2
Children (Male, 11-13yrs)	15	Squat jump↑*, CMJ↑**, Standing long jump distance ↑**, Standing triple jump ↑**,30m sprint↑**	15	Squat jump↑*, CMJ↑**, Standing long jump distance ↑**, Standing triple jump ↑**,30m sprint↑**	9	2

|= no change, ↑= increase, ↓= decrease, *=p<0.01, **=p<0.001, 1RM=one repetition maximum, CK= creatine kinase, LDH= lactate dehydrogenase, Mb= myoglobin

The Impact of Sand Training on Athletes' Agility and Balance

Agility refers to the ability to change the direction of body movement and is an integration of various physical qualities such as strength, reaction time, speed, explosive power, and coordination. Plyometric training (PT) can improve motor unit recruitment and neuromuscular control, thereby enhancing agility performance. Consequently, the muscle strength gained from PT on ST is expected to enhance agility. However, there is conflicting evidence regarding whether ST offers advantages over hard surfaces (HT).

The T-test and Illinois agility test are common methods for assessing agility. Hammami et al. (2020) conducted a 7-week study with adolescent male handball players, performing PT three times a week on ST. They found significant improvements in both the modified T-test and Illinois agility test scores compared to HT [13]. Conversely, other studies involving adult athletes have not demonstrated the superiority of ST over other surfaces [5, 28]. For example, Amrinder et al. (2014) randomly assigned 40 national hockey players to ST and HT groups and conducted a 4-week PT program, performed three times a week. They found no significant difference in Illinois agility test performance improvements between the ST group (17.31±1.85 to 18.15±1.94s) and the HT group (16.72±1.77 to 17.77±2.16s) [28].The discrepancies in these results may be due to variations in the participants, indicating a need for further research to determine the impact of ST on agility in different populations.

Muscle strength is a crucial factor affecting dynamic balance, and increasing muscle strength can effectively enhance dynamic balance ability [33]. Therefore, plyometric training on ST is an effective method for improving dynamic balance. Training on unstable surfaces induces greater skeletal muscle activation to maintain body stability[34]. Since knee joint strength is a predictor of dynamic balance[35], the improvement in muscle strength around the knee joint due to ST is a significant reason for the enhancement of dynamic balance.

The Star Excursion Balance Test (SEBT) is a convenient method to assess lower limb injury risk and dynamic balance ability in athletes. Binnie et al. measured the dynamic balance ability of female team sport athletes using the SEBT after an 8-week ST program and found that ST not only improved dynamic balance ability but also reduced the risk of lower limb injuries [8].

In summary, extensive research has demonstrated the positive effects of ST on both agility and balance abilities, although the magnitude of these effects varies.

The Impact of Sand Training on Athletes' Aerobic and Anaerobic Capacities

The body's energy metabolism system is closely related to athletic performance [36], and robust aerobic and anaerobic capacities are fundamental for many sports [37-39]. VO2max, heart rate, and Wingate peak power are important indicators of an athlete's aerobic and anaerobic capacities. Training intensity and volume are crucial factors influencing aerobic and anaerobic adaptations [40], with high-intensity training providing effective stimuli for both [41]. The high-intensity nature of ST is one reason for the improvement in endurance qualities following ST.

VO2max levels are influenced by the oxygen transport system, cardiac pumping function, and the ability of muscle tissue to utilize oxygen. Binnie found that compared to GT (44.1±4.1 ml·kg-1·min-1 increased to 47.0±4.1 ml·kg-1·min-1), ST resulted in a greater improvement in the relative VO2max of team sport athletes (44.4±3.4 ml·kg-1·min-1 increased to 48.6±2.9 ml·kg-1·min-1), with significant differences in absolute VO2max (L·min-1) between the two groups ($p=0.019$) [8]. The improvement in VO2max from ST may be due to enhanced cardiac pumping function. Binnie measured heart rate changes in athletes running at three different speeds (9 km/h, 11 km/h, 13 km/h) after 8 weeks of sand intervention. The study found that heart rates decreased at all three speeds, indicating that ST is an effective means of improving cardiorespiratory function [8].

Blood lactate is an indirect indicator of both anaerobic and aerobic capacities. Lower post-exercise blood lactate levels at the same training intensity suggest improved acid tolerance. Binnie et al. (2014) found that after an 8-week intervention, blood lactate levels in the ST group significantly decreased during repeated sprints (8×20m) from 6.5±2.3 mmol·L-1 to 4.1±1.5 mmol·L-1, indicating an enhanced ability to buffer blood lactate [8]. However, the improvement in anaerobic capacity from ST was smaller. Ahmadi et al. (2021) used the Wingate test to measure peak power as a reflection of anaerobic capacity and found that, compared to hard ground training (1.9%), the ST group showed a slightly larger improvement in anaerobic capacity (2.2%), but the difference was not significant [5].

In summary, ST is an effective means of increasing VO2max and improving cardiorespiratory function, but its impact on anaerobic capacity is not significantly different from that of hard surface training.

The Impact of Sand Training on Joint and Muscle Injuries

Joint and muscle injuries commonly occur during training practices. The training surface is a critical factor influencing sports injuries, with sand surfaces significantly reducing the risk of joint injuries compared to hard surfaces. The high stiffness of hard surfaces results in large ground reaction forces upon landing from jumps, which are a major cause of knee joint injuries. To mitigate joint injuries, individuals often adopt knee and hip flexion upon landing to cushion vertical ground reaction forces, but there remains a significant risk of knee joint injury with increasing jump height. Studies indicate that sand, as a softer surface, significantly reduces ground reaction forces upon landing compared to hard surfaces[3].

Muscle fiber damage often occurs post-strength training, characterized by reduced strength and joint range of motion, mitochondrial swelling, and increased levels of creatine kinase (CK) and myoglobin in the blood. Miyama et al. (2004) investigated muscle damage following consecutive jumps on different surfaces (sand vs. wood), finding that within 1-hour post-exercise, both surfaces did not cause excessive muscle soreness. However, 24 hours later, the wood surface training group exhibited significantly higher muscle soreness and CK levels compared to the sand training group[42]. This suggests that sand training is beneficial in alleviating immediate delayed-onset muscle soreness and muscle fiber damage.

Impellizzeri et al. assessed muscle soreness among soccer players using the Likert muscle soreness scale after 4 weeks of sand training. The average muscle soreness score in the sand group during the 4-week intervention was 2±1.1, while in the grass group, it was 2.5±1.6[13].

In conclusion, sand training effectively reduces joint stress upon landing, lowering the risk of joint injuries, and also reduces muscle fiber damage. Therefore, it is crucial for individuals with joint injuries and serves as a preferred training modality during the season to minimize muscle injuries.

Conclusion

Enhancing athletic performance while preventing injuries is a pressing need in the field of competitive sports. For individuals with joint or muscle injuries, appropriate training methods can promote recovery while preventing muscle strength deterioration. ST offers high energy expenditure, improved athletic performance, and injury prevention for joints and muscles, providing significant benefits for public fitness, competitive sports, and rehabilitation fields. ST effectively enhances muscle strength, agility, balance, and aerobic capacity while increasing energy expenditure, though it may negatively impact eccentric utilization. The primary mechanisms of ST include the extension of the eccentric and concentric phases, the prolongation of the eccentric-concentric transition phase, and the improvement of muscle fiber recruitment capacity.

Currently, research on ST primarily focuses on team sports, lacking application studies in other sports. In competitive sports, cyclic events require prolonged exercise, which may lead to joint and muscle injuries. Therefore, ST can be integrated into seasonal training schedules as an alternative to enhance athletic performance. Future research should more thoroughly consider its adaptive characteristics, combining the specific features and practical needs of various sports to explore ST training programs that are suitable for both specialized athletes and the general fitness population.

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EVALUATING SPRINTING SPEED IN VARIOUS DIRECTIONS

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Abstract
This study investigates maximal sprint speeds in forward, backward, and sideward directions among twelve local ranked male soccer players. Sprints were measured over 60 meters forward, and 40 meters each for backward and sideward, with speeds recorded using a radar system post a standardized warm-up; the sequence of trials was randomized. Results demonstrated significant speed disparities: forward sprinting was fastest at 29.89 ± 1.97 km/h, while both backward and sideward sprinting were considerably slower, both averaging 18.92 km/h, with standard deviations of 1.42 and 1.69 respectively. The findings underscore the unique kinematic and energetic demands of non-forward sprints, attributing the reduced speeds in backward and sideward movements to variations in stride frequency and length relative to forward sprints. These findings further emphasize the significance of recognizing these differences, allowing for the potential integration of such sprinting modalities into soccer training programs.

Keywords: *sideways, sideward, backward, lateral running, multidirectional*

Introduction

In soccer, players spend over half of their playing time moving in non-forward directions (Taylor et al., 2017). The ability to run fast in different directions is important in many team sports (Sheppard & Young, 2006). Traditionally, studies have extensively explored forward and backward sprinting, given their prevalence in gameplay (Taylor et al., 2017; Uthoff, Oliver, Cronin, Harrison, et al., 2018). Mainly, athletes sprint forwards, as it is the most efficient way of movement across the playing field, but other movement directions help players to meet their tactical tasks, as well as to be able to manage their energy levels during a game (Uthoff et al., 2021; Uthoff, Oliver, Cronin, Harrison, et al., 2018).

Studies that compared backward (BR) to forward (FW) sprinting, showed that only about seventy percent of forward sprinting speed can be achieved during BR gait (Arata, 1999; Wright & Weyand, 2001). Proposed explanation to this is in the fact that lower levels of ground reaction force can be produced during BR gait, which is determined by kinematical demands of such type of movement (Uthoff et al., 2021). BR gait is described as "soft landing-hard take-off" (Cavagna et al., 2011) indicating that BR is less efficient in utilizing elastic energy, relying more on the contractile properties of the motor units for movement (Uthoff, Oliver, Cronin, Winwood, et al., 2018). Lower speed during BR acceleration phases mainly results from diminished horizontal ground reaction forces, leading to shorter strides and lower flight times. Despite lower speed during BR, its unique energetic demands due to inefficient ground reaction force applications make it a valuable conditioning tool (Uthoff et al., 2021).

To the best of our knowledge, no studies have yet investigated sideward running at maximal speeds. Analysis of sideways walking reveals that it is metabolically more demanding and slower than forward walking, primarily due to the frequent starts and stops. (Handford & Srinivasan, 2014). It is also reported that sideways locomotion encompasses three distinct gait patterns that vary with speed and necessitates different biomechanical and metabolic demands, highlighting the need for tailored approaches in sports training and rehabilitation(Yamashita et al., 2013). Ground reaction forces during side stepping and cross-over stepping gaits are lower than in moderate running, suggesting a reduced risk of injury; however, their potential to cause muscular imbalances that could lead to overuse injuries requires further study (Kuntze et al., 2009). This study aims to investigate and compare the maximal running speeds in three different directions—forward, backward, and sideways—to better understand their implications in soccer.

Methods

Participants

Total of 12 male participants (age=21.4±3.2 yrs, height=179.6±8.4 cm, weight=74.2±9.1 kg) participated in the study. Inclusion criteria was set as follows: i) minimum of five years of experience in soccer (in field positions), ii) male sex. All participants were informed about the study and have provided signed informed consent. Study design followed Helsinki declaration recommendations. All participants are considered as tier 2 according to recent proposed participant classification framework (McKay et al., 2022).

Study design

The sprint speed was assessed in three different directions: (a) forward (60 m), (b) sideward (40 m), and (c) backward (40 m). The sequence of these sprints was randomized. All sprints were tested on the same day.

Participants began with a 15-minute standardized warm-up session. This included dynamic stretching, muscle activation exercises, and gradual accelerations across five levels of intensity, ranging from 50 to 90% of their individual maximum effort. The warm-up also covered all the directions tested later in the sprints. Each sprint type was repeated three times, with the fastest speed, measured in km/h, being recorded for analysis. The rest interval between repetitions was three minutes, consisting of passive standing or walking at speed less than 2 km/h.

A radar system (Stalker Pro, Applied Concepts Inc., Richardson, Texas, USA), mounted on a tripod at a height of 1 meter and located 2 meters behind the start line, was used to measure sprint speed. Participants started at an auditory signal, which also initiated the recording of sprint speed.

Results

The main results indicated significant differences in sprinting speeds among the various directions. As anticipated, the highest speed was recorded during forward sprinting (Figure 1), registering at 29.89 ± 1.97 km/h. Comparatively, both backward and sideward sprinting demonstrated significantly slower speeds, both at 18.92 km/h, with standard deviations of 1.42 and 1.69 respectively. Notably, significant differences were observed between forward and backward sprinting, as well as between forward and sideward sprinting, but no significant difference was found between backward and sideward sprinting.

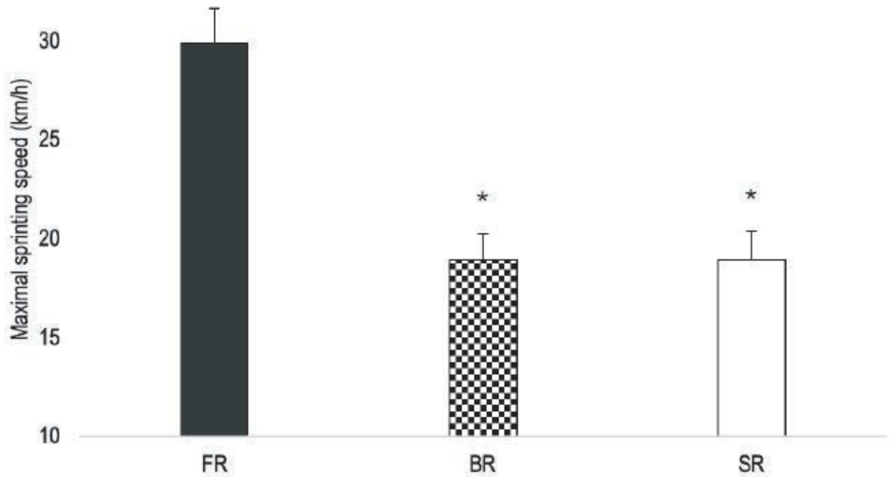

Figure 1. Sprinting speed in different directions
Legend: FR=frontal running; BR= backward running; SR=sideward running; * statistically significant differences ($p<0.05$) in comparison to FR.

Discussion

Sprinting speed during frontal running, as expected, is the highest when compared to backward and sideward sprinting (Figure 1). This aligns with findings from Arata (1999), which indicated that the top speed during backward running (BR) is approximately 70% of that during forward running (FR). Although these results are consistent with expectations, it is noteworthy that there is no significant difference in speed between backward and sideward sprinting. The kinematic determinants of BR gait differ significantly from those of sideward running. For example, running speed is affected by the interplay between stride length and stride frequency (Debaere et al., 2013), while the ability to generate substantial ground reaction forces during brief contact periods is characteristic of fast runners (Weyand et al., 2000).

Both backward and sideward sprinting possess distinct kinematic demands when compared to forward sprinting, especially concerning stride frequency and stride length. These differences are pivotal, as they influence the athlete's ability to generate significant ground reaction forces, which are vital for high sprinting speeds (Kuntze et al., 2009; Wright & Weyand, 2001). This variation in biomechanical requirements explains the observed differences in sprinting speed between the directions. For instance, during a sideward gait, the biomechanical roles assigned to the athlete's feet are notably different: the "front" foot is primarily responsible for producing greater vertical force, while the "trailing" foot focuses on developing more horizontal force, crucial for lateral movement (Kuntze et al., 2009). In contrast, the motion in backward running mirrors that of forward running to a greater extent; it is characterized by a more symmetrical use of the legs, which aligns closely with the natural mechanics of forward running, although the force dynamics and postural alignment differ (Wright & Weyand, 2001). This biomechanical symmetry might account for why backward running, despite its unique demands, can still utilize some of the efficient movement patterns seen in forward sprints.

However, these types of gait could be of interest in creating training programs as an novice or different movement modality. Future studies should investigate the relations of maximal sprinting and maximal aerobic speed in backward and sideward directions.

Conclusion
This study examined the differences in maximal sprinting speeds across three directions: forward, backward, and sideward. The results demonstrated that forward sprinting achieved the highest speeds, while backward and sideward sprints were significantly slower. Notably, this is the first study to analyze the specific differences between backward and sideward sprinting. Considering that this research was narrowly focused on a particular type of sideward movement, employing varied techniques such as the crossover step might lead to different outcomes. Furthermore, it is crucial to acknowledge that soccer players often transition from lateral movements to forward sprints during play. This dynamic underscores the importance of this research in deepening our understanding of the interplay between different running modalities. Such insights are invaluable for developing comprehensive training programs that incorporate a variety of movement strategies to enhance athletic performance.

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INJURIES SURVEILLANCE IN CZECH YOUTH FOOTBALL: A 23-WEEK EXAMINATION WITH U-19 AND U-18 PLAYERS

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Abstract
This aimed to describe the characteristics of injuries sustained by youth football players from a professional team in the Czech Republic, considering the context, type, location and severity throughout the 23-week football season. Thirty-three male players from U-19 (n=19) and U-18 belonging to a football club were monitored during the 23-week season in 2023. Information regarding injury context (match or training), type, location and severity (slight, minimal, mild, moderate or severe) was collected by an injury form, at the end of week 23. The prevalence of injuries among the players were 64% (n=21), (U-19 n=11; U-18 n=10). In U-19, 64% of cases of injuries occurred during the matches and for U-18, 80% occurred during the training sessions; The knee (24%) and ankle (29%) were the locations more frequent for the injured. The type of injury most frequent in U-19 was nerve injury (30%) and in U-18 was muscle rupture/ strain/ tear/ cramps (40%). Among the players, 43% of cases were classified as severe injuries (U-19 n=5; U-18 n=4). In conclusion, the study reveals a concerning prevalence of injuries among youth football players from a professional team in the Czech Republic. The findings highlight a significant proportion of severe injuries, with the knee and ankle being the most frequently affected locations. Additionally, there are notable differences in the context and types of injuries between the U-19 and U-18 age groups, indicating potential variations in injury patterns based on age categories.

Keywords: *injury; severity; soccer; classification; incidence.*

Introduction

Injury in football is a pressing issue that requires strategies to address both the physical well-being of players and the financial costs incurred by football clubs (Vasileiadis, 2020). Understanding the incidence, type and location of injuries is imperative to implement effective preventative measures and rehabilitation protocols(Ekstrand, 2016). Each injury type, whether it be muscle strains, ligament sprains or fractures, carries its own set of challenges and considerations impacting return-to-play timelines. Similarly, recognizing the specific anatomical sites prone to injuries, such as the knees and ankles, allows for targeted prevention efforts. The implementation of a comprehensive injury prevention program in football is crucial to reduce the incidence and severity of injuries. By gathering data on injury patterns and risk factors, developing targeted training programs, and implementing proper rehabilitation protocols, football clubs can minimize the impact of injuries (Walls et al., 2016; Ekstrand, 2026, Vasileiadis, 2020).

Consequently, it is essential for football coaches and staff related to the team, to be aware of the most common injuries recurrent in our team, and to tailor a specific and effective strategy for injury prevention and management. Preventing and managing injuries in football is crucial, especially for junior players who are transitioning to adult and professional teams. Injury in this category could lead to a career-ending or postponement, considering the severity of such injuries (Porter, 1999; Koutures et al., 2010). Therefore, this study aims to describe the prevalence of injuries sustained by junior players belonging to a professional team in the Czech Republic, considering factors such as the severity, context and player category over the course of the 23-week football season.

Methods

Participants

Thirty-five Czech male football players belonging to the U-18 and U-19 professional teams were monitored during a 23-week season in 2023. The inclusion criteria were to enroll in training and matches during the season and answer the injury form after the end of 23 weeks. Two players were excluded due to not answering the form. The study is part of a major project, approved by the Ethics Committee (EKV-2022-054) hosted by a University in the Czech Republic.

Study Design

Players from a professional team from the Czech Republic were followed during the training and matches. The 23 weeks comprehended January to June of 2023. Week one and two were preparatory for the matches, the following weeks included 3-4 weekly training sessions and one match during the weekends. After the season, the players answered an injury form.

Injury Report

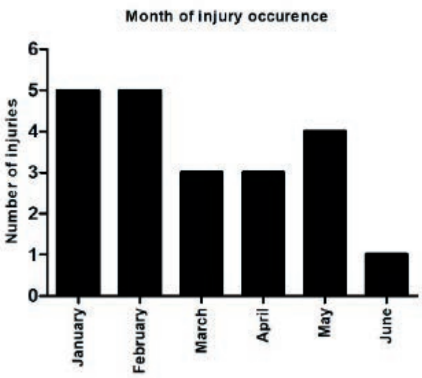
Information about the occurrence of injuries during the season was taken using the injury consensus statement in studies of football, from the study of Fuller et al (2006). The form includes the date of the injury, whether the injury was sustained during training or a match, the date of the player's return to full participation and the nature of the injury (location, type, side injured, recurrence). The severity of the injury was classified according with days out of activity, namely: slight (0 day); minimal (1–3 days); mild (4–7 days), moderate (8–28 days), severe (>28 days).

Statistical Analysis

Due to the nature of the study, data were displayed via descriptive analysis was performed using central tendency (mean) and dispersion (standard deviation) as well as the absolute and relative frequency. Procedures were carried out using the statistical packages JAMOVI and GraphPad.

Results

From a total of 33 players (U-19 n=19; U-18 n=14), the occurrence of injury was 64% (n=21). When separated by category, in U-19 the occurrence was 58% (n=11) and in U-18 was 71% (n=10). Figure 1 describes the month of the occurrence of the injury and the severity. It was possible to notice that the majority of the injuries occurred at the beginning of the season, in January and February. Moreover, most of the injuries (43%) were classified as severe (U-19 n=5; U-18 n=4).



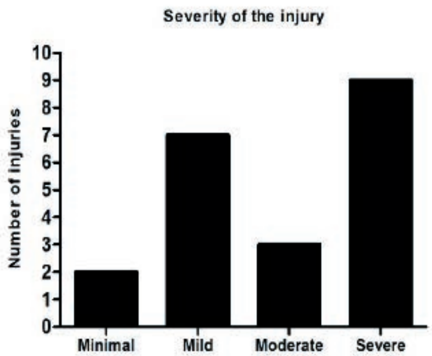


Figure 1. Trend of injury occurrence and severity throughout the football season in both categories (n=21).

In the context of the injuries, for the U-19, 64% (n=7) occurred during the matches, and for U-18, 80% (n=8) occurred during the training. Table 1 presents the location and type of injury, separated by categories. The knee (24%) and ankle (29%) were the locations more frequent for the injury. Sprain/ligament was the type of injury most frequent between the categories. U-19 nerve injury (30%) and U-18 muscle rupture/ strain/ tear/ cramps (40%).

Table 1. Injury location and type of injury throughout the football season, separated by the categories, described relative and absolute frequency.

	Category			Category	
Location of the injury	U-19 (n=11)	U-18 (n=10)	Type of the injury	U-19 (n=10)	U-18 (n=10)
Knee	18% (n=2)	30% (n=3)	Lesion of meniscus or cartilage	10% (n=1)	10% (n=1)
Ankle	27% (n=3)	30% (n=3)	Sprain/ligament	20% (n=2)	30% (n=3)
Hip/groin	9% (n=1)	20% (n=2)	Tendon/rupture/tendinosis/bursitis	10% (n=1)	10% (n=1)
Low back/ sacrum/ pelvis	18% (n=2)	20% (n=2)	Muscle rupture/ strain/ tear/ cramps	10% (n=1)	40% (n=4)
Lower leg/ Achilles tendon	18% (n=2)	0	Nerve injury	30% (n=3)	0
Foot/toe	9% (n=1)	0	Bruise	20% (n=2)	0
			Other bone injury	0	10% (n=1)

Discussion

The primary objective of this study was to investigate the injuries sustained by U-19 and U-18 players considering the context, type, location and severity throughout the 23-week football season. The main findings demonstrated that: i) prevalence of injuries among the players was 64% (n=21); ii) 64% of cases of injuries occurred during the matches in U-19 and 80% occurred during the training sessions in U-18; iii) knee (24%) and ankle (29%) were the locations more frequent for the injured; iv) type of injury most frequent in U-19 was nerve injury (30%) and in U-18 was muscle rupture/ strain/ tear/ cramps (40%); lastly, v) 43% of cases were classified as severe injuries (U-19 n=5; U-18 n=4).

The injury rates in youth football players have been demonstrated to be higher than in other contact sports (Koutures et al., 2010). Recently, a review pointed out that at least every third player sustains an injury during a football season (Wik, 2022). In the present study the prevalence was 64% during a 23-week season, which is in line with previous literature reported that injury rates among youth footballers can range from 50% to 91% in the U-18 to U-21 age groups (Jones et al., 2019). Regarding the context of the injury, the results were different considering the categories, in which for the U-19, 64% of cases of injuries occurred during the matches on the other and, for U-18, 80% occurred during the training sessions. A previous study supports these results, reporting that injury incidence increased during the matches and decreased during training according to the player will progress in age (Ergun et al., 2013).

Concerning the type, location and severity of the injuries, the findings in the current study are in agreement with previous literature. The ankle, knee and hip/groin are the parts injured more often by youth players (Kolstrup et al., 2016; Wik, 2022). Similarly was found in the youth players in the study, 24% of knee injuries and 29% of ankle. Moreover, some has been found that the most common injuries are classified as mild, with contusions being the most prevalent type (Stuart et al., 2002; Gall et al., 2006), however, a literature review demonstrated a significant proportion of injuries are severe, with muscle strain presenting a large portion (Jones et al., 2019). Severe injuries, classified in our study as more than 28 days off football practice, were found in 43% of cases, and muscle strain also presented a percentage (40%), especially in the U-18 category. The major limitations of this study include the investigation of a specific football team during a 23-week season and the injury form answered at the end of the season. The investigation of a specific team reduces the sample size and limits the extrapolation of the findings. Therefore, caution is necessary when interpreting the results considering U-19 and U-18 players from the Czech Republic. Also, a longitudinal investigation, over more seasons could generate more comprehensive information about the topic, helping to understand the dynamic of injury surveillance in youth players.

Conclusion

In conclusion, the study reveals a concerning prevalence of injuries among junior football players from a professional team in the Czech Republic, particularly during the early stages of the 23-week football season. The findings highlight a significant proportion of severe injuries, with the knee and ankle being the most frequently affected locations. Additionally, there are notable differences in injury types between the Under-19 and Under-18 age groups, indicating potential variations in injury patterns based on age categories.

These findings play a key role in understanding the importance of injury prevention strategies tailored to the specific needs of junior football players. Implementing targeted conditioning programs, focusing on strengthening vulnerable areas such as the knee and ankle, may help mitigate injury risk. Furthermore, enhancing injury surveillance protocols and providing timely medical intervention and rehabilitation could contribute to reducing the incidence and severity of injuries among junior football players.

For future studies, it is recommended to explore the underlying factors contributing to the observed injury patterns, including training intensity and individual player characteristics. Longitudinal studies tracking players over multiple seasons could provide important insights into injury trends and risk factors over time. Additionally, investigating the effectiveness of preventive interventions, such as neuromuscular training programs, could further inform evidence-based strategies for reducing injury rates in junior football players.

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THE INFLUENCE OF DIFFERENT COMPLEXITY COGNITIVE TESTS ON CHANGES IN REACTION SPEED TO VISUAL STIMULI IN BASKETBALL

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Abstract
In basketball as an open skill sport, directing attention and focus is extremely important, i.e., it is important for a player to select key factors from the environment that will then determine the response in the form of motor action. Obtaining information about reactive agility is extremely complex due to the need to react to stimuli in contrast to already preplanned movements of changing direction. The role of cognitive components related to decision-making during the game, which also include visual scanning, anticipation, and recognition of certain patterns, is increasing. The main aim of this research is to determine whether a specific motor task, in this case dribbling the ball, affects player performance in a reactive agility test at three levels of complexity. The sample of participants consists of Faculty of Kinesiology students who have successfully finished the mandatory course of Basketball. The methodology used in this research emphasizes the importance of implementing different variations of unpredictable visual stimuli to improve cognitive components of player decision-making in specific situational conditions For testing purposes in this research, three variations of a reaction agility test were performed using Witty SEM system (Microgate). Final result for each tested variation, without the ball and while dribbling the ball, was the best total reaction time after three trials. A two-factor ANOVA was performed, and a statistically significant difference was determined between the various levels of test complexity, as well as between the test results depending on whether it was conducted with or without dribbling the ball ($p<0.001$). It can be concluded that in the second and third variation (level of complexity) of the test the participants had issues with recognizing the correct stimuli, which in turn resulted in a slower reaction. In the first variation (level of complexity) of the test the results were significantly faster when compared to other two variations ($p<0.001$).

Keywords: *reactive agility, basketball, witty SEM*

Introduction

The requirements of modern sports are continuously changing, and expectations from athletes are becoming higher, which is why there is a growing need for continuous monitoring of their development (Till et al., 2022). With regard to the aforementioned, it is necessary to continuously create and update tests and protocols applied in sports diagnostics (Mackala et al., 2023). Also, in order to obtain real information about the athlete's performance, it is important to focus on diagnostic procedures that simulate specific situational conditions of a specific sport. For example, within so-called invasive sports, changes of direction are often performed, and the athlete is required to continuously respond to various stimuli from the environment, which can in turn relate to the movement of teammates, opponents, or the ball (Young et al., 2015). Invasive team sports are those such as in where two teams moving in opposite directions seek to advance forward into their opponent's territory to score. Also, decision making in invasive team sports is complex given the number of players on the field and the unpredictable way that patterns of play evolve (Janssen et al., 2023). In particular, basketball is certainly an example of such a sport, as reactive agility is one of the key factors of an athlete's performance (Scanlan et al., 2013). A large number of diagnostic procedures in basketball refer to defining the performance level of various agility tests, especially in more complex situational conditions that include dribbling the ball (Sisic et al., 2016). In order to determine an athlete's level of reactive agility, the applied testing protocols must contain some external stimuli that will then "load" the player's visual system and visual scanning abilities in general, as well as anticipation and decision-making abilities (Scanlan et al., 2013). Concretely, reactive agility is one of the main characteristics of open skill sports. Open skill sports are defined as those in which players are required to react in a dynamically changing, unpredictable and externally paced environment (Wang et al., 2013). Thus, in basketball as an open skill sport, directing attention and focus is extremely important, i.e., it is important for a player to select key factors from the environment that will then determine the response in the form of motor action. Unhindered scanning of information must be at a high level, considering that the player is simultaneously handling and dribbling the ball while also moving on the court. For that reason, the inclusion of cognitive-motor training in the training process could be important. The aforementioned type of training refers to the combination of physical and cognitive components within a particular task or exercise, and it is believed that this will have a greater impact on the athlete's overall performance than when he exclusively conducts physical training (Lucia et al., 2022).

Obtaining information about reactive agility is extremely complex due to the need to react to stimuli in contrast to already predefined and preplanned movements of changing direction. Today, in research and in general testing protocols, light devices which direct the athlete's movement in a certain direction are often used. Also, the complexity and requirements of such tests can be changed in order to influence the development of the athlete's stimuli perception and giving an appropriate and timely response (Oliver et al., 2009; Lockie et al., 2014). The speed of execution of various technical, but also technical-tactical elements in basketball is extremely important and it is necessary to optimize the athlete's performance. Precisely because of this, according to Przednowek et al. (2019), it is necessary to develop interconnection between the development level of hand and foot reaction time in relation to visual and spatiotemporal perceptions. In basketball, this is extremely emphasized due to the continuous and dynamic changing of the scenario during the game and numerous actions and changes of movements that happen every 1-2 seconds (Scanlan et al., 2014). Studies in the field of teams sports have identified that vision plays a major role in human perceptual ability (Wu et al., 2013., Schumacher et al., 2019). This is highlighted in basketball where optimization of the motor potential of each player within the team is certainly defined by peripheral vision, hand reaction time, but also by their sports experience and the degree of development of motor skills and abilities (Schumacher et al., 2019; Twa, 2021). The role of cognitive components related to decision-making during the game, which also include visual scanning, anticipation and recognition of certain patterns, is increasing, and nowadays more attention is given in the training process to tasks that require its involvement (Hornikova, 2022).

With regard to the aforementioned, the aim of this research is to determine whether a specific motor task, in this case (dribbling the ball), could affects the performance in a reactive agility test at three levels of complexity.

Methods

Participants

The sample of participants consists of students from the Faculty of Kinesiology University of Zagreb (21.25±1.53 years, 173.63±11.49 cm, 71.89±15.91 kg), who have successfully finished the mandatory course of Basketball. All participants were informed about the objectives of the research and based on the information received about the research, signed their consent to participate. Ethics Committee of the Faculty of Kinesiology, University of Zagreb (Croatia) approved the study (13/2024), which was performed following the ethical standards of the Declaration of Helsinki.

Testing protocol

For testing purposes in this research, three variations of a reaction agility test (of different complexity) were performed: 1) reaction to green colour only, 2) reaction to the small green letter 'c' that appeared in a multitude of symbols of other colours, and 3) reaction to the small green letter 'c' that appeared in a multitude of green symbols.

The participants were standing in the middle of the square bounded by four Witty SEM cells and, on the signal of the measurer, started the test. The participants were required to react as fast as possible with the dominant or non-dominant hand to the cells which lit up with the required colour or symbol. The same was repeated when the participants simultaneously dribbled the basketball. Each variation of the test consisted of 10 visual reactions, and the visual stimuli were generated immediately after each response. The final result for each tested variation, without the ball and while dribbling the ball, was the best total reaction time after three trials. The recovery time between each trial was 2 minutes.

The Witty SEM diagnostic system (Microgate , Bolzano, Italy) used in this study included four indicators which were placed in the form of a square, with a 5-meter distance among them. Through previous research, various ways of applying SEM indicators in sports have been presented (Kolodziej et al., 2018; Dugdale et al., 2020; Hornikova et al., 2021).

Statistical analysis

Basic descriptive parameters for all measured variables were calculated. A two-factor ANOVA was used to determine the difference in the results achieved during the performance of the test at three levels of complexity, in the version without the ball and while dribbling the ball. Also, the Tukey's post-hoc test was used for determining the differences between the tested interactions of the factors. The results were considered significant when $p<0.05$. Statistical package Statistica version 13.5.0.17 (TIBCO Software Inc., Palo Alto, CA, USA) was used for data analysis.

RESULTS

Table 1. Descriptive parameters of achieved results.

FACTORS		N	x	Min	Max	SD
no ball	condition 1	96	19.494	16.550	22.840	1.334
	condition 2	96	20.986	18.230	24.180	1.358
	condition 3	96	21.014	17.470	25.610	1.667
ball	condition 1	96	21.446	18.050	26.150	1.905
	condition 2	96	22.638	18.120	29.290	1.781
	condition 3	96	23.009	19.210	29.220	1.994

Legend: condition 1 - reaction to green colour only, condition 2 - reaction to the small green letter 'c' that appeared in a multitude of symbols of other colours, condition 3 - reaction to the small green letter 'c' that appeared in a multitude of green symbols

In Table 1, the basic results of descriptive statistics are presented for each variation of the test, without the ball and while dribbling the ball. The fastest mean result was achieved in the simplest test in the version without the ball (x=19.494), while the slowest mean reaction time was recorded in the third, most complex level of conducting the test, in the version when the test was performed while dribbling the ball (x=23.009).

A two-factor ANOVA was performed, and it was determined that there is a statistically significant difference between the various levels of test complexity, as well as between the results when the tests were conducted with or without dribbling the ball ($p<0.001$). Based on the aforementioned, the Tukey post-hoc test was conducted to determine the exact differences between certain factor interactions (Table 2).

Table 2. Results of Tukey post-hoc test when observing interactions of two factors.

INTERACTION	BALL	CONDITION	{1}	{2}	{3}	{4}	{5}	{6}
1	1	1		<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2	1	2	<0.001*		1.000	0.411	<0.001*	<0.001*
3	1	3	<0.001*	1.000		0.485	<0.001*	<0.001*
4	2	1	<0.001*	0.411	0.485		<0.001*	<0.001*
5	2	2	<0.001*	<0.001*	<0.001*	<0.001*		0.650
6	2	3	<0.001*	<0.001*	<0.001*	<0.001*	0.650	

Legend: *p<0.05; ball 1 - without the ball, ball 2 - dribbling the ball, condition 1 - reaction to green colour only, condition 2 - reaction to the small green letter 'c' that appeared in a multitude of symbols of other colours, condition 3 - reaction to the small green letter 'c' that appeared in a multitude of green symbols

Based on the results presented in Table 2, it can be concluded that there are differences among individual factor interactions, which for example refers to a statistically significant difference between interactions 1 and 4, 2 and 5, and 3 and 6, that is, between the performed versions of the tests without the ball and while dribbling the ball at all 3 levels of complexity in performing the reaction agility test ($p<0.001$). Also, the difference was statistically significant when observing the first variation in relation to the second or third variation of performing the test, regardless of whether it was performed without the ball or while dribbling the ball ($p<0.001$). However, it is noticeable that there was no difference when separately comparing the second and third variation of performing the test, also regardless of whether the tests were performed without the ball ($p=1.000$) or while dribbling the ball ($p=0.560$).

Discussion

The main aim of this research was to determine whether a specific motor task, in this case dribbling the ball, could affect the performance in a reactive agility test at three levels of complexity. Based on the results, it can be concluded that there are differences between the performed versions of the tests without the ball and while dribbling the ball at all 3 levels of complexity in performing the reaction agility test ($p<0.001$). Reactive agility tests include basic and specific tasks for assessing the athlete's performance. This research used visual stimuli from LED lights that show different colours, numbers and letters. Reactive agility refers to the quick reaction and change of direction while tracking visual stimuli. The main goal of the activity is to try and imitate situational conditions during a basketball game.

While performing the test, the player primarily needs to have a good perception of where the right stimulation is and then has to make a quality decision on where and how to move toward the light. Based on this the player finally executes the movement, i.e . performs a motor action (Janssen et al., 2023). Two main movement activities in the three variations of assessing reaction agility were observed in this research. The participants demonstrated the best performance in the test performed in the first variation without dribbling the ball was 19.49 sec. The testing time was progressively prolonged as the variations were more complex and when the ball was included in the activity. The ball dribbling activity led to an increased time by 2 sec per each test variation. As the participants were not highly trained basketball players, this can be adhered to the lack of basketball specific dribbling knowledge, which is also the main limitation of this research. Nevertheless, the importance of observing reactive agility in specific conditions is highlighted by Scanlan et al. (2013). They concluded that response time ($r=0.76$) and decision-making time ($r=0.58$) had high to very high correlation to reactive agility time. Also, findings by Horicka & Simonek (2019) suggest that change of direction and reactive agility are two different and independent skills. In addition, they also state that as the complexity of the agility exercise increases, simultaneously the share of agility motor predictors decreases, while the share of mental cognitive abilities increases (Horicka & Simonek, 2019). Furthermore, Hornikova et al., (2021) used the Witty SEM system and concluded that reactive agility test results are primarily determined by reactive strength and the change of direction speed. Hassan et al., (2022), observed the influence of reactive agility training in basketball and determined an increased speed of visual reaction and improved dribbling skills by 19%. Together, these studies highlight the important role of reactive agility and its training in enhancing athletic performance.

In basketball, the action of the defensive player directly affects the reaction of the offensive player, and the overall success of the offense often depends on the timely and appropriate response and motor action of the offensive player. The same is in the reverse situation, the action of the offensive player requires an appropriate reaction of the defensive player in order to stop offensive penetration and scoring (Li et al., 2021). In order to influence the player's motor reaction ability depending on the specifics of the situation during the game, it is necessary to apply various simple and more complex tasks in the training process, which will ultimately improve the player's performance during the basketball game.

This research proves that the use of reactive lights can be used both for testing and in the training process, as both of the mentioned activities improve physical, visual, and motor skill capabilities. It is very important to progressively incorporate unplanned agility tasks in specific conditions, such as dribbling the ball while changing direction and reacting to different visual stimuli, as it has been proved this enhances athletes' situational performance.

The tests performed for the purpose of this research were conducted in the same form by using four sensors at an identical distance, with the only difference in the visual stimulus to which it was necessary to react. It can be concluded that in the second and third variation (level of complexity) of the test the participants had issues with recognizing the correct stimuli, which resulted in a slower reaction and overall performance. The first stimuli that was performed both without the ball and while dribbling the ball was only the colour green, which represented the easiest cognitive stimulus, and where the results were significantly faster when compared to the other two variation ($p<0.001$). The performed test and variations were very demanding for the participants as they included cognitive factors, such as recognition and decision, as well as motor abilities, such as reaction speed and agility.

Conclusion

The results of this research show that the fastest test results were accomplished where the participants needed to react to only one simple stimulus, without showing different symbols on other sensors. Upon implementing the activity of dribbling the basketball, an identical trend in the test results was determined as when the tests were performed without the ball. The methodology used in this research emphasizes the importance of implementing different variations of unpredictable visual stimuli to improve cognitive components of player decision-making in specific situational conditions. The application of such test protocols in the training process certainly has a significant impact on player performance in the basketball game, which refers to increased skills in terms of giving an adequate motor response and reaction depending on the situation in the game. In future studies, it would be interesting to incorporate and compare respondents with different levels of basketball playing experience, as well as to determine the differences between male and female players to get a clear insight into the possible differences of the gained results. Also, it is necessary to continue working on the creation of similar measurement protocols which could be included in the training process with the aim of improving the athlete's performance.

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RELATION BETWEEN UPPER BODY FORCE - VELOCITY PROFILE AND HANDBALL THROW VELOCITY

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Abstract
Upper body force-velocity profile is a type of diagnostics used to determine various deficiencies in an athlete's development and, therefore, used to form high-quality explosiveness training. This paper aimed to determine the relation of upper body force-velocity profile and handball throwing velocity from a 7m throw and a throw with a three-step run-up. Previous studies on this topic showed a significant correlation between handball and volleyball players' upper body force-velocity profile and sport-specific movement of throwing and hitting. In this research, 14 active handball players, all University of Zagreb students, were included, whose upper body force-velocity profiles were examined using bench press exercise during which the velocity of the bar was measured; after that, the handball throw velocity was also measured using a radar gun. Statistical analysis showed no statistically significant correlation between the upper body force profile and the handball throw velocity during the standing 7-meter throw and the throw with a run-up.

Keywords: *explosiveness, correlation, power, team sport, diagnostics*

Introduction
A common doubt within handball and strength and conditioning coaches is whether to use high maximal and submaximal efforts and, in that way, develop more successful force production, or to use smaller loads and develop faster movement. One of the ways to solve this problem is using the force-velocity profile test and measuring velocity of different movements during training itself. Force – velocity profiling represents a way to discover whether a player has deficits in force development or velocity during an explosive movement. Force/velocity profiling is based on a fact that two athletes can have identical power outputs in a single movement, but that power output can be formed of different force and velocity ratios as main parts of power which of course has direct implications on performance of explosive movements such as jumps, sprints and throws. (Samozino et al., 2012)

Lower body force/velocity profiles measured using different jumping methods were more often used and measured in many scientific papers (Jiménez-Reyes et al., 2017; Samozino et al., 2014)

On the other side upper body force velocity profile is less used in everyday coaching practice and in scientific papers. Different methods were used for measuring the upper body force velocity profile, one of which is using an accelerometer while others even used an adjusted cycling ergometer for this cause. (Chelly et al., 2010)
Rahmani et al. (2018) were investigating the efficiency of the ballistic bench press in measuring the upper body force velocity profile using an alternative calculating method with upper body mass, barbell flight height and push-off distance, which was compared to the results gathered using an accelerometer as a gold standard for measuring force, power, and velocity. Results shown a great reliability in repeated measurements, and high validity as strong correlations with the "gold standard" were shown. In this research Gyko Accelerometer was used, which has proved reliability and validity. (Jorge et al., 2019)

García-Ramos et al. (2016) analysed the differences between the traditional and ballistic bench press concerning force and velocity variables. Both types of bench press showed great corelation and linear relation. Results of this study have shown that both the traditional as well as ballistic bench press can be equally used to assess the upper body force velocity profile.
Handball throw velocity was investigated in women and men handball players on different levels of competition and in different types of execution – with or without run up, standing or jump shot. Research has shown a significant correlation in throw precision despite the throw type, on the other side concerning throw velocity, three step run up showed highest velocity. (Wagner et al., 2011)

Force – velocity values of the upper body were already related in recent studies. Study from Chelly et al. (2010) related power (which is composed of force and velocity) , strength and muscle volume of the upper and lower body muscles with the handball throw in handball players, and it shown great correlation of force-velocity variables of both the upper and lower body and the handball throw. But studies weren't done only on handball players, but also on volleyball players where force-velocity values showed great correlation to volleyball spike and serve. (Baena-Raya et al., 2021)

The goal of this paper is to determine which upper body force-velocity profile shows the greatest correlation to handball throw velocity in standing handball shot and three step run up standing shot.

First hypothesis is that the force-velocity profile which show better velocity capabilities will show a higher correlation to handball throw velocity.

Second hypothesis is that the force-velocity profile which show better force capabilities will show a higher correlation to handball throw velocity.

Methods

Subjects

Fourteen University of Zagreb students (age = 22,6   1,9; h=181,7   6,23 m; m = 82,5   7,54 kg), volunteered to participate in this study. All participants are active handball players in Croatia on different levels of competition. All of them had at least one handball practice and one match a week during the handball season. This research procedure was approved by the Ethics Committee of the Faculty of Kinesiology University of Zagreb and conformed to the recommendations of the Declaration of Helsinki.

Experimental procedure

Research was conducted in two parts. In the first part of the research the upper body force- velocity profile was measured using the bench press exercise in a way that we first estimated one repetitio maximum (1RM) in the bench press exercise. Before testing all participant completed a set of warm-up exercises to mobilise, activate and prepare the neuromuscular system to preform and avoid injury. Next part of testing comprised of a standardised 1RM testing procedure in which the subjects incrementally increased the lifting weight until the maximum weight that the subject could lift was reached. Creating the upper body force velocity profile of every subject was performed such that the bench press exercise was executed explosively for three repetitions on 30, 40, 50, 60 and 70% of the previously estimated 1RM and the velocity of the bar was measured using a Gyko accelerometer device. Between every set of repetitions subjects had 2 minutes rest.
Second part of testing included measuring the handball throw velocity, with a Stalk 2 Radar Gun. Handball throw velocity was measured from a standing handball shot, and from a three-step run up. In both types of shot, subjects performed three shots, all of them were recorded, and the highest one was taken in consideration for analysis. Between these two parts of testing, there was at least one rest day for complete recovery.

Statistical analysis

All recorded data was inserted in an excel sheet and then later analysed in the "Statistica" program for statistical analysis. First part of analysis was gathering descriptive data of all values and determining the normality of distribution. Velocity data gained from the measurements of the bar velocity of every subject was compressed in one number using the mean value of velocities on every percentage of 1RM value. To get a central value to be used to discriminate subjects into group "velocity" or "force", median value was used. Last step was using Pearson coefficient of correlation to put into relation groups with force or velocity with the velocities of the handball throw.

Results

Descriptive analysis shows that handball shot velocity was higher after a three-step run up throw (v9m) (83,02   4,58km/h), than from a standing 7-meter throw (v7m) (75,97   3,99km/h). Bar velocity (vbp) measurements showed the highest speeds on the lowest load on the bar (1,34   0,25 m/s) and the lowest speed on the biggest load. (0,69   0,29 m/s)
Results of the Pearson correlation analysis didn't show statistically significant correlations between the force-velocity profiles and the standing 7m shot ($r = -0,20$, $p = 0,48$), nor the three-step run up ($r=0,05$, $p=0,99$). Only statically significant correlations were found between the velocities of the 7-meter standing throw and the three step run up ($r=0,80$, $p=0,001$). All measured variables showed a normal distribution using the Kolmogorov-Smirnov test. (vbp, $p= 0,31$; v7m $p= 0,73$; v9m, $p=0,4$)

Discussion

The goal of this paper was to determine relation between the upper body force-velocity profile in handball players and the velocity of the handball throw from a standing shot and a three-step run up.

Determining the force – velocity profile is a well-known diagnostic tool for directing and correcting the training process especially for developing explosive capabilities of an athlete. Using force velocity profiling can contribute exactly to that. Recent studies have mostly been investigating lower body force velocity profiling and ways of measuring it, mostly using different types of jumps, but upper body force velocity profiling mostly aimed at different types of throwing wasn't used in so many recent studies. (Jiménez-Reyes et al., 2017; Samozino et al., 2012, 2014) This paper is one of few concerning exactly the upper body force-velocity profiling and its relation to handball throwing capabilities.

In this study we used the traditional bench press exercise to determine the upper body force-velocity capabilities. Studies up to now have used various ways to determine this force velocity relationship, from the ballistic bench press to an adapted cycling ergometer for upper body. García-Ramos et al. (2016) study showed that both the traditional and ballistic variations of the bench press exercise were valid and reliable for this kind of experiment. Traditional bench press was used in this study because of added security benefit for the subject.

Accelerometer “Gyko” was used to gather velocity data during this experiment, and although it showed reliable and valid comparing to other devices in recent studies (Jorge et al., 2019), it has shown some flaws during the measuring process, because in some cases it failed to record the velocity of single reps, which could have also impacted the study results.

Chelly et al. (2010) study had the most similar experimental design was the one from, where the relation of power, strength and muscle volume of the upper and lower body muscles with the handball throw was investigated, and it shown great correlation of force-velocity variables of both the upper and lower body and the handball throw. Previous research was done also on volleyball players where force- velocity values showed great correlation to volleyball spike and serve.(Baena-Raya et al., 2021) On the other side, in this study no correlation was found between the force - velocity profile values and the handball throw, even more a negative, but not statistically significant correlation was found between the standing shot and the force – velocity measures.

Only statistically valid correlation was noticed between the velocity of the standing 7 meter and three step run-up handball throws, which was also shown in recent studies that handball players with higher velocity in a standing shot will show a higher velocity in a standing shot (Wagner et al., 2011)

There are many possible reasons why no correlation was found in this study. One of them can be found in a lack of experience in explosive execution of the bench press within the subjects, with greater experience we could have gotten better differentiation between subjects and consequently better results. Second reason could be that up to now in studies we don’t have data on how an optimal upper body force- velocity profile should be formed and because of that we didn’t have an optimal profile to compare the individual profiles of the subjects and divide them into force or velocity groups. Having an optimal profile would help in that process and maybe give us a more precise picture of the two different groups of subjects, further research should be pointed towards forming the optimal upper body force velocity profile.

Considering the given results, we can say that neither the first nor the second hypothesis was confirmed in this study.

Conclusion

Handball throw is one of the key elements of the handball game which directly effects the efficiency of a player in a handball game, and upper body explosiveness is crucial for successful execution of the handball throw. There are many ways to improve upper body muscle power and explosiveness and handball throwing ability. One useful way to direct and control the development of upper body explosive capabilities is by using the force velocity profiling.

The goal of this paper was to determine the correlation between the upper body force velocity profiles and standing 7 meter and three step run up handball throw. After gathering the data, the statistical analysis was conducted.

Results of the analysis didn’t show statistically significant correlation between the force-velocity profile values and the handball throw velocities. Recent studies have shown different results, in handball players force - velocity and handball throw on one side and volleyball spike and serve values on the other both shown great correlation results.

Potential reasons for such results and downsides of this research could be found in a lack of experience of the subjects in explosive execution of the traditional bench press exercise, and in not having a formed optimal upper body force velocity profile to compare individual results of the subjects and better differentiate the subjects in “force” and “velocity” groups.

Given results have brought the conclusion that neither of the two hypotheses weren’t confirmed because no statistically significant correlation was found. Considering that this was one of rare papers concerning the upper body force velocity profiles a recommendation for future research would be in a way of forming the optimal upper body force- velocity profile as we have already for the upper body, and also comparing different training programs in optimising ones force-velocity profiles so that there could be a positive translations to specific sports movements like throwing and hitting.

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MONITORING INTERNAL TRAINING LOAD AND WELLNESS PARAMETERS IN JUDO

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Abstract
The study aimed to determine the relationship between training load and selected wellness parameters in judokas over a five-week mesocycle. The sample consisted of 14 judokas (average age: 21 ± 2.4 years), with a frequency of at least three training sessions per week. The training load was calculated by multiplying the results on the RPE scale by the total duration of training in minutes. During the experimental period, participants completed a psychological questionnaire that assessed their fatigue, sleep quality, general muscle soreness, stress levels, and mood on a Likert scale from 1 to 5. A mixed model ANOVA with the corresponding effect size was applied to assess differences in training loads within the five-week cycle. Pearson's correlation coefficient was used to determine the association between training load and wellness parameters. High training loads were associated with a significant increase in perceived fatigue and decreased sleep quality – critical factors for recovery and overall performance. The study found a moderate negative correlation between training load and overall wellness, indicating the need to balance loading phases with rest phases during training cycles. Adequate periodization and recovery strategies are crucial for optimizing performance and preventing overtraining. The results suggest that while higher training loads can cause difficulties in the athletes' recovery process, effectively managing these loads through tailored training can improve performance.

Keywords: *training load volume, combat sports, wellness*

Introduction

Judo is an Olympic sport practiced by more than 100 million people worldwide in over 200 countries, making it one of the most popular sports globally. Judo techniques are performed in direct contact with an opponent, aiming for the symbolic destruction and control of the opponent. The diversity of judo is exceptionally rich, and its complexity is further enhanced by the fact that, in addition to a large number of technical and tactical elements, judokas are also required to have an exceptionally high level of physical fitness (Miarka et al., 2014). The training loads during a competitive judo match vary from moderate to maximal, partially depending on the quality of the opponent. A match's very high intensity highlights the importance of a judoka's functional capacities, particularly anaerobic endurance. A competitor can have up to 7 matches in one day, where aerobic endurance is crucial in recovery between matches. In addition to functional abilities, motor skills are also necessary, with strength, speed, and coordination being the most dominant (Franchini et al., 2011). Adequate training must be complemented by sufficient rest between training sessions to achieve the highest accomplishments in a sports career. High training loads, combined with inadequate physiological recovery, can cause injuries and lead to overtraining. (Robson-Ansley et al., 2009). Numerous methods exist for monitoring and controlling training, some of which are invasive and expensive, such as venous blood and saliva sampling. On the other hand, methods like heart rate variability, questionnaire use, and rate of perceived exertion (RPE) are practical, accessible, and reliable for monitoring and controlling training load. Therefore, the primary aim of this study is to determine the relationship between training load and wellness parameters in judokas during a single mesocycle.

Methods

The sample consisted of 14 judokas (average age: 21 ± 2.4 years), with a frequency of at least three training sessions per week. The criteria for participation in the study included: a) possession of a valid sports-health certificate (medical examination) and b) satisfactory health status of the participants (no severe pain or injuries in the previous year). The Faculty of Kinesiology Ethics Committee in Split approved all experimental procedures, adhering to ethical standards for studies on humans.

To measure internal training load, the study used the subjective rating of perceived exertion (RPE; Borg, 1998), which was calculated by multiplying the duration of training in minutes by the subjective load assessment. During the experimental period, participants completed a psychological questionnaire for wellness (WB) assessment (McLean et al., 2010). The questionnaire assessed their fatigue, sleep quality, general muscle soreness, stress levels, and mood on a Likert scale from 1 to 5. Participants were monitored over a five-week mesocycle, during which they completed a total of 22 training sessions. Each training session was structured similarly, including warm-up phases, the main part of the training, and stretching.

Descriptive statistics for all variables were presented using the arithmetic mean and standard deviation (SD) calculation. The Shapiro-Wilk test was used to check the normality of data distribution. A mixed model ANOVA with the corresponding effect size was applied to assess differences in training loads between the five weeks of training. Mauchly's test was used to verify the assumption of sphericity. If sphericity was not met, the Geisser-Greenhouse correction was applied to the p-level. Pearson's correlation coefficient was used to determine the correlation between training load and wellness parameters. Data analysis was conducted using the statistical software Statistica 14.0 (Dell Inc., Round Rock, TX, USA).

Results

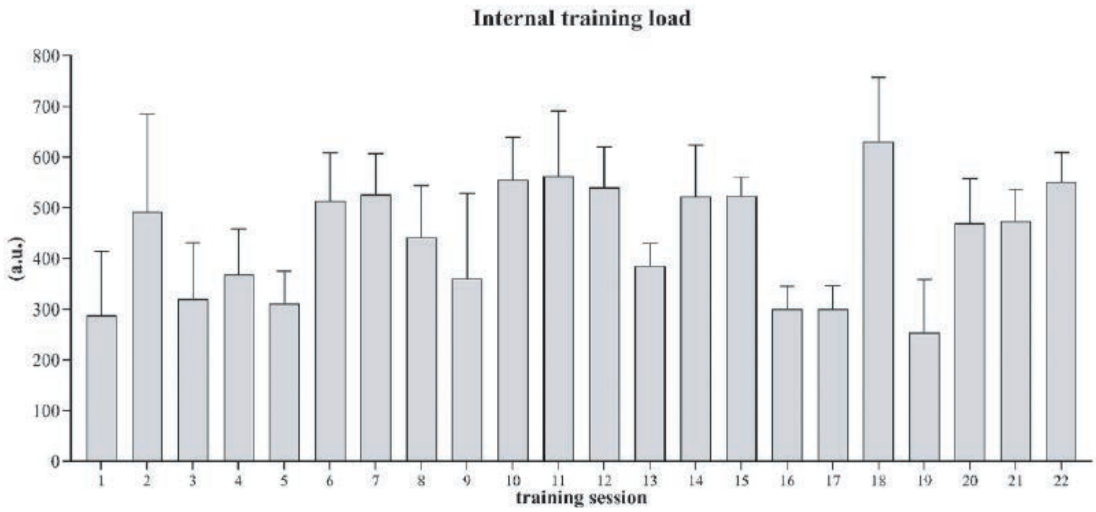

Figure 1. Training load during the mesocycle.

In Figure 1, the values of the training load during the mesocycle are shown. Mauchly's test indicated that the assumption of sphericity was not met ($p > 0.05$). Therefore, the Geisser-Greenhouse correction was applied. The results of the ANOVA indicated significant differences between the weeks ($F = 6.81$, Geisser-Greenhouse's epsilon = 0.519; $p < 0.01$). The highest training load was recorded in the third week (382 a.u.), while the lowest was in the fifth week (180 a.u.).

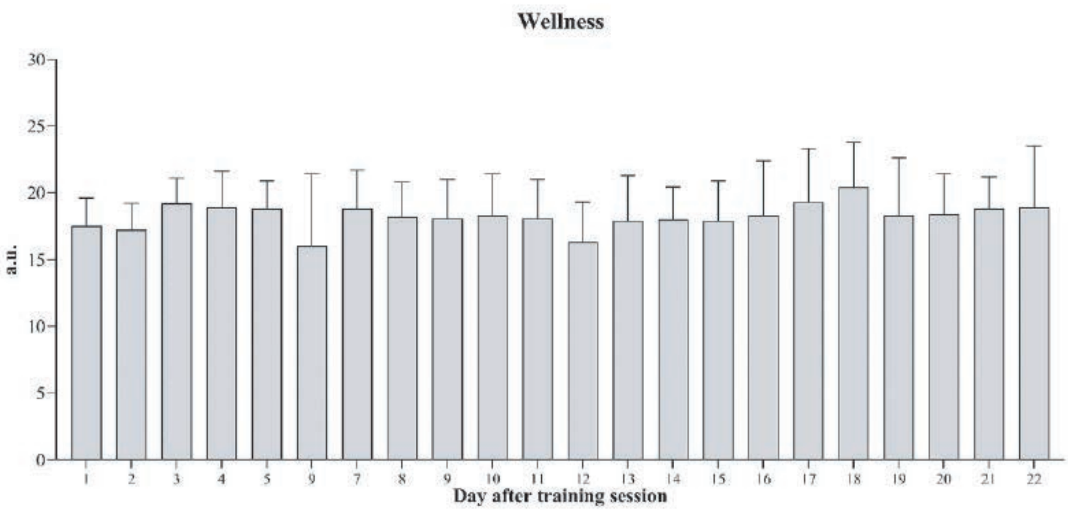

Figure 2. Values of wellness questionnaire during the mesocycle.

In Figure 2, the values of wellness parameters (total values) during the mesocycle are shown. The highest values were recorded on day 18, while the lowest values were recorded on day 9 after training.

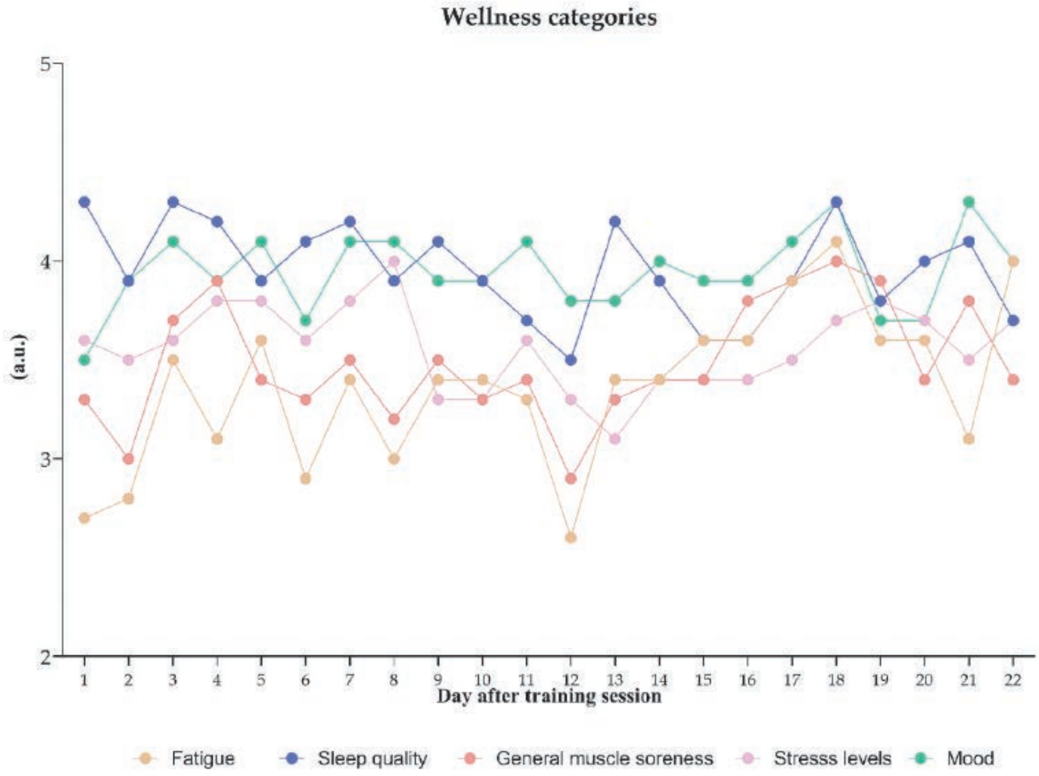

Figure 3. Values of wellness categories (fatigue, sleep quality, general muscle soreness, stress levels, and mood) during the mesocycle.

Figure 3 shows the values of individual categories of wellness parameters during the mesocycle. When observing the values of each category, participants had the lowest perceived fatigue values (3.32 a.u.), while the highest values were recorded in the mood category (3.93 a.u.).

Table 3. Correlation between average daily training load and five wellness categories, as well as total wellness (WB).

Variable	mean	[95%CI]	r
Internal training load	442.71	/	/
Fatigue	3.32	[-0.25 ; -0.06]	-0.1
Sleep quality	3.97	[-0.31 ; -0.01]	-0.16*
General muscle soreness	3.47	[-0.36 ; -0.09]	-0.24**
Stress levels	3.57	[-0.24 ; 0.08]	-0.09
Mood	3.93	[-0.23 ; -0.09]	-0.07
WB	18.21	[-0.33 ; -0.01]	-0.18*

Legend: * - p < 0.05; ** - p < 0.01; 95%CI – confidence interval; r – correlation coefficient;

Table 3 presents the results of the correlation between average daily training load and various wellness parameters. Significant negative correlations are observed between internal training load, sleep quality, WB, and general muscle soreness.

Discussion

A study conducted by Halson in 2014 emphasized the significance of monitoring training load in sports to enhance performance and reduce the likelihood of overtraining. During the five-week monitoring period in judo, the average daily training load played a crucial role in assessing its influence on several elements of athlete well-being. The training load in judo is intricate since athletes are required to meet multidimensional demands, such as explosive power, endurance, flexibility, and mental resilience (Franchini et al., 2011). Hence, comprehending the associations between training load and wellness measures necessitates a particular context of judo training.

The weak negative correlation ($r = -0.1$) between training load and exhaustion implies that larger training loads may lead to a heightened experience of fatigue among athletes despite the low strength of this relationship. Nevertheless, it is important to exercise caution when interpreting this discovery, as it lacks statistical significance ($p > 0.05$). The observed negative association ($r = -0.16$) between sleep quality and training load suggests that as the training load of judokas increases, their sleep quality may decline. The results presented here align with other research indicating that an excessive workload might have a detrimental effect on sleep, which is a crucial element in the process of recuperation (Thorpe et al., 2015). In judo, where reaction time is crucial for success, poor sleep quality can be particularly detrimental (Sawczuk et al., 2018). The significant negative correlation with general muscle soreness is consistent with research suggesting a significant link between training load and the perception of muscle soreness after exercise (Flann et al., 2011). Such findings reflect the specific challenges that judo training can present, especially the need for intense recovery after training to prevent injuries and allow continuous progress (Torres-Luque et al., 2013). Stress levels and mood showed very weak negative correlations with training load ($r = -0.09$ and $r = -0.07$, respectively), implying that changes in training did not significantly affect these psychological variables. Although this was not expected, adaptive mechanisms in athletes may allow for the maintenance of stable stress levels and mood despite fluctuations in training (McGuigan, 2017). As an indicator encompassing all the mentioned variables, overall wellness showed a significant negative correlation ($r = -0.18$) with training load. This implies that when the intensity of training increases, the overall well-being of athletes may decrease, aligning with the holistic approach in sports that highlights the significance of maintaining a harmonious equilibrium between training and recovery. (Kenttä & Hassmén, 1998).

Despite the limitations in sample size and the need for further study, these findings can serve as a basis for enhancing training and preventive measures to enhance the well-being of judokas.

Conclusion

The research on the impact of training load on judokas shows that increasing load can negatively affect fatigue and sleep quality, which are key recovery components. This can be particularly challenging for athletes in judo. Weak correlations with stress levels and mood suggest the stability of these psychological factors despite fluctuations in training. Overall, athlete wellness showed a moderate negative correlation with training load, highlighting the need for a balanced approach to training. The results underscore the importance of periodization and adjustments in training programs to preserve athlete wellness and maximize performance. The study emphasizes the need for further research to shed light on the long-term effects of training on judokas and to provide a foundation for optimizing training in high-intensity sports like judo.

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EVALUATION OF THE LEVEL OF THE BASIC MOTOR ABILITIES OF INTERVENTION FORCE MEMBERS WITH AN EMPHASIS ON THE IMPORTANCE OF EXPLOSIVE POWER AND REPETITIVE RELATIVE STRENGTH LEVELS

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Abstract
The main aim of the article was to analyse the level of basic motor abilities of two groups, members of intervention forces. The research was conducted on the convenient sample, consisted of 76 members of intervention forces (G1), of whom 36 police officers were members of intervention forces and 40 were members of special forces (G2). Using Mann-Whitney U test we have determined statistically significant differences between two groups of intervention forces concerning level of motor abilities (p<0,05). The results of members of the special police compared to members of the intervention forces revealed significantly higher level of explosive strength of lower limbs (standing long jump ((S L J) (U=310,5)), repetitive relative strength of arm musculature and shoulder girdle ((“DIPS” – ON BARS) (U=497,5)), leg muscles (maximum squats in 1 minute ((SQU 1 MIN) (U=194,0)), repetitive relative strength of arm musculature and shoulder girdle ((CHIN UPS) (U=231,0)) and repetitive strength of abdominal musculature, trunk muscles (maximum sit-ups in two minutes ((SIT-UPS 2 MIN) (U=340,0)). Statistically significant difference between members of intervention forces in favour of members of special police (G 2) in terms of level of motor abilities can very likely be attributed to a better selection process of candidates, and possibly to a much broader scope of special police training. Members of special police train more on a daily basis. Intervention police (G 1) carry out their official tasks daily, doing so they are forced to reduce the number of both, striking and maintaining micro cycles of specialized training which probably contributes to a generally lower level of monitored motor skills.

Keywords: *motor abilities; intervention and special police; anthropometric attributes*

Introduction

The operational ability of the intervention forces (intervention and special police) is based on the highest level of anthropological characteristics, which determines their situational efficiency in the actual work environment. Members of the special police need the highest level of explosive strength and strength to overcome various loads, clearing the buildings, vehicles, or vessels. Speed, explosiveness, strength, and agility are abilities that come dominantly to the fore in "urban operations". The highest level of anthropological characteristics is also required of members of the intervention police, concerning that members of the intervention police carry out significantly more official tasks compared to members of the special police, which ultimately means that the system of specialist training conducted by members of the intervention police is probably carried out in significantly smaller amount. The scope of work and engagement of intervention forces require the highest level of physical preparedness and situational efficiency when using coercive means in performing official tasks. Due to the complexity of situations and related unforeseen circumstances, which are manifested in situational actions, and which appear during the execution of official tasks, members of the intervention forces are expected to undergo continuous training in specialties (general and specialist physical preparedness, police proceedings and interventions, familiarity in firearms, handling and shooting skills, training for emergency police divers. Considering the wide range of official tasks performed by members of the intervention forces, it is essential to continuously evaluate the level of basic motor skills of the members of the intervention forces in order to monitor the effectiveness of specialist training programs and the process of upgrading existing training programs that must meet the authentic needs of police officers.

Aim of the paper

The basic aim of this article as to determine levels of the basic motor abilities of two groups, i.e. intervention and special police. Both groups are members of intervention forces of the Ministry of the Interior of the Republic of Croatia.

Methods

Participants

Research was conducted on the convenient sample which was consisted of 76 members of intervention forces. 36 police officers, members of intervention police comprised first group, and the second group was consisted of 40 police officers, members of special police forces.

Sample of variables

In the analysis of efficiency of training treatment of special physical preparation designed for members of intervention forces, valorisation of official program was made by using evaluation of motor ability levels of entities. That is, set composed of five variables was used to evaluate motor ability levels: standing long jump (S L J), pull-ups on the bar with overhand grip (CHIN-UPS), sit-ups in two minutes (SIT-UPS in 2 MIN), dips on bars (DIPS ON BARS) and squats in 60 seconds (SQU 1 MIN) (Jukić et al., 2008; Jozić, 2020).

Description of experimental procedure

Official programme of specialised skills training designed for intervention forces is conducted in accordance with approved plans, and depends on the level, frequency of arrangement of intervention forces for performing the most complex official duties. Programme is saturated with elements of martial arts (Kosanović, 1988; Sertić & Segedi, 2015; Marins et al.,2019) karate, boxing, police self-defence, defences against armed and unarmed attacker, individual and group tactics of police proceedings, overcoming passive and active resistance, training elements for training of tactical elements against counter-terrorism, training elements for improvement of mountain-hill activities (long walks with full equipment, overcoming terrains during winter conditions, skiing, etc). Training operators are adjusted to individual characteristics of intervention forces. Trainings were held according to schedule, anticipated cycles of specialized training. Exercises of specific endurance were significantly represented (White at al., 2004; Šalaj & Šalaj, 2011; Dominski et al., 2018), as well as specific powers for muscle groups of entire body with an emphasis on exercises for strengthening of lower body extremities and abdominal musculature. In addition to previously listed, larger amount of training was used to improve, enhance karate, judo and boxing techniques as well as police self-defence (Kosanović, 1988). Training programme designed for intervention forces is significantly saturated with training elements in order to develop aerobic endurance (medium intensity running for 25 minutes (75% anticipated max heart rate), strength elements – tasks of lifting and tasks of lifting and carrying (handling with materials – by weight) (Hendrickson, 2010; Blair, 2015; Šimenko et al., 2015; Dominski et al., 2018; Verhage et. al., 2018; Blair et. al., 2019), conditioning elements (sprint: 40,60 and100 meters wearing sport gear and official uniform). Training with weights take significant place in specialized training through application of circle- and stationery methodical organisational type of work with individual and group dosage of volume of loads, elements of trainings with weights, training elements for improvement of strength (leg press, bench press, shoulder press, back extensor hold, vertical jump (Pryor et al., 2012; Šalaj & Šalaj, 2011; Pryor et al.,2012; Šimenko et al.,2015).

Data processing methods

Parameters of descriptive statistics were calculated for listed group of variables. In order to determine normality of distribution, central and dispersive elements will be determined for all variables: arithmetic means (Mean), standard deviation (S.D.), minimal results (Min.), maximal results (Max.), skewness-coefficient of asymmetry of the distribution (a3), coefficient of Kurtosis (a4). Since the presented results of variables do not have normal distribution (K-S test), Mann – Whitney U test was used to determine differences between two independent observed groups. Data were processed by statistical package Statistica for Windows ver. 13.4 at University of Zagreb, Faculty of Kinesiology.

Results

Numerical values of central and dispersion parameters of analysed groups of examinees are presented in the tables 1 (motor ability results of intervention police) and 2 (motor ability results of special police). Based on the measure of dispersion of results (table 1 and table 2) relatively high variability of certain indicators of motor ability levels is observable. After examining results in the tables 1 and 2 we observed quality distribution results which can be, without hesitation, sent to further analyses. Mann – Whitney U test is used because some variables of both groups do not have normal distribution of results (table 3).

Table 1. Results of descriptive statistics of the first group of intervention forces, (intervention police) (G1)

	Descriptive Statistics; K=1								
Variable	N	Mean	Mode	Freq.	Min	Max	S.D.	a3	a4
S L J	36	237,22	230,00	7	200,00	270,00	18,73	-0,24	-0,39
CHIN UPS	36	10,61	Multiple	7	4,00	17,00	3,64	-0,16	-1,11
SIT UPS 2 MIN	36	72,50	Multiple	3	33,00	100,00	17,20	-0,80	0,17
DIPS ON BARS	36	18,22	20,00	10	8,00	26,00	4,27	-0,53	0,50
SQU 1 MIN	36	49,17	51,00	5	30,00	62,00	8,46	-0,78	-0,12

Table 1. (S L J) Standing long jump, (CHIN-UPS) Chin ups, (SIT UPS 2 MIN), sit ups in two minutes, (DIPS), dips, (SQU 1 MIN), squats in 1 minutes. Results for descriptive statistics (G1- intervention police): Valid N (number of subjects), Ar. Mean (arithmetic mean), min (minimal result values), max (maximal result values), S.D. (standard deviation), a3 (coefficient of asymmetry, skewness), a4 (measure of exposure of distribution – kurtosis)

Table 2. Result for descriptive statistics of the second group, (special police) (G2)

	Descriptive Statistics; k=2								
Variable	N	Mean	Mode	Freq.	Min	Max	S.D.	a3	a4
S L J	40	254,55	260,00	12,00	220,00	280,00	10,79	-0,87	2,25
CHIN UPS	40	15,93	15,00	11,00	8,00	25,00	4,07	-0,01	-0,42
SIT UPS 2 MIN	40	87,73	101,00	10,00	50,00	109,00	14,45	-0,88	0,25
DIPS ON BARS	40	21,25	20,00	10,00	10,00	41,00	6,75	0,54	0,76
SQU 1 MIN	40	58,28	60,00	19,00	50,00	65,00	3,55	-0,87	0,00

Table 2. (S L J) Standing long jump, (CHIN-UPS) Chin up, (SIT UPS 2 MIN), sit ups in two minutes, (DIPS), dips, (SQU 1 MIN), squats in 1 minutes. Results for descriptive statistics (G2- special police): Valid N (number of subjects), Ar. Mean (arithmetic mean), min (minimal result values), max (maximal result values, S.D. (standard deviation), a3 (coefficient of asymmetry, skewness), a4 (measure of exposure of distribution – kurtosis)

Table 3. Mann-Whitney U Test

	Mann-Whitney U Test; Marked tests are significant at p <,05000						
Variable	Rank Sum	Rank Sum	U	Z	p-value	N1	N2
S L J	976,50	1949,50	310,50	-4,25	0,00	36	40
CHIN UPS	897,00	2029,00	231,00	-5,08	0,00	36	40
SIT UPS 2 MIN	1006,00	1920,00	340,00	-3,95	0,00	36	40
DIPS ON BARS	1163,50	1762,50	497,50	-2,31	0,02	36	40
SQU 1 MIN	860,00	2066,00	194,00	-5,47	0,00	36	40

Table 3. (S L J) Standing long jump, (CHIN-UPS) Chin up, (SIT UPS 2 MIN), sit ups in two minutes, (DIPS ON BARS, dips on bars, (SQU 1 MIN), squats in 1 minutes, Rank Sum, Rank Sum, U (value of Mann-Whitney U Test), Z (standardized values), P- value (error in conclusion, $p < 0.05$), G1 (group one-intervention police), G2 (group two – special police).

Analysis of these presented results obtained by Mann-Whitney U test (table 3) of two independent groups of examinees has shown that there are statistically significant differences in all five tested variables, that is, a level of statistical significance of .05 for all five tests S L J (standing long jump), CHIN UPS, SIT-UPS, SQUATS IN 1 MINUTES and "DIPS ON BARS".

Discussion

When we compare the results of two independent groups of intervention forces, we noticed that two independent groups statistically significantly differ in all five tests for assessment of level of several basic motor abilities ($p<0,05$). Based on the results obtained by Mann-Whitney U test for assessment of differences of arithmetic means of examinees, high level of explosive strength of lower limbs of both examined groups of intervention forces were observed (table1, table 2, table 3). Results of standing long jump (S L J) of both groups of intervention forces belongs to a category of great results (Jukić et al., 2008; Milavić et al., 2010; Šalaj and Šalaj, 2011; Šimenko et al., 2015; Jozić, 2020; Marcou, 2022). Results presented in tables 2 and 3 are higher than results of military specialists (Jukić et al., 2008; Milavić et al., 2010; Jozić, 2020) and were significantly higher when compared to intervention police members. Explosive jumping strength is important factor of success of police officers in general, in those moments when of the utmost importance is to give huge acceleration to body mass, to mass of specific topological body areas or some found object (jumps, hopping, box jump on and off, throwings (judo, wrestling, elements of close combat)) sprint elements with and without specialized equipment, leg and hand kicks, kicking different objects, “opponents”, so they should be practised continuously.

That is, according to (Dominski et al., 2018), there is correlation between level of physical activities (level of motor abilities) of police officers and their body fat percentage with a quality of performance in required reaction time. Entities with lower level of physical activities in urgent situations, situations of decision making can be slower, which consequently have negative influence on their rifle accuracy (Dominski et al., 2018; Yapici at al., 2018). While, more active police officers, who have higher level of motor abilities, with acceptable body fat percentage are cognitively more capable for working activities. System of specialist training of intervention forces (members of intervention and special police) should be extra studied in future research to define procedures for improvement of specialist training through further increasement of level of their anthropological status, total fitness of police officers. That is, experts of police integral training are responsible for adjusting, developing contemporary training models for tactical athletes to improve performing their tasks which have highest total importance. Recommendation is to try to research efficiency of programmed combination of resistance and interval training, in order to improve all aspects of fitness with emphasize on their contribution in aspects which were proved to have probably more importance in totality.

Conclusion

Results of motor abilities of both intervention force groups demonstrate acceptable level of motor abilities. Results of special police members when compared to intervention force members demonstrate significantly better level of explosive and repetitive relative strength, which is important when conducting counter-terrorism activities. Modern tactical teams of special units perform official tasks in populated areas, urban buildings and different areas where physical activities of overcoming obstacles of different complexity, e.g. fast running, significantly come to highlight, i.e., duties which are comprised but also require the utmost level of agility (side motions), dexterity and the utmost level of fast reaction. Police officers who are physically more active have quicker cognitive processing which consequently improves work efficiency of police officers during riding/driving a car, reacting in situational circumstances, handling firearms and in urban actions in restricted areas. Programme of intervention forces should be focused on improvement of aerobic capabilities, flexibility of entire body, core and muscle strength, that is, it should be continuously directed to maintain the highest level of muscle strength. Statistically significant difference between members of intervention forces in the favour of special police members concerning level of motor abilities probably can be assigned to a better selection process of candidates before they enter in a unit as well as to a wider range of training of special police members. Members of special police train more on daily basis, obtain higher intensity and extensity training in specialized drill when compared to members of intervention police. Intervention police carry out their official tasks daily, and doing so they are forced to reduce the number of both, striking and maintaining micro cycles of specialized drill, which probably contribute to the generally lower level of monitored motor abilities.

Programmes designed for intervention forces should emphasize need of regular aerobic conditioning and development of improved flexibility because poor strength of both, core and hip contribute to back injuries while carrying protective equipment.

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THE IMPACT OF SURFACE TYPE ON THE SPEED OF DIRECTION CHANGE FOR FOOTBALL PLAYERS

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Abstract
Motor skills are one of the key factors in achieving success in football game. The most important motor skills that directly impact individual performance in football are speed and agility. They enable anticipation, reaction to opponents and their decisions, and faster response in unpredictable situations that in football occur most of the time. The aim of this research is to determine whether the surface on which football players move influences the speed of direction change and reaction speed. The study was conducted on 10 senior football players with an average age of 23,40 years, an average height of 184,68 cm, and an average weight of 81,78 kg. They were tested in July and August of 2023., on three surfaces: natural grass, artificial turf, and on parquet floor in a sports hall. The observed variables and comparisons included the following motor tests: Lateral shuffle (s), 20-yard sprint (s), T – drill Test (s), Arrowhead test (s), 20 – meter sprint (s). The collected data and results of all tests were obtained using highly precise Microgate Witty sensor photocell system. To obtain results Statistica 14.0 was used. The test results revealed a statistically significant difference among the three surfaces ($p < 0.05$). However, what is crucial for football gameplay is that on both natural grass and artificial turf surfaces, there is no statistically significant difference across the 7 tested variables ($p > 0.05$). The results for all variables indicate a distinction, although not statistically significant.

Keywords: *motor skills, football, surface impact, speed, agility*

Introduction
„The primary aim of the game of soccer is to defeat the opponent by scoring more goals." (Gabrijelić, 1964). The multitude of twists and celebrations upon scoring goals is one reason why soccer is one of the most popular sports in the world. Soccer can be played on natural grass, artificial turf, and increasingly popular hybrid turf. Natural grass is the traditional and often preferred choice for soccer fields, especially at the professional level. Well- maintained natural grass provides players with a natural feel, good ball contact, and an authentic sensation underfoot. The advantages of artificial soccer fields include the ability to play on them year-round regardless of weather conditions, including rain, snow, and extreme temperatures, as well as requiring significantly less maintenance compared to natural grass. Soccer is a sport that demands a multitude of tactical and technical elements, as well as requiring highly developed motor knowledge. The ability to change direction- agility, and speed are integral parts of soccer. Therefore, given that soccer is played on different surfaces, the biomechanics of movement and changes in direction on these surfaces differ. Gould et al. (2020) investigated the impact of surface on lower extremity injuries and found an increased risk of foot and ankle injuries on artificial turf, with no statistically significant difference in knee and hip injuries between artificial and natural turf. Xiao et al. (2022) found that female soccer players have a significantly higher risk of anterior cruciate ligament injury on artificial turf compared to male players. Comparing futsal players and soccer players in agility tests it was found that there is no statistically significant difference in agility between soccer players and futsal players, but the sports differ in dynamics (Milanović et al., 2010). Testing students from American football, performing 40-yard sprint and agility tests on both surfaces, Gains et al. (2010) found no significant differences in the 40-yard sprint test, but there were differences in the change of direction test. As for physiological reactions and performances on artificial and natural turf, there were no differences in average heart rate, blood lactate concentration, or number of repeated sprints between the two surfaces (Hughes et al., 2013), nor any significant impact on recovery patterns (Stone et al., 2016). Artificial fields have become increasingly implemented over the last 20 years, following technological advancements, with soccer being the most widespread and popular sport on the planet, thus being one of the first sports to use fields with artificial turf in training and official matches (Burger et al., 2022).

Methods
Entities
This research has been made from a sample of ten (10) senior football players, average age 23,4 years, height 184,67 cm and weight 81,78 kg.

Variables
Testing the motor abilities of senior soccer players was conducted over a period of three weeks and assessed through five motor ability tests. Participants were evaluated in motor ability tests with corresponding measurement units as shown in Table 1. The motor tests were conducted using the Microgate - Witty system of photocells.

Table 1. Variables

ID	Test	Unit of measurement
KUS	Sidesteps	Second (s)
20yard	Agility test- 20 yards	Second (s)
Tdrill	T – drill test	Second (s)
Arrow	Arrowhead agility test	Second (s)
ArrowBall	Arrowhead agility test with a ball	Second (s)
20m	Running, 20 meters	Second (s)

Statistics
For analyzing the obtained results, the statistical software package STATISTICA, ver. 14.0.0.15, is used. Descriptive statistical parameters will be presented for all mentioned variables, and differences in the achieved results between two measurement points of the same group of participants will be tested using multivariate analysis of variance for repeated measures (MANOVA for repeated measures). Results will be considered statistically significant at $p<0.05$.

Results
In Table 2, descriptive indicators of testing on natural grass are presented, while Table 3 contains the values of descriptive parameters for testing on artificial turf. The same values for testing on parquet are found in Table 4.

Table 2. Descriptive indicators - testing on natural grass

Variables	N	AM	Min	Max	Std.Dev.
KUS	10	7,38	6,71	8,27	0,47
20yards	10	4,39	4,21	4,83	0,19
Tdrill	10	10,33	10,02	10,79	0,26
ArrowR	10	8,21	7,93	8,65	0,22
ArrowL	10	8,26	8,01	8,65	0,20
ArrowBall	10	9,85	9,38	10,33	0,30
20m	10	3,22	3,04	3,44	0,13

Legend: N- number of participants, Mean - arithmetic mean, Min - minimum value, Max- maximum value, Std. Dev. - standard deviation

Table 3. Descriptive indicators - testing on artificial grass

Variables	N	AM	Min	Max	Std.Dev.
MAGKUS	10	7,61	6,89	8,33	0,44
20yards	10	4,50	4,31	4,75	0,16
T-Drill	10	10,02	9,40	10,67	0,40
Arrowhead R	10	8,06	7,64	8,45	0,23
Arrowhead L	10	8,03	7,65	8,41	0,23
Arrowhead Ball	10	9,62	9,01	10,30	0,41
20m sprint	10	3,20	3,01	3,40	0,13

Table 4. Descriptive indicators- testing on parquet

Variables	N	AM	Min	Max	Std.Dev.
MAGKUS	10	7,99	7,27	8,66	0,45
20yards	10	4,76	4,38	5,63	0,39
T-Drill	10	10,59	10,01	11,54	0,48
Arrowhead R	10	8,52	8,21	9,03	0,28
Arrowhead L	10	8,53	8,18	9,30	0,34
Arrowhead Ball	10	10,46	10,09	11,15	0,30
20m sprint	10	3,25	3,08	3,58	0,14

The values of ANOVA analysis are presented in Table 5, while Post-hoc test values are found in Table 6.

Table 5. One way ANOVA

	Test	Value	F	p
Surface	Wilks	0,22	2,89	0,01

Legend: F – F-test, p –statistical significance

Table 6. ANOVA Post – hoc tests (Tukey HSD)

Variable- MAGKUS			
Surface	NG (7,38)	AG (7,61)	IN (7,99)
NG		0,53	0,02
AG	0,53		0,19
IN	0,02	0,19	
Variable- 20yards			
Surface	NG (4,39)	AG (4,50)	IN (4,76)
NG		0,64	0,02
AG	0,64		0,14
IN	0,02	0,14	
Variable- T-Drill			
Surface	NG (10,33)	AG (10,02)	IN (10,59)
NG		0,23	0,35
AG	0,23		0,01
IN	0,35	0,01	
Variable- Arrowhead R			
Surface	NG (8,21)	AG (8,06)	IN (8,52)
NG		0,41	0,03
AG	0,41		0,00
IN	0,03	0,00	
Variable- Arrowhead L			
Surface	NG (8,26)	AG (8,03)	IN (8,53)
NG			0,10
AG	0,18	0,18	0,00
IN	0,10	0,00	
Variable- Arrowhead Ball			
Surface	NG (9,85)	AG (9,62)	IN (10,46)
NG		0,32	0,00
AG	0,32		0,00
IN	0,00	0,00	
Variable- 20m			
Surface	NG (3,22)	AG (3,20)	IN (3,25)
NG		0,93	0,90
AG	0,93		0,71
IN	0,90	0,71	

Legend: NG - natural grass, AT - artificial turf, IN - indoor (parquet). The values in the table are p-values

Discussion

Results of this research indicate statistically significant differences in the tested variables across three different surfaces. Through ANOVA analysis, the results significantly differ between the three surfaces, and detailed Post-hoc (Tukey HSD) analysis has identified the variables and surfaces with statistically significant differences. ANOVA analysis in this study confirmed significant differences in all variables involving change in direction (sidestep, 20-yard agility test, T-drill test, Arrowhead test). Results suggest that the tested soccer players move slowest on the parquet floor in the indoor facility. However, it should be noted that these players have much more experience playing on natural and artificial turf. Athletes performed tasks on natural and artificial turf wearing cleats, while in the indoor facility, they wore sneakers suitable for the parquet surface. During the research, it was evident that athletes adjusted their acceleration, stopping, change of direction, and ball handling techniques on each surface. On natural grass, athletes had their body's center of mass placed higher, enabling them to stop and change direction more easily using the cleats on their shoes. They took longer strides, resulting in fewer steps and making turns or changes of direction easier with the help of the cleats. In tests where high speed could not be developed (sidestep, 20-yard agility test), participants achieved better times on natural grass. In the Arrowhead tests, differences in movement technique were also noticeable, which was most like the T-drill test. On artificial turf, athletes appeared most stable and confident during direction changes, starting to slow down by shortening their steps, lowering the center of gravity, and maneuvering around cones much closer. During testing in the indoor facility, differences in running technique and direction change were also evident. In the sidestep test, athletes took more steps, were less stable, and had significantly slower times compared to other surfaces. In the 20-yard test, changes in turning technique were noticeable as athletes lowered their center of mass even further to achieve better conditions for changing direction, but the change of direction was slower compared to other surfaces. Since there is a statistically significant difference in the results of tests assessing agility and change of direction speed, the hypothesis about the existence of a statistically significant difference in the investigated variables between three different surfaces is confirmed. In this study, three surfaces were tested but only two surfaces (natural and artificial turf) are allowed for official soccer matches. Parquet is used for small-sided soccer matches, i.e., futsal, but also represents most of the time spent by school children during regular physical education classes. In the testing conducted in this research, there is no statistically significant disproportion in agility tests between natural and artificial turf. However, there is room for further research including hybrid turf surface, which combines the previous two mentioned and is increasingly used in soccer systems. Considering the results of this research, in the training process of soccer players who train and play matches on artificial turf, it is recommended to increase the adaptation time or warm-up time to better prepare all joints of both lower and upper extremities for the efforts on a surface where players do not have a natural feeling of movement and ball handling, but also face a higher risk of injury on artificial turf. Also, if a soccer player trains on artificial turf and plays matches on natural grass, due to the change in surface, longer and adequate warm-up is recommended for the same reasons.

Conclusion

One of the key factors for success in soccer is high motor skills, which players should develop from birth throughout their careers. Excellent motor skills enable athletes to more easily and effectively adopt technical-tactical elements. With well-developed agility, defensive players can position themselves better against attackers, react faster to unknown impulses, and have more time to make appropriate decisions. Midfielders, with well-developed agility, can navigate better in the midfield where changes in direction are frequent and crucial for domination, while forwards and wingers use agility to overcome opponents, create space, and seize opportunities to score goals, which is ultimately the main goal of the game. This research has found a statistically significant difference in changing direction on the parquet floor in the indoor facility, but there is no statistically significant difference on surfaces where official soccer matches are played. The results of this testing can help in developing training plans and programs because there is room for improvement in the technique of changing direction among the tested athletes, as well as among children and other competitors.

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PREVALENCE OF INJURIES AMONG BALET AND CONTEMPORARY DANCE STUDENTS IN ZAGREB DANCE SCHOOLS

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Abstract
The objective was to ascertain the prevalence of injuries and the frequency of occurrence among students enrolled in dance education schools, while identifying the most commonly injured body parts, and to explore potential disparities in injury rates between elementary and high school dance students. The research was conducted through a questionnaire administered to 47 dance students from various dance schools in Zagreb, Croatia with aim to determine total injury frequencies, injury frequencies categorized by body regions, and differences in injury counts and affected body regions between groups using a nonparametric Mann-Whitney U test. The findings revealed that the most commonly injured body parts were the foot and ankle (41%), followed by the knees (23%). A majority of injuries occurred in the lower extremities, including the hips, knees, and feet/ankles, accounting for 67% of all injuries (96 in total). The research did not identify any statistically significant increase in injuries among high school dance students compared to elementary school students. However, there was a noticeable overall increase in lower extremity injuries among high school students (29%) compared to elementary school students. The most frequent injuries among both elementary and high school dancers were foot/ankle injuries, constituting 45% among elementary school students and 37.5% among high school dancers. In artistic dance schools, dancers primarily prepare their bodies through dance technique, with less emphasis on conditioning and sports training. More attention needs to be devoted to comprehensive physical preparation that is not dance-specific but rather focuses on exercises to develop overall physical abilities.

Keywords: *dance education, injury localization, injury risk*

Introduction
With the escalating concern regarding injuries in dance, there has been a noticeable rise in research efforts investigating the factors associated with injury prevalence within dance disciplines. Previously conducted research findings demonstrate a total of 196 injuries among 99 professional ballet dancers, averaging 1.9 injuries per dancer, equivalent to 1.4 injuries per 1000 dance-hours (Novosel, Sekulic, Peric, Kondric & Zaletel, 2019). Studies on different dance techniques collectively reported 0.72 injuries per dancer in six-month period among urban dance, rock and roll and standard/latin dancers (Sekulić, Prus, Zevrnja, Perić, & Zaletel, 2020). Building on previous studies, more research questionaries unveiled a significant prevalence of musculoskeletal injuries with ankle sprains constituting a significant portion of these injuries (69.8%) in professional dancers and 42.1% in non-professionals. Among professional dancers, pirouettes emerged as the primary mechanism of injury (67.9%), while repetitive movements prevailed among non-professionals (28.1%). Gender differences were observed, with ankle sprains predominantly affecting women (90%) and muscle sprains more prevalent among men (54.5%), while ankle joint injuries were most common in both sexes among professional dancers, with rates of 67.6% in women and 40.9% in men (Costa, Ferreira, Orsini, Silva & Felicio, 2016). In studies of injury predictors, researchers have conclusively demonstrated that a history of previous injury emerged as a robust predictor of future injury occurrence (Ursej, Sekulic, Prus, Gabrilo, & Zaletel, 2019) as well as the outcome and pace of recovery from injuries (Mainwaring & Finney, 2017). Noteworthy is the observation that less experienced dancers displayed elevated rates of absenteeism due to injury compared to others (Novosel et al., 2019). Additionally, some researchers have also demonstrated that dynamic balance, as assessed by the Star Excursion Balance Test (SEBT), serves as a significant protective factor against injury occurrence, regardless of age or dance experience (Sekulic et al., 2020). Moreover, given that dancing involves asymmetrical movements and body positions, it is anticipated that dancers may develop asymmetries in their bodies after several years of training, potentially leading to injuries in these areas (Prus & Zaletel, 2022). Other scientific evidence indicates that various psychological factors, including stress, psychological disorders, sleep patterns, eating habits, and social support, play significant roles in influencing injury occurrence. (Mainwaring & Finney, 2017). Followed by previous findings, the principal objective of this study is to ascertain the prevalence of injuries among dance school students in the City of Zagreb, focusing solely on injury prevalence and affected body parts, excluding other influencing factors. Additionally, a secondary aim is to examine whether there is a statistically significant disparity in injury frequency and affected body parts between elementary and high school dance students.

Methods
Respondents included elementary and high school students from dance schools in Zagreb, namely the Ana Maletić School for Contemporary Dance, School for Classical Ballet, and Artistic Dance School Silvija Hercigonja. The survey instrument,

adapted from Reynolds, Kerchief, and Boyce's (2013) study on injury prevalence among female dancers, consisted of eight questions. Prior to data collection, principals and parental consent was secured, with 47 students (21 elementary, 26 high school) participating. Although gender distribution was not explicitly specified, it is noteworthy that the majority of respondents were female. Information on age, height, weight, weekly training hours, years of dance experience, additional exercise, and injury counts in specific body regions over the past year were collected and categorized into groups representing upper extremities, lower extremities, head/neck, and torso for analysis. The data processing was conducted using Statistica 13.0, which provided descriptive statistics of the sample. Total injury frequencies for both groups, as well as injury frequencies categorized by body regions, were determined. Considering the previously identified need for nonparametric statistical analysis based on the Shapiro-Wilk testing of variables, differences in injury counts and affected body regions between groups were assessed using a nonparametric Mann-Whitney U test.

Results

The age of elementary dance school students (N=21) was 11.1±0.9 years, with a height of 150.1±10.1 cm and a weight of 37.7±7.2 kg, while the age of high school dance students (N=26) was 15.7±1.4 years, with a height of 167.1±6.1 cm and a weight of 56.3±5.4 kg. The majority of participants from the elementary school group reported engaging in dance for 9-11 hours per week, while most of the high school participants responded with 18 to 20 dance hours per week. If we were to consider only the hours spent in the dance school, then even greater differences in the number of hours within the sample of elementary and high school participants would be evident. The result of the number of dance hours represents the sum of dance hours in the dance school and training hours in dance clubs or studios. The majority of elementary school students indicated that they have been engaged in dancing for 6-8 years, while for high school students, the range extends to 9-11 years, not necessarily considering years of dance education. In response to inquiries regarding engagement in physical activities outside of dance training, 51% of participants responded affirmatively, with a smaller subset specifying the types of these activities (most commonly cardio training, followed by plyometric exercises, and least frequently weight training).
The surveyed students (N=47) reported a total of 96 injuries, of which 40 injuries were reported by elementary school students (41.6%) and 56 injuries by high school students (58.3%).

Table 2. Number of injuries by body parts expressed as a percentage (%)

	He	S	A/H	B	Hi	K	F/A
ES	7,5	2,5	10	5	5	25	45
HS	3,6	14,3	10,7	8,9	3,6	21,4	37,5
IT	5	9	10	7	4	23	41

Legend: ES – Elementary School; HS – High School; IT – In Total; He – Head; S – Shoulders; A/H - Arms/Hands; B – Back; Hi – Hips; K – Knees; F/A – Feet/Ankles

Among elementary dance school students most injured body parts were feet/ankles (45%), followed by knees (25%), arms/hands (10%), head (7.5%), back and hips (5% each) and finally shoulders (2.5%). Also, among high school dance students most injured body parts were feet/ankles (37.5%), followed by the knees (21.4%), shoulders (14.3%), arms/hands (10.7%), back (8.9%) and finally head and hips (3.6% each). The results of the total number of injuries according to body parts lead to the conclusion that the greatest number of injuries sustained, as many as 39, were those of feet and ankles, indicating that they account for an average of 41% of the total number of injuries. These are followed by knee injuries (23%), then arms/hands injuries (10%), shoulders (9%), back (7%), head (5%) and finally hips (4%). According to the previous division in groups of injuries the total number of injuries by these groups are head/neck 5 injuries (5.2%), torso 7 injuries (7.3%), upper extremities 19 injuries (19.8%) and lower extremities 65 injuries (67.7%).

Table 5. Differences between total number of injuries and total number of lower extremity injuries

	N	N	Rank Sum (ES)	Rank Sum (HS)	U	Z	p	Z-adj	p	2*1sided exact p
IT	21	26	472,00	656,00	241,00	-0,67	0,50	-0,70	0,48	0,50
IT/LE	21	26	462,00	666,00	231,00	-0,89	0,37	-0,94	0,35	0,38

Legend: Rank Sum (ES) – sum of elementary school ranks; Rank Sum (HS) – sum of high school ranks; N – number of participants; IT – in total (total number of injuries); IT/LE – total number of lower extremity injuries (in total)

The Mann-Whitney U test showed that there is no statistically significant difference between elementary and high school dance students in total injuries ($p = 0.5$; modified $p = 0.48$). Also, there is no statistically significant difference in the number of lower extremity injuries between elementary and high school dance students ($p = 0.37$; modified $p = 0.35$).

Disscusion

From this data it is possible to conclude that injuries of the lower extremities are most common among dance school students of the City of Zagreb (more than 50%). A study of the prevalence of injuries among elementary and high school dance students in the City of Zagreb showed that students most often injure the lower extremities in a percentage of 67.7%. The results of previous research, where the most commonly injured body parts were lower extremities (77%), trunk (16%), head and neck (3%), and upper extremities (3%) (Ekegren, Quested & Brodrick, 2014), are mutually comparable with the findings of injuries among dancers in Croatia. According to the total number of injuries of elementary and high school dance students, it can be noticed that the number of injuries of high school dance students is higher compared to the number of injuries of elementary dance school students. An increase in the number of injuries is noticeable in all body parts except in the case of the head, where the number of injuries is higher in elementary dance school students, and in the case of hips, where the number of injuries is equal, which means that the increase in injuries did not occur. The most significant increase in the number of injuries in high school compared to elementary school is visible in the number of shoulder injuries, where an increase in injuries by 5 times was recorded. Ballet and other dance forms are known to be highly demanding activities, with injury rates reported to reach as high as 90% over a dancer's lifetime (Prisk, O'Loughlin & Kennedy, 2008). According to Chmelar, Fitt, Schultz, Ruhling & Zupan (1987) injuries to the back and knees of modern dance dancers can be attributed to unusual and sometimes extreme movements in the spinal area, which often involve various twists, bends, leans, twists, and rapid changes in the direction and position of the spine. Furthermore, in modern dance, movements on and across the floor are very common and characteristic, as well as rapid and sudden changes in body levels and a large number of jumps, which can also explain the occurrence of the aforementioned injuries.

Mainwaring and Finney (2017) presented a review of risk factors and consequences of dance injuries, emphasizing seven factors that influenced the occurrence of injuries in dancers: stress, psychological distress, amount of sleep, eating disorders, personality, coping ability in stressful situations, and social support, while a total of five factors influenced injury outcomes: stress, psychological distress, eating disorders, passion for dance, and coping ability in stressful situations. As increased flexibility and joint mobility are desirable in dance, the question arises as to whether dancers with these genetic predispositions actually benefit from them. Increased flexibility and joint mobility require the development of strength and power in the corresponding muscles, which act as stabilizers during jumps, turns, and other demanding technical elements. This is important as significant muscle force is exerted, thus increasing the risk of injury if the muscle-tendon-joint structures are not prepared to withstand such loads. A review on the association between muscle strength and injury occurrence through eight studies concluded that dancers with weaker lower extremity muscle strength are more likely to experience injuries (Moita, Nunes, Esteves, Oliveira & Xarez, 2017). The circumstance that half of the dancers in the samples report some type of injury is somewhat concerning, and these injuries are either chronic or acute injuries in the past six months that undoubtedly affect their dance performance (Bowling, 1989).

Conclusion

In artistic dance schools, dancers primarily prepare their bodies through dance technique, with less emphasis on conditioning and sports training. It is important to emphasize that more attention needs to be devoted to comprehensive physical preparation that is not dance-specific but rather focuses on exercises to develop overall physical abilities. Due to the numerous factors influencing injury occurrence, it's impossible to entirely eradicate the risk through preventive measures. However, such measures undoubtedly reduce the likelihood of injury by a certain percentage. Further and more detailed research of injuries of dance school students is needed, examining the causes and consequences that these injuries have and will have on the dance performance of students in further education, but also later in professional dance activities. In addition to the actions of the dancers (balanced diet, a sufficient amount of rest and sleep, coordinated other daily activities and taking care of their body and mind), the influence of environmental factors is very important, which include adequate conditions for training in terms of quality dance floor, hall temperature etc., then a balanced number of training hours to avoid overtraining, the influence of trainers in planning and training programming, but also providing psychological support and understanding of dancer's abilities.

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THE IMPACT OF INTER-SET REST INTERVAL DURATION ON TRAINING INTENSITY IN YOUNG TRAINED MALES

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Abstract
The study aimed to investigate the impact of inter-set rest interval duration on training intensity during resistance training among young trained males. Participants (n = 26, age = 20 ± 1 years, body mass = 81.5 ± 8.8 kg, height = 184.4 ± 6.1 cm, and training experience = 4 ± 1.7 years) were divided into two groups: one with a one-minute rest interval (G1 group, n = 13) and the other with a three-minute rest interval (G3 group, n = 13). For eight weeks, participants underwent a structured resistance training program three times a week. The program included seven exercises, and participants trained until momentary muscle failure. One-repetition maximum (1RM) testing was conducted before the training period to determine individual starting weights for each exercise (70% 1RM). Results revealed significant differences in weights used between the two groups across five out of seven exercises ($p < 0.025$). The G3 group consistently used higher weights compared to the G1 group, indicating better performance with longer rest intervals. These findings suggest that longer rest intervals allow for more complete muscle recovery between sets, leading to better performance and higher training intensity. The study highlights the importance of adjusting rest interval duration based on training goals. Longer rest intervals may increase overall volume load, promoting muscle growth and strength. However, short rest intervals also have advantages, such as increasing anabolic hormone concentration and developing local muscle endurance. Practical implications include optimizing resistance training programs by adjusting rest intervals according to athletes' specific goals.

Keywords: *resistance training, exercise performance, muscle recovery, training volume*

Introduction

Resistance training programs are developed and shaped through the manipulation of training variables, which Kraemer (1983) termed "acute program variables." Proper resistance training programming involves adjusting each acute program variable specific to the given goals (Kraemer & Ratamess, 2004). Changes to these variables can significantly impact training stimuli and potentially motivate exercisers to maintain or increase their performance. There are numerous ways to manipulate acute program variables, and a resistance training program is a composite of them, including 1) type of muscle actions, 2) exercise selection, 3) exercise order and structure, 4) intensity (or loading), 5) training volume, 6) repetition velocity, 7) training frequency, and 8) inter-set rest interval duration (Kraemer et al., 2002).

Among them, in particular, rest interval refers to the time dedicated to recovery between sets and exercises, with an emphasis on the time between sets. The duration of rest intervals between sets and exercises depends on several factors such as training load, goals, training level, and desired energy systems. It is an important factor in resistance training programming as it can significantly affect metabolic, hormonal, and cardiovascular responses during resistance training, as well as fatigue, muscle recovery, training goals, performance of additional sets, training duration, or other training adjustments (Goto et al., 2004; Schoenfeld et al., 2016; Willardson, 2006).

Studies have shown that rest interval duration can have a significant impact on force production in muscles (Schoenfeld, 2010). Specifically, short rest intervals of one minute can significantly decrease mechanical force output and strength in muscles, while these same short intervals are beneficial for hypertrophy and local muscular endurance development. For instance, Kraemer's (1997) research has found differences in performance between three-minute and one-minute rest intervals. All subjects were able to perform 10 repetitions at a 10 RM load in three sets when rest intervals in leg press and bench press exercises lasted three minutes. However, when rest intervals were reduced to one minute, they performed 10, 8, and 7 repetitions per set.

Although the duration of rest intervals is an important factor when designing resistance training programs, it is often overlooked, and, as far as the authors are aware, there is a lack of scientific evidence regarding its impact on training intensity. It is generally assumed that longer rest intervals allow for complete muscle recovery, which helps maintain high intensity, resulting in better performance. Longer rest intervals can also allow the muscles to recover and prepare for the next set, leading to a higher total volume load (Buresh et al., 2009; Fink et al., 2017; Schoenfeld et al., 2016). Additionally, taking longer rest intervals can provide time for mental rest, which can help maintain concentration and focus during training, resulting in better performance.

On the other hand, short rest intervals lead to a higher systemic elevation of anabolic hormones (mainly growth hormone), which can induce greater muscle growth (American College of Sports Medicine, 2009; Wernbom et al., 2007). However, if rest intervals are tailored to the specific needs of muscle groups activated in a given exercise, better recovery and a higher workload can be achieved. For example, if exercises using the same muscle groups are performed, such as the shoulder press after the bench press, longer rest intervals can help in the recovery of fatigued muscles. It is important to note that using long rest intervals can lead to performing sets to momentary muscle failure, which can result in a higher total volume load.

It is important to ensure that all acute program variables are as equal as possible when comparing two training programs. This is crucial to assess the role of rest intervals on training intensity accurately. It is unclear how different rest interval durations affect load in subsequent working sets during resistance training.

Therefore, this study aimed to evaluate the specific effects of equal resistance training programs with different inter-set rest interval durations on load in subsequent sets. The hypothesis stated that resistance training programs with longer rest intervals would lead to a statistically significant increase in load compared to programs with shorter rest intervals in young trained men.

Methods

Participants

A priori power analysis conducted in the G*Power software® (Germany, Düsseldorf, version 3.1.9.7) based on t-tests, with minimum practically significant effect sizes of 0.70, alpha level of 0.05, and statistical power of 0.80, yielded a required sample size of 26 participants.

Therefore, the final sample of participants consisted of 26 young, healthy, and physically active male individuals, students at the University of Zagreb Faculty of Kinesiology. The criteria for selecting the participants included minimal knowledge and experience in resistance training, being healthy without any existing neurological and musculoskeletal disorders, and having no history of trunk, upper, or lower extremity injuries. The participants' age, body mass, height, and training experience were 20 ± 1 years (range 18-22 years), 81.5 ± 8.8 kg, 184.4 ± 6.1 cm, and 4 ± 1.7 years (mean ± SD), respectively. All participants were fully informed about the aims and risks of the study and gave their informed consent to participate in the experiment. The research was conducted in full compliance with the Helsinki Declaration (World Medical Association, 2013), and the experimental protocol was approved by the Scientific and Ethical Committee of the University of Zagreb Faculty of Kinesiology. Participants were not allowed to participate in any other systematic training program during the experiment except for their usual academic activities.

Study Design

The study lasted for nine weeks at the University of Zagreb Faculty of Kinesiology. The first week included measurements, while the following eight weeks consisted of a training program intervention. Participants were instructed not to engage in strenuous exercises within 48 hours before the measurements to ensure that muscles were fully recovered and capable of achieving maximum performance (Grgic et al., 2018). Each participant was familiarized with the measurement protocol before the initial testing. The aim was to determine basic anthropometric characteristics and one-repetition maximum (1RM) for all exercises included in the training program. The study randomly assigned participants to two different resistance training groups: (1) the G1 group, which had a one-minute rest interval between sets (n = 13), and (2) the G3 group, which had a three-minute rest interval between sets (n = 13). Over the following eight weeks, participants underwent the training program three times a week. A detailed diary was maintained to record the weights lifted, repetitions, and sets for each training session.

Procedure

One-Repetition Maximum (1RM)

All participants underwent 1RM testing for each exercise before the intervention training period. The testing was conducted according to the guidelines set by the National Strength and Conditioning Association (Haff et al., 2016) to determine individual starting weights for each exercise. All exercises were tested in a single session with a testing order that reflected the exercise sequence used during training. A 5-minute rest interval was given between exercises.

Before the testing started, the participants did a general warm-up, which included a three-minute run with tasks and brief dynamic stretching. After that, they did a specific warm-up for each exercise. This involved 5 repetitions at 50% of the estimated 1RM, followed by 1-2 sets of 2-3 repetitions with a load approximately equal to 60-80% of the estimated 1RM. The weight was gradually increased in later one-repetition sets until the participants were able to perform the concentric muscle action through the full range of motion.

The heaviest weight lifted with proper technique was considered as the obtained 1RM. A 3-minute rest interval was allowed between each consecutive attempt. All 1RM values for each exercise were determined within five attempts.

Training Program

The resistance training program consisted of seven exercises performed in a specific sequence. However, to avoid any order effects on dependent variables, participants started each session with a different exercise such as Incline Leg Press, EZ Bar French Press, Barbell Bicep Curl, Leg Extension, Prone Leg Curl, Cable Triceps Extension, and Dumbbell Scott Curl.

The program included a standardized warm-up, which consisted of a three-minute run with tasks, followed by a short dynamic full-body stretching routine using a wooden stick. Before the working sets, a specific warm-up was carried out, which involved doing one set for each exercise at 30% 1RM for 10 repetitions.

Moreover, the prescribed intensity was individualized and corresponded to 70% of 1RM in each exercise. All sets were performed until momentary concentric muscle failure, which means the point at which it was no longer possible to perform the next concentric repetition while maintaining proper technique (Zaroni et al., 2019).

Repetition tempo was also controlled, thus, the only acute program variable expected to make a difference between the groups for exercise was the inter-set rest interval. The G1 group strictly adhered to a one-minute inter-set rest interval, while the G3 group had a three-minute rest interval.

Statistical analysis

All statistical analyses were performed using the Statistical Package for the Social Sciences (IBM Corp. Released 2016. IBM SPSS Statistics for Macintosh®, Version 24.0. Armonk, NY: IBM Corp.) and spreadsheet software Microsoft Excel® (Microsoft Corporation. Retrieved from: https://office.microsoft.com/excel). We calculated means and standard deviations for all variables and assessed the normality of distributions using the Shapiro-Wilk test. To determine whether there were differences in load between both groups, we conducted an independent (unpaired) samples t-test. Effects of inter-set interval durations on weight used between groups were assessed using Cohen's effect size index (ES; the difference between G3 an G1 group means divided by the standard deviation of the G1 group). An effect size of 0.2 was considered small, 0.5 moderate, and 0.8 large (Cohen, 1988).

Results

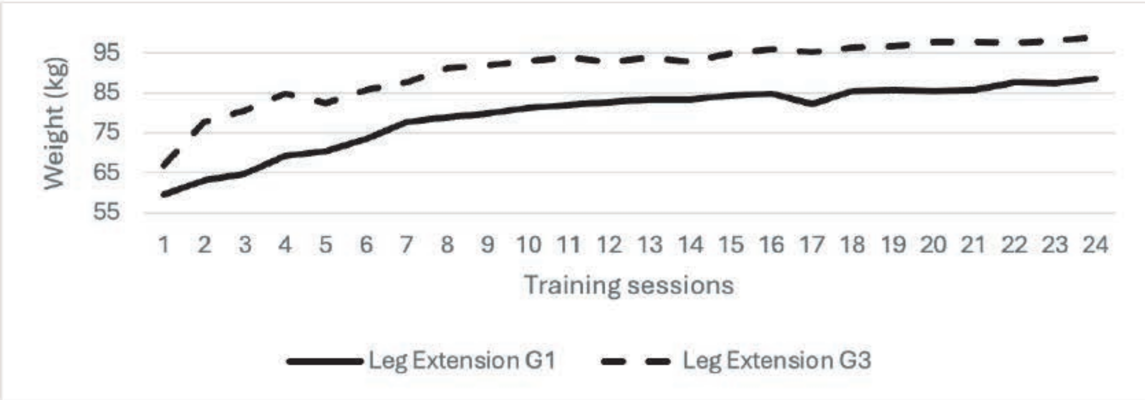
Table 1 and Figure 1 provide information on the average weights and their variation across different training sessions. The data reveals that there are significant differences between groups in five out of seven exercises concerning weights used.

Table 1. Average weights for all exercises in both groups and the statistical significance of differences between the G1 and G3 groups.

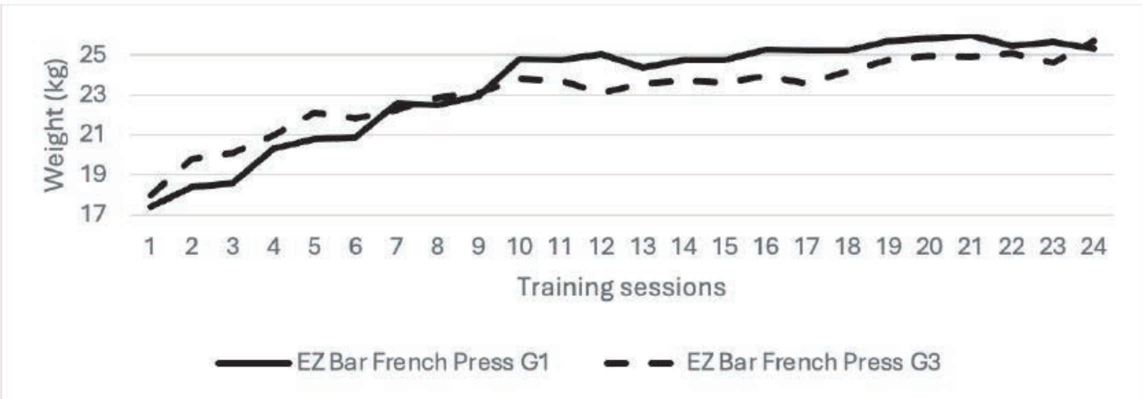
Group	Incline Leg Press	Leg Extension	Prone Leg Curl	EZ Bar French Press	Cable Triceps Extension	Barbell Bicep Curl	Dumbbell Scott Curl
G1	211.8 ± 25.4	79.4 ± 8.3	59.6 ± 4.8	23.4 ± 2.7	31.9 ± 1.7	21.6 ± 1.9	19.9 ± 1.3
G3	240.6 ± 22.6	91.0 ± 7.8	67.4 ± 5.6	23.1 ± 1.9	34.9 ± 2.6	22.4 ± 1.8	18.9 ± 1.6
ES	1.13	1.40	1.63	-0.11	1.76	0.42	-0.77
p	**0.000***	**0.000***	**0.000***	0.603	**0.000***	0.199	**0.024***

*$p < 0.05$


Weight (kg)
250
200
150
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Training sessions
Incline Leg Press G1
Incline Leg Press G3


Weight (kg)
95
85
75
65
55
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Training sessions
Leg Extension G1
Leg Extension G3


Weight (kg)
75
65
55
45
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Training sessions
Prone Leg Curl G1
Prone Leg Curl G3


Weight (kg)
25
23
21
19
17
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Training sessions
EZ Bar French Press G1
EZ Bar French Press G3

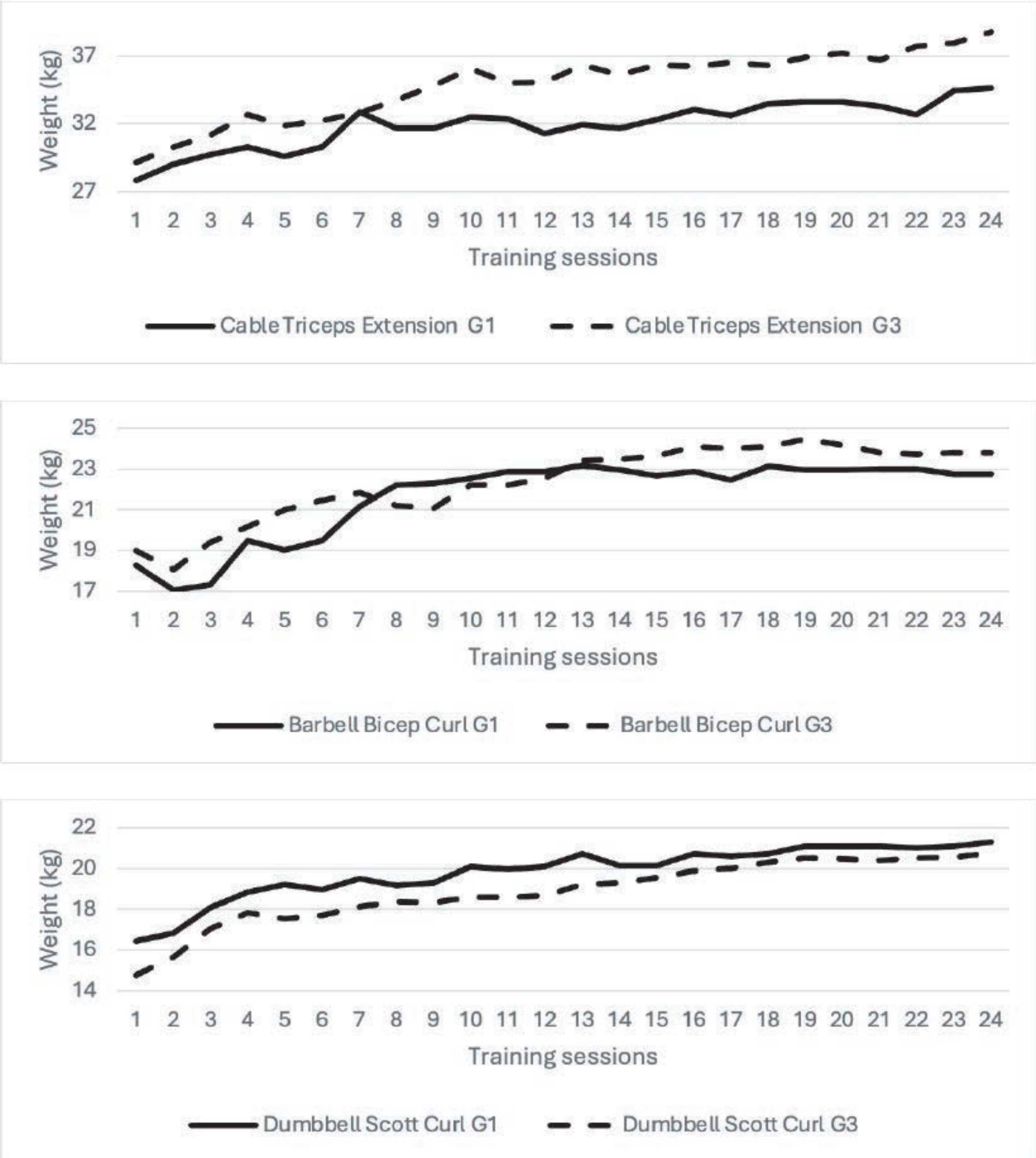


Figure 1. Trends in average exercise weights (in kg) for both groups during each training session.

Discussion

In this study, we investigated whether the duration of inter-set rest intervals in resistance training programs affects the weights in subsequent sets among young trained males. The results showed significant differences in weights between the two experimental groups. This suggests that the duration of rest intervals during resistance training affects training intensity.

It's worth noting that the participants in both experimental groups were trained young males, which ensures that the results are relevant and comparable to this population. Additionally, their initial fitness levels were similar, which eliminates the potential impact of differences in baseline fitness levels on the outcomes.

Our results indicate that individuals who took a three-minute rest interval between sets experienced better performance and achieved higher weights compared to those who only rested for one minute. This is in line with earlier research that suggests that longer rest intervals facilitate better muscle recovery between sets, leading to better performance and higher weights (Willardson, 2006). Longer rest intervals can allow muscles to recover from accumulated fatigue and muscle acidity, which can improve performance in subsequent sets (American College of Sports Medicine, 2009; Wernbom et al., 2007). The results suggest that taking longer rest intervals during training sessions can help individuals maintain higher loads. According to a recent review paper and meta-analysis conducted by Carvalho et al. (2022), training with higher loads results in a greater increase in muscle strength compared to training with lower loads. The study also found that the highest loads provide the greatest benefit when it comes to intensity, following the dose-response relationship. This finding is consistent with previous research conducted by Campos et al. (2002), Fatouros et al. (2005, 2006), Jenkins et al. (2016), Jessee et al. (2018), Kubo et al. (2021) and Lasevicius et al. (2018, 2022) which also demonstrated that using a higher external load leads to a greater increase in muscle strength. Additionally, using heavier weights leads to a higher volume load, which is crucial in promoting muscle growth and strength (Schoenfeld et al., 2017). Therefore, athletes who aim to maximize their training for improving muscle mass and strength can benefit from using longer rest intervals.

However, it is important to note that short rest intervals also have their advantages in certain situations. Short rest intervals can lead to a greater systemic elevation of anabolic hormones such as growth hormone, which can promote muscle growth, even though they do not result in as much of an increase in weights as longer rest intervals do (American College of Sports Medicine, 2009; Wernbom et al., 2007). Additionally, short rest intervals can be useful for developing local muscle endurance and hypertrophy in certain situations (Campos et al., 2002).

The findings of this study highlight the significance of designing an appropriate resistance training program and modifying inter-set rest interval duration based on the specific goals of the athlete. Proper adjustment of rest intervals could play a crucial role in enhancing training outcomes and attaining desired goals in terms of muscle mass, strength, and endurance. It is important to note that this research was limited to young trained males, and therefore, the results may differ in other populations such as women or older individuals. Additionally, future studies could investigate the impact of different rest interval durations on other performance parameters, such as metabolic responses or hormonal changes during resistance training.

Conclusions

This study sheds light on the effect of inter-set rest interval duration on intensity during resistance training in young trained males. The research shows that the duration of rest intervals has a significant impact on the training intensity during resistance training.

The study found that participants who used a longer rest interval of three minutes were able to use higher weights in most exercises, compared to those who used a one-minute rest interval. This indicates that longer rest intervals allow for more complete muscle recovery between sets, leading to better performance and higher intensity.

Using longer rest intervals may increase the overall volume load, which can be beneficial for promoting muscle growth and strength. However, short rest intervals also have their advantages, such as increasing the concentration of anabolic hormones and developing local muscle endurance.

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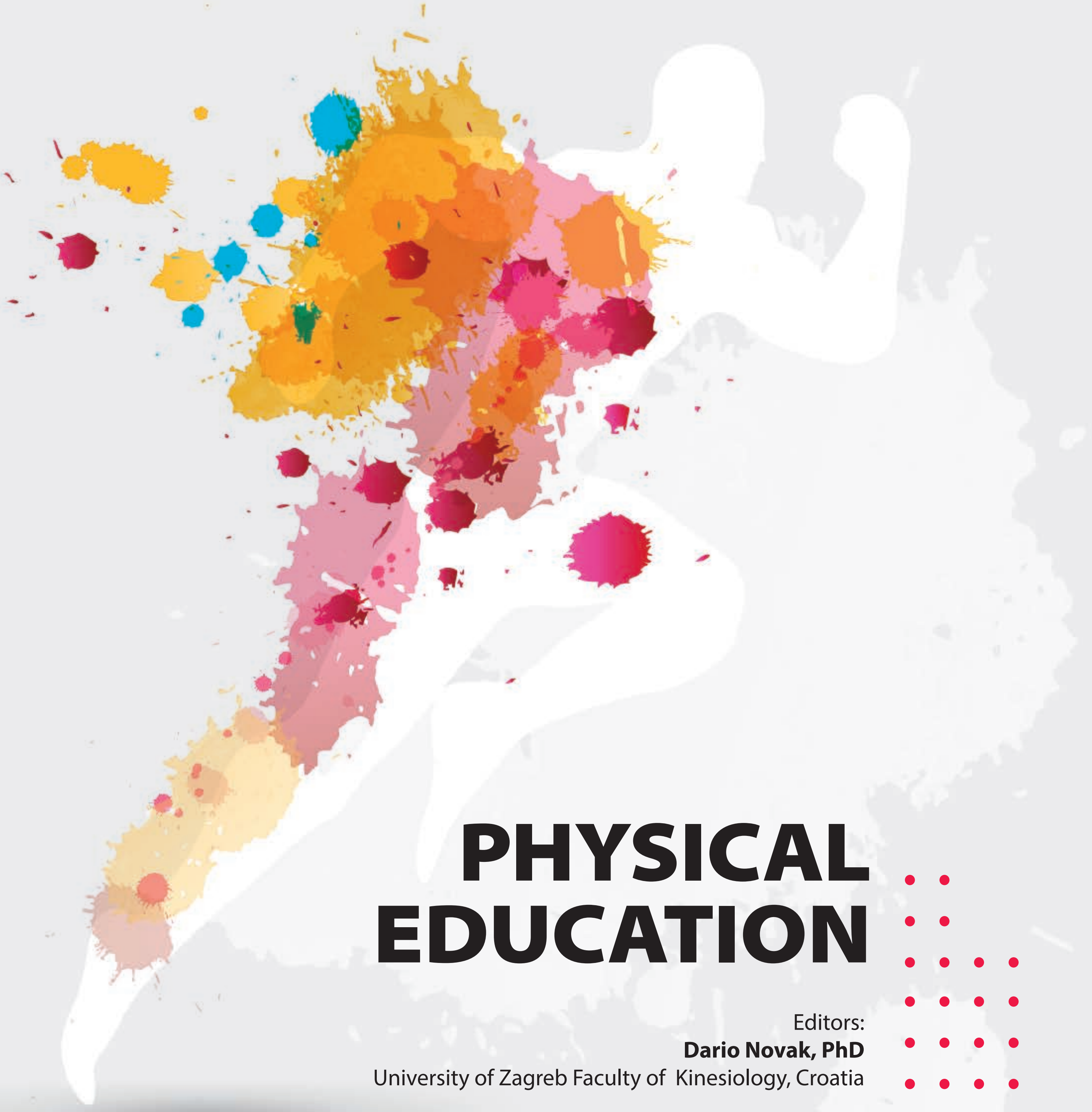
CURRENT TRENDS AND INNOVATIONS IN KINESIOLOGY RESEARCH: PROCEEDINGS



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THE CORRELATION BETWEEN COORDINATION AND VISUAL-MOTOR INTEGRATION IN PRESCHOOL-AGED CHILDREN

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Abstract
Motor activity plays a key role in improving coordination and refining fine manipulative movements, including hand-eye coordination. Coordination is the ability to control movements of the whole body or parts of the locomotor system, manifested by swift and precise execution of complex motor tasks, or rapid resolution of motor problems.Visual motor integration (VMI) refers to the ability to coordinate visual perception with motor skills, particularly fine motor skills. It involves the integration of visual information from the eyes with the motor output of the hands or other body parts to perform tasks accurately and efficiently.

The aim of the research was to determine the connection between coordination and visual-motor integration in preschool-aged children.The study was conducted on a sample of 100 preschool-aged children (52 girls and 48 boys). Coordination was assessed using three tests: Running around the cones, Walking on all fours, and Step by step. The level of visual-motor integration was assessed using the Visual-Motor Integration Test (VMI). The results of this research indicate that there is a positive correlation between coordination and visual-motor integration in both preschool boys and girls. Therefore, preschool children with better coordination is assumed to have more developed visual-motor integration.

The results obtained from this research can have practical applicability in a way that experts designing didactic materials aimed at improving visual-motor integration in preschool-aged children should, in addition to known methods, also incorporate motor activities that enhance children's coordination abilities.

Keywords: connection, early childhood, graphomotor skills, motor development

Introduction
The development of motor skills in a child involves increasing their ability to control their own body and manipulate objects in order to achieve specific goals. The process of motor development can be described as a child learning about movement patterns and motor skills (Malina et al., 2004). The development of motor skills in early childhood is closely linked to the rhythm of growth and development, including the maturation of neurological and muscular systems, physiological predispositions, and physical characteristics (Šalaj, 2012). Motor activity plays a crucial role in strengthening a child's muscles, improving coordination, and practicing precise manipulative movements, including eye-hand coordination (Clark Brack, 2009). Motor development represents a continuous process that results from the complex interaction of various factors. These factors include the maturation of the neuromuscular system, which is largely determined by genetics, physical characteristics such as body size, proportions, and body composition, as well as the pace of growth and development that alternates between phases of accelerated growth and developmental stages. Additionally, previous motor experiences play an important role, including movements during the prenatal period, as well as new experiences, stimulations, encounters, practice, and the integration of different movements. The environment, parents, and the stimuli the child receives from them also significantly influence motor development. The most significant motor skill of a child is coordination. Prskalo & Sporiš (2016) interpret coordination as the ability to control the movements of the entire body or parts of the locomotor system, leading to rapid and precise performance of complex motor tasks and solving motor problems. This complex motor skill, also referred to as motor intelligence, is involved in executing both simple and complex movement patterns (Sekulić & Metikoš, 2007). Coordination is naturally linked to other abilities of the child because all of the child's abilities, including motor skills, do not develop individually but rather iteratively. Given the complexity and multitude of factors involved in coordination, this concept can be classified into three main types: general, specific, and situational coordination. General or basic coordination refers to the property of the neuromuscular system and the ability to efficiently use muscle potentials to perform general motor activities and movements (Idrizović, 2011). Basic coordination plays a crucial role in executing various movements and represents a prerequisite for the development of specific and situational coordination. The level of basic coordination significantly depends on the number of performed motor movements and the level of their adoption, so individuals who have adopted a greater number of these movements have a higher level of basic coordination. On the other hand, Specific coordination denotes possessing a certain level of technical skill and the ability to perform motor tasks specific to a particular sport. This type of coordination can also be described as the degree of adoption of knowledge about

specific motor tasks (Sekulić & Metikoš, 2007). The ability of situational coordination manifests through solving complex motor challenges in real competitive conditions. This coordination depends on many factors and is reflected through various sports disciplines and the anthropological characteristics of athletes (Jukić, et al., 2011). The greatest influence on the development of coordination occurs in early childhood (Pistotnik, 2003).According to Bavčević (2020), visual-motor integration represents one of the fundamental functions in performing tasks such as writing and drawing symbols. This process involves the neuromuscular coordination of visual information and motor executors to achieve precise motor actions. The concept of visual-motor integration often refers to the coordination between the eyes and the muscles of the hands, or the hand, enabling the execution of precise manual activities (Bavčević & Bavčević, 2015). This process is crucial for the development of fine motor skills and motor knowledge.The peak of visual-motor integration development occurs during the preschool and early school years. Visual-motor integration skills encompass the ability to transform visual perceptions into motor functions, including control, precision, psychomotor speed, and coordination (Sanghavi & Kelkar, 2005). The manifestation of visual-motor integration is evident through graphomotor skills, i.e., the ability to write and draw symbols precisely. Visual-motor integration plays a crucial role in fine motor activities, requiring coordination between visual receptor information from the eye and the fine muscle structures of the hand.

Since visual-motor integration depends on the interaction of visual abilities, visual perception, and motor skills (Exner, 2001), it is expected that better general coordination will contribute to better visual-motor integration. Therefore, the aim of the research was to determine the connection between coordination and visual-motor integration in preschool-aged children.

Methods

The study was conducted on a sample of 100 preschool-aged children (52 girls and 48 boys) in the year before starting school (children aged six and seven years) at the Kindergarten "Žižula" Šibenik. The study included children with normal psychomotor development who were healthy on the day of testing. Children with special needs and those younger than 6 years old were excluded from the study. Prior to the research implementation, consent was obtained from the institution for conducting the study, as well as written consent from the parents for their child's participation. The level of general coordination was assessed using three tests:"Running around the cones":The participant's task is to run a slalom around four cones placed at the following distances: the first cone is one meter from the starting line, and each subsequent cone is placed two meters ahead in a forward direction. At the last cone, the participant turns around and runs the slalom back to the finish line. The participant measures the time in seconds it takes to complete the slalom.; "Walking on all fours":The participant's task is to move on all fours to a cone located three meters from the starting line, turn around it, and return to the starting line using the same movement method. The participant measures the time in seconds it takes to complete the task. The task is completed when the participant crosses the starting line with their entire body, and "Step by step": The participant's task is to move sideways, step by step, to a line three meters away and back. This task needs to be done three times. The participant measures the time in seconds it takes to complete the task.

The level of visual-motor integration was assessed using the Visual-Motor Integration Test (VMI) (Bavčević & Bavčević, 2015). The VMI test consists of two parallel broken lines, spaced 1.5 cm apart, drawn on A4-sized paper. These lines form a path consisting of a total of 59 segments, with the distance between the starting and ending points being 178.5 cm. The paper is placed horizontally in front of the participant, and the task is to connect the starting and ending points by drawing a line with a pencil in the shortest possible time. The line must be drawn continuously, avoiding contact with the outer lines of the path. A B-2B type pencil is used, and the participant uses their dominant hand. The time required to complete the task is measured in seconds, while the examiner records the number of errors, which include breaks in the line or touching the outer lines of the path. The final test score is obtained by adding the time required to complete the task and all errors, which are then multiplied by two.

Descriptive parameters were calculated (Mean, Minimum and Maximum scores, Standard deviation, Skewness, and Kurtosis). The normality of the data distribution was tested using the Kolmogorov-Smirnov test. T-test was used to asses' differences in motor coordination and visual- motor integration regarding preschool children gender. The correlation between the level of general coordination and visual-motor integration was determined using Pearson correlation coefficients. The results were analysed using the IBM SPSS Statistics V 29.0 software package.

Results

Descriptive results of measured tests for general coordination and visual-motor integration are presented for the total sample, as well as separately for boys and girls (Table 1). In the total sample of 100 preschool-aged children, there are 48 boys and 52 girls. Boys achieve better average scores on two tests assessing general coordination (Running around the cones and Walking on all fours), and on the test assessing visual-motor integration (VMI) compared to girls. On one test assessing general coordination (Step by step), the results of arithmetic mean of boys and girls are the same value. The reported arithmetic means values suggest that boys have better developed general coordination and visual-motor integration compared to girls.

Table 1. Results of descriptive statistics for the total sample (N=100), for boys (N=48), and girls (N=52)

Test		N	AM	SD	Min	Max	K - S
Running around the cones	Total	100	6,66	0,83	5,15	8,75	0,029
	Boys	48	6,53	0,87	5,37	8,75	0,015
	Girls	52	6,78	0,79	5,15	8,46	0,2
Walking on all fours	Total	100	5,76	1,28	3,3	10,58	0,2
	Boys	48	5,56	1,31	3,3	10,58	0,021
	Girls	52	5,96	1,23	3,84	9,37	0,2
Step by step	Total	100	4,4	0,71	3,24	7,5	0,17
	Boys	48	4,4	0,79	3,24	7,5	0,2
	Girls	52	4,4	0,62	3,27	6,05	0,2
Visual-motor integration	Total	100	61,16	12,29	41,55	121,03	0,2
	Boys	48	58,36	9,82	41,55	80,35	0,2
	Girls	52	63,75	13,79	44,83	121,03	0,2

Legend: N - number of participants, AM - arithmetic mean, SD - standard deviation, Min - minimum score, Max - Table 2. Gender differences in tests assessing motor coordination and visual motor integration (Nm=48; Nf=52)score, K-S - Kolmogorov-Smirnov test, p - significance level 0.01

The results of the conducted research confirm the findings of numerous previous studies indicating that boys, compared to girls, achieve better results on tests assessing global motor competences (Golding et al., 2014; Goodway et al., 2014; Valtr et al., 2016; Jelovčan, & Zurc, 2016; Gadzic, & Milanov, 2021). But, the results of the conducted research do not confirm the findings of numerous previous studies indicating that girls, compared to boys, achieve better results on tests assessing fine motor skills (Freitas et al., 2014; Pahlevanian, & Ahmadizadeh, 2014; Ambrosi-Randić & Glivarec; 2016) or indicating that there are no gender differences concerning fine motor skills of preschool children (Lazarević et al., 2016). From the results obtained by the t-test, boys have statistically significant better results on test assessing visual motor integration than girls

Table 2. Gender differences in tests assessing motor coordination and visual motor integration (Nm=48; Nf=52)

Test	AM m	AM f	t	df	p
Running around the cones	6,53	6,78	-1,49	98	0,14
Walking on all fours	5,56	5,96	-1,58	98	0,12
Step by step	4,4	4,4	0,04	98	0,97
VMI	58,36	63,75	-2,23	98	0,03*

Legend: AMm - arithmetic mean for males, AMf - arithmetic mean for females, t- t test, df- degree of freedom, p - significance level 0.05

Table 3 shows the results of the positive correlation between tests assessing coordination and the Visual-Motor Integration (VMI) in preschool-aged children for the total sample (N=100). Children who achieve better results on coordination tests also perform better on the Visual-Motor Integration test. For boys, correlation is statistically significant between all three tests assessing coordination and visual-motor integration. Girls have significant correlation only for two test (running around the cones and walking on all fours) and visual-motor integration. Furthermore, the correlation coefficient values indicate that the correlation is more pronounced in boys compared to girls. Some of the previous studies have found a positive correlation between coordination and visual-motor integration (Bavčević, 2015; Skowroński et al., 2018), while other researches did not confirm such a correlation (De Barros, 2003; Rezende, 2005; Coelho et al., 2014). Bavčević (2020) pointed out a statistically significant positive correlation in the preschool-age subsample, suggesting the presence of a common underlying mechanism influencing the expression of motor structures. However, over the years, this correlation has decreased. The reduction in the correlation between variables and dimensions of body coordination and visual-motor integration in first and second-grade students suggests the beginning of a gradual separation of underlying mechanisms responsible for expressing macro-motor and micro-motor knowledge and skills. In third and fourth-grade students, there is no correlation between the observed dimensions, implying a complete differentiation of mechanisms responsible for expressing the observed knowledge and skills at the macro-motor and micro-motor levels.

Contrary to the results obtained in this study regarding the positive correlation between coordination and visual-motor integration, some research suggests that the processes of developing gross motor skills and fine motor skills occur separately (Darrah et al., 2003). Their conclusions indicate that motor dimensions develop independently of each other, which is contrary to expectations of stability within individuals.

Table 3. Correlation between coordination and visual-motor integration for the total sample (N=100), for boys (N=48), and girls (N=52)

Test		Running around the cones	Walking on all fours	Step by step
Visual-motor integration	Total	0,45**	0,50**	0,36**
	Boys	0,62**	0,65**	0,59**
	Girls	0,32*	0,39**	0,21

Legend: significance level **p<0,01; *p<0,05

Discussion

In the case of a determined positive correlation between coordination and visual-motor integration in preschool-aged children, it can be concluded that activities aimed at improving coordination skills would indirectly impact the enhancement of visual-motor integration as well. Sekulić and Metikoš (2007) identify three main groups of key techniques for improving coordination: expanding the depth and scope of motor skills, creatively applying previously acquired knowledge, and complete or partial reorganization of habitual movements. The first strategy for expanding the scope of knowledge involves a variety of motor activities familiar to the child, while the depth of motor knowledge is reflected in the quality with which these contents are acquired. It is crucial to provide children with diverse motor experiences, which manifest from a very young age through various forms of biotic movement. The foundation for acquiring other motor skills lies in biotic knowledge contributing to the formation of a diverse set of motor knowledge in kinetic memory. The general coordination factor improves with the acquisition of a large number of motor tasks. The next strategy for enhancing coordination involves the innovative application of already acquired motor skills in everyday situations. This technique manifests through various courses and adaptations of familiar games during interactions with children. The final approach that can foster the development of coordination involves partial or complete reorganization of habitual movements. It is essential to adapt and reshape the structure of individual movements into a meaningful and transformative content to encourage the development of coordination skills in individuals (Sekulić & Metikoš, 2007). Visual-motor integration can be improved through various activities and techniques aimed at fostering synergy between visual information and motor responses. These are several strategies that can help improve visual-motor integration: Eye tracking exercises; Visual games and tasks; Motor exercises with visual focus and Sports activities.

Conclusion

Since the results of this study indicate a positive correlation between coordination and visual-motor integration in preschool-aged children through the use of kinesiological interventions aimed at improving children's coordination abilities, there is an indirect influence on their enhanced visual-motor integration. During the sensorimotor stage (0-2 years), infants learn through their senses and motor activities. The coordination of visual and motor skills begins with simple actions such as reaching for objects and progresses to more complex activities like stacking blocks. These early experiences are critical for developing VMI as they involve the integration of visual perception with motor actions. Also, it is always important to adapt activities to the individual needs and abilities of each child. Furthermore, educators should always create learning environments that promote VMI through play, structured activities, and social interaction. early intervention programs that provide appropriate activities and experiences. Future research should focus on exploring other factors that contribute to better visual-motor integration in preschool-aged children. Moreover, longitudinal studies should monitor motor coordination and visual-motor integration during children preoperational stage (2-7 years) and thus the development of these abilities would be better understood.

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OBESITY AND AEROBIC CAPACITY IN PRIMARY EDUCATION STUDENTS

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Abstract
The aim of this work was to determine differences in aerobic capacity and morphological characteristics in subgroups classified according to the level of nutrition.

Overweight or obesity among school children has reached a high level of prevalence throughout the world. The level of aerobic capacity is decreasing, and one of the reasons is that recommendations on the amount of daily physical activity are not being followed. The research included 430 4th grade elementary school students from the Republic of Croatia. Subjects average age was 10.37 ± 0.49 years, and the sample was divided into three subsamples according to the nutrition level (normal body weight, overweight and obese). Body height was measured with a stadiometer, while body mass, body mass index – BMI and fat tissue (%), adipose tissue mass, muscle mass were measured using a two-frequency body composition analyser (TANITA DC-360P). Waist circumference and hip circumference were measured with a tape measure, and the waist-to-hip ratio (WHR index) was calculated based on their ratio. The waist-to-height ratio was calculated as waist circumference /body height. Aerobic capacity was measured by a multi-stage 20-meter run test (Shuttle run test). Analysis of variance (ANOVA) showed the existence of statistically significant differences ($p = 0.00$) between the subsamples defined according to level of nutrition in all investigated variables. The results show that there is a significant difference in the level of aerobic capacity between students with normal level of nutrition and those with excessive body mass, which is based on values of the number of meters run or number of laps run by research subjects. A greater proportion and application of exercises that influence development of aerobic capacity in Physical and Health Education classes certainly contributes to its improvement as well as to reduction of obesity among school children.

Key words: health, aerobic capacity, children, obesity, 20 m shuttle run test

Introduction

Almost 30% of children in European countries live with overweight/obesity, and the prevalence may be increasing (World Health Organization European, 2022). Results of the CroCOSI 2021/2022 research show that 36.1% of children aged 8.0 to 8.9 in the Republic of Croatia are overweight or obese (Capak, 2024). There is evidence that indicates great physiological role of aerobic fitness in future health of children and adolescents (Rowland, 2007). Physical activity has a positive effect on the level of aerobic capacity (Ortega et.al., 2008). Overweight or obese children with low levels of cardiorespiratory fitness show an unfavorable cardiometabolic profile, while a high level of cardiorespiratory fitness has a protective effect on cardiometabolic health of school children (Bagatini et.al., 2023). Cardiorespiratory fitness is the most researched and assumed to be the strongest predictor of future health (Prince et.al., 2024; Ruiz et al. 2009). Low level of aerobic capacity is strongly associated with cardiovascular risk factors such as abdominal obesity already in preschool age (Carnethon et.al., 2005). Aerobic capacity is the most important human capacity because without aerobic capacity, other cells in the body cannot function either (Sekulić & Metikoš, 2007) and is an important clinical parameter for diagnosing and monitoring current and future functional and metabolic health of obese youth (Aucouturier & Thivel, 2018). Aerobic capacity is directly related to integrated functions of numerous systems in the body and is therefore considered a reflection of overall health of the body (Ross et.al., 2016), and is defined as the highest rate at which oxygen is consumed during dynamic exercises. Aerobic capacity is also called aerobic energy capacity, aerobic endurance, cardiorespiratory endurance or aerobic fitness. Research so far clearly proves that aerobic capacity is an indicator of health status and is significantly related to health outcomes, such as obesity and abdominal obesity in youth (Raghuveer et.al., 2020). Bad eating habits and physical inactivity are key determinants of obesity in young people (Vilallonga et.al., 2017). A higher level of aerobic capacity during childhood and adolescence is associated with a lower body mass index and reduced body fat in later life (García-Hermoso et.al., 2020). Van der Fels et al. (2020) in Netherlands found on a sample of 891 students that children who participated as a part of the intervention group and spent more time engaging in moderate to vigorous physical activity had a higher level of aerobic capacity. Nqweniso et.al., (2020) in the South African Republic on a sample of 853 students found that high aerobic capacity and longer time participating in sports are negatively related to body mass index (BMI). A study by Vandoni et al. (2021) on a sample of 485 Italian students found that physical nutrition has an inverse correlation with aerobic capacity. Longitudinal two-year research (Klakk et al., 2014) on a sample of 800 Danish students established a significant connection between aerobic capacity and obesity, and it was concluded that aerobic abilities have a greater influence on obesity in boys.

The paper aims to explore and determine differences in the level of aerobic capacity among primary education between subsamples defined according to levels of physical nutrition.

Methods

There were 430 respondents from the Republic of Croatia who participated in the research. Average age of the students was 10.37 ± 0.49 years. The sample was divided into two subsamples according to gender, which consisted of 206 girls (10.35 ± 0.49 years) and 224 boys (10.39 ± 0.50 years). All procedures in this research were carried out according to the Declaration of Helsinki. Health status of all students has been checked, which was a prerequisite for them to be healthy at the time of the research. For the participation in the study, parental consent was obtained according to the Code of Ethics for research with children. Body height was measured using a height meter (Seca® 213, Hamburg, Germany), and body mass, body mass index - BMI, fat tissue (%), adipose tissue mass, muscle mass with a two-frequency body composition analyzer (TANITA DC-360P). This measuring instrument is based on the principles of bioelectrical impedance, which has satisfactory metric characteristics (Lee et.al., 2023) for assessing body composition, and is different from other measuring instruments because it uses surface electrodes. Waist circumference and hip circumference were measured with a tape measure, and the waist-to-hip ratio (WHR index) was calculated based on their ratio. The WHtR was calculated as waist circumference /body height. Based on the calculated body mass index, through the tables recommended by the International Obesity Task Force (Cole et al., 2000), the subjects were classified into three groups according to the level of nutrition: normal body weight, overweight and obese. In this field test, subjects run back and forth between two set lines at a distance of 20 meters (Leger & Lambert, 1982). Multi-stage 20-meter running test has good metric characteristics for the assessment of maximum oxygen intake in school-aged children (Brito et.al., 2022). During data processing, basic descriptive parameters were calculated for all investigated variables: arithmetic mean, standard deviation, coefficient of variation, skewness and kurtosis. The significance of the differences between subjects classified according to the level of nutrition and aerobic capacity and morphological characteristics were checked by one-factor analysis of variance - ANOVA. The statistical significance of the differences of the arithmetic means between the groups was determined through the F-value. Variables that showed a statistically significant F value were additionally analysed using the Scheffe post hoc test for determining differences between the arithmetic means of groups, which is very strict when large differences appear. Statistically significant difference was assessed at the significance level of $p < 0.05$. The program STATISTICA version 14.0.0.15., TIBCO Software Inc. was used for data processing.

Results

Frequencies of the results on the total sample of respondents according to the level of nutrition (table 1) show that 69.30% of students have a normal level of nutrition, while 30.70% of them are overweight or obese.

Table 1. Level of nutrition of the total sample of primary education students

Classification	N	%
obesity	31	7.21
overweight	101	23.49
normal body mass	298	69.30

N = number of respondents; %= Percenta

From the results in table 2, average height of the studied students is 147.99 ± 7.34 centimetres, and body weight is 41.17 ± 9.97 kilograms. The result of the body fat percentage is 19.02 ± 7.61, while values of the body mass index are 18.63 ± 3.46. The results of the examined students show that the total sample of respondents have normal parameters according to normative values (Jureša et.al., 2018). The values of skewness and kurtosis are within the limits of -2 to 2, and with the satisfaction of this criterion (Tabachnick & Fidel, 2013), the researched variables were included in the parametric analysis.

Table 2. Descriptive statistics of morphological characteristics and aerobic capacity of the total sample (N=430)

Variables	Mean	SD	CV%	Skewness	Kurtosis
BH (cm)	147.99	7.34	4.96	0.25	0.35
BW (kg)	41.17	9.97	24.21	0.82	0.64
BF (%)	19.02	7.61	40.02	0.50	-0.45
ATM (kg)	8.44	5.27	62.49	1.22	1.43
MM (kg)	31.01	5.21	16.80	0.52	0.19
BMI (kg/m²)	18.63	3.46	18.55	0.86	0.43
WC (cm)	63.55	8.90	14.00	1.14	1.50
HC (cm)	80.54	8.61	10.69	0.47	-0.10
WHR	0.79	0.05	6.94	0.26	1.90
WHtR	0.43	0.05	12.53	1.09	1.20
Run (m)	466.84	270.39	57.92	1.25	1.45

Mean=arithmetic mean; SD = standard deviation; CV%= coefficient of variation; Skewness =asymmetrical distribution; Kurtosis = tailedness of distribution; BH= Body height; BW= Body weight; BF= Body fat; ATM=Adipose tissue mass; MM=Muscle mass; BMI=Body mass indeks; WC Waist circumference; HC Hip circumference:WHR= Waist and hip ratio;WHtR= Waist to height ratio; Run=distance

From the results in Table 3, according to the level of nutrition in all investigated variables it is evident that based on the analysis of variance (ANOVA) there is a statistically significant difference (p = 0.00) defined between subsamples. Determining the differences between groups categorized according to the level of nutrition was determined by post hoc analysis. The Scheffe test was used to analyze variables that assess aerobic capacity and morphological characteristics in those where statistical significance was determined.

The results show that there is a significant difference in the level of aerobic capacity between students with normal level of nutrition and students with excessive body mass, which is based on the results of the number of meters run or the number of laps run by research subjects. Normally fed students have significantly better values of aerobic capacity than students who are obese. Also, students who are overweight have significantly higher aerobic fitness scores than obese students. Observing the variables that are considered indicators of obesity, it is evident that normally fed students have a lower body mass, significantly lower values of body fat percentage, BMI and waist and hip circumference than overweight or obese students.

Table 3. Results of analysis of variance for determination of differences in morphological characteristics of aerobic capacity according to level of nutrition

	Normal weight		Overweight		Obesity		ANOVA	
	N=298		N=101		N=31			
Variables	MEAN	SD	MEAN	SD	MEAN	SD	F test	P value
BH (cm)	146.72	7.17	150.47*a	7.25	152.13*b	5.74	16.22	.00
BW (kg)	36.24	5.97	49.51*a	5.86	61.43*b/c	7.33	368.26	.00
BF (%)	15.14*a/b	4.81	26.42*c	4.35	32.15	4.98	344.91	.00
ATM (kg)	5.65*a/b	2.42	13.15*c	3.09	19.88	4.57	554.70	.00
MM (kg)	28.97	4.06	34.45*a	3.95	39.39*b/c	4.39	140.03	.00
BMI	16.74*a/b	1.72	21.81*c	1.29	26.46	1.82	745.73	.00
WC(cm)	59.10*a/b	4.44	70.58*c	5.73	83.42	7.50	456.16	.00
HC(cm)	76.32*a/b	5.65	87.99*c	4.83	96.84	5.31	322.67	.00
WHR	0.78*a/b	0.04	0.80*c	0.06	0.86	0.07	48.43	.00
WHtR	0.40*a/b	0.03	0.47*c	0.04	0.55	0.04	398.69	.00
Run (m)	523.49*a/b	287.58	354.06*c	164.40	289.68	171.80	24.38	.00

*statistical significance p<0.05; Mean=arithmetic mean; SD = standard deviation * Post hoc Scheffe test a= Normal weight-overweight; b= Normal weight-obese; c= Overweight-Obese; BH= Body height; BW= Body weight; BF= Body fat; ATM=Adipose tissue mass; MM=Muscle mass; BMI=Body mass indeks; WC Waist circumference; HC Hip circumference:WHR= Waist and hip ratio;WHtR= Waist to height ratio; Run=distance

Discussion

Based on the obtained results, it was established that there is a statistically significant difference in the level of aerobic capacity of primary education students between the subsamples defined according to the levels of physical nutrition. In the conducted research, 79.11% of students have normal physical nutrition, and 12.60% of students are overweight. The fact that there are 8.29% of obese students in the examined sample is worrying. The results obtained are similar to those in research (Álvarez et.al., 2020; Nqweniso et.al., 2020). In the research, a 20-meter running test was used to assess aerobic capacity, and raw data on the number of meters run and the number of laps were used. The 20-meter run test (20M Shuttle run test) is considered the most effective field measurement of aerobic capacity for children and youth and is the most widely used method worldwide (Catley & Tomkinson, 2013). Analysis of variance showed that the studied subsamples differ statistically significantly according to the level of nutrition in the variable for assessing aerobic capacity. Observing the differences between the subsamples, it is evident that there is a significant difference between students with normal level of nutrition who ran significantly more meters (523.49) than students with excess body weight (354.06) or obese students (289.68). The results obtained in this way in the distance run are lower than the research results of Bagatini et.al., 2023; Hamlin et.al., 2014; Tambalis et.al., 2019; Santos et.al., 2014. Also, in a systematic review by Lang et al. (2018) it was found that students from Tanzania had higher values of distance run, while Mexican school children showed significantly lower aerobic capacity results than in our study.

Furthermore, the results clearly indicate that there are differences between students with normal physical nutrition and obese students in various aerobic capacities. Similar results were obtained in research by Artero et.al., 2010; García-Hermoso et.al., 2019; Greier & Drenowatz, 2018. Students with normal physical nutrition have statistically better aerobic capacity results than those who are obese or overweight, while no significant differences were observed between the group of normally nourished and overweight students (Caamaño-Navarrete et.al., 2021). A high level of aerobic capacity is an important factor in healthy and normal physical development of children and young people. Almost all research in recent years shows significant differences in the level of aerobic capacity between groups of children classified according to their level of nutrition. The obtained significant differences can certainly be explained by the method of conducting the 20-meter run test (20M Shuttle run test). Its performance requires a continuous change of speeding up and stopping movements, and in this change, there is a strong inertia of the body, which is very demanding for subjects who have more ballast mass in their body (Roca, 2023). A higher percentage of body fat makes cardiorespiratory performance less efficient (Demirkan et.al., 2016). High values of aerobic capacity are positively associated with cardiovascular health (Raghuveer et.al., 2020). All previous research findings show that changes in body mass index (BMI) as one of the clearest indicators of obesity in epidemiological research and cardiorespiratory fitness are interrelated during growth and development of children (Pereira et.al., 2024). This fact points to a need to research causes that lead to this state and based on that, create new guidelines that will finally stop the rapid decline in physical fitness, which is jointly made up of cardiorespiratory and muscle component of fitness. This kind of research should be conducted in future at a younger age of students, when starting school, given that the age limit for physical activity has moved to time of pre-puberty. Likewise, future research should also measure the physical activity of students, because previous research has shown that aerobic capacity largely depends on the physical activity of children and adolescents. Also, it would be good to investigate the longitudinal effects of aerobic capacity in primary education and their reflections in adolescence and adulthood.

Conclusion

Creating and implementing different exercise programs that affect development of aerobic capacity in school children can have an effect on reducing obesity. One of the possible programs for increasing the level of aerobic capacity among primary students would be a mandatory activity of walking 3 times a week for 60 minutes along regular physical and health education classes. This activity would be implemented after the end of school classes and outside the school premises under the guidance of a primary education teacher. It can be expected that the walking program could significantly improve the aerobic capacity of students, especially those who belong to the obese or overweight group. In addition, with reduction of cardiovascular risk and obesity, the main generators of this trend are daily physical activity with a continuous reduction in sedentary lifestyle and adjusted diet of school children. A greater role and application of exercises that influence development of aerobic capacity in Physical and Health Education classes is certainly a contribution to improving aerobic capacity, and therefore a strong predictor of better health in the future.

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PUPILS' PERSPECTIVES ON THE INVOLVEMENT OF COACHES IN TANDEM TEACHING IN PHYSICAL EDUCATION

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Abstract
The aim of the research was to investigate the perspectives of primary school pupils (first level) on the coaches who were involved in tandem teaching of physical education (PE) in Slovak schools during the school year 2022/2023 as part of the "Coaches in School" programme. The study involved 1945 pupils from the first to fourth grades of primary schools. Of these, 1654 formed the experimental group (EG), which had a coach in addition to the teacher once a week during PE classes in the school year 2022/2023. The control group (CG) consisted of 291 children who did not have a coach during PE classes and attended classic lessons with the teacher. An electronic questionnaire was used to obtain the pupils' perspectives. The Chi-squared (X^2) test of independence was used to investigate the relationship between the children in the experimental and control groups and their perspectives about the coach or teacher. We found statistically significant relationships in multiple items. Pupils in the EG were more likely to report that coaches in tandem PE teaching use more visual demonstrations and that they understand their instructions and demonstrations. Based on our findings, we believe that tandem teaching involving sports coaches in the PE teaching process at the primary level could eliminate problems with the quality of teaching and make PE classes more efficient.

Keywords: tandem teaching, physical education, pupils' perspectives, 1st grade of primary school, " Coaches at school “

Introduction

Curricular reform is currently underway in Slovakia, focusing on meeting the needs of 21st century education. The new physical education (PE) curriculum also opens the door for the implementation of a special teaching method: tandem teaching. This form of work in primary education is not completely unknown, but on the other hand, it is not a very common practice in Europe and the world.

Tandem teaching is a form of management of the PE teaching process in which the process is conducted simultaneously by two educators, they work together, support each other, help each other, yet have some autonomy in the work. It is mainly applied in the first grades of primary school and can take various forms. In the area of primary education in PE education, one possibility is the cooperation of the class teacher with the teacher of PE, or with a coach or instructor, who actively participate in the teaching and have clearly divided competences (Antala et al., 2023).

In some European countries, such as Germany, France and Ireland, class teachers are supported by sports coaches or consultants in some PE classes. Tandem teaching also exists as a positive practice in Slovenia. In this country, general education teachers and PE specialists collaborate on PE classes in primary schools. This concept is highly valued by both groups of teachers (Klincarov et al., 2018). Several years of experience with tandem teaching are also available in North Macedonia, where this teaching model was introduced in physical and health education (the official name of the subject) in 2019. The implementation took place gradually, from the first grade to the next grade in each school year (Popeska, 2022).

Tandem teaching is gradually being implemented in primary and secondary schools in Slovakia with the aim of improving the quality of PE teaching. It is not yet a common form of PE teaching, but in recent years it has gradually gained importance and is being implemented in various forms in schools, especially at the first level (or first cycle) of primary school. In Slovak schools, it is implemented in PE with the help of teachers who come either from outside the school environment (coaches, instructors) or from the internal environment of the school (PE teacher, teacher's assistant) (Antala, 2024).

Program "Coaches in Schools" implemented in Slovak primary schools in the 1st and 2nd grades since the school year 2020/2021 is an example of tandem teaching. Program involves qualified, trained coaches in the teaching process of PE at the 1st grade of primary school, who, in cooperation with the teacher, develop pupils' versatile movement literacy. The coach and teacher create a tandem that brings pupils better PE classes. However, coaches do not replace the teacher, but rather help with the teaching of PE classes and try to inspire the teacher. Therefore, great emphasis is placed on cooperation with teachers and their active involvement in the process itself (Barák et al., 2021; Dovičák & Kobulnický, 2022).

The aim of the research was to investigate the perspectives of primary school pupils on coaches who were involved in tandem teaching of physical education at Slovak schools in the school year 2022/2023 as part of the "Coaches in School" programme.

Methods

The research was conducted in the school year 2022/2023 in Slovakia and the sample consisted of 1945 pupils from the 1st to 4th grade of primary schools. The pupils were divided into two groups:

- Experimental Group (EG): 1654 children (51.2% girls and 48.8% boys) who, during the 2022/2023 school year, had a coach in addition to the classroom teacher once a week during PE classes as part of the "Coaches in School" program.
- Control Group (CG): 291 children (46.7% girls and 53.3% boys) who did not have a coach during PE classes and had traditional classes with a teacher.

Tandem teaching of PE lessons was implemented through the "Coaches in Schools" program, which involved 192 schools, 950 classes, 152 coaches, and more than 22,000 children in Slovakia in the 2022/2023 school year. An electronic questionnaire designed for the purpose of this research was used to collect the observed empirical data. The questionnaire contained 9 closed-ended questions using a 4-point Likert scale ("always", "often", "sometimes", "never"). The questionnaire also included validation questions to check for consistency and exclude unreliable respondents. The same questionnaire was used for both groups, with the term "coach" replaced by "teacher" in the control group. At the end of the school year, the questionnaire was to be completed by the pupils with the help of a parent at home, so that the parent had to read each question slowly and explain to the child by example exactly what the question meant. The child was then asked to tick one answer.

The obtained empirical data were evaluated at the level of percentage analysis and the Chi-square independence test for contingency tables (X2) was used to assess the significance of the evaluated relationships. We chose the level of statistical significance $\alpha=0.05$. When evaluating the substantive significance of the relationships, we used Cramer's V and the interpretation was based on the rules proposed by Cohen (1988): .10 = small effect, .30 = medium effect and .50 = large effect.

Results

The following section presents how children evaluated the "Coaches in School" program coaches, who they had during PE classes (once a week) in the school year 2022/2023. To provide additional context, we also include the opinions of children from the control group (who did not have a coach during PE classes in the 2022/2023 school year), which were expressed about the generalist teacher.

Table 1. Chi-Square and Cramer's V Results (Experimental group vs. Control group)

Coach (in the case of the experimental group) or **generalist teacher** (in the case of the control group)		**always**	**often**	**sometimes**	**never**	
is the main commander and we obey	**EG**	58.7%	28.2%	12.1%	1.0%	X^2 (1, N = 1945) = 3.49 p =.322 V =.04
	CG	54.6%	29.9%	13.4%	2.1%	
gives instructions in PE class that I understand.	**EG**	64.8%	27.3%	7.6%	0.3%	X^2 (1, N = 1945) = 8.39 p = **.039** V =.07
	CG	59.8%	27.9%	11.3%	1.0%	
explains and demonstrates things in a way that I can understand easily.	**EG**	72.7%	22.4%	4.7%	0.2%	X^2 (1, N = 1945) = 29.85 p <**.001** V =.12 (**small** effect)
	CG	59.4%	28,9%	11.0%	0.7%	
shows us what to do and how to do it	**EG**	87.8%	8.7%	3.1%	0.4%	X^2 (1, N = 1945) = 110.71 p <**.001** V =.24 (**small** effect)
	CG	65.6%	18.2%	13.8%	2.4%	
will praise me if I succeed in something	**EG**	48.5%	23.6%	22.2%	5.7%	X^2 (1, N = 1945) = .88 p =.831 V =.02
	CG	46.4%	25.8%	21.6%	6.2%	
evaluates us after the lesson and praises those who made an effort	**EG**	44.8%	21.0%	20.7%	13.5%	X^2 (1, N = 1945) = 18.28 p <**.001** V =.10 (**small** effect)
	CG	32.6%	28.9%	25.8%	12.7%	
will help me if I encounter any difficulties.	**EG**	60.1%	19.4%	15.9%	4.6%	X^2 (1, N = 1945) = 3.95 p =.267 V =.05
	CG	57.4%	18.9%	20.3%	3.4%	

Legend: EG – experimental group, CG – control group, X2 - Chi-square independence test value, N - sample size, p – value for Chi-square test, V - Cramer´s V value

Table 1 presents the percentage of responses to the questionnaire questions from pupils in the experimental group (n=1654) and the control group (n=291), as well as the Chi-square test results in the form: X2 (degrees of freedom, N = sample size) = chi-square statistic value, p = p value. All tests were performed at the significance level α=.05. The table also shows the Cramer's V result - measure of effect size for the Chi-square independence test.

Based on the evaluation results of the first question, we can conclude that the pupils in the experimental group perceive the coach as an authority figure almost equally to the pupils in the control group who perceive their teacher as an authority figure. The chi-square independence test showed statistically significant differences primarily in the use and comprehensibility of explanations and demonstrations during PE classes. Children understood instructions and demonstrations better in a tandem teaching environment with coaches than in classes where only teachers were present. The biggest difference between the children involved in the program and the children from the control group was in the answers to the question of whether the coaches or teachers showed them what to do in class. 87.8% of the children in the experimental group stated that the coach they had in class always used a visual demonstration (in the control group it was 65.6%). Visual demonstrations are a more effective learning tool for young children than just verbal descriptions.

We were also interested in the relationship between children from the experimental group to the coaches they had during physical education classes. "I like the coach" - 92.4% of the children answered always or often, and as many as 94.2% of the children answered that they always or often trust the coach.

Discussion

The implementation of tandem teaching in PE at the primary level of primary education has been one of the most significant reforms in PE in recent years, also in North Macedonia. A pilot study conducted by the Faculty of Physical Education, Sport and Health of St. Cyril and Methodius University in Skopje at five primary schools produced positive results. One of these was that the introduction of tandem teaching eliminated the cancellation of physical and health education classes, and all classes were conducted in full. The classroom teachers, pupils, and parents also had a positive attitude towards this teaching model. The study by Popeska et al. (2023) examined the roles and responsibilities of teachers in tandem teaching (n=198). They found that PE specialists were more involved in content selection, demonstrations, and lesson delivery, while generalist teachers focused more on discipline, social-emotional climate, and pupils' behavior. Differences were also noted in organization and involvement in extracurricular activities, activities with parents and on school level. These findings are consistent with our results, which showed that the involvement of coaches in tandem teaching of PE has a positive impact on pupils' perception of the lessons, especially in the area of comprehensibility of explanations and demonstrations.

Further studies examined various aspects of tandem teaching. Balga et al. (2023) examined the impact of tandem teaching of PE in primary school on the popularity of the subject among pupils. The results showed that the popularity of PE increased in the group of pupils who participated in tandem teaching during the monitored period (school year 2021/2022). Results of further research (Aleksovska-Velichkovska et al., 2022) suggest that tandem PE teaching also has a positive effect on the body composition and motor skills in young school-aged children compared to traditional teaching. The results suggest that innovative lessons (implemented by the classroom teacher and the PE teacher) are much better planned, organized, implemented and delivered compared to traditional lessons implemented only by the classroom teacher.

We believe that tandem teaching in PE in primary school offers numerous benefits. The presence of a coach or a second teacher during PE classes allows for dividing pupils into smaller groups and providing them with more individualized attention. Two teachers within one classroom can significantly enrich and revitalize the lesson, which can lead to increased motivation and interest in PE among pupils. However, for tandem teaching to be effective, it is crucial for teachers to set common goals, mutually respect each other, and be willing to share their pedagogical expertise. Intensive collaboration between both teachers is the key to the effective learning of all pupils in the classroom.

Based on our findings, we believe that tandem teaching and the involvement of sports coaches or specialist PE teachers in the teaching process of primary physical education lessons could eliminate problems with the quality of teaching and make these lessons more efficient. The present study has certain limitations that need to be acknowledged. The sample size of the control group (n=291) is relatively small compared to the experimental group (n=1654). The study includes pupils of different ages (1st to 4th grade), which can lead to variations in the perception of tandem learning. Another limitation is the possible bias caused by parents helping their children to complete the questionnaire. Future research could address these issues by having students complete the questionnaire at school under the supervision of teachers, which would prevent parents from influencing children's responses and make the results more reliable.

Despite these limitations, our results indicate the potential of involving coaches in tandem teaching in PE and suggest the need for further research in this area.

Conclusion

The research provides valuable insights into pupils' perceptions of coaches in elementary schools, which can aid in the further development of tandem learning programs. The results showed that children perceive the coach as an authority figure and appreciate their effective explanations and demonstrations. Our findings indicate that coaches more frequently employ visual demonstrations, which helps pupils to understand the tasks and exercises in physical education better. The research suggests that tandem learning can increase pupils' trust in coaches and contribute to more effective physical education instruction. Overall, this study is an important contribution to understanding the impact of tandem learning on pupils' perceptions and its potential to improve the quality of physical education instruction. However, further research efforts and consideration of the limitations mentioned are needed to draw more reliable conclusions.

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EFFECTS OF RECREATIONAL FOOTBALL AND HIGH-INTENSITY INTERVAL TRAINING ON BODY COMPOSITION IN OVERWEIGHT ADOLESCENTS

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Abstract
The aim of this study is to evaluate and compare the effects of six weeks of High-Intensity Interval Training (HIIT) and recreational football on body composition in overweight adolescents. The study included forty five overweight adolescent males from school classes in southern Serbia. Twenty two participants (with an average height of 175.97±5.29 cm and age of 13.5±0.5 years) were assigned to a HIIT group, while the remaining twenty three (with an average height of 176.92±8.71 cm and age of 13.7±0.6 years) formed the recreational soccer group (small-sided games - SSG). The HIIT group exhibited a significant improvement in body fat (BF) and body fat percentage (BF%), in comparison to the SSG group ($p < 0.05$), while no significant changes ($p > 0.05$) were observed for body mass, BMI, and muscle mass in both groups. After six weeks of training, both the amount and percentage of fat significantly improved in the HIIT group. In the SSG group, all variables maintained their values, while the percentage and amount of fat increased.

Keywords: training, football, adolescents, weight

Introduction
Adolescent physical inactivity and obesity present a pressing concern in today's society, with far-reaching implications for health and well-being (Skogen, & Høydal, 2021). The lack of regular exercise not only leads to weight gain but also exacerbates the risk of developing various health complications, including cardiovascular diseases, diabetes, and mental health issues (Skinner, Perrin, Moss, & Skelton, 2015). Moreover, adolescents who are obese often face social stigmatization and psychological distress (Jebeile, Cardel, Kyle, & Jastreboff, 2021), which can further perpetuate the cycle of inactivity and poor health outcomes. High-Intensity Interval Training (HIIT) and recreational football are two prevalent physical activity strategies that have gained substantial attention for their roles in tackling overweight conditions amongst adolescents (Hammami, et al., 2017; Hadjicharalambous et al., 2022; Cvetković et al., 2018; Cvetković, et al, 2018). HIIT is typically defined as exercise consisting of repeated bouts of high-intensity work performed above the lactate threshold, interspersed with intervals of low-intensity exercise or complete rest (Laursen & Buchheit, 2019). It is a beneficial strategy for developing fitness, mimicking the specific demands that will be encountered during competitions in sport (Stone & Kilding, 2009). HIIT is considered an optimal type of training for improving both aerobic and anaerobic capacities and thus appears to be an effective method of conditioning training for professional players but also for recreational athletes (Cook, Cathcart, Scott & Easton, 2010; Foster et al., 2015). One of the advantages of HIIT training is that it is potentially the most efficient way to achieve the goals of adaptive exercise (Laursen & Buchheit, 2019). Therefore, HIIT is a good and time-efficient strategy to enhance fitness components in adolescents (Batrakoulis, Jamurtas, & Fatouros, 2021). Small-sided games (SSGs) in recreational football are a popular and effective way to enjoy the sport while reaping numerous health and social benefits. These games typically involve fewer players on each team, often played on smaller fields, which fosters increased involvement, more touches on the ball, and enhanced participation for all players (Luchesi, et al. 2023). Beyond the fun factor, SSGs offer a dynamic and engaging way to improve fitness, technical skills, and tactical understanding in a less structured environment compared to traditional full-field matches (Clemente, Afonso, & Sarmento, 2021). While existing research may explored the impacts of HIIT and recreational soccer on body composition separately, there is limited research that compared this two training modalities in adolescents. Investigating the changes in body composition following HIIT or recreational soccer interventions could provide valuable insights into the efficacy and feasibility of these approaches as sustainable strategies for managing overweight in adolescents. Therefore, the aim of this study is to evaluate and compare the effects of HIIT and recreational football on body composition in male overweight adolescents.

Methods

Participants

The study comprised forty five overweight adolescent males from various school classes in southern Serbia. Twenty two participants (age 13.5±0.5 years) were assigned to recreational soccer group (SSG), while the remaining twenty three (age 13.7±0.6 years) formed the HIIT group, while both groups were involved in their regular physical education activities. Inclusion criteria were adolescents aged between 12 and 15 years, having a body mass index (BMI) to be considered overweight according to Cole et al. (2000); (absence of any medication affecting study outcomes, and no involvement in structured exercise training within the past six months, except for standard physical education classes lasting up to 90 minutes per week. Both participants and parents were informed about potential risks associated with the experimental procedures and provided consent to participate. The study protocol adhered to the Declaration of Helsinki guidelines and received approval from the ethics committee at the Faculty of Sport and Physical Education.

Table 1 Descriptive characteristics of participants

	AS ± SD
Age (years)	13.6 ± 0.6
Body height (cm)	177.64 ± 6.5
VO2max	38.1 ± 2.04

Testing procedures

Body composition measurements for all participants were conducted in the school hall at both the initial and final assessments. All measurements took place early in the morning, before 10 a.m., during both the initial and final assessments. Consistency was maintained by employing the same researchers for both sets of measurements, following the same sequence and utilizing identical instruments.

Body height was measured under standard conditions with a Martin anthropometer with an accuracy of 0.1 cm. The InBody770 (Body Composition Analyzer – InBody770, InBody Co., Ltd., Chungcheongnam-do, Korea was used, which has been verified for its reliability with 95% accuracy (McLester, et al., 2020). We recorded several body composition metrics, including body mass index, skeletal muscle mass, percentage of body fat mass, fat-free mass, total body water, and basal metabolic rate.

Training Program

Children were randomly assigned to either the recreational football group (SSG) (22 players) or the High-Intensity Interval Training (HIIT) group (23) during the six weeks. In addition to the SSG and HIIT programs, all children continued to participate in their regular physical education classes. It was ensured that all children received the same conditions, except for the HIIT and SSG components.

HIIT Training

High-Intensity Interval Training was conducted on 20-meter-long fields, with 15-second work intervals followed by 15-second rest intervals, with intermittent runs (Table 2). The individual running intensity was selected based on the children's V30-15IFT, as previously demonstrated (Bucheit, 2008)

Table 2. HIIT program

week	Program	VIFT
1	3 bouts (5 x 15"-15" HIIT)	90% VIFT
2	3 bouts (5 x 15"-15" HIIT)	90% VIFT
3	3 bouts (8 x 15"-15" HIIT)	90% VIFT
4	3 bouts (8 x 15"-15" HIIT)	90% VIFT
5	4 bouts (6 x 15"-15" HIIT)	95% VIFT
6	4 bouts (8 x 15"-15" HIIT)	95% VIFT

Small-Sided Games (SSG)

The ontent of the SSG program is inspired by and modified from several protocols. We used teams of three or four participants in each team, as this elicits the best responses both physiologically and in terms of skill development. The average heart rate during SSG training was 154±18 beats per minute (85-89% of HRpeak). The exercise program lasted for six weeks. Sessions were conducted using the 4x4 and 3x3 methods on fields measuring 20x15 m and 25x18 m.

The protocol included several rule changes to increase the intensity of the game. Participants were allowed a maximum of two touches during the first ten minutes. Furthermore, each time the ball went out of play, the coach immediately introduced another ball, resulting in a continuous flow of the game and thus avoiding any significant reduction in participants' physical demands. These exercises were conducted twice a week.

Statistical analysis

We used SPSS statistical program version 22 for statistical analysis (SPSS Inc., Chicago, IL, United States). Kolmogorov–Smirnov test was used for the normality of distribution. Independent t test was used to determine the differences on the initial testing. A two-way analysis of variance (ANOVA) was used to test group (HIIT vs. SSG) and time (pre-test vs. post-test) effect and group x time interaction for body composition values. Statistical significance was set at $p \leq 0.05$ level of significance.

Results

Based on the results of the independent samples t-test, it was concluded that the average values of both groups did not statistically significantly differ at the initial testing ($p > 0.05$)

Table 3. Results of body composition parameters before and after the six-week SSG and HIIT training programs

	SSG N=22		HIIT N=23	
	pre	post	pre	post
Body height (cm)	176.29 ± 6.1	176.49 ± 6.2	180.57 ± 6.6	180.77 ± 6.5
Body mass (kg)	73.41 ± 9.71	74.45 ± 8.61	81.89 ± 9.12	82.72 ± 8.73
Body water (kg)	41.49 ± 4.98	41.73 ± 5.01	46.75 ± 6.04	47.41 ± 6.00
Body fat (kg)	16.75 ± 4.85	17.49 ± 3.55	18.02 ± 1.82	17.44 ± 1.22*
Fat %	22.25 ± 4.97	23.44 ± 3.99	23.20 ± 2.02	22.96 ± 2.92*
BMI	25.35 ± 2.52	25.72 ± 2.11	26.98 ± 1.89	27.23 ± 1.79
Muscle mass (kg)	31.93 ± 4.11	32.08 ± 4.16	36.42 ± 5.02	37.01 ± 4.99

* difference compared to SSG group, $p<0.05$

The two-way repeated measures ANOVA revealed that the HIIT group significantly altered body composition after six weeks of testing compared to the SSG group (Table 3). The HIIT group exhibited a significant improvement in body fat (BF) and body fat percentage (BF%), in comparison to the SSG group ($p < 0.05$), while no significant changes ($p > 0.05$) were observed for body mass, BMI, and muscle mass in both groups.

Discussion

The aim of this study was to determine the effects of HIIT and recreational football on body composition in overweight adolescents The findings of the current study showed that six weeks of HIIT decreased some risk factors, specifically body fat and body fat % compared to recreational football. Body composition is not only considered a prerequisite for health but also tightly integrates into the structure of sports performance and, together with other factors, determines the quality of human movement and the final level of performance (Williams, et al., 2013). Regarding the findings of body composition values, the current results have shown that after the eight-week training program, levels of body fat (BF) and body fat percentage (BF%) in the HIIT group decreased compared to the increase observed in the SSG group. Based on these results, the increase in body mass in both groups, from the initial to the final measurement, was logical and could be explained by an increase in lean tissue. The increase in lean tissue is a result of an increase in muscle tissue, suggesting that the strength of the players has also improved. Research has shown that HIIT can positively impact body composition among adolescents (Costigan, et al., 2015). However, in the present study involving a HIIT and SSG intervention, this was not reflected in BMI outcomes. This discrepancy was supported by a meta-analysis indicating that school-based physical activity interventions often fail to influence BMI, although they do yield other beneficial health outcomes (Harris, et al., 2009). Moreover, BMI is not regarded as the most accurate parameter for depicting genuine changes in body composition, as alterations in BMI do not necessarily signify simultaneous increases in muscle mass and reductions in fat mass (Aasheim, et al., 2011).

Conclusion

After six weeks of training, both the amount and percentage of fat significantly improved in the HIIT group. In the SSG group, all variables maintained their values, while the percentage and amount of fat increased. These findings suggest that, even for a short period, HIIT can help achieve improvements in body composition that impact the adolescent overweight adolescents compared to SSG. Based on this, HIIT implementation is considered a time-efficient training strategy for overweight adolescent.

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STUDY ON DUAL CAREERS AND MENTAL HEALTH PROBLEMS OF CATEGORISED ATHLETES IN CROATIAN SECONDARY SCHOOLS

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Introduction

Since 2007, the Croatian Olympic Committee (CRO OC) has been working with various partners from the education sector on dual career (DC) projects with the main goal that we have an organised DC support system for athletes. During this time and in many projects aimed at different target groups identified as important for athletes' sporting success (micro, mezzo and macro level (Thompson et all, 2022), we have found that athletes' motivation for DC varies: they tend to favour sport over education or vice versa, but for the organisational DC support system, those who are equally motivated for education and sport are the most important. In the implementation of projects and promotional activities, we have followed the European guidelines for dual careers (2012) and examples of good practise, helping to ensure that DC in sport is recognised in the National Sports Programme 2019-2026 and the importance of supporting the education of athletes is highlighted in the Sports Act (2022). The need to improve the care of athletes (Measure 5.3. from the National Sports Programme, p. 110-111) aims to take all necessary measures to improve the status of athletes in society and their successful post-career careers, as well as their health status during and after their sports careers.

Comparison of sports high school system models in Europe

There are 437 grammar schools in the Republic of Croatia: most of them, 42.7%, are grammar schools. Of the 437 schools, only 18 offer special conditions and support for athletes. In the Republic of Croatia there is only one public sports high school and 15 public high schools with sports classes and two private sports high schools. Students who are listed in the ranking of a particular national sports federation have the right to apply for admission to the sports class of the Croatian public sports high school in Zagreb and other public high schools with sports classes. The success of sports high schools depends on many factors, such as the education system, the image of the schools, the goodwill of people in key positions, funding, teacher motivation, school resources and local conditions (sports infrastructure, transport, sports scholarships, etc.).

In Croatia, in addition to the county as the founder of grammar schools, various religious orders (Silesians and Franciscans) were also the founders of grammar schools with physical education. One of the aims of this study was to analyse the satisfaction of athletes with the conditions and support at these schools. In Europe, there are many different models of schools that are customised for athletes: Sports high schools in Finland (Aunola et al. 2018), football high school in Sweden (Andersson and Barker-Ruchti, 2018), German elite schools of sport, elite school of kayaking in Wang (Henriksen et al, 2011), Swedish national elite schools of sport (Erikson et al, 2017), elite schools of sport in Norway (Martinsen and Sundgor-Borgen, 2013), Specialised sports academies - high schools in Norway (Moseid et al. 2019), etc.

The main problem of Croatian sport is the lack of a national sports centre for the preparation of athletes. We have several institutes at the Faculty of Kinesiology in Zagreb and Split, as well as the newly established Athlete Career Centre at CRO OC. Apart from the history of Croatian elite athletes in football, handball and water polo, as well as in the combat sports of judo, taekwondo, sailing, skiing, archery and shooting, we do not have colleges specialising in the athletes of one sport, nor do we have an organisational system for monitoring quality at the national level. Walton et all (2021) found that participation in sport contributes to the physical health and psychosocial development of adolescents. The relationship between sport participation and adolescent mental health is bidirectional. When studying a large longitudinal sample of adolescents with assessments at ages 12 and 14, it was found that the amount of time they participated in organised sport predicted better future mental health and vice versa (Vella, 2019). The aim of this article is to present an analysis of athletes' categorised responses to anonymous questionnaires on DC support and mental health issues in competition at 11 Croatian high schools targeting athletes: 1 sports high school and 10 of them have sports classes.

Keywords: Sedentary behaviour, environment, child

Methods
The target group of this study are secondary school sports students at the schools that are partners in the project "Mental health of young athletes – protection and promotion". Each school - a partner in the project - has invited young athletes from the school who are interested in participating in the DC and mental health workshops. At the end of each DC and mental health workshop organised by the Athlete Career Centre 2023, we asked athletes to complete a 31-item questionnaire collecting information on the following: demographic data (school, gender, age, grade, sport), sport participation (sport experience, time dedicated to sport and level of grading), DC problems (change of school or grade, main problems), support for DC in school and sport, support for DC in school and sport club, cooperation between school and club, absence from school due to sport commitments, implementation of DC policy in school, and career planning and interest in future training.

The last questions related to mental health, such as: Stress factors, difficulty concentrating and what motivates them in difficult times during competitions. The anonymous questionnaires were completed by 71 students categorised as athletes by the CRO OC: 33 of them were male (m) aged x=16.5, sd=0.93 and 38 female (f) aged x=16.68, sd=1.11. Most of them are 3rd grade students 37 (f=19, m=18) 52.7% and 4th grade students 14 (f=9, m= 5) 19.72%. In 1st grade 8 (f=4, m=4) 8.1/% and in 2nd grade 12 (f=6, m=6) 16.9% we found the same number of categorised athletes in terms of gender. Descriptive statistics were generated for all variables analysed. The differences between the categorised athletes in terms of gender and the observed variables were tested using the Chi2 ($\chi 2$) test. When the expected frequency per cell was less than 5, Fisher's exact test was used for all tests, with a significance level of 5% considered statistically significant unless otherwise stated.

Results and discussion
Most of the categorised athletes 24 (f=13, m=11), 33.8% trained one of the sports (volleyball, basketball, football, handball, ice hockey) and then 14 (m=7, f=7), 14.72% water sports (swimming, water polo), 11 f=8, (m=3) 15.49% trek and fields and then 8 (m=7 and f=1), 11.27% martial arts We found that the categorised athletes in secondary schools have a long sports career: 10 years - 11 athletes (f=6, m=5) 15.49%, 11 years – 10 athletes (f=4, m=6) 14.9%, 8 years – 8 athletes (f=4, m=4) 11.27%, and 7 years – 8 athletes (f=3, m=5) 11.27%. Most athletes 45 (f=29, m=16), 63.38% exercise daily, while more male athletes 22 (f=5, m=17) 30.99% exercise several times a day. We found significant differences in terms of athletes' gender and training frequency (Chi2=14.0184, df=3, p=0.0029).

Table 1. Results of the athletes' level of categorization regarding gender

Level of categorization	Female		Male		Total		
	f	%	f	%			
Elite I.	-	-	-	-	-	-	Fisher's Exact Test Chi2=5.7107, df=4 p=0.1931
Elite II.	0	0	1	1.41	1	1.41	
Elite III.	15	21.13	6	8.45	21	29.58	
Excellent IV.	15	21.13	14	19.72	28	40.85	
Talented V.	5	7.04	9	12.68	14	19.72	
Talented VI.	3	4.23	3	4.23	6	8.45	
total	38	53.52	33	46.48	71	100	

In Table 1. we have presented the results of the categorised athletes by level of categorisation and by gender and found that apart from the years of experience and daily training: 21 (29.58%) are categorised as elite (III.) athletes and 28 (40.85%) as excellent (IV). We found no significant statistical differences between categorisation and gender. The results of this study on the problems of coordinating and successfully fulfilling their school and sports commitments are in line with previous studies we have conducted on young Croatian athletes (Caput-Jogunica, 2007; Caput-Jogunica and Jazbec 2021). In this study, 24 (m=12 and f =12), (33.8%) stated that they did not have enough time to study because they wanted to be with their friends. Scrubbeltrang et al. (2016) emphasise that athletic students (14-19 years) have less time for peers outside of sports and participate less often in activities. According to Henriksen et al. (2011), the environment should provide athletes with space for personal identities outside of sport (student, friend, mentor for younger athletes). In line with previous studies (Kristiansen, 2018; Caput-Jogunica and Jazbec, 2021), Croatian athletes categorised the importance of family support as first response 57 (f=29, m=28) 80.28% and friends 22 (f=11, m=11) 30.99% and coaches 19 (f=8, m=11) 26.76% as second choice.

Despite the categorisation, the majority of athletes 52 (f=32, m=22) 73.24% stated that their sports club did not take care of their DC.

Only 9 (f=3, m=6) 12.68% of athletes stated that there are meetings with their parents. Pursuing a dual career is often a difficult balancing act for young sports students. In addition to a supportive family and friends, sports clubs and sports associations should also recognise the important role and cooperate with the school. The results in Table 2 are to be expected as high schools take care of athletes. Most athletes 29 (f=14, m=15) 40.85% are absent from school several times a month. Only 5 (f=1, m=4) stated that they were absent for a few months during the school year. The data shows no statistical differences between the categorised athletes in terms of gender.

Table 2. Results of the frequency of absence of categorized athletes in the school year and data on gender differences

	Female		Male		Total		
Scale of training frequencies	**f**	**%**	**f**	**%**	**f**	**%**	
a few months in the school year	1	1.41	4	5.63	5	7.04	Fisher's Exact Test Chi2=7.4364;st.sl. =6; p=0.3028
up to 2 weeks per month	3	4.23	2	2.82	5	7.04	
2-3 school hours per week	3	4.23	3	4.23	6	8.45	
every day 1-2 school hours	2	2.82	4	5.63	6	8.45	
several school hours /several times a week	8	11.27	3	4.23	11	15.49	
several school hours several times a mounts	14	19.72	15	21.13	29	40.85	
I' am not absent	7	9.86	2	2.82	9	12.68	
Total	38	53.52	33	46.48	71	100	

When asked about the special conditions and support offered to athletes at their schools, the majority 44 (f=19, m=25) 61.97% of categorised athletes responded: Exam by arrangement and 12 (f=10, m=2) 16.90% choose student tutor support and 9 athletes (f=4, m=5) 12.68% choose professor mentor. Regarding future plans, most of them expressed their interest in staying in sports 30 (f=16, m=14) 42.25%, but less than 20% (14: f=9, m=5, 19.47%) answered that they did not know. Most of them are high school students, which means that they have to complete an academic degree programme. Apart from staying in sports as professors or coaches, they have expressed interest in medicine and entrepreneurship, which is consistent with the results of previous studies on Croatian female athletes (Caput-Jogunica, 2007). We found statistical differences in interest in an academic career by gender (Chi=18.1474, df=10, p=0.0525). In the last part of the questionnaire, we wanted to find out what causes stress in the categorised athletes during competitions.

Table 3. Results on the stressors of the categorised athletes during competitions and differences by gender

	Female		Male		Total		
Stressors in competitions	**f**	**%**	**f**	**%**	**f**	**%**	
Stage fright	6	8.45	9	12.68	15	21.13	Fisher's Exact Test Chi2=8.1773, df=6, p=0.2325
Expectation from others	11	15.40	12	16.90	23	32.39	
Injustice	2	2.82	1	1.41	3	4.23	
Opponents	10	14.08	3	4.23	13	18.31	
Pressure from the coach	4	5.63	1	1.41	5	7.04	
Unplanned situation	4	5.63	3	4.23	7	9.86	
No stress	1	1.41	4	5.63	5	7.04	
Total	38	53.42	33	46.48	71	100	

The most common factors influencing categorised athletes' stress during competition are related to DC fans: expectations from: Family, friends and teammates 23 (f=11, m=12) 32.39% and stage fright 15 (f=6, m=9) 21.13%. We found no significant differences between the genders of the categorised athletes. These results have confirmed the findings of the study by Delay et al. (2023) that categorised athletes are not only observed by peers, teammates and opponents, but also by coaches, parents and in many cases spectators, and that female athletes appear to be at greater risk than male athletes (Roccha and Osorio, 2018), which is not confirmed in this study.

Table 4. Analysis of responses on the topic of loss of concentration during competition and differences in the categorised athletes in relation to gender

Concentration/competition	Female f	Female %	Male f	Male %	Total f	Total %	
Beginning of the performance	6	8.45	2	2.82	8	11.27	Fisher's Exact Test Chi2=15.5420, df=4, p=0.0029
Poor performance/situation	16	22.54	8	11.27	24	33.80	
Lack of strength and fatigue	4	5.63	10	14.08	14	19.72	
Concentration does not fall	6	8.45	13	18.31	19	26.76	
Thinking about other things	6	8.45	0	0	6	8.45	
Total	38	53.52	33	46.48	71	100	

Table 5. Analysis of motives in difficult competitive situations and differences between male and female categorised athletes

Motives	Female f	Female %	Male f	Male %	Total f	Total %	
Effort invested	6	8.45	8	11.27	14	19.72	Fisher's Exact Test Chi2=0.6126, df=4, p=0.9837
Support from the environment	8	11.27	10	14.08	18	25.35	
Goal achieved	12	16.90	11	15.49	23	32.39	
Challenge	6	8.45	7	9.86	13	18.31	
No motives	1	1.41	2	2.82	3	4.23	
Total	33	46.48	38	53.52	71	100	

At the end of the questionnaire, we asked the categorised athletes what motivates them in difficult times during competitions? Most of them 23 (f=12, m=11) 32.39% answered: Goal achieved, while 18 (f=10, m=8) 25.35% cited support from family, friends and teammates. Other athletes were motivated by the thought of all the effort invested 14 (f=8, m=6) 19.72% and by the challenge to get even better: 13 (f=7, m=6) 18.31%. We found no statistical differences in motives in difficult competitive situations in relation to gender. More needs to be done to create environments and synergies between the education and sport sectors that promote mental wellbeing and resilience in the long term.

Conclusion

This study is the first study in Croatian secondary education aimed at informing young athletes and their teachers about mental health and the importance of an organised dual career and support for athletes who need it. The analysis of the responses showed that the young categorised athletes aged 16-17 years have a long sports experience (7-12 years) in different sports categorised by the CRO OC. We found significant gender differences in training frequency, with more male athletes training multiple times a day than females, and statistical differences in interest in an academic career. The data analysis shows that we need to educate young athletes to care more about DC planning (about 20% of them, more females than males, do not know) and that we need to improve collaboration between the sports and education sectors at different levels to make the environment less stressful for athletes and help them achieve an academic degree for their desired profession.

Further research is needed to gain a deeper understanding of how the dual career workshop and the mental health promotion tools presented impacted the athletes who participated in this project and whether there are differences between them and other athletes in sports schools who were not involved. The data from this study cannot be generalised to all Croatian sports schools and categorised athletes.

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PSYCHOMETRIC PROPERTIES AND GENDER-RELATED DIFFERENCES IN THE HULA-HOOP TEST FOR CHILDREN

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Abstract
The overarching aim of this research was to develop and assess the reliability and validity of the Hula-Hoop test for children, and to subsequently identify any gender mediated differences. In accordance with the aim, a sample of 44 randomly selected children (Boys: N1=22, mean age: 4.92±0.47y; Girls: N2=22, mean age 5.01±0.63 y) were assessed by 6 expert judges according to defined criteria. Utilising a one-way ANOVA, no systematic bias between judges scores (p=0.35; η2=0.03) was evident, while average inter item correlation (IIR=0.90) and Cronbach alpha (Cα=0.98) further indicated appropriate reliability. Factor analysis demonstrated the validity of scoring system through extraction of one significant factor, named Hula-Hoop-specific coordination & movement, explaining 91.3% of judge's scores variability. Independent samples t-tests revealed significant gender-related differences (p=0.01). The results indicate that the Hula-Hoop test can be used as simple and cheap way to assess motor skills in pre-school children. Further studies are needed to introduce, develop and inspect psychometric characteristics, and the veracity of the Hula-Hoop test in larger samples, ages and ethnicities.
Keywords: gymnastics, sex differences, health, measurements, fundamental skills.

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Introduction
Whilst benefits of life-long physical activity, and deleterious consequences of sedentary behaviour are accepted, there is a growing trend of the use of contemporary virtual technologies (for example; mobile phones, tablets) as a tool for the upbringing of children; with empirical data suggesting it already occupies a significant part of their free time in the pre-school age (3-5 years) (Colley et al, 2011). Tentatively, the increasing rates of virtual technology use, and incumbent sedentary time, has been linked to the rise in childhood obesity rates (Flegal et al, 2010), which, if remains unresolved, will facilitate faster and more frequent short-term and long-term ill-health effects, primarily with increased risk for many diseases like cardiovascular, Type 2 diabetes mellitus, and other (Skinner et al, 2015). Accordingly, identifying and scientifically evaluating diverse and challenging physical activities to rival virtual technology use is particularly important.

Among the most popular physical activities, that are equally appealing to both sexes, are games where the development of object control skills is evident. It appears that young footballers and universal sport-school attendees demonstrate a higher level of these skills than gymnasts, for example (Kezic, Simunovic & Delas Kalinski, 2020). Gross motor skills that include a manipulative component comprise: throwing, catching, kicking, trapping, striking, volleying, bouncing, ball rolling and punting (Gallahue & Donnelly, 2003), whilst, the equipment used to perform such tasks, generally, include bats, balls, racquets, or jump ropes. An additional piece of equipment which is accessible, easy to use, equally fun and interesting for pre-school girls and boys is the Hula-Hoop. In a practical and applied setting, several types of movements are often performed: rotation, rolling, swinging, jumping through, circling around the body or parts of the body, throwing and catching, picking up and creeping through it. Accordingly, its usage appears to promote body/spatial awareness, control of movements, balance, coordination and proper development of body posture. The Hula-Hoop is also an official apparatus in Rhythmic Gymnastics and an introductory apparatus in rhythmic gymnastics schools, whereas a high level of fundamental movement skills is required in different learning stages for mastery of elements (Kezic, Miletic & Kujundzic-Lujan, 2018), mostly object control skills.

Differences in Fundamental Movement Skills (FMS) are typically not yet manifest in preschool children (LeGear et al., 2012). However, some equivocality exists both for locomotor and manipulative skills; for instance, some studies have reported that levels of manipulative skills are similar between genders (LeGear et al., 2012), whilst others have reported preschool boys outperform their female counterparts (Kokštejn, Musálek, & Tufano, 2017). Notwithstanding, it is feasible that such contradictory results may be due to the age discrepancies of the tested children as well as the environmental factors and technical nuance of the various motor development or competence tests utilised.

As previously noted, the Hula-Hoop is a simple and robust tool, which permits the integration of various manipulative skills, that, hitherto, has not been utilised to objectively measure and quantify manipulative skills. Therefore, given the tools' preponderance across educational and home environments, and its ease of usage, the aims of this study are, 1) to construct and test the psychometric characteristics of the Hula-Hoop test, and, 2) to investigate differences between boys and girls.

Methods
The present study consisted of 44 participants (Boys: N1=22, mean age: 4.92±0.47y; Girls: N2=22, mean age 5.01±0.63 y) whom were randomly selected from several kindergartens from the same city. Participant's parents were required to answer a simple questionnaire that was designed to assess anecdotal engagement in recreational or sport activities which included the Hula-Hoop as a tool. Consequently, one participant was removed because of their participation in recreational gymnastic programs. Parents of all participants were informed about study's purpose and hypothetical risks and they all signed written consent, whilst children gave assent to participate in the study. This study was conducted in accordance of the Declaration of Helsinki, and institutional Ethical Board written approval was attained.

The testing was performed during two consecutive days, indoors on wooden gymnasium floor. Prior to the measurement, all 6 judges had 60 minutes seminar where they were instructed on details of the scale by the experienced kinesiologist. During judge's education, several details were clarified, and the final grading scale was approved (Table 1). Measurement started with low-intensity warm-up that included low-intensity running and several children's games. All performances were recorded via digital recorder (Panasonic HC-V770K Full HD Camcorder, 1080p, 20×Digital zoom). All participants were informed about testing procedure and had one testing trial without recording. The initial position of the examinee is to stand in an upright position with a hula-hoop lying on the lumbar part of the spine. The task is to rotate Hula-Hoop around the waist and to keep the rotation as long as possible and graded using established criteria (Table 1). Participants performed three trials with approximately 30 seconds of rest between trials. Participants performed the test wearing their choice of slim fit T-shirt and shoes.

Table 1. Hula-Hoop test grading criteria

Grade	Qualitative criteria
1	• Unable to spin hula-hoop around the waist • does not know how to bore the hula-hoop around the body
2	• does not understand the motion of the body • knows how to spin hula-hoop around the body
3	• does not understand the motion of the body • knows how to rotate hula-hoop • knows the motion of the body • does not coordinate the rotation of the hula-hoop around the waist - it can only make 2 to 3 rotations
4	• knows how to rotate hula-hoop • knows the motion of the body • performs a greater number of rotations with hula-hoop around the waistband • rotations are not dynamic - rotation is performed stiff -knees are shrive
5	• performs the exercise without any load; relaxed, • controls rotations with hula-hoop • performs a greater number of rotations with hula-hoop

Homogeneity and internal consistency of judge's scores was assessed by using One-way between subject analysis of variance (ANOVA) and Cronbach's alpha (Cα) coefficient, respectively. Reliability was additionally estimated using average inter-item correlation (IIr). Exploratory factor analysis was applied due to the identification of validity of the applied scoring system. Factor structure matrix together with absolute (ExplVar) or percentage of amount of variability (%Var) explained by judge's scores was presented. Judges scores were accumulated using mean values. The Kolmogorov-Smirnov test was utilised to ascertain normality, and showed no statistically significant deviation from normality ($p>0.20$). Descriptive statistical parameters were calculated, including; mean, standard deviation, coefficient of variation, together with Skewness and Kurtosis indicators. Differences between genders were inspected by using an independent samples t-test. Cohen's d and partial eta squared (η2) were calculated for effect size assessment in the t-test and ANOVA, respectively. The threshold for statistical significance was set at $p<0.01$. Data analysis software system Statistica ver. 13.2. (Dell Inc, Tulsa, OK, USA) was used for all calculations.

Results
One-way between subject ANOVA showed no systematic bias between judges scores (F5,215=1.149; p=0.350; η2=0.025) together with high Cronbach's alpha coefficient (Cα=0.981) and average inter-item correlation (IIr=0.90). Furthermore, factor analysis revealed one significant factor, interpreted as Hula-Hoop-specific coordination & movement, that explains 91.3% of judge's scores variability (Table 2).

Table 2. Factor Analysis results: Factor structure matrix (Factor 1), absolute amount of variability explained by judge's scores (ExplVar) or percentage of amount of variability explained by judge's scores (% Var).

Table 2. Factor analysis results

	Judge #1	Judge #2	Judge #3	Judge #4	Judge #5	Judge #6	Expl Var	% Var
Factor 1	-0.972	-0.967	-0.941	-0.969	-0.954	-0.930	5.479	0.913

There was a significant difference, accompanied by a large effect size, between boys and girls scores in the Hula-Hoop test; descriptive and inferential analyses are highlighted in Table 3.

Table 3. Descriptive parameters and independent samples t-test: mean value ±standard deviation (mean±σ), minimum-maximum values (Range), coefficient of variation (CV) skewness (α3), kurtosis (α4), t-value (t), level of significance (p), effect size (Cohen's d).

Table 3. Descriptive parameters and independent samples t-test

Variable	Mean±σ	Range	CV	α_3	α_4
Hula-Hoop (BOYS)	1.85±0.68	1.00-3.00	36.68	0.30	-0.73
Hula-Hoop (GIRLS)	3.02±1.17	1.00-4.83	38.55	0.03	-0.90
	t=2.81; p=0.002; Cohen's d=1.22				

Discussion

The aims of this study were twofold: first, to construct and test the psychometric characteristics of the Hula-Hoop test, and second, to investigate differences between boys and girls. In accordance with the aforementioned aims, the key finding of this study was that the psychometric properties of the Hula-Hoop test demonstrate it is a valid and reliable assessment.

With regards to reliability, the present study results are comparable to the widely used Test of Gross Motor Development 2nd edition (TGMD2) (Ulrich, 2000), which consists of 12 fundamental movement skills, including locomotor and object control skills, and takes approximately 20 minutes to administer. The psychometric properties of the TGMD2 have been evaluated and the manual reports good internal consistency (Cα= 0.85 and 0.88 for locomotor and object control subtests, respectively). However, the present study has demonstrated greater internal consistency (Cα=0.981), and validity, where exploratory factor analysis resulted in an extraction of a single factor with a high percentage of explained variability, evident with a score of 91.3%; indicating good construct validity. Notwithstanding, due to the TGMD2 popularity, construct, content, and concurrent validity have also been determined for children aged 3 to 10 years in the TGMD2 and had led to the development of a third edition of the test. Although we highlight the favourable performance of the Hula-Hoop test, this must be interpreted with caution. The aim of this study was to demonstrate the utility of a cheap and preponderant tool in the objective assessment of children's movement. Clearly, the TGMD assesses a large number of skills; however, this detail is concomitant to time-consuming equipment set-up and grading. The Hula-Hoop test, on the other hand, is easy to administer, to train assessors, and to grade. Nevertheless, further work must seek to expand on the current study to ascertain whether reliability and validity are retained across ages, and, indeed, how Hula-Hoop skills develop longitudinally. This will help in determining if the Hula-Hoop test can serve as a long-term assessment tool, monitoring the progression of motor skills over time.

By observing mean values for both genders, it can be seen that children from this sample, generally, have some basic performance skills. According to the assessment criteria, scores ranged from, not being able to perform the skill, to flawless performance. Notwithstanding, positive values of the skewness, in both male and female samples, indicated a mild positive asymmetry, i.e. the tendency of grouping results in the lower value range. Whilst the slightly negative values of the kurtosis parameter indicated a slight tendency of results over-dispersion. This tendency towards a lower score may be indicative of age. During the development phase of FMS, the integration of all components of the learned movement structures in coordinated, accurate and effective performance is undergoing integration (Goodway & Branta, 2003), and therefore, in the age of the sample, may not have been mastered to facilitate higher scores.

In addition to the psychometric properties of the Hula-Hoop test being investigated, we concomitantly sought to investigate whether any gender-mediated differences were manifest (Bozanic & Miletic, 2011). Girls outperformed their male counterparts, rotating the Hula-Hoop a significantly larger number of times. It is conceivable that this difference is manifest from previous experience with gymnastics or dance-based movements, which, stereotypically, are performed more readily by females, than males, particularly at a young age. Nevertheless, this must be investigated further to corroborate. Further, whilst a general axiom is that boys tend to display more advanced object control skills than girls, evidence on gender differences in locomotor skills is much more equivocal (Barnett et al. 2016a; 2016b), where many studies show that girls outperform boys in locomotor skills and object control skills (Bolger et al, 2018), whilst a comparable number of studies demonstrate that boys have equal (Slykerman et al, 2016) or higher locomotor skill competence; however, methodological issues, complexity or lack of specificity may be contributing to the discord across the literature. Thereby highlighting the benefit of a simple to use, cheap, quick and reliable Hula-Hoop test.

A significant limitation of the current study is the relatively small and homogeneous sample size, which may affect the generalizability of the findings. The sample was not sufficiently diverse in terms of demographics, which limits the ability to generalize the results to a broader population. Future research should aim to include a larger and more diverse sample to validate the results and ensure that the findings are applicable to different groups of children.

The findings of this study have practical implications, particularly in preschool settings. The Hula-Hoop test, with its ease of administration and minimal equipment requirements, offers a practical tool for early childhood educators and physical education instructors to assess motor skills quickly and efficiently. This can be particularly useful in large group settings where time and resources are limited. Moreover, understanding gender differences in motor skill performance can help educators tailor interventions to address specific needs. For example, girls in this study outperformed boys, potentially due to greater engagement in activities like gymnastics or dance. Interventions that encourage boys to participate in similar activities could help balance skill development. Conversely, ensuring that girls engage in a variety of motor skills, including those where boys typically excel, could promote a more balanced motor development across genders.

Comparing the Hula-Hoop test to other psychometric instruments used in early childhood, such as the Peabody Developmental Motor Scales (PDMS-2) and the Movement Assessment Battery for Children (MABC-2), further contextualizes its utility. The PDMS-2, for instance, provides a comprehensive assessment of gross and fine motor skills but requires more time and specialized training to administer (Folio & Fewell, 2000). Similarly, the MABC-2, while thorough, involves detailed equipment and scoring systems (Henderson, Sugden, & Barnett, 2007). The simplicity and quick administration of the Hula-Hoop test make it a valuable addition to these more complex instruments, especially for initial screenings and regular monitoring.

There is significant potential for longitudinal studies using the Hula-Hoop test to observe how motor skills develop over time. Longitudinal data would provide insights into the effectiveness of early interventions, tracking improvements or identifying persistent deficiencies in motor skills. This could help in formulating targeted strategies to enhance motor development from an early age, contributing to better physical health outcomes in the long run.

Conclusion

The results of this study demonstrate that the Hula-Hoop test can be used to assess motor skills in pre-school children. The Hula-Hoop, as a tool, is inexpensive and ubiquitous among educational and home settings, whilst the Hula-Hoop test shows promising psychometric properties, and is easy to administer. Further studies are needed to introduce, develop and inspect psychometric characteristics and the veracity of the Hula-Hoop test in larger samples, ages and ethnicities. Furthermore, a bank of Hula-Hoop performance scores should be collated, so that normative, and longitudinal values may be ascertained.

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HEIGHT-RELATED DISPARITIES IN COORDINATION SKILLS AMONG STUDENTS

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Abstract
This study aimed to investigate whether there are statistically significant differences between different categories of body heights and coordination levels among female and male students at the University of Zagreb Faculty of Kinesiology. The study encompassed five generations of students enrolled in the first year of university integrated undergraduate and graduate study of Kinesiology. The sample consisted of 306 female students and 551 male students divided into 3 height groups: average, taller, shorter. Motor coordination ability was evaluated utilizing the Backward Locomotion Test (MKOPOL) for reorganization of movement stereotypes (Metikoš et al., 1989) and Turning Test (MKOPLO) to evaluate the coordination of the entire body (Neljak et al., 2012). Statistical data analysis was conducted using the Statistic 14.0 software. Descriptive statistics (mean, standard deviation, minimum, maximum) were used to characterize the participant sample, and the Shapiro-Wilk test was employed to assess the normality of variable distributions. Given significant deviations from normal distribution, differences in coordination tests between height groups were examined using the non-parametric Kruskal-Wallis test. The findings revealed statistically significant disparities between height groups in the tested variables, both for female and male students.

Keywords: Bacward Locomotion Test, Turning Test, height groups, differences

Introduction
Motor coordination has a crucial role in various physical activities and sports, and it is defined as the ability to perform complex motor tasks in a time and space and in an efficient and energetically rational manner (Sekulić & Metikoš, 2007). All movements, voluntary movements, and reflex (automatic) ones, created as a reaction to an external stimulus, are realized by contractions. Coordination is the ability to perform simple and complex movements, specialized movements, drawing upon a spectrum of fundamental movement skills (Burns et al., 2017).

The mechanism for movement structure (Metikoš & Hošek, 1972; Gredelj et al. 1975; Metikoš et al., 1979) also referred to as the general coordination factor (Metikoš, et al., 2003) defines the profficiency level for executing complex movement structures. It is also responsible for coordination as “the ability to perform complex motor tasks by activating different muscle (synergy) groups efficiently in space, time and energy”.

In this study, we observed dimensions of coordination: reorganization of movement stereotypes - as the ability to adapt learned motor programs and movement structures to new conditions, whereby the adopted, stable motor program changes according to given conditions, as well as observing the coordination of the whole body - as the ability to manage the whole body in space in the realization of various complex motor structures (Metikoš et al., 2003; Sekulić & Metikoš, 2007; Neljak et al, 2012).

During growth and development morphological characteristics are changing under the influence of genetic and social factors. The high quality conditions of life influence faster growth, in which the average body height in adult age increases, compared to previous generations, the so called phenomenon of “biological acceleration” or, the secular trend (Brničevićet et al., 2014). According to Mišigoj-Duraković (2008) the causes of secular trend are in better life and habitation conditions, vaccination, urbanization, medical advances, increase of food availability, increase of population mobility, reduction of family size and other. Body heights of female and male students of the Faculty of Physical Education do not differ to any significant extent from their colleagues from other faculties of Zagreb University (Mišigoj-Duraković et al., 1998).

This research aims to investigate whether there are statistically significant disparities in coordination levels regarding height among different height range groups of female and male students, under the assumption that taller students achieve lower results in specific coordination assessment tests.

Methods
This study observed five generations of full-time, first-year students over a span of five consecutive academic years: 2019/2020, 2020/2021, 2021/2022, 2022/2023, and 2023/2024. These students were enrolled in the integrated

undergraduate and graduate studies program in Kinesiology at the Faculty of Kinesiology, University of Zagreb, with an average age of 19±1.3 years. The students' morphological characteristics were assessed by measuring body height.

During the regular classes at Basic Kinesiology Transformations 1, the students' coordination ability was assessed using the following tests: Backward Locomotion Test (MKOPOL) for the reorganization of movement stereotypes (Metikoš et al., 1989) and Turning test (MKOPLO) to evaluate the coordination of the entire body (Neljak et al., 2012). These motor tests were conducted in three repetitions, with the result of each repetition recorded in seconds, and the data processed by calculating the mean value of all three repetitions. The criteria for categorizing students into height groups is based on the mean height along with the corresponding standard deviation. Students in the "average" group have their height within the range of the mean minus one standard deviation to the mean plus one standard deviation. Students in the "shorter" group are shorter than the mean minus one standard deviation, while the "taller" group is taller than the mean plus one standard deviation.

The results of the measured variables were analyzed using the Statistic 14.0 software. The sample characteristics were outlined using descriptive statistics, and the normality of the data distribution was tested using Shapiro-Wilk test. Due to deviations from normal distribution, differences between body height and coordination test results were analyzed using non-parametric Kruskal-Wallis test.

Results
Morphological characteristics were measured on 306 females (body height 168.21±3.31 cm), and 551 males (body height 181.96±3.46 cm). Body height groups were defined based on the mean value and standard deviation of body height within each gender group, separately for coordination tests.

Table 1. Descriptive parameters of Backward Locomotion Test (MKOPOL), Turning Test (MKOPLO) (s) and Body Height (cm)

group		N	Mean ± SD		BH range (cm)
			MKOPOL (s)	**BH** (cm)	
FEMALE	**average**	204	10.36 ± 1.67	168.21 ± 3.31	162.23 – 174.75
	taller	53	10.97 ± 1.41	178.04 ± 3.11	> 174.75
	shorter	49	9.62 ± 1.61	159.31 ± 2.28	< 162.23
MALE	**average**	368	8.80 ± 1.33	181.96 ± 3.46	176.05 – 188.49
	taller	86	9.53 ± 1.37	192.19 ± 3.18	> 188.49
	shorter	83	8.69 ± 1.68	173.4 ± 2.39	< 176.05
group		**N**	**Mean ± SD**		**BH range** (cm)
			MKOPOL (s)	**BH** (cm)	
FEMALE	**average**	181	7.36 ± 1.15	167.85 ± 3.42	161.9 – 174.68
	taller	46	7.98 ± 0.99	178.24 ± 3.25	> 174.68
	shorter	40	6.8 ± 0.97	158.83 ± 1.63	< 161.9
MALE	**average**	361	6.22 ± 1.09	182.24 ± 3.37	176.09 – 188.39
	taller	91	6.76 ± 1.42	191.65 ± 2.83	> 188.39
	shorter	99	6.14 ± 0.97	173.59 ± 2.32	< 176.09

Legend. N = number of students, Mean = average value, SD = standard deviation, MKOPOL = Backward Locomotion Test (s); MKOPLO = Turning Test (s); BH = Body Height (cm); average/taller/shorter = students with body height in listed BH range

For participants measured in the Backward Locomotion Test (MKOPOL), body height ranges for the female groups are as follows: average (162.23 - 174.75 cm), taller (>174.75 cm), and shorter (<162.23 cm), while the height ranges for male groups are: average (176.05 - 188.49 cm), taller (>188.49 cm), and shorter (<176.05 cm). The results indicate that the group of "shorter" students achieved the best results in the Backward Locomotion test, both for females (9.62±1.61 s) and males (8.69±1.68 s). For participants measured in the Turning Test (MKOPLO), the body height ranges for female groups are as follows: average (161.9 - 174.68 cm), taller (>174.68 cm), and shorter (<161.9 cm), while the height ranges for male groups are: average (176.09 - 188.39 cm), taller (>188.39 cm), and shorter (<176.09 cm). The results of the Turning Test also indicate that the group of "shorter" students, both females and males, achieved the best results, with times of 6.8 ± 0.97 s for females and 6.14 ± 0.97 s for males. In both measured tests and for both genders, it was found that the "taller" groups achieved the lowest average results.

When conducting Kruskal-Wallis test, general significant differences were determined in Backward Locomotion Test for females (H = 17,14; p < 0,01) and males (H = 25,79; p < 0,01) and in Turning Test for females (H = 23,88; p < 0,01) and males (H = 13,09; p < 0,01).

Table 2. Kruskal-Wallis test of differences for Backward Locomotion Test (MKOPOL) and Turning Test (MKOPLO) (s) and Body heights (cm)

Kruskal-Wallis test							
		MKOPOL			**MKOPLO**		
FEMALE		**N = 306**			**N = 267**		
		average	taller	shorter	average	taller	shorter
	average		0.03*	0.03*		0.00*	0.03*
	taller	0.03*		0.00*	0.00*		0.00*
	shorter	0.03*	0.00*		0.03*	0.00*	
MALE		**N = 537**			**N = 551**		
		average	taller	shorter	average	taller	shorter
	average		0,00*	0.29		0.00*	1.00
	taller	0.00*		0.00*	0.00*		0.00*
	shorter	0.29	0.00*		1.00	0.00*	

Legend. * = significant differences between generations at p<0.05 for females, and p<0.03 for males; MKOPOL= Backward Locomotion Test; MKOPLO = Turning Test

Multiple comparison of p-values and summarizes the significant differences identified between pairs of body height groups (average, shorter, taller) in the results of the Backward Locomotion and Turning Test, based on the post-hoc test following the Kruskal-Wallis test.

Statistically significant differences in females are present between all height groups (”average”, “shorter” and “taller) in both tests. Statistically significant differences in males exist between the "taller" height group and the other groups in both tests. In contrast, there are no significant differences between the "average" and "shorter" height groups in both test.

Discussion

A significant deviation from the normal distribution of results is attributed to the sample of participants, consisting of selected students admitted to the Faculty of Kinesiology based on their above-average level of motor skills and knowledge. These students regularly engage in various sports activities through practical classes at the university, elite sports, and/or recreational pursuits, thereby preserving and enhancing their acquired motor skills during critical life phases (Horvatin et al., 2023).

The total number of female and male students measured varies for each test, as the Backward Locomotion Test (MKOPOL) was conducted during theoretical-practical classes, while the Turning Test was administered as part of the exercises.

Analyzing the influence of predictor variables related to morphological characteristics on individual criteria of coordination abilities, previous findings indicated that the predictor systems employed exhibited statistically significant correlations with all individual criteria of coordination skills at a significance level of .00 ($p = .00$). Specifically, body height (BOH) demonstrated a significant correlation ($p = .00$), suggesting that individuals with shorter stature displayed better arm and leg coordination results (Stanković & Malacko, 2011). Similar findings were obtained in this study, where shorter female students significantly differed with the best performance results in coordination tests, while taller students significantly differed with the poorest performance in coordination tests. Another study that aimed to examine the correlation between body height and motor coordination among college students, dividing male and female participants into four single-sex groups based on their height categories, indicated significant variations in performance scores across different height groups for both basic skills and double routine skills, where those in the shortest height category demonstrated the lowest performance scores. The study results showed that male students in the 175–179 cm group and female students in the 165–169 cm group exhibited the highest performance scores on all indicators, contrary to conventional beliefs associating better coordination with shorter height. The study concluded that the specific height range of participants in sport dancing training influenced dancesport performance and motor coordination (Li et al., 2015). The sample of respondents consisted of the student population, selected first-year students of the Faculty of Kinesiology, with a high level of fitness, long-term active athletes, involved in an extremely demanding process of practical classes. Assuming that at the age of 19±1.3 they completed the phase of accelerated growth and development, the relationship between height and coordination abilities did not significantly affect the obtained results.

Conclusion

Stanković et al. (2023) emphasize that individuals exhibiting proficient motor coordination often demonstrate superior sports performance, enhanced fine motor skills, and overall improved physical functioning, underscoring the significance of motor coordination in everyday activities (Cortis et al., 2009). Based on the above, it can be presumed that height will be a significant factor in the manifestation of results in coordination tests involving traversing through a frame of Swedish boxes of defined dimensions (as is the case in the Backward Locomotion Test (MKOPLO) and Turning Test (MKOPLO), which is crucial to consider when selecting coordination assessment tests and interpreting the results.

In the stages of accelerated growth and development of children, due to intensive growth in height (during puberty and adolescence), there is a significant reduction in the level of the general factor of coordination, therefore, in physical and health education classes and especially in fitness training, it is necessary to pay more attention to tasks that will re-establish intermuscular and various coordination factors.

It is necessary to study the morphological characteristics of exercisers, athletes of different sports, sports disciplines and roles in the sports game in order to individually plan training sessions, improve general fitness and improve performance with a good training strategy (Moncef et al., 2012).

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VALIDATION OF TESTS FOR ASSESSING MOTOR ABILITIES IN PRESCHOOL CHILDREN AND MONITORING THEIR DEVELOPMENT DEPENDING ON INVOLVEMENT IN PHYSICAL ACTIVITIES

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Abstract
The main goal of this paper is to validate the metric characteristics of tests for assessing the motor abilities of preschool children. Additional goals are to establish the trend in the development of children's motor abilities and to determine whether there is a difference in motor abilities between children who attend physical education (PE) in kindergarten and children who are additionally engaged in organized sports. The research was conducted on 98 children between the ages of 4 and 6, of which 51 children attend a regular program of PE in kindergarten, while the other 47 attend an organized sports activity in addition to the regular program. The variables consisted of a battery of four tests: Four-legged around coens (FAC), standing long jump (SLJ), Sit-and-reach (SAR) and Standing on one leg (SOL). Based on the collected data, the basic descriptive parameters, Kolmogorov Smirnov test, Inter-item correlation and Cronbach's alpha were calculated for the purpose of determining the metric characteristics of the tests. In order to monitor the development trend of children's motor abilities, a polynomial regression analysis was calculated, while a t-test analysis was performed for independent samples to calculate the difference between the measured groups of respondents. The obtained results show high values of all parameters that define the metric characteristics of the tests for assessing children's motor abilities, therefore it can be concluded that they are sensitive, reliable and homogeneous and applicable in practice. Polynomial regression analysis shows a positive trend in the development of the measured motor abilities with the age of the children ($F(4,93)=39,04$ $p<0,00$). Also, it is evident that children involved in an additional organized sports program mostly achieve better results in all tests, and the t-test analysis proved statistical significance in the test for assessing flexibility (SAR $p\leq0.00$) and balance (SOL $p\leq0, 02$). Based on the obtained results, it can be concluded that the more physically active children are during the week, the better their motor abilities are developed and thus they have a positive impact on their growth and development.

Keywords: metric characteristics, organized physical activity, motor abilities, preschool age

Introduction

Motor abilities are largely involved in the realization of all kinds of movements, which is an indicator of the importance of developing these same abilities in children from an early age. Zatsiorsky (2002) defines motor abilities as those aspects of intensity (strength or speed) and extensity (duration or number of repetitions) of motor activity that can be described by the same parameter system, measured and evaluated by an identical set of measures and in which operates the analogous physiological, biochemical, morphological and biomechanical mechanisms. Numerous studies have confirmed the intricate structure of motor abilities, underscoring the importance of understanding this complexity. Milanović states (2009) that according to Meinel (1977) it's a complex structure of quantitative (strength, speed, endurance, mobility) and qualitative (coordination, agility, balance and precision) motor abilities. Prskalo and Sporiš (2016) state that motor abilities determine the motor capacity of the examinee (e.g. explosive power, coordination, flexibility, agility). Motor abilities are developed using different training methods and modalities, and the degree of their development is determined by validated tests for the assessment of each individual ability. In the pre-school period, but also later through schooling, the child's basic form of organized physical activity is a physical education class and possible additional sports programs for children who participate in such forms of activity. In this way, children are encouraged to exercise with interesting content and through play, and an effort is made to instill in them new knowledge and abilities that they need for overall healthy growth and development and an active lifestyle. Also, Mišigoj Duraković (2008) states that physical activity is proven to be an important factor in children's development. During growth, children change according to biological laws that mark certain stages of their development. The dynamics and quality of changes in their anthropological characteristics depends on external and internal factors. This is where physical activity is very important because, if it is carried out professionally and regularly, its educational and transformational effectiveness increases. Thus, physical exercise becomes a direct and irreplaceable factor in optimizing the growth and development of children. Accordingly, in addition to involvement in a systematic process of physical exercise, it is also necessary to regularly carry out measurements or checks of motor abilities in order to monitor the child's progress. The tests that are applied must be scored and adapted to children of a certain age, which is verified by calculating their metric characteristics (Dizdar, 2006). Metric characteristics are prerequisites or standards that qualify a measuring instrument (Prskalo and Sporiš, 2016). They are of particular importance not only in scientific research, but also in practice for the needs of precise diagnostics, selection, determining the quality of exercise programs and monitoring individual development. Therefore, the main goal of this paper is to validate the metric characteristics of tests for assessing the motor abilities of preschool children. Additional goals are to establish the trend in the development of children's motor abilities and to determine whether there is a difference in motor abilities between children who attend physical education in kindergarten and children who are additionally engaged in organized sports.

Methods

98 children from three institutions for early and preschool education in the city of Zagreb participated in the research. The participants who took part in the research had an average age of 5 (+- 1 year). In order to achieve the goals of the work, the sample of participants was divided into two groups. The first group consists of 51 children who are included in the regular program of PE in kindergarten, while the second group consists of 47 children who, in addition to the regular program of PE, are included in an additional organized sports program that they attend twice a week. The sample of variables consists of a battery of four tests for measuring motor abilities. Explosive power was measured using the Standing long jump (SLJ) test, flexibility using the Sit-and-reach (SAR) test, coordination was assessed using the Four-legged around coens (FAC) test, and balance using the Standing on one leg (SOL) test. The data collected in the research were processed with the statistical package Statistica 14. Basic descriptive parameters were calculated for all variables (arithmetic mean, standard deviation, minimum and maximum score and range of scores). Validation of metric characteristics was performed using the Kolmogorov Smirnov test to determine the instrument's sensitivity, Cronbach's Alpha to determine reliability, and Inter-Item Correlations to assess the homogeneity of tests for assessing children's motor abilities. In order to monitor the trend of motor abilities development of children with their age, a polynomial regression analysis was calculated. Polynomial regression analysis shows the dynamics of development of results in all measured motor abilities in relation to the age of the subjects. While a t-test analysis for independent samples was calculated to determine the differences in the measured groups of subjects depending on their involvement in physical activities.

Results

Based on the collected data, basic descriptive parameters were calculated for all measured motor abilities (arithmetic mean, minimum and maximum score and standard deviation) for both groups of respondents in this study (Table 1). It can be seen that children who additionally practice in an organized sports activity twice a week achieve better results in most of the measured motor abilities.

Table 1. Descriptive statistics of tests of motor abilities of children who attend regular PE classes in kindergarten and children who take additional organized exercise

	N 0	**N 1**	**Mean 0**	**Mean 1**	**Min 0**	**Min 1**	**Max 0**	**Max 1**	**SD 0**	**SD 1**
Standing long jump	51	47	86,18	95,12	30,00	47,67	134,33	136,67	26,96	24,82
Sit-and-reach	51	47	-6,42	0,23	-21,67	-9,33	7,67	10,00	6,51	5,19
Standing on one leg	51	47	13,78	18,47	1,49	1,62	30,00	30,00	10,38	9,12
Four-legged around cones	51	47	9,13	9,20	4,34	4,92	28,36	18,40	5,38	3,61

Legend: 0-children who attend PE in kindergarten; 1-children who attend additionally organised sport activities

Table 2. Metric characteristics of tests of motor abilities in preschool children

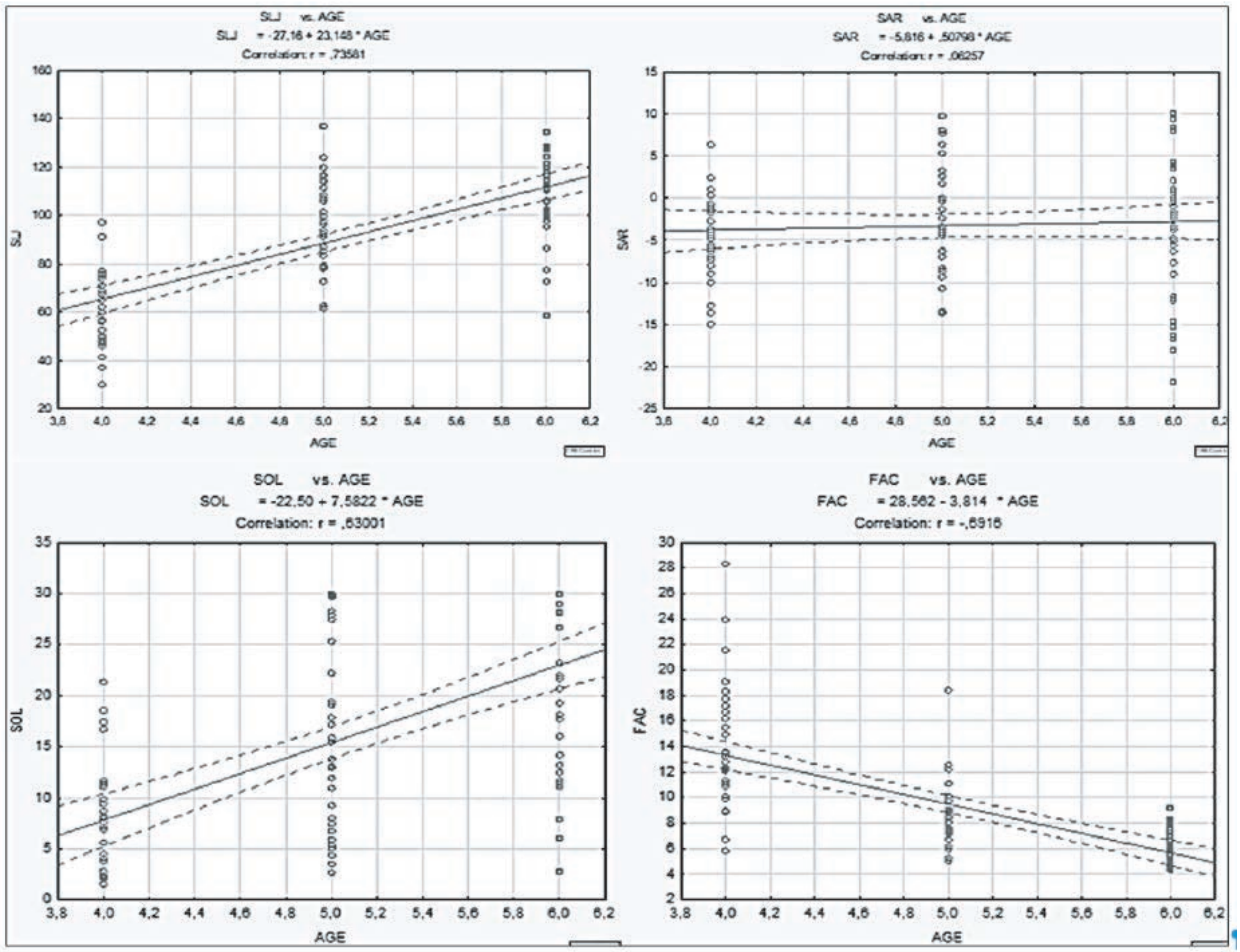
	Kolmogorov Smirnov test	Cronbach's Alpha	Inter-Item Corelation
Standing long jump	0,11	0,96	0,89
Sit-and-reach	0,06	0,98	0,95
Standing on one leg	0,14	0,98	0,95
Four-legged around cones	0,18	0,91	0,76

From Table 2, it can be seen that high values were obtained for all the parameters that define the metric characteristics of the evaluated tests, that is, the results show their good sensitivity (0.06 ≤ K-S ≥ 0.18), reliability (0.91 ≤ α ≥ 0.98) and homogeneity (0.76 ≤ r ≥ 0.95).

Table 3. The results of the polynomial regression analysis of the trend in the development of children's motor abilities

Regression Summary for Dependent Variable: AGE R= ,79 R2= ,62 Adjusted R2= ,61 F(4,93)=39,04 p<0,00			
N=98	**b***	**t(93)**	**p-value**
Standing long jump	0,41	4,23	0,00*
Sit-and-reach	0,01	0,14	0,89
Standing on one leg	0,22	2,69	0,01*
Four-legged around cones	-0,27	-2,83	0,01*

b*- standardized regression coefficient; * level of significance p<0.05



Picture 1. Graphical presentation of the trend of results in the measured motor tests for the assessment of children's motor abilities

The results of the polynomial regression analysis show a positive trend in the development of the measured motor abilities of children ($F(4,93)=39,04$ $p<0,00$) (Table 3 and Figure 1). Also, it is visible that the group of children who are additionally involved in the organized sports program mostly achieve better results in all the measured tests, and the t-test analysis showed a statistically significant difference between the measured groups of subjects in the flexibility assessment test (SAR $p \leq 0.00$) and balance (SOL $p \leq 0.02$) (Table 4).

Table 4 Results of a t-test analysis of motor abilities between children who attend PE and an additional organized sports program

	Mean 1	Mean 0	t-value	df	p
Standing long jump	95,12	86,18	1,70	96,00	0,09
Sit-and-reach	0,23	-6,42	-5,56	96,00	0,00*
Standing on one leg	18,47	13,78	2,37	96,00	0,02*
Four-legged around cones	9,20	9,13	0,12	96,00	0,90

* level of significance $p<0.05$

Discussion

Looking at the obtained results of this research, it can be determined that the tests performed to assess the motor abilities of coordination, explosive strength, flexibility and balance were appropriate for the age of the children who were included in the research, that is, high values of sensitivity (K-S), reliability (α) and homogeneity (r). Also, a positive trend in the development of children with age in all motor abilities is visible, and a statistically significant difference in flexibility and balance is evident in favor of children who do additional organized sports activity. A similar study was conducted by the authors Hraski, Horvat and Bokor (2016). Their goal was to determine the metric characteristic of tests for assessing coordination, speed, and balance in four-year-old children. Out of a total of six tests that were validated, two were also Four-legged walking around cones (FOC) and Standing on one leg (SOL). The results obtained in their study show that these two tests meet the reliability criteria, but the results obtained in the tests of homogeneity and sensitivity indicate worse values and the need for further research on older children. Also, the research conducted by the authors Jenko Miholić, Nikolić and Butorac (2017) aimed to examine the metric characteristics of tests for assessing the motor ability of balance in children aged 5 and 6 years. In total, five different tests were performed, of which only the test of standing with one foot on a cube meets the metric characteristics and can be recommended for measuring the motor ability of balance in children aged five to six years. Furthermore, the research objective of Cupeiro et al. (2020) was to examine the existence of a relative influence of age (RAE) on the motor abilities of preschool children. Motor abilities were assessed in 3147 children (3-5 years) using the PREFIT battery. By analyzing the results, they obtained a significant effect of age ($F10,5996 = 369.64$; $p < 0.001$) throughout the entire battery of tests. In general, abilities improved as relative age increased, as found in this study. Also, effects on children's motor abičities depending on involvement in physical activity were examined by Mačak et al. in his study conducted in 2021 on 72 preschool children. In their research, they had an experimental group of children who engaged in organized physical activity for 45 minutes every day and a control group who participated in organized exercise twice a week for 30 minutes. Overall, their research shows that after 6 months of a daily exercise program, preschool children improved muscle strength compared to their peers in the control group.

However, a limitation of this study is that it does not address potential preferences or the influence of external factors such as socioeconomic factors or the influence of parental involvement on access to organized sport, which could allow for a more comprehensive analysis of the data that could influence the study results. The validity of the metric characteristics of the tests should be confirmed in the future on a larger number of participants, and the examination should be extended to other racial groups of children. Song, Lau, and Wang (2022) pointed out in their research that, for Chinese children, due to different cultural and parenting practices, international assessment tools should be used with caution. Also, Fu and Burns (2018) concluded that those children with high socio-economic status displayed higher motor abilities levels than lower socio-economic status children.

Conclusion

In accordance with the main goal of this research, the validation of metric characteristics of tests for assessing the motor abilities in 4- to 6-year-old children is provided. Based on the results it can be concluded that tests Four-legged around cones

(FAC), Standing long jump (SLJ), Sit and reach (SAR) and Standing on one leg (SOL) are suitable for assessing coordination, explosive strength, flexibility and balance because high values of sensitivity ($0,06 \leq$ K-S $\geq 0,18$), reliability ($0,91 \leq \alpha \geq 0,98$) and homogeneity ($0,76 \leq r \geq 0,95$) were obtained. Understanding the fact that motor abilities are latent dimensions and that can be assessed only by well-constructed instruments the results and conclusions of this research are of great importance for practical application with preschool children.

Furthermore, for monitoring and determining the development of children's motor abilities the polynomial regression analyses was conducted. Polynomial regression analysis shows the dynamics of development of results in all measured motor abilities in relation to the age of the subjects.Based on the results, it can be concluded that a positive trend of children's development is present ($F(4,93)=39,04$ $p<0,00$) in all motor abilities. These findings are very important because they indicate that with age children who are involved in some form of organized sports activity and systematically exercise do not deviate from the correct curve of growth and development. Moreover, the conclusion of this study is that children who are involved in an additional organized sports program two times per week mostly achieve better results in all motor tests, also the t-test analysis showed statistical significance differences in the test for assessing flexibility (SAR $p \leq 0.00$) and balance (SOL $p \leq 0, 02$). So, it can be concluded that children who are more involved in organised physical activities during the week have higher level of development of motor abilities and thus a positive impact on their entire growth and health. The period in which children today grow up and spend a large part of their time in front of various screens is not conducive to their development. For this reason, they should be encouraged on physical activities. Physical education classes, organised sports programs, and any time spent outdoors must encourage the child to be active and develop positive life habits for entire life.

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POSSIBILITIES OF EVALUATING THE BASIC SWIMMING COMPETENCES OF THE SCHOOL POPULATION

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Abstract
Developing and validating assessment standards for basic swimming competences could be a valuable tool for optimizing swimming instruction and improving swimming proficiency in school children, particularly by aligning instruction with their developmental potential. This study investigated the basic swimming competency levels of younger schoolchildren and assessed the suitability of a test battery for differentiating these competencies among primary school pupils. The sample consisted of 36 children with an average age of 8.03 ± 2.6 years. The children were divided into two groups: the younger group (YG, N = 20) aged 6-8 years and the older group (OG, N = 16) aged 9-11 years. The Mann-Whitney U test was applied to assess the statistical significance of differences in groups. To quantify the strength of the observed relationships, we calculated effect sizes (ES) based on Cohen's criteria. The justification for including the utilized tests, we conducted a relational analysis When assessing the success of the test items, the OG performed significantly better on Tests 1, 2, 6, 7 ($p \leq .05$) and in Test 3 ($p \leq .001$). In contrast, no significant difference was found between the groups for Test 4 and 5 (p = ns). In conclusion, these findings suggest that a basic swimming competency test battery may be a useful tool for assessing the swimming competency of younger school-aged children.

Keywords: swimming, primary education, swimming competences, diagnostics

Introduction

Concepts for assessing the competence of the school population and its development are gaining traction in the European context. They are based on various models. According to Harter's model, competences can be considered a primary motivator and may be linked to cognitive, affective, and behavioural outcomes (Harter, 1982). Assessing perceived competence holds both pedagogical and scientific value, especially in childhood. Several Slovakian authors (Ružbarská, 2018; Masaryková, 2021; Antala et al., 2021) have addressed the concept of evaluation as specific performance dispositions. The concept of the authors Hermann et al. (2019) brings an innovative approach in the field of complex motor performance disposition based on basic motor competences. A cross-sectional study offering a new perspective on the area of assessment of basic motor competences of 6- to 8-year-old children is presented by Wälti et al. (2023). They analyzed and presented the results of the already established test battery MOBAK-1-2. The study involved 11 regions in 10 European countries. A recent meta-analysis of global sports and leisure activities worldwide found that swimming is still rated as one of the top five physical activities that children and adolescents participate in during their leisure time in Africa, the Eastern Mediterranean, the Western Pacific, the Americas, and Europe (Hulteen et al., 2017). A specific area of motor competence is basic swimming competence. It can also reflect differences in drowning rates (Stempski et al., 2015). Among those often rescued are individuals referred to as "half-swimmers," mostly men (Baran, 2006; Čechovská & Miler, 2008). Sufficient opportunities to learn to swim and gain positive experiences at an early age are important (Macejková et al., 2005). The term "from swimming skill to water competence" represents a significant shift from swimming skills alone to a broader concept of swimming competence (Stallman et al., 2017). Masaryková (2021) provides an example of how swimming skills can be incorporated into the school curricula of countries where children naturally come into contact with water, such as coastal countries. The authors Morgado et al. (2020) have created the Pictorial Scale of Perceived Water Competence. There is a lack of validated diagnostic procedures currently available in Slovakia for assessing basic swimming competencies. The aim of the study was to investigate the level of basic swimming competencies of younger school-age children. By applying the test battery to point out its availability of implementation as a suitable tool for assessing the differentiation of the level of swimming competencies of pupils at the primary level of education.

Methods

The participant selection process for this study involved recruiting children aged 6-11 from a local swimming school who had enrolled in a three-month beginner swimming course. This ensured a similar baseline in swimming skills. Informed consent was obtained from parents, and children with prior formal swimming training, competitive experience, or medical conditions affecting physical activity were excluded. A total of 36 children met the criteria and were divided into two age-based groups: 20 children aged 6-8 years (younger group, YG) and 16 children aged 9-11 years (older group, OG). This division accounted for developmental differences between early and middle childhood, allowing for age-specific analysis and instruction. Younger children aged 6-8 are developing coordination and basic motor skills, critical for learning swimming techniques, while older children aged 9-11 have more refined motor skills, better cognitive understanding, and greater physical endurance, affecting their learning pace and competency. Dividing participants into these age groups allowed instructors to tailor teaching methods and pace to each group's developmental level, facilitating accurate skill assessment and competency. When choosing test tasks, we took into account the results of previous national and international projects (Čechovská & Miler, 2008; Macejková & Benčuriková, 2014; Morgado et al., 2020). Competency tests measuring swimming skills ensuring the tests were age-appropriate and sufficiently challenging. Regular tests track each child's progress, provide feedback, and allow for training adjustments to meet individual needs. Regular tests track each child's progress, provide feedback, and allow for training adjustments to meet individual needs. This approach ensures all participants reach a certain level of competency for their safety, identifying those needing additional support.

Measurements were taken at the beginning of the swimming course, during the first lessons. The first 5 minutes were devoted to a dry-land warm-up, followed by a warm-up in the pool and testing. Test 1 " Immersion and exhalation in water" assesses a swimmer's ability to inhale through the mouth, submerge the whole head underwater, and exhale through both the nose and mouth. The swimmer starts in a standing position in the water (shoulder-deep level) facing the pool wall. They grasp the gutter of the pool wall with both hands at shoulder level. After taking a deep breath through their mouth, they submerge their face below the water's surface, exhaling through both their nose and mouth into the water, for a minimum of 5 seconds To earn 3 points, successful performance requires an oral inhalation, an independent submersion of the head including the face and ears, and an exhalation through both the nose and mouth for at least 5 seconds ("bubbling"). Partial credit, or 2 points, is awarded for a brief and quick submersion, holding the breath underwater for up to 3 seconds without exhaling into the water. Swimmers who are unable to complete the task receive 1 point. Test 2, "Floating on the front," assesses a swimmer's ability to hold a horizontal body position with their face submerged. Starting from a standing position, swimmers take a deep breath and then glide into a horizontal chest position with their upper limbs slightly higher than their lower limbs (front star). Earning 3 points requires achieving this position independently, keeping their face underwater, and holding their breath for at least 5 seconds. 2 points is awarded for using an aid like water noodles to achieve the chest position with a bent body, submerged face, and a 3-second breath hold. Swimmers who are unable to complete the task receive 1 point. Test 3, "Floating on the back," assesses a swimmer's ability to hold a horizontal body position on the back on the surface of the water. Starting from a standing position and then glide into a horizontal back position with their upper limbs slightly higher than their lower limbs (back star). Earning 3 points, requires achieving this position independently and lasts at least 5 seconds. 2 points are awarded for using an aid like water noodles under shoulder or back, and a 3-second breath hold. Swimmers who are unable to complete the task receive 1 point. Test 4, "Gliding on the front," evaluates a swimmer's ability to maintain a streamlined horizontal chest position while gliding through the water. After pushing off from the pool wall or floor, swimmers assume a streamlined position with their arms extended overhead and their face submerged. Earning 3 points requires independent completion of the task: a forward glide in the prescribed horizontal chest position for a minimum distance of 5 meters. 2 points are awarded for completing the task with the aid of a buoyancy device (holding a noodle or kickboard in extended arms) and gliding in the chest position for up to 5 meters. Swimmers who are unable to complete the task receive 1 point. Test 5, "Gliding on the back," assesses a swimmer's ability to maintain a streamlined horizontal back position while gliding through the water. After pushing off from the pool wall or floor, swimmers assume a streamlined position on the back with their arms extended overhead. Earning 3 points requires independent completion of the task: a forward glide in the prescribed horizontal back position for a minimum distance of 5 meters. 2 points are awarded for completing the task with the aid of a buoyancy device (holding a noodle or kickboard in extended arms) and gliding in the back position for up to 5 meters. Swimmers who are unable to complete the task receive 1 point. Test 6, "Catching an object from the depth," evaluates a swimmer's ability to dive to a depth of 1.5 meters, orient themselves underwater, and retrieve an object from the bottom of the pool. Swimmers submerge the entire head and torso to a specified water depth and retrieve an object from the bottom of the pool (e.g., puck, rubber ring). To earn 3 points, the swimmer must independently perform the task by submerging their entire head and successfully retrieving the object. If the swimmer makes an independent attempt at submerging their entire head with unsuccessful object retrieval, they earn 2 points. If the swimmer is unable to complete the task receive 1 point. Test 7, " Jump into the water " evaluates a swimmer's ability to jump straight forward from the edge of the pool into the water on their feet. A forward straight jump is executed from a standing position at the pool's edge (toes hooked over the edge). The diver springs forward and aims for a feet-first landing in the water (maximum depth 1.5 meters). To earn 3 points, the swimmer independently executes the jump from a standing position and land feet-first. If the swimmer uses a noodle for assistance but still manages a feet-first landing, they earn 2 points. If the swimmer does not jump, they earn 1 point. The research was granted an ethical approval by The FPES CU Committee of Ethics in Bratislava (ref 9/2023) and was in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki).

The study employed basic statistical and mathematical methods for data analysis. The Mann-Whitney U test was used to assess the statistical significance of differences between the groups. Statistical significance was set at $p < .05$ and $p < .001$. To quantify the strength of the observed relationships, we calculated effect sizes (ES) based on Cohen's criteria (1994). Small ES was defined as $r < .3$, medium ES as $r = .3 - .5$, and large ES as $r > .5$. To evaluate the justification for including the utilized tests, we conducted a relational analysis. Spearman's rank correlation coefficient and the calculation of the coefficient of determination were employed. The SPSS statistical software package (version 23.0) was utilized for all data analyses.

Results

Based on the Figure 1, it can be determined that tests T5, T4, and T3 were the most challenging for the younger group (YG). These tests yielded the lowest scores out of the total possible points for each individual test. Tests T1 and T2 were the least challenging for the YG, achieving the highest average scores on a scale of total possible points. The older group (OG) found tests T5 and T4 to be the most difficult, as evidenced by Figure 2. Tests T1, T2 and T3 yielded the highest average scores compared to the maximum possible points for each test, suggesting they were the easiest for the OG. The YG achieved an average score of 11.7 out of 21 possible points (53% success rate), while the OG scored higher with an average of 15.8 points (75% success rate).

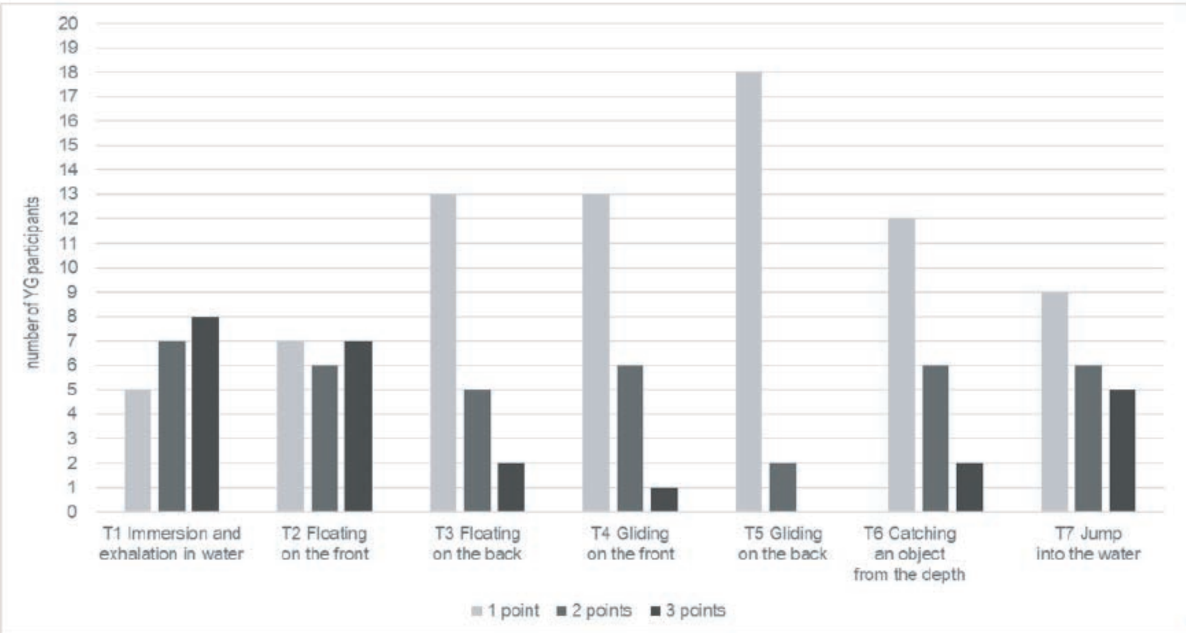

Figure 1. Swimming competences score achieved by the younger group

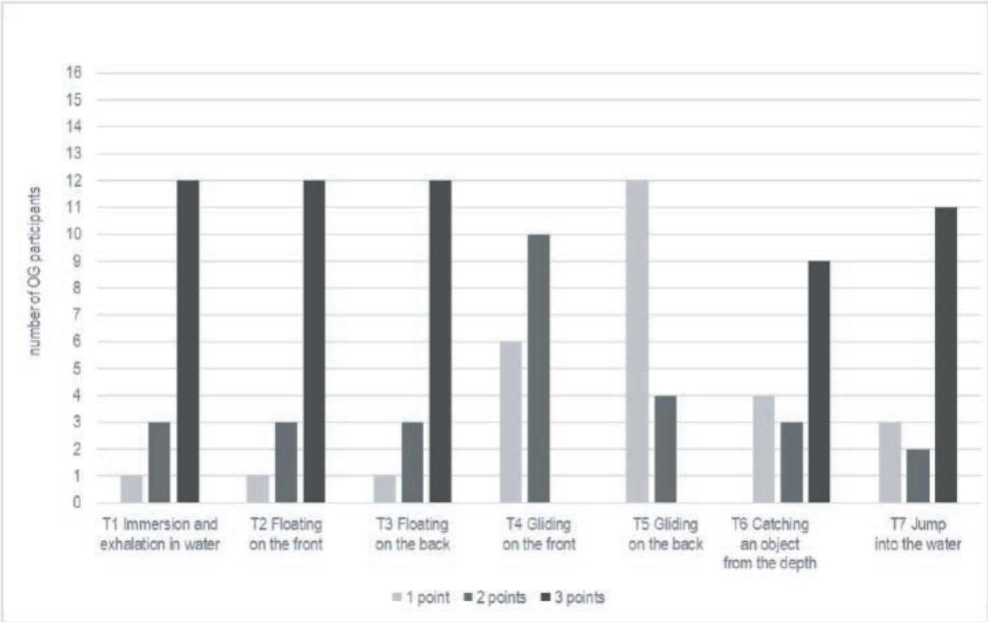

Figure 2. Swimming competences score achieved by the older group

As shown in Table 1, the Immersion and exhalation in water test showed significantly greater success in the OG compared to the children in the YG ($p < .05$; large ES). We found significant differences in the Floating on the front test, with greater success ($p < .05$; medium ES) in the OG compared to the children in the YG. We observed a significant difference in the Floating on the back test, where the OG achieved greater success ($p < .001$; large ES) compared to the YG. No statistically significant differences (p = ns; small ES) in the Gliding on the front test and Gliding on the back test were found between the OG and the YG in terms of the specified swimming competence. The Catching an Object from Depth test revealed a significantly higher success rate ($p < .05$; medium ES) in the OG compared to the YG. The Jump into the water test showed significantly greater success ($p < .05$; medium ES) in the OG compared to the children in the YG.

Table 1 The level of swimming competences for the groups

swimming competence test	group	1 point	2 points	3 points	M ± SD points	significance *p*	effect size *r*
T1 Immersion and exhalation in water	YG	25%	35%	40%	1.85 ± .81	.002	.507
	OG	6%	19%	75%	2.69 ± .6		
T2 Floating on the front (front star)	YG	35%	30%	35%	2 ± .86	.012	.417
	OG	6%	19%	75%	2.69 ± .6		
T3 Floating on the back (back star)	YG	65%	25%	10%	1.45 ± .69	< .001	.688
	OG	6%	19%	75%	2.69 ± .6		
T4 Gliding on the front	YG	65%	30%	5%	1.4 ± .6	.156	.236
	OG	38%	62%	0%	1.63 ± .5		
T5 Gliding on the back	YG	90%	10%	0%	1.1 ± .3	.237	.197
	OG	75%	25%	0%	1.25 ± .45		
T6 Catching an object from the depth	YG	60%	30%	10%	1.5 ± .69	.006	.455
	OG	25%	19%	56%	2.31 ± .87		
T7 Jump into the water	YG	45%	30%	25%	1.8 ± .83	.017	.399
	OG	19%	12%	69%	2.5 ± .82		

Table 2 presents the significance of the relationships between the variables and the total score in the test battery, as well as their contribution to predicting the outcome of the conditional effect on the measure of conditionality of both studied datasets.

Table 2 The relation of monitored tests to the total score

swimming competence test	group	total score r_s	significance *p*	coefficient of determination R^2
T1 Immersion and exhalation in water	YG	.908	< .001	.824
	OG	.775	< .001	.601
T2 Floating on the front (front star)	YG	.939	< .001	.882
	OG	.775	< .001	.601
T3 Floating on the back (back star)	YG	.837	< .001	.701
	OG	.775	< .001	.601
T4 Gliding on the front	YG	.833	< .001	.694
	OG	.860	< .001	.740
T5 Gliding on the back	YG	.524	< .05	.275
	OG	.769	< .001	.591
T6 Catching an object from the depth	YG	.877	< .001	.769
	OG	.917	< .001	.841
T7 Jump into the water	YG	.938	< .001	.880
	OG	.837	< .001	.701

The magnitude of the correlation coefficient (rs) indicates a very high dependence of the overall results on the success in the tests. The relationship between almost all of the included swimming competence tests and the results was statistically significant ($p < .001$) in both the YG and OG groups. In test T5, statistical significance was shown at a lower level ($p < .05$) in the YG group. According to the high values of the coefficient of determination (R2), which expresses the proportion of the variability of the dependent variable that is predicted by the statistical model, it is evident that these findings point to the limitations of the pilot study. These limitations are particularly related to the low number of subjects in both samples.

Discussion

We agree with Barett et al. (2015) that the environment in which testing is conducted plays an important role in achieving adequate results and is a prerequisite for obtaining reliable measures of perceived competence. The results of the study indicate an overall lower level of swimming competence in the YG. For the YG of children, psychological factors such as fear or apprehension of an unfamiliar environment may have also negatively influenced the results. Similar findings are reported by Stallman et al. (2017). We think that the differences were probably due to age differences, experience with the aquatic environment, the level of development of motor competence, and the higher cognitive maturity of older children, related to the child's ontogenesis. In Slovakia, swimming is taught as part of school physical education and in specialized institutions such as swimming schools. Therefore, it is important to search for and unify the methodological procedures in both cases. A simple test battery, based on a three-level point assessment of basic swimming competencies, will help educators and coaches quickly identify a child's weak and strong points and allow them to be effectively divided into training groups. At the beginning of swimming lessons, it is important to create homogeneous groups in terms of experience and adaptation to the aquatic environment. This will ensure the application of adequate procedures in the teaching process. An individual needs a wide range of swimming competencies that will enable them to react appropriately in various situations. The variety of swimming skills differs in terms of their movement structure, but all of them, together with movement skills and knowledge, are basic prerequisites for the subsequent acquisition of the correct technique of swimming locomotion. This process includes a sequence of stages: preparatory, basic, and refinement. Since the three-point evaluation of movement tasks also captures progress (gaining 2 points), success in test tasks at the end of swimming lessons can be a criterion for meeting the goals of the given stage. The above is not yet implemented in practice using uniform swimming tests adapted to the stages of swimming lessons (Macejková & Benčuriková, 2014). The findings of the relationship analysis support the development of a test battery to evaluate basic swimming skills.

Conclusion

Learning to swim is a long-term and complex process involving sensorimotor learning. Several internal and external factors influence this process. Therefore, we recommend implementing the proposed test battery at the beginning of the swimming course, specifically during the first two hours. The objectivity of the assessment is ensured by a three-member team that includes an experienced expert. Perform the test tasks in shallow water, where the water level reaches between the waist and shoulders. Provide a sufficient number of swimming aids, such as noodles and swimming boards. When administering the test items, ensure sufficient space in the pool. It is also crucial to always follow the same methodical protocol for measurements. The results of the research cannot be generalized to the observed age categories due to the smaller number of subjects. Because of this limitation of the pilot study, to ensure external validity (the generalizability of findings), the proposed test battery should be implemented on a larger research sample. Additionally, verifying other properties of the test battery, such as its sensitivity to different skill levels, age and socioecomonic factors would strengthen its validity and reliability. Based on a thorough verification of validity and reliability, the three-point scoring basic swimming competency test battery can be a valuable and accessible tool for assessing the level of swimming competence of younger school-aged children.

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CORRELATION BETWEEN CHILDREN'S BODY MASS INDEX AND KINEMATIC MOVEMENT PATTERNS IN TASKS OF MASTERING RESISTANCE

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Abstract
The aim of the research was to make a kinematic analysis of the motor structure of lifting and putting down objects in children of an early and preschool age and to determine possible deviations from the ideal structure of movement when performing them. The research was conducted with children of early and preschool age, i.e., a total of 174 children (97 girls and 77 boys). The children attended the regular all-day programme of the Rijeka Kindergarten in the Primorje-Gorski Kotar County and their average age was 71 months. The independent variables were: age, height and body weight, and body mass index. Dependent variables were obtained by the kinematic analysis of motor structures, i.e., video recordings of children performing motor tasks of lifting and putting down different objects processed in the Kinovea program. Basic descriptive parameters were calculated, and Pearson's correlation coefficient was used to determine the relationship between variables. The results indicate a significant correlation between BMI and calculated knee and hip angles when lifting heavy objects. Children with a higher BMI have significant deviations in their motor pattern when lifting, which can lead to significant health consequences.

Keywords: children, kinematic movement, mastering resistance, body mass index

Introduction
Lifting and putting down objects are two inseparable activities, because what is lifted usually has to be put down. Lifting and putting down is a process in which a certain effort is invested in lifting an object, and then transferring it to a certain place that can be closer or more distant, higher, lower or at an equal location as the place from which it was lifted. The lifting and putting down techniques are easily applicable and necessary in everyday life, which is why work on natural forms of movement applying lifting and putting down are recommended in organized exercise processes (Rašidagić et al., 2014). Lifting and carrying mainly affect the muscles of the arms, trunk and legs. Lifting is a motor action that occurs before carrying and putting down, and the reason for this is the fact that children will not carry a certain object until they have fully mastered the ability to walk. Some of the activities of kinesiologically adapted biotic motor knowledge from the domain of mastering resistance are precisely: lifting and carrying cubes and squares, lifting and carrying a ball, lifting and carrying a medicine ball, lifting and carrying a medicine ball along given lines, lifting and carrying a mat, lifting and carrying a medicine ball in pairs, lifting and carrying a mat in groups, lifting and carrying objects of different sizes and weights in pairs or groups (Petrić, 2022). Motor tasks of lifting and putting down objects should include both adapted exercises and equipment. Modern research shows that motor activities that encourage mastering resistance in children increase their muscular endurance, but they should be carried out in conditions controlled by an expert in order to prevent possible injuries to the children's locomotor system and ensure their proper growth and development (Radovanović, 2019; Shenouda et al., 2017).

The movement of the human body in space is extremely complex, and its position should be defined by the coordinates of body points that depend on time and forces, whereby movement can be viewed as a phenomenon (Dodig, 2019). It is kinematics that can be used for the multidimensional analysis of human movement, i.e., with it, it is possible to perform in-depth analysis such as object control, ejection speed, ejection angle, stability and other parameters (Clark et al., 2016). Looking at research conducted using kinematic analysis on children, two directions can be recognized most frequently. The first includes research related to the correct approach to teaching children when mastering different motor skills (Jurak et al., 2020; Ghorbani et al., 2022). Another direction of research includes the health component of children's motor patterns, i.e., the determination of kinematic characteristics in movement that can lead to possible injuries, and how to prevent them (Wei et al., 2021).

It is precisely during the realization of motor patterns when lifting and putting down objects that an injury can occur, and the implementation of natural forms of movement with the mentioned patterns is recommended to be carried out in organized kinesiology activities with children (Rašidagić et al., 2014). This is certainly one of the key reasons why such research is necessary, as it is important to determine the level of acquisition of the aforementioned motor skills and possible deviations, and to prevent certain unwanted health situations on time. On the other hand, low muscle strength during childhood is a risk for the development of diseases and must be identified early (Song and Qu, 2014). The above establishes the fact that it is necessary to constantly encourage motor tasks of mastering resistance in everyday activities with children.

Therefore, the goal of this research is to make a kinematic analysis of the motor structure of lifting and putting down objects in early and preschool children, i.e., to determine possible deviations from the ideal movement structure when performing certain motor tasks.

Methods

Participants

The research was conducted with children of early and preschool age, i.e., a total of 174 children (97 girls and 77 boys). The children attended the regular all-day programme of the Rijeka Kindergarten in the Primorje-Gorski Kotar County and their average age was 71 months (min = 29, max = 85). The average body height of children was 107.95 cm, body weight 19.63 kg and body mass index 16.62 m/kg^2.

Sample of variables

The independent variables in this research are the children's age (requested from the parents), body height and body mass, which were calculated with a digital scale and anthropometer, and the body mass index, which represents the ratio of the value of body mass expressed in kilograms to the square of the value of body height expressed in meters. The dependent variables used in the research are: knee angle, hip angle and ankle angle. The mentioned variables were defined by three set tasks, i.e. when picking up and putting down a marker hat, a volleyball and a 1 kg medicine ball.

Research protocol description

The research was conducted in the Z-active sports playroom, in accordance with the Code of Ethics for children. It was approved by the president of the Society for Sports and Recreation in Duga Resa and by the Professional Council for Teaching at the Teacher Training College in Rijeka. The parents were informed with the research protocol and gave their consent for their child's participation in the research, recording and photography as part of the contract they had signed with the aforementioned playroom. The research was carried out during the regular activities in the playroom, and the recording was done on several occasions, considering the dynamics of the group and the number of children present. The recording was realized with two cameras. One recorded the frontal plane, and the other the lateral plane. The motor tasks performed by the children were: lifting, carrying (5 m) and putting down the marker hat (photo 1); lifting, carrying (5 m) and putting down the volleyball (photo 2); lifting, carrying (5 m) and putting down a 1 kg medicine ball (photo 3). Before starting the measurement, the task was demonstrated and explained orally to the children. One child at a time performed the task, and the start of the task was indicated orally. The start was marked by one cone located on one of the pre-marked hall lines.

All tasks were recorded with a video camera and the videos were subsequently analysed in the Kinovea program (Version 0.9.5). The reference points for measuring the values of the angles were the ankle, the top of the knee, the top of the foot, the hip, and the top of the shoulder. The angles were measured at the moment when the specific object touched the ground for the first time.

Statistical processing

The data were analysed in the Statistica 14.0.1.25 program. Basic descriptive parameters were calculated for all variables: arithmetic mean, standard deviation, minimum and maximum score. Association was tested by the Pearson's correlation coefficient. All data are presented in the form of tables, graphs and photographs, and statistical significance is tested at the $p<0.05\%$ level.

Results

Table 1 shows the descriptive parameters of the children's morphological characteristics. Relatively high heterogeneity can be observed in all variables. The most deviations are present in the body mass variable. Although on average they differ within 5 kg, the difference between the minimum and maximum results is almost 17 kg. BMI indicates that in this sample there are children who are obese (21.73) and those who are undernourished (13.26). The smallest deviations are present in the body height variable, although there is also a difference of 23 cm between the minimum and maximum results.

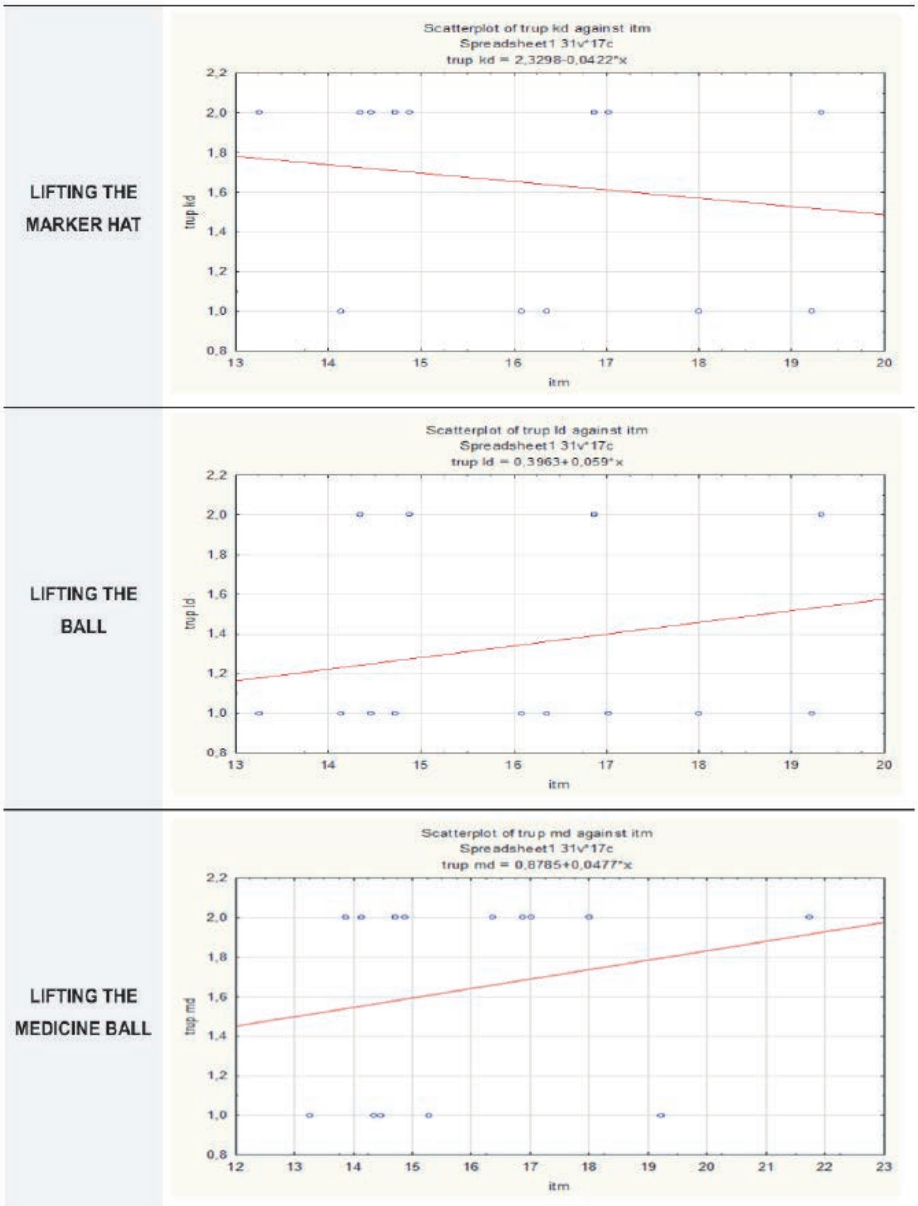
Table 1. Descriptive parameters of the participants' morphological characteristics

	Angle variables	M ± SD	Min	Max
MORPHOLOGICAL CHARACTERISTICS	Height	1.12 ± 0.07	1.00	1.23
	Mass	20.65 ± 4.53	13.80	30.00
	Body mass index	16.41 ± 2.40	13.26	21.73

M- mean; SD- standard deviation; Min- minimum; Max- maximum

Graph 1 shows the trend of the relationship between body mass index and the way the trunk is used when lifting a marker hat, ball and medicine ball. It can be seen very clearly that the average direction increases with increasing object weight. In other words, children with a higher BMI use more flexion of the trunk when lifting a medicine ball than when lifting a ball or marker hat, which is not good. Children with lower BMI usually have an upright trunk position when lifting objects.

It can be said that a higher weight of the object significantly disrupts the motor movement pattern when lifting objects in children with a higher BMI, consequently encouraging the compensation by certain parts of the body, more precisely, the trunk, in order to be able to perform the given task.



Graph 1. The trend in the relationship of BMI and the way the trunk is used to lift the marker hat, ball and medicine ba

Legend. Trup- trunk; ITM- body mass index

Table 2. Descriptive parameters of measured ankles and their correlation with the body mass index

	Angle variables	M ± SD	Min	Max	r BMI
MEDICINE BALL	Knee lifting	88.93 ± 20.56	44.30	116.70	**0.50****
	Hip lifting	44.56 ± 7.38	33.00	56.50	**-0.56****
	Ankle lifting	79.77 ± 6.49	68.80	94.40	0.37
	Knee putting down	99.69 ± 21.03	45.50	122.50	0.38
	Hip putting down	42.52 ± 14.16	23.40	76.90	0.23
	Ankle putting down	85.77 ± 9.93	72.60	107.20	0.36
BALL	Knee lifting	91.44 ± 30.07	37.10	143.80	-0.41
	Hip lifting	43.79 ± 7.07	36.40	65.10	-0.44
	Ankle lifting	79.69 ± 11.84	61.30	95.10	-0.46
	Knee putting down	86.48 ± 27.47	33.80	124.30	0.22
	Hip putting down	38.88 ± 11.09	17.80	53.30	0.28
	Ankle putting down	85.21 ± 7.26	71.70	97.00	0.22
MARKER HAT	Knee lifting	106.86 ± 26.76	52.10	154.50	-0.14
	Hip lifting	48.01 ± 22.92	23.10	95.60	-0.06
	Ankle lifting	80.72 ± 6.56	68.00	92.30	-0.08
	Knee putting down	94.07 ± 25.50	49.70	133.40	0.23
	Hip putting down	45.78 ± 19.09	20.10	76.70	0.08
	Ankle putting down	82.34 ± 11.12	66.90	99.80	0.25

Legend. M- mean; SD- standard deviation; Min- minimum; Max- maximum; r- correlation, BMI- body mass index

Table 2 shows the minimum, maximum and average values of the angles in the hip, ankle and knee when lifting and putting down the marker hat, ball, and medicine ball, as well as their relationship with BMI. Regardless of the object with which the task was performed, we can see relatively large differences in all measured angles when comparing the minimum and maximum results. There are also relatively high deviations from the average. It can be said that in this sample there is almost no standard movement pattern when lifting and putting down objects, and that each child performs these movements in their own specific way. Furthermore, there is a statistically significant correlation ($p=0.00$) between the body mass index and the angle in the knee and hip when lifting the medicine ball. A higher BMI causes significant changes in the movement pattern in such a way that the knee angle increases and the hip angle decreases. The same describes the recognizable movement pattern when lifting, so that the legs are straighter at the knees (there is almost no flexion), while the trunk is bent.

Discussion

The BMI results indicate that there is an extremely large heterogeneity among children in the level of nutrition. Contemporary research obtained almost identical results when it comes to heterogeneity in diagnosed BMI values (Shah et al., 2022; Vlašić, 2020). Research results indicate a constant growth of BMI values, especially from the second to the eighth year of a child's life (Jovancevic, 2019; Jerković Gavran & Krijan, 2019). We can say that the problem of obesity already appears regularly among children of an early and preschool age. It is necessary to start the planned prevention programmes already in the nursery, i.e., from the earliest age of the child. It is precisely institutions such as kindergartens that could play a significant role, because in them, children should encounter organized physical exercise for the first time, and start acquiring the basics of motor literacy.

Furthermore, there is a large heterogeneity in the kinematic variables of the research. This indicates that motor patterns differ between children when performing motor resistance tasks. Motor patterns in a child are emphasized from birth, and they begin to perform them instinctively, without the instruction of an adult. We call them biotic motor knowledge and they enable children to express themselves motorically by mastering space, obstacles, resistance and handling objects (Petrić, 2022). The period of the child up to the fifth year of age is crucial for the achievement of complete motor development, i.e., for the optimal development of the central nervous system (Vujičić & Petrić, 2021). In the specified period, we can significantly influence the establishment of quality lifelong motor patterns. Understanding the individual characteristics of children and their motor patterns becomes imperative for a full understanding of the benefits of motor development (WHO, 2019). Almost 70 % of children in the Republic of Croatia have a below-average level of motor skills (Vukelja et al., 2022). Contemporary research indicates significant intra-individual biological variations in motor movement patterns, which represents an exceptional need for further research in order to better understand what is happening to their motor development and the health of the locomotor system (Steen et al., 2022; Harsted et al., 2019). The above was confirmed by this research.

The results of the relationship between body mass index and hip and knee angles when lifting and putting down objects point to the fact that when lifting heavier objects, children with a higher body mass index cannot do it properly. When performing the task, children with higher BMI values achieve higher values in the knee angles, and lower values in the hip angle, which means that when lifting, the trunk is significantly used instead of the leg muscles. Contemporary research also indicates that overweight children tend to use different strategies when performing motor tasks, i.e., they show significant deviations from expected movement patterns, are extremely insecure, and the possibility of locomotor injury increases significantly (Gill et al., 2014).

The fact that children with higher BMI values lift heavier objects with the torso in a forward position can be connected to the conclusions of the research by Gentier et al. (2013), which pointed out that children with higher BMI values show a lower level of manual dexterity and also achieve worse results in fine motor skill tasks that require precision. Obese children also achieve worse results in gross motor tasks, in which it is necessary to make larger movements during motor tasks (Gentier et al., 2013). Cheng et al. (2016) came to similar conclusions - with an increase in body mass there is a decrease in motor skills in children, especially when performing motor tasks of mastering resistance. It is clear that BMI negatively affects the development of children's motor potential and, in addition to cardiovascular diseases, it represents a significant risk for locomotor injuries in children and prevents their motor development.

Research indicates that encouraging children to engage in physical activity is crucial for their motor and overall development (Eyre et al., 2021; Parvinpour et al., 2020). Active movement enhances motor skills and abilities, facilitating the acquisition of new skills and participation in new challenges. Encouraging the acquisition of biotic motor skills through play has been proven effective for children's motor development (Sutapa et al., 2021). Integrated learning through movement, which includes various activities, represents a new approach in early education (Vujičić & Petrić, 2021). This approach, in addition to being scientifically based, serves as an important intervention method as it allows early education institutions to significantly contribute to the proper development of motor patterns and the creation of lifelong movement habits (Vujičić, Petrić, & Pejić Papak, 2018).

Reduced levels of physical activity diminish the quality of children's motor patterns, posing a serious issue for pediatric health. Children with lower levels of motor skills are more prone to obesity, poorer cardiorespiratory fitness, and a higher risk of chronic diseases (Jurakić, 2015). Additionally, inadequate motor patterns can negatively impact the overall health of the child (Ljubičić et al., 2022). Encouraging physical activity and developing motor skills are essential for promoting the overall health and well-being of children.

Conclusion

It can be concluded that there is a significant correlation between BMI and the calculated knee and hip angles when lifting heavy objects. Children with a higher BMI have significant deviations in their motor pattern when lifting, which can lead to serious health consequences. It is important to carry out motor activities of mastering resistance in controlled conditions with children from an earliest age in order for children to adopt the correct movement patterns when lifting heavy objects. Moreover, there is a need for them to be carried out by an expert who knows how to ensure optimal motor development in children by applying integrated contents, guided by the correct principles of lifting, carrying and putting down objects.

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EFFECTS OF TANDEM TEACHING MODELS ON PUPILS´ MOTOR COMPETENCIES DEVELOPMENT IN PRIMARY SCHOOL PHYSICAL EDUCATION

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Abstract
This study investigates potential differences in the development of pupils' motor competencies when exposed to two distinct tandem teaching models within primary school PE. One cohort of pupils (grades 1, 3, and 5) received instruction from a PE specialist paired with an assistant (n=47). The second cohort (grades 1, 3, and 5) participated in PE classes led by a Class Teacher paired with an assistant (n=61). The Mann-Whitney U test was utilized to evaluate differences between groups, and effect sizes were calculated. Overall, results indicated statistically significant differences in 3 motor tests (long jump, beep test, pull-up hold) favouring the cohort taught by a PE specialist and assistant (PE group), with medium effect sizes. These disparities were most evident in grade 3, where the PE group consistently excelled in the long jump, beep test ($p < 0.05$), agility 4x10m test, and pull-up hold ($p < 0.01$) with large effect sizes. Grade 5 pupils exhibited comparable outcomes between groups, and no significant differences were observed in grade 1. While these results suggest the tandem model led by a PE specialist may be more conducive to motor competencies development, the study indicates that the amount of time pupils engage in extracurricular sports activities could be a substantial contributing factor, particularly at this developmental stage.

Keywords: tandem teaching, physical education, motor competencies, primary school

Introduction

Early development of fundamental motor skills is crucial for long-term health (Cattuzzo et al., 2016), but many children are not meeting recommended physical activity levels, impacting their motor skill mastery (Guthold, 2020). Tandem teaching in PE, although not widespread, may offer a solution and lead to significant improvement of motor competencies. It offers several benefits, including targeted instruction (Kraft, 2020), differentiated learning (Bryan & Strnadová, 2021), increased engagement (Finn & Zimmer, 2012), and improved classroom management (Evertson et al., 2003). Additional advantages, such as increased physical activity and holistic learning, have also been reported (Klincarov et al., 2018; Antala, 2024). However, specific benefits may vary depending on the model.

While tandem teaching is not a novel concept within primary education, its implementation remains relatively uncommon across Europe and globally. However, some schools successfully utilize collaborative models where PE specialists and classroom teachers work together to deliver PE (Ward et. al, 2021). In tandem teaching in the Republic of Macedonia and Slovenia, both generalist teachers and PE specialists collaborate in delivering PE classes at the elementary level. This approach has garnered positive evaluations from both teacher groups (Klincarov et al., 2018).

The aim of this study was to compare the effectiveness of two tandem teaching models on pupils' motor competencies – PE specialist with an assistant teacher versus Generalist teacher (Class teacher) with an assistant teacher.

Methods

The study aimed to investigate the differences between two tandem teaching models in primary school Physical Education classes. Differences in students' fundamental motor competencies (e.g., speed, endurance, agility, strength, flexibility, etc.) were analysed to demonstrate the effects of tandem teaching models where a Physical Education specialist is paired with an assistant teacher versus a model where a Class Teacher is paired with an assistant teacher.

Study participants
Two tandem teaching models involved in the study comprised of:

1. Physical Education teacher with an assistant teacher – groups of pupils (n=47):
   Grade 1: n=14 (9 girls, 5 boys), age 6.9 years, height 123.6 cm, weight 24.6 kg
   Grade 3: n=14 (6 girls, 8 boys), age 8.8 years, height 137.8 cm, weight 30 kg
   Grade 5: n=19 (11 girls, 8 boys), age 10.8 years, height 146.5 cm, weight 37.4 kg

2. Class teacher with an assistant teacher – groups of pupils (n=61):
   Grade 1: n=20 (11 girls, 9 boys), age 6.8 years, height 123.9 cm, weight 23.6 kg
   Grade 3: n=20 (13 girls, 7 boys), age 8.9 years, height 136.7 cm, weight 29.3 kg
   Grade 5: n=21 (9 girls, 12 boys), age 10.8 years, height 145.9 cm, weight 39.0 kg

Data collection
The Ministry of Education, Research, Development and Youth of the SR shall ensure, once a year in cooperation with primary schools, universities, and sports organizations, nationwide testing of the motor competencies of pupils in the first and third grades of primary schools (Act No. 440/2015 "Sports Act"). The mandatory battery of physical development and motor tests was used to collect the data in October 2023 by a group of PE teachers working at the school where this study was conducted. It consists of the following tests: Body height and body weight, Sit and reach, Bar routine, Pull-up hold (overhand grip), Standing broad (long) jump, Sit-ups in 30 seconds, Rolling 3 balls, Shuttle run 4x10 m agility test, Flag tag, Beep test (endurance shuttle run 20 m), (www.testovanieziakov.sk). Five motor tests are included in EUROFIT test battery which is considered a reliable battery of tests to assess physical fitness in research and practice in the school population (Grgic, 2022).

Data evaluation
Data analysis was conducted using Microsoft Excel and IBM SPSS Statistics (Version 2023). Due to the small sample sizes, the Mann-Whitney U test was employed to assess differences between the groups, as it is difficult to reliably determine if the data follows a normal distribution with limited observations. A level of significance was set up at $p < 0.05$. Additionally, effect size was calculated to quantify the magnitude of the observed effect. A commonly used interpretation is to refer to effect sizes as small ($d = 0.2$), medium ($d = 0.5$), and large ($d = 0.8$).

Results
Overall, the results show statistical differences between pupils taught by the PE specialist with an assistant teacher (PE group) and those having PE with the Class Teacher and an assistant (CT group) in 3 motor tests (long jump, beep test, pull-up hold), with a medium effect size when the PE group achieved better scores in comparison to the CT group (table 4). Examining the findings by grade, these differences were most pronounced in the 3rd grade, where the PE group consistently outperformed the CT group in the long jump, Beep test ($p<0.05$), agility 4x10m test, and pull-up hold test ($p<0.01$) with large effect sizes (table 2). Grade 5 pupils demonstrated very similar results in motor skill tests in both groups. PE group performed better in the long jump test ($p<0.05$, medium effect size) but significantly worse in the agility 4x10m test ($p<0.01$, large effect size), (table 3). Finally, the results show no significant difference between the pupils of grade 1 after 2 months of having Physical Education classes at school (table 1).

Table 1. Comparison of motor test results in grade 1 between Physical Education teacher and Class teacher tandem groups

Tests	**Mean**		**Standard deviation**		**Sig.**	**Effect size**
	PE -1	**CT-1**	**PE-1**	**CT-1**		
Sit & reach (cm)	5.14	3.55	4.05	3.03	0.192	0.44
Long jump (cm)	118.86	119.15	22.38	18.20	0.877	0.01
Beep test (n)	15.50	13.45	8.78	5.10	0.416	0.29
4x10m run (s)	14.98	14.94	1.18	1.21	0.743	0.03
Bar routine (s)	28.31	28.95	8.97	12.22	0.931	0.06
Ball rolling (s)	32.46	35.26	8.31	8.60	0.457	0.34
Pull-up hold (s)	10.81	8.65	15.18	7.23	0.904	0.18
Sit-up test (n)	29.14	31.55	7.88	4.96	0.396	0.37
Flag tag (n)	8.36	6.95	4.34	4.17	0.192	0.33

Key to abbreviations: PE-1: a group of grade 1 pupils taught by a Physical Educator and an assistant teacher; CT-1: a group of grade 1 pupils taught by a Class Teacher and an assistant teacher; Sig.: Significance

Table 2. Comparison of motor test results in grade 3 between Physical Education teacher and Class teacher tandem groups

Tests	Mean		Standard deviation		Sig.	Effect size
	PE -3	CT-3	PE -3	CT-3		
Sit & reach (cm)	5.64	3.55	6.20	7.19	0.478	0.31
Long jump (cm)	149.21	131.60	20.11	19.20	0.056*	0.90
Beep test (n)	33.79	22.60	15.73	11.13	0.039*	0.82
4x10m run (s)	13.38	14.84	0.97	1.02	0.000**	1.47
Bar routine (s)	19.16	20.38	4.41	4.61	0.274	0.27
Ball rolling (s)	30.43	32.09	7.80	8.36	0.616	0.21
Pull-up hold (s)	17.24	7.21	7.80	6.41	0.001**	0.75
Sit-up test (n)	37.14	34.15	6.36	9.00	0.112	0.38
Flag tag (n)	5.64	7.60	3.86	4.54	0.259	0.47

Key to abbreviations: PE-3: a group of grade 3 pupils taught by a Physical Educator and an assistant teacher; CT-3: a group of grade 3 pupils taught by a Class Teacher and an assistant teacher; Sig.: Significance; $*p<0.05$; $**p<0.01$s

Table 3. Comparison of motor test results in grade 5 between Physical Education teacher and Class teacher tandem groups

Tests	Mean		Standard deviation		Sig.	Effect size
	PE -5	CT-5	PE -5	CT-5		
Sit & reach (cm)	0.74	-2.86	8.10	8.98	0.478	0.31
Long jump (cm)	154.6	142.4	18.94	22.02	0.044*	0.58
Beep test (n)	35.74	32.43	13.56	14.93	0.469	0.23
4x10m run (s)	13.27	12.04	1.17	0.95	0.002**	1.15
Bar routine (s)	19.89	18.28	4.71	6.04	0.078	0.30
Ball rolling (s)	18.99	19.60	5.68	6.43	0.851	0.10
Pull-up hold (s)	8.38	7.65	4.88	4.21	0.555	0.16
Sit-up test (n)	35.21	39.33	7.01	9.05	0.187	0.51
Flag tag (n)	4.95	3.86	2.30	2.29	0.117	0.48

Key to abbreviations: PE-5: a group of grade 5 pupils taught by a Physical Educator and an assistant teacher; CT-5: a group of grade 5 pupils taught by a Class Teacher and an assistant teacher; Sig.: Significance; $*p<0.05$; $**p<0.01$

Table 4. Comparison of motor test results between Physical Education teacher and Class teacher tandem groups

Tests	Mean		Standard deviation		Sig.	Effect size
	PE ∑	CT ∑	PE ∑	CT ∑		
Sit & reach (cm)	3.51	1.34	6.82	7.46	0.236	0.30
Long jump (cm)	142.3	131.2	25.32	21.82	0.026*	0.47
Beep test (n)	29.13	22.98	15.65	13.54	0.031*	0.42
4x10m run (s)	13.81	13.91	1.34	1.72	0.588	0.06
Bar routine (s)	22.18	22.33	7.30	9.44	0.850	0.02
Ball rolling (s)	26.41	28.83	9.39	10.32	0.291	0.25
Pull-up hold (s)	11.74	7.84	10.28	5.99	0.025*	0.46
Sit-up test (n)	33.98	35.08	7.68	8.46	0.879	0.14
Flag tag (n)	6.17	6.10	3.71	4.06	0.592	0.02

Key to abbreviations: PE ∑: a group of all the pupils taught by a Physical Educator and an assistant teacher; CT ∑: a group of all the pupils taught by a Class Teacher and an assistant teacher; Sig.: Significance; $*p<0.05$

Discussion

The study results demonstrate that students taught PE by a specialist with an assistant teacher (PE group) exhibited significantly better performance in several motor tests compared to those taught by a Class Teacher with an assistant (CT group). These differences were most pronounced in the 3rd grade, with the PE group outperforming the CT group in the long jump, Beep test, agility, and pull-up hold with large effect sizes. Similarly, the 5th-grade pupils with the PE specialist demonstrated advantages in the long jump. These results align with previous research highlighting the benefits of specialized PE instruction (Morgan & Bourke, 2008; McKenzie & Lounsbery, 2009). The PE specialists' expertise in movement pedagogy likely contributes to their students' greater motor skill development. But, interestingly, both grade 5 groups showed very similar results in almost all motor tests, and what is more, the CT group performed better in the agility 4x10m test. These results are very surprising because the 5th graders spent the past 4 years with differentiated instruction therefore the expectations would be quite on the contrary in favour of the PE specialist. The question is, how much can 2 PE lessons per week influence pupils' motor competencies development along with the sport-oriented extracurricular activities, and what amount of such physical activities do the pupils have in their spare time? Participation in sports-oriented extracurricular activities is associated with better overall performance in motor tests assessing areas like coordination, balance, strength, speed, and agility (James et al., 2023). Research shows that students of grades 1 through 9 improved their motor competencies with extended physical activity and motor training as well as the differences in motor competencies between boys and girls decreased with extended physical activity and extra motor training (Ericsson, 2011). Finally, we agree with Ericsson (2011) that the school has good potential for stimulating students' development of motor competencies, but two lessons of PE per week are not enough. No matter what type of teacher or tandem is in charge.

The generalizability of these findings is limited by the specific socioeconomic and cultural context of the participating schools, and pre-existing differences in students' physical activity and parental involvement. These uncontrolled factors could have confounded the results and should be considered when interpreting the findings. Further research with a more diverse sample is needed to assess generalizability and explore the long-term effects and specific instructional strategies within tandem teaching.

Conclusion

While the results of our study support the value of specialists in motor competencies development, it's important to acknowledge the strengths of classroom teachers in facilitating holistic learning and their existing rapport with students. However, the findings do suggest a need for enhanced professional development for classroom teachers responsible for PE instruction, ensuring they have sufficient pedagogical knowledge in this area (Stylianou et al., 2016). Recent research emphasizes that all teachers involved in PE should have adequate training and support, regardless of whether they are specialists or classroom teachers (Ward et. al, 2021; Centers for Disease Control and Prevention, 2022). In conclusion, tandem teaching models existing in Macedonia or Slovenia which involve both a PE specialist and a Classroom Teacher seem to be excellent possibilities to get advantages of both for primary school pupils.

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INFLUENCE OF SOME ANTHROPOMETRIC MEASURES ON FUNDAMENTAL GYMNASTICS ELEMENTS IN TEN-YEAR-OLD CHILDREN

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Abstract
Fundamental gymnastics skills are very important motor knowledge in children due to their healthy and harmonious influence on growth and development. The aim of the investigation was to determine how certain anthropometry measurements affect the performance of fundamental gymnastic skills. Investigation was conducted on a sample of 78 ten-year-old children (29 boys and 49 girls), participants of Summer School of Health – „Living Healthy ". The sample of variables consisted of two groups: anthropometric HEIGHT, WEIGHT, BMI; motor skills: FORW_ROLL - forward roll, BACK_ROLL – backward roll, CARTW – cartwheel. For the predictive and criterion variables, basic descriptive parameters and correlation coefficients were calculated. Regression analysis was used to determine the influence of anthropometric measures, or criterion variables, on motor knowledge, or gymnastic elements, at the statistical inference error level of $p<0.05$. Results have shown that BMI negatively contributed to the forward ($b^*=0,30$) and backward roll ($b^*=0,30$) in girls. Preschool age is the ideal time to learn the fundamentals of gymnastics, and smaller body dimensions are preferred.

Key words: forward roll, backward roll, cartwheel, motor skills

Introduction

A forward roll, backward roll and cartwheel are a fundamental element in gymnastics. It is a fundamental skill that is usually taught to beginners with the aim of increasing strength, flexibility, and coordination. Rolls, which can be classified as forward or backward, are fundamental acrobatic elements in which the performer rotates 360 degrees around the body's transversal axis while gradually altering the support of various body parts on the surface (Živčić Marković & Krističević, 2016). Kinesiological motor skills are those movement-related motor structures whose main purpose is to help children to develop specific aspects of their anthropological status, mainly all the morphological and motor characteristics (Babin et al., 2013). In order to determine the relationship between morphological characteristics and motor skills of representative teaching topics of the accepted curriculum of physical and health culture, 152 fifth-grade primary school children participated in the study (Vlahović & Babin, 2018). Similar investigation was conducted with the aim of determining the connection between morphological characteristics and motor skills of representative teaching topics on a sample of 152 schoolgirls aged 11 years (Vlahović et al., 2016). Connection connections among the motor skills and motor abilities of representative teaching themes investigated authors Babin et al., (2013) of the physical education curriculum for eleven-year-old pupils in the fifth grade in elementary schools. Delaš et al., (2007) investigated the factor structures of morphological characteristics and basic motor skills in competitive gymnastics in 126 female children aged 12 years. The author Kovač, (2012) examined the performance differences between genders and tried to ascertain whether the test's backward roll design is suitable for assessing students. Živčić Marković & Ćavar, (2011) investigated 153 students from three generations of the University of Zagreb's faculty of Kinesiology and found that during their primary education, female students in the faculty lacked sufficient motor knowledge about artistic gymnastics. Although it is an extremely current theoretical and practical topic of importance for kinesiology education, the relationship between morphological characteristics and motor skills has never received enough scientific attention. The aim of this investigation was to identify the impact of some anthropometric measures on the execution of basic gymnastic elements in 10-year-old children.

Methods

Data was collected during the Summer School of Health – „Living Healthy" from August 8, 2023 until September 3, 2023 (separated in four weeks). In investigation were participated 78 (29 boys and 49 girls) ten (mean= 10,45) year old children. Participants finished the fourth-grade elementary schools in the county of Zagreb's (Bregana, Samobor, Strmec, Sveta Nedjelja). There were four child groups that attended summer health school for one week each group. They stayed at a hotel in Sveta Nedjelja and participated in various kinds of sports activities (such as volleyball, football, badminton, walking, running, swimming, parkour, and gymnastics) each day for seven days. Additionally, none of the participants belong to a gymnastics club and they are not trained gymnastics. Anthropometer, which allows for 0.1 cm precision in reading the data was used to measure weight. Simple digital scale that allows the pointer to be adjusted to the zero position and allows for the accurate readout of findings at 0,5kg, were used to measure height. An evaluation of basic gymnastics elements was carried out by three professors of kinesiology. Grade for execution of the elements were from 1 to 5 (Table 1). Average grades from three professors are considered. Sample of variables consisted of three basic gymnastic elements: FORW_ROLL - forward roll, BACK_ROLL – backward roll, CARTW – cartwheel. BMI was calculated by BMI Calculator for Child and Teen CDC (Centres for Disease Control and Prevention) (CDC, n.d.). The Statistica 14.0.0.15 program was used for data processing. Basic descriptive parameters and correlation coefficients were calculated for predictor and criterion variables. Multiple regression analyses were used to determine relationship of anthropometric measures on motor knowledge (gymnastic elements) at the statistical inference error level of $p<0.05$. Dependent variable was gymnastics elements and independent variables anthropometric measures. Regression analyses was used to understand and predict relationships between variables. Here, regression analysis was used to check the relationship between anthropometry and the performance of elements.

Table 1. Scale for assessment the elements

Grade	Gymnastics elements
Exellent (5)	the task is performed, dynamically, fluently, and with no errors in execution
Very good (4)	smaller errors in performance
Good (3)	the performance is not dynamic, safe, and has more errors in all phases of performance
Sufficient (2)	very insecure with large errors at all phases of performance
Insufficient (1)	the performance does not look like the default element

Results

Table 1 shows the basic descriptive statistics results.

Table 1. Descriptive Statistics

Variable	Valid NM	Valid NW	MeanM	MeanW	MinM	MinW	MaxM	MaxW	Std.Dev. M	Std.Dev. W
GENDER	29	49	1,00	2,00	1,00	2,00	1,00	2,00	0,00	0,00
AGE	29	49	10,48	10,43	10,00	10,00	11,50	11,00	0,53	0,48
HEIGHT	29	49	148,23	147,19	135,00	135,00	158,00	160,00	5,82	6,39
WEIGHT	29	49	40,62	41,87	29,80	27,20	64,40	79,70	9,91	9,92
BMI	29	49	18,47	19,61	14,30	19,8	26,30	31,1	3,59	4,14
PERCENTILES	29	49	53,89	63,07	4	3	97,3	99,30	33,28	29,91
FORW_ROLL	29	49	3,47	3,41	0,00	1,33	5,00	5,00	1,24	0,90
BACK_ROLL	29	49	2,95	2,99	0,00	0,33	4,67	5,00	1,28	1,14
CARTW	29	49	2,78	3,50	0,00	0,67	5,00	5,00	1,35	1,37

Legend. FORW_ROLL – Forward roll; BACK_ROLL – Backward roll; CARTW – Cartwheel; Valid NM – number of sample - boys; Valid NW– number of sample - girls; MeanM – average values for boys; MeanW – average values for girls; MinM – minimum values for boys; MinW – minimum values for girls; MaxM – maximum values for boys; MaxW – maximum values for girls; Std.Dev. M – Standard Deviation for boys; ; Std.Dev. W – Standard Deviation for girls.

Table 2 shows the results of the corelation in girls between morphological variables and gymnastics elements. There are significant negative correlation coefficient between BMI and BACK_ROLL at the level of statistical significance p<0,05.

Table 2. Correlation coefficients for girls

Variable	FORW_ROLL	BACK_ROLL	CARTW
HEIGHT	-0,13	-0,02	0,03
WEIGHT	-0,27	-0,18	-0,10
BMI	-0,30*	-0,30*	-0,16

Legend. *statistically significant value, p<0,05

In Table 3 the predictor variables explain 7% of the variance of the criterion variable FORW_ROLL. The variable BMI negatively contributes on the forward roll with a coefficient of b*= -0,30.

Figure 1 shows the results of the correlations between BMI, height, weight and gymnastics elements in girls.

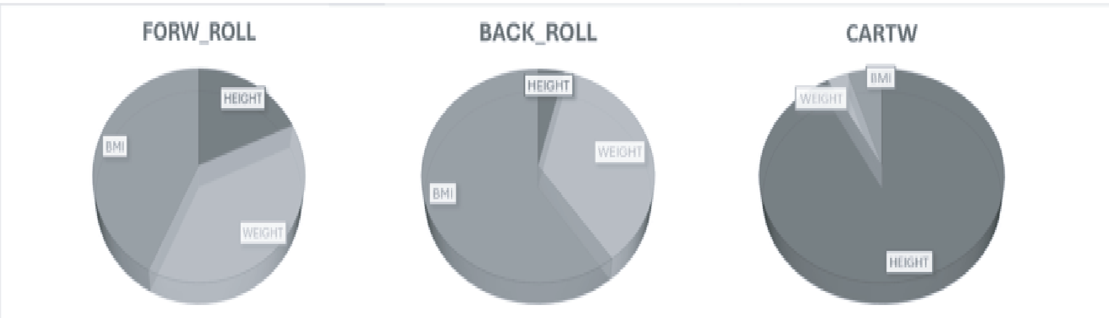

Figure 1. Correlation for forward roll (FORW_ROLL), backward roll (BACK_ROLL) and cartwheel (CARTW) in girls

Table 3. Regression analyses for dependent variable BMI and independent FORW_ROLL for girls

N=49	Regression Summary for Dependent Variable: FORW_ROLL, R= ,30189455 R²= ,09114032 Adjusted R²= ,07180288 F(1,47)=4,7132 p					
	b*	Std.Err. of b*	b	Std.Err. of b	t(47)	p-value
Intercept			4,71	0,61	7,7	0,00*
BMI	-0,30	0,14	-0,07	0,03	-2,2	0,04*

Legend. *p= statistically significant value, p<0,05

In Table 4 are presented the regression analysis where predictor variable explains 9% of the variance of the criterion variable BACK_ROLL. The BMI negatively contributes on the backward roll whit a coefficient of b*= -0,30.

Table 4. Regression analyses for dependent variable BMI and independent BACK_ROLL for girls

N=49	Regression Summary for Dependent Variable: BACK_ROLL, R= ,30481388 R^2= ,09291150 Adjusted R^2= ,07361175 F(1,47)=4,8141 p					
	b*	Std.Err. of b*	b	Std.Err. of b	t(47)	p-value
Intercept			4,64	0,77	6,0	0,00*
BMI	-0,30	0,14	-0,08	0,04	-2,2	0,03*

Legend. *p= statistically significant value, p<0,05

Results of correlation coefficients for boys are shown in Table 5. There are no statistically significant results, but mostly variables have negative correlations except BACK_ROLL and HEIGHT, CARTW and BMI.

Table 5. Correlation coefficients for boys

Variable	FORW_ROLL	BACK_ROLL	CARTW
HEIGHT	-0,08	0,03	-0,23
WEIGHT	-0,23	-0,11	-0,10
BMI	-0,24	-0,13	0,01

Legend. *statistically significant value, p<0,05

The correlation between boys' BMI, height, weight, and gymnastics elements are presented in Figure 2.

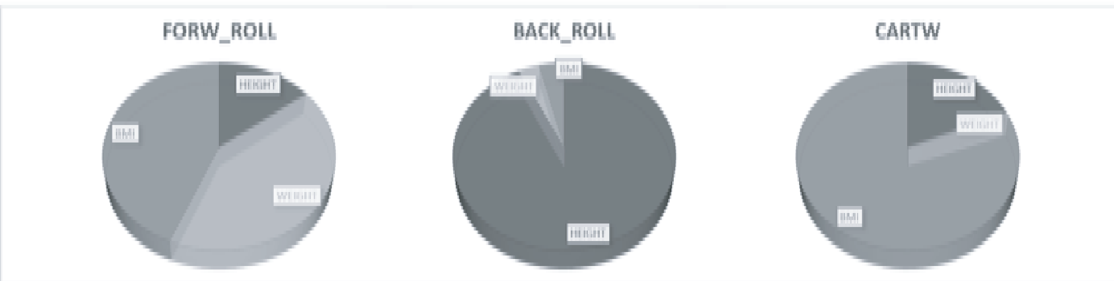

Figure 2. Correlation for forward roll (FORW_ROLL), backward roll (BACK_ROLL) and cartwheel (CARTW) in boys

Discussion

Results have shown that some anthropometric measures, especially BMI have negative correlations on rolls in both genders. In girls, there are significant negative correlation coefficients between BMI and BACK_ROLL, which means that higher values of BMI will decrease grades in rolls and vice versa. Children with higher BMI will have problems with execution of forward and backward roll. These results can be supported investigation of Vlahović & Babin, (2018) where students have better success in the performance of motor skills tests, who mostly belong to the mesomorphic body structure. Both rolls are the elements of coordination, and for execution is important the strength of the arms. The obtained results indicate that the endomorphic body of the test subjects, which manifested as a clearly disturbing factor, is definitely responsible for a worse performance of motor skills in this research (Vlahović et al., 2016). During this investigation, according to average BMI values for boys (18,47), and girls (19,3) they belong to the healthy weight (5th percentile to less than the 85th percentile). Backward roll and cartwheel in boys are the elements with lower grades (average grade 3) than grades in girls (average grade 4). For gender differences in backward roll performance, 36 students were evaluated, and no statistically significant differences in the performance of boys and girls were found (Kovač, 2012). Also, similar investigation explained the negative effects of adipose voluminosity on the performance of the squat vault and backward pullover mount, the second pair of canonical factors also explained the importance of the transverse dimensionality of the arm skeleton, arm flexibility, and explosiveness in performing cartwheels and squat vaults (Delaš et al., 2007). Children with increased body weight and BMI should be included in learning forward and backward rolls but in easier conditions, for example by using a slope mat, assistance and various aids. In Osijek and Baranja county, Croatia, physical education teachers of 5th to 8th grades dedicated 20 hours per grade to gymnastic content and this amounts to thirty percent of all gymnastic content, elements like forward and backward rolls, handstands, cartwheels (Badić et al., 2012). According to Bučar Pajek et al., (2010) Slovenian physical education teachers invest 9,8 hours per academic year to gymnastics, primarily teaching fundamental skills such as forward roll, backward roll, cartwheel, handstand, etc., Fundamental gymnastic skills are elements which have to be learned in the lower grades of elementary school. Based on the eight fundamental gymnastic movement structures (forward roll, backward roll, right cartwheel, left cartwheel, handstand, pullover, forward walk on the balance beam, and safety walk on the balance beam). Živčić Marković & Ćavar, (2011) state that second-year students of the Faculty of Kinesiology did not gain practical information about fundamental gymnastic movement skills during their primary school and that their knowledge about artistic gymnastics is at an inadequate level. These findings may contribute to the improvement of gymnastics curriculum content so that it can be more frequently implemented in elementary schools. Basic gymnastic elements should be included in training programs for other sports as well, with the exception of gymnastics, where these skills are crucial for upgrading heavier elements. As learning the previously mentioned elements does not require material conditions like specialized appartaus or gymnmastics hall. Most of them can be learned in modest conditions using a mat, but there is the possibility of learning on children's playgrounds.

Conclusion

Gymnastics is a very well-liked recreational activity in addition to a professional sport. Despite the three basic sports, it is also one of the most recommended for a child's healthy development and maturation. As it can be adapted to all ages and categories, but also to the level of gymnastic knowledge, it is also applicable in primary schools, especially in lower grades. The study's limitations is that it looked only at four schools in the Zagreb region and one sample of ten-year-old children. To enhance understanding of the utilization and placement of fundamental gymnastic elements, it would be imperative to incorporate all educational institutions within the Zagreb and Croatia regions. Enhancing physical education curricula and sports training programs with gymnastics can result in a comprehensive development of motor skills, mental toughness, and physical fitness. Gymnastics skills can be the basis for performing a variety of physical activities throughout life.

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SERVICE LEARNING ACTIVITIES IMPLEMENTATION IN CURRICULA FOR KINESIOLOGY STUDENTS

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Abstract
Service learning (SL) is a developing pedagogical approach in higher education for kinesiology students. By implementation of SL activities, benefits such as better connection with stakeholders and society, improvement of students' theoretical and practical knowledge, and improvement of reputation of higher institution through better quality of education are expected in the higher education area of kinesiology. The objectives of this study were to determine dominant kinesiology fields chosen by kinesiology students for the preparation of SL projects and to analyse the impact of motivational climate on different kinesiology fields (sport, recreation, or kinesitherapy) while preparing SL projects, separately by gender. At the first stage of study, Motivational Climate on Physical Education Scale (MCPES) questionnaire was implemented on the sample of 58 kinesiology students. At the second stage, students were involved in creating SL projects in accordance with the needs of society through compulsory program. Female students most often chose kinesitherapy (41,2%) and male students most often chose recreation (66,7%), and only 9,4% of total subject sample selected sport field for the preparation of SL project. According to the Two-way analysis of variance, significant effect was defined $F = 2.19$ ($p = 0.04$) for the kinesiology fields factor. According to the Tukey post-hoc test, task climate dimension is emphasized among students who selected recreation kinesiology field for the preparation of SL projects, especially among male students. Further studies are needed with purpose of analysing efficient way to implement SL components in curricula for kinesiology students.

Key words: motivational climate, kinesiology fields, service learning projects

Introduction

Service learning (SL) is a well-known, modern pedagogical tool in higher education area in many educational fields which is manifested through numerous benefits for students, educational institutions and society (Martínez-Campillo et al., 2019; Salam et al., 2019.). According to Salam et al., (2019) in some academic disciplines, such as sport, the incorporation of SL in curricula is still in the initial stage. Therefore, the increased number of scientific papers regarding implementation of SL benefits for physical education (PE) and sport higher education area in the last decade, is not surprising (Carsson & Raguse, 2014; Chiva-Bartoll, et al. 2019; Pérez-Ordás et al., 2021, Chiva-Bartoll & Fernandez-Rio, 2022). With implementation of SL activities in higher education area of kinesiology, various benefits are expected such as better connection with stakeholders and society, improvement of students' theoretical knowledge, as well as practical skills, and improvement of reputation of higher institution through better quality of education. For systematic and effective curricula improvement further studies are needed with the purpose of analysing efficient way of incorporating SL components in curricula for kinesiology students. The most common application of SL activities in higher education programs is through SL projects. Miletić et al., (2024) explained how traditional education can transfer to contemporary, modern education in the field of physical activity and sports through conceptual framework of service learning in physical education. During SL classes students used acquired theoretical knowledge and practical skills to prepare projects related to kinesiology fields. Students worked in teams with mentors and created projects based on new ideas, acquired knowledge and skills, previous dominant motor skills and their perspective of societal needs. The main goal of this projects was to apply their knowledge and ideas to real-world contexts. In the field of kinesiology, students chose topics of their interests related to social issues and topics frequently connected with their previous motor skill experience and mastering (Miletić, at al.2023). In the process of preparing SL projects student were encouraged to critically evaluate their academic learning and to foster innovative and creative perspectives within the field of kinesiology. In effective curricula, this is a reversible process where students' ideas become a generator of changes in the academic field of kinesiology and in their social environment. Also, increasing critical thinking skills results in thorough understanding of the underlying causes of the societal problems. For physical activity and sports academic areas, SL implementation in academic curricula can be linked to several Sustainable Development Goals (SDG) regarding good health and well-being, quality education, and economic growth.

Students' motivation in the field of kinesiology can be efectively explained with two foundational social cognitive theories: Achievement Goal Theory (AGT) and Self Determination Theory (SDT). Motivational climate, whithin the AGT, define how individuals perceive their competence and pursue distinct goals (Braithwaite et al., 2011). The authors (Soini, et al., 2014) developed the tool for assessing the motivational climate in physical education. Motivational Climate on the Physical Education Scale (MCPES), is commonly used to analyse dimensions that presented social relatedness, perceived autonomy, and task - involving and ego - involving climate. According to all the above, participation in SL activities, changes the role of kinesiology students. Their academic and personal skills, critical thinking skills, teamwork, and effective communication are improving and they are becoming competent to reach new academic goals and to contribute to the modern society.

With the intention to effectively implement SL activity in higher education in the field of kinesiology, the objectives of this study were to: (1) determine dominant kinesiology fields chosen by kinesiology students for the preparation of SL projects; (2) analyse the impact of motivational climate on different kinesiology fields (sport, recreation, or kinesitherapy) while preparing SL projects among female and male students.

Methods

In the first phase resarch was conducted on a sample of 30 female and 28 male subjects, students of kinesiology aged from 21 to 24, studying full-time at Master level on the Faculty of Kinesiology. At this stage, Motivational Climate on Physical Education Scale (MCPES) questionnaire was implemented according to the study of Soini, et al., (2014), where 18 scales were subsequently grouped into four distinct factors: autonomy, social relatedness, task involving climate, and ego involving climate. The MPCES scale was used in the research because it has been validated multiple times in the context of measuring key categories that determine motivational climate at PE classes. In the second phase, through compulsory program students were introduced with the concept of SL and its application in kinesiology aimed to act in accordance with the needs of society. During classes, teams of 3-5 students were creating SL projects. Kinesiology students are engaged in both theoretical and practical learning through conventional education. When preparing and realizing SL projects, they then channel this knowledge with main objective of applying the acquired theoretical understanding into real-world contexts, refining it to address the actual societal demands of our community. Simultaneously, this process encourages students to critically evaluate their academic learning and foster innovative and creative perspectives within their profession. In this study samples of subjects were divided in subgroups according to their preferences and areas of interest, in different areas of applied kinesiology. According to the conceptual framework of service learning in physical education, defined by Miletić et al (2024), by embarking on projects related to different areas of kinesiology, students actively contribute to the resolution of particular societal challenges, while also cultivating a deep reflective understanding of the underlying causes of these problems. This reflective process, subsequent to project realization, empowers students to leverage their practical knowledge and experiences in influencing the evolution of the academic curriculum. As a result, the curriculum becomes dynamically aligned with the prevailing social requisites.

Creation of SL project plan consisted of the following elements: project title, appointing of the team leader and members of the team, choosing of external organization, description of needs in the external organizations and description of planned activities (place and time of project implementation period and expected number of hours spent in the organization, plan and outline of activities), expected learning outcomes, defining benefits to society in project, defining students' expectations from project realization, preparing a backup plan if the original plan fails, choosing a mentor for project realisation. Educational intentions were also to develop student – centred approach and to encourage critical thinking. Student - centred approach was based on students' responsibility and activity with respect of student's individual differences, interest, abilities and experience, and it was carried out through individualization, interaction, and integration. According to Anstee et al. 2008., students have reached three of six SL model stages: stage 1 (resource mapping, key stakeholder identification, matching community needs); stage 2 (diversity awareness and education, developing student interest); stage 3 (preparation of research design). In this process students were able to choose the field of kinesiology that they consider most appropriate to prepare SL projects. Thirty-two students, 17 females and 15 male completed the process of creating SL projects.

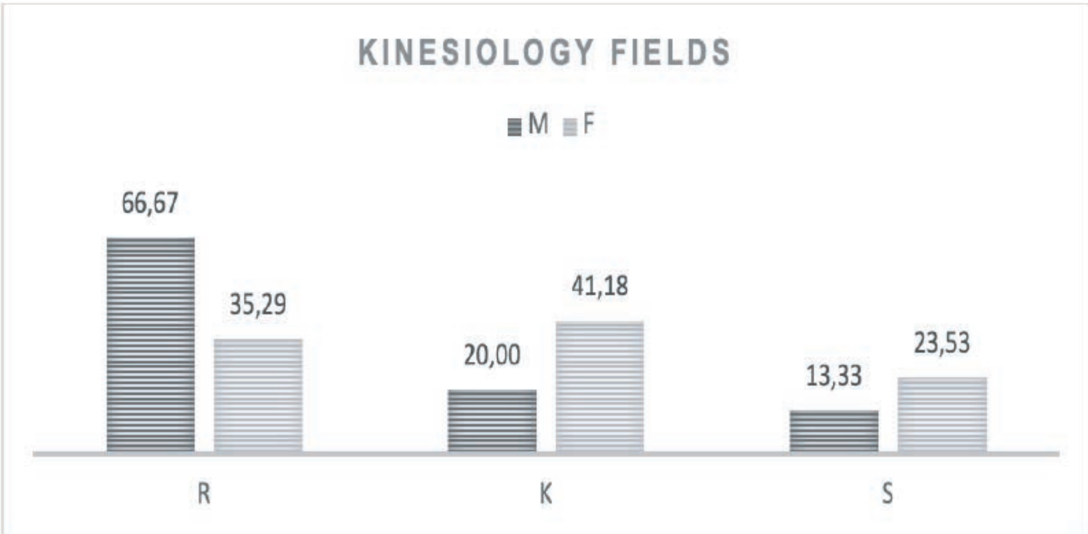
Statistics

In order to determine the impact of motivational climate on different kinesiology fields (sport, recreation, or kinesitherapy), especially according to gender, a Two-way analysis of variance (Two-way ANOVA) was used with the independent variables of: a) gender (male and female students), and b) kinesiology fields (sport, recreation and kinesitherapy). The Tukey post-hoc test was used to determine the significant differences among means. Statistica 13.0 (TIBCO Software Inc, USA) was used for all analyses and a p-level of 95% was applied.

Results

In accordance with the first objective of this study, determination of dominant kinesiology fields, chosen by kinesiology students when preparing SL projects, all four applied areas of kinesiology (education, sport, recreation and kinesitherapy) were in options for preparing SL projects. From total number of subjects, 50 % of students chose a field of recreation, 40,6 % chose a field of kinesitherapy and 9,4 % chose a field of sport. The reason why students did not choose field of education at all, is because it is considered covered by institutional education and students do not recognize field of education in kinesiology as additional societal need. Gender differences in selecting kinesiology fields when preparing SL projects are noted in Fig 1. Male students most often chose recreation (66,7%) and female students most often chose kinesitherapy (41,2%). Consequently, recreation and kinesitherapy are kinesiology fields that kinesiology students considered the most appropriate for preparing SL projects. Activities in the field of recreation and kinesitherapy students connect with target groups most needed in society for application of kinesiology activities.

Fig 1. Differences between kinesiology fields (S- sport, R - recreation and K –kinesitherapy) chosen by students when preparing SL projects in percentage, separately by gender



In the first phase of resarch conducted on the sample of 58 students, Cronbach's alpha was calculated to analyse reliability and internal consistency of the MCPES subscales that were satisfactory (0.72 - 0.81). According to the Two-way analysis of variance, significant effect was defined F = 2.19 (p = 0.04) for the kinesiology fields factor. In task climate dimension, according to the Tukey post-hoc test (Table 1), significant differences were obtained between sport female and recreational male group (p < 0.05) in favour of the recreational male group. Furthermore, Tukey post-hoc test shows significant differences between the recreational and sport group in total (< 0.05) in favour of the recreational group. In social relatedness dimension, the Tukey post-hoc test showed significant differences between female sport group and male kinesitherapy group in favour of female sport group (p=0.01). In autonomy dimension, Tukey post-hoc test shows significant differences between the female recreational and sport group in total (< 0.05) in favour of the sport total group. According to Soini et al. (2014) task climate dimension represents trying one's best while enjoying learning new things and seeing mistakes as part of the learning process. It appears that this type of motivational climate is emphasized among students who select recreational kinesiology field for preparing SL projects, especially among male students. Social relatedness dimension means that students express cohesion and team work when practicing which is highlighted especially among students in sport kinesiology field group. Autonomy dimension is expressed with students' possibility to make choices and to influence the way PE lessons are run, which is again the most pronounced among students in sport kinesiology field group.

Table 1. Mean values and standard deviations (M ± SD) of the three kinesiology fields groups for males and females separately, in MCPES subscales (I, II, III and IV) and main results of Two-way analysis of variance (two-way ANOVA) with the independent variables of gender and kinesiology fields and Tukey post hoc test.

	KINESITHERAPY			RECREATION			SPORT			Total N=32
	male n=3	female n=7	total n=10	male n=10	female n=6	total n=16	male n=2	female n=4	total n=6	male n=15 femalen=17
I	2.13±0.42	2.60±1.01	2.46±0.88	3.12±0.46[a]	2.76±0.57	2.99±0.52[c]	2.90±0.14	1.85±0.62	2.20±0.73	2.89±0.57 2.48±0.83
II	2.92±0.38	3.93±0.43	3.62±0.63	3.85±0.49	3.62±1.03	3.76±0.71	3.75±0.00	4.69±0.31[b]	4.37±0.54	3.65±0.56 4.00±0.77
III	4.13±0.30	4.34±0.39	4.28±0.37	4.02±0.30	4.17±0.29[d]	4.07±0.30	4.30±0.99	4.65±0.34	4.53±0.55	4.08±0.39 4.35±0.38
IV	2.25±0.66	2.82±1.01	2.65±0.92	2.72±0.64	2.42±0.82	2.61±0.70	2.50±0.35	2.06±0.75	2.21±0.64	2.60±0.61 2.50±0.89

[a]: $p<0.05$ from sport group females, [b]: $p<0.01$ from kinesitherapy group male, [c]: $p<0.05$ from sport group total, [d]: $p<0.05$ from sport group total,

MCPES subscales: I - task climate; II - social relatedness; III - autonomy; IV - ego climate (rang 1-5)

Discussion

According to Madsen and Turnbull (2006), SL represents a multi-faceted pedagogical approach, closely tied to experiential learning. Presented founding's suggested that curricular activities in the fields of kinesiology can bear social significance in a structural way, through syllabi by bridging the gap between theory and practice. According to Prentice and Garcia (2000), SL can be considered as a type of experiential education, that intertwines the realms of occupational and/or academic learning with a commitment to community service. Although this is pioneering study that analyses students' preferences in preparing SL projects with general aim of effective implementation of SL activities in higher education curricula for kinesiology students, the limitation of this study in the small samples of subgroups should be taken seriously. Very few students selected sport field, and none of them selected education field for preparing SL project. Small samples make it impossible to generalize the results and limit the conclusions. In future research, for better understanding the motivation and perspectives of stakeholders, as crucial for successful SL implementation, extend research to stakeholders, such as teachers and external NGO representatives, are recommended. Then, institutions can capitalize present results regarding kinesiology fields, more precisely on the transformative potential of SL, foster student engagement, and contribute to the evolution of innovative and student-centred pedagogical practices. This approach will not only enhance learning but also will prepared students for the complexities of a transversal society. This study brings first data identifying gender differences in the motivation climate and participation in SL activities. This could result with creating optimal educational climate and environments that resonate with the motivations and preferences of both male and female students. This research represents experience from only one PE faculty, and for identifying the general benefits of SL for different field of kinesiology students, separately by gender, is recommended to be explore in future studies.

Conclusion

This is the first study that analyses content of SL projects prepared by kinesiology students with general goal of improving higher education curricula with intention of improving students' academic and personal skills, critical thinking skills, teamwork, and effective communication. The most frequently selected kinesiology fields for preparing SL projects were recreation and kinesitherapy. Also, motivational climate plays significant role in preparing effective SL projects. Further studies, on larger samples of subjects are needed to confirm effect of autonomy, social relatedness and task involving climate dimensions connected with different fields of kinesiology.

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THE EFFECT OF FOLKLORE DANCE CONTENTS ON MOTOR SKILLS OF PRESCHOOL CHILDREN

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Abstract
The aim of this research was to determine the effect of folklore dance contents on motor skills and balance of preschool children. The research included preschool-aged children (N=62) from 5 to 7 years old. The experimental group (N=31) attended a kindergarten folklore program twice a week for eight weeks. Children of the control group (N=31) carried out usual activities at the kindergarten in accordance with the preschool curriculum. The Test of Gross Motor Development (TGMD-2) assessed locomotor motor skills. To assess balance, the test of standing on one leg was used. Univariate analysis of covariance (ANCOVA) was used to calculate the differences between the control and experimental group, with the inclusion of covariates, the results of the initial measurement. The results showed a statistically significant difference in favor of the folklore group in all tests: run (F=8,18, p=0,01), gallop (F=35,02, p=0,00), hop (F=31,32, p=0,00), leap (F=97,78, p=0,00), horizontal jump (F=11,45, p=0,00), slide (F=23,86, p=0,00), the total score in locomotor test (F=105,07, p=0,00), and balance (F=29,85, p=0,00). This research suggests that the usual preschool education program is not sufficcient for children's adequate motor development, and programs that support it are needed. In this study, the advantages of folklore dance education are clearly indicated.

Keywords: balance, dance, folklore, motor skills, preschool age

Introduction
As Duran (2003) considers, the term folklore for children, among others, refers to texts that adults used before sleep, but also to activate the child when they would distract the child from pain or encourage them to speak, walk, etc. The same author defines children's folklore as a way of objectifying children's tradition, that is, as the language of children's subculture. In every culture, folklore is extremely important for preserving immaterial traditional culture. Therefore, if folklore content were not applied in educational institutions (kindergartens and schools), which include, among other things, games, dances, songs, music, etc., the traditions of each country would fade. Children like to include in their activities what has been created for them by adults and what they create themselves, which is the key to preserving tradition, that is, folklore. Thus, through folklore, they get to know the traditions of their country and learn about history, customs, and values. Folklore helps children build their personalities but also helps them develop a sense of belonging and tolerance while dancing. Dancing also teaches children to respect diversity (especially gender) and develops cooperation during group and teamwork (Halužan, 2019). Horvatin-Fučkar et al. (2004) state that dance is one of the most suitable activities for working with preschool-aged children and that dance has a positive impact on the development of children's abilities, such as the sense of rhythm and movement and the sense of the beauty of performing aesthetic movements, as well as the development of motor skills, strength, flexibility, coordination, balance, and speed. Zachopoulou et al. (2004) point out that physical and musical activities improve the development of rhythm when performing motor skills.

This research aimed to determine the effect of folklore dance contents on changes in preschool children's locomotor motor skills and balance. In other words, do children who engage in folklore achieve better results in motor skills and balance tests than children who do not.

Methods
The research included preschool-aged children (N=62), 5 to 7 years old. According to gender, the sample consisted of 41 girls (66%) and 21 boys (34%).

The Test of Gross Motor Development (TGMD-2) was used to assess motor skills, which assesses the motor development of children aged 3 to 10 years (Ulrich, 2000). The test measures locomotor and manipulative skills, and the research used a test of locomotor skills. The locomotor test includes run, gallop, hop, leap, horizontal jump, and slide. A test for assessing balance, standing on one leg, was also conducted. The research was conducted from 15 March until 1 June 2022 in kindergartens in Varaždin. The control group (N=31) had usual activities in the kindergarten in accordance with the preschool curriculum. The experimental group (N=31) attended a kindergarten folklore program twice a week for eight weeks. The program was led by preschool teachers with many years of experience of working with children in folklore sections in cultural and artistic societies. Each class lasted for 60 minutes, and dynamic children's games (Lanac probijanac, Lovice, etc.), children's games with singing (Na drvenom konjiću, Mi smo djeca vesela, Savila se bijela loza vinova, Ivo i Mara, Ko je moje guske krao, etc.) and folk dances (Zagorski tanec, Ciciljona, Lončići, Jelena je kruha pekla, Na drvenom konjiću, Crni kos, Ančice Bančice, etc.) were conducted. In the introductory part of each class (10 min) 2 dynamic games were performed, then 2 folk dances (45 min), and at the end a static game (5 min). In the context of the dance zones of Croatia, dance content from the Alpine and Pannonian zones was applied. Children's parents were informed about the research following the Code of Ethics for research with children (Ajduković and Kolesarić, 2003); they approved their children's participation with their written consent.

Univariate analysis of covariance (ANCOVA) was used to calculate the differences between the control and experimental groups with the inclusion of covariates, to control the initial group differences in motor skills and balance. The research results were processed in the IBM SPSS Statistics 23 program.

Results

Table 1. Univariate analysis of covariance (ANCOVA) in the final measurement of experimental group (EG) and control group (CG)

Variable	Mean EG	Mean CG	*F* (1,59)	*p*
Run	6,35	5,58	8,18	**0,01**
Gallop	6,85	4,85	35,02	**0,00**
Hop	7,91	6,15	31,32	**0,00**
Leap	5,20	2,80	97,78	**0,00**
Horizontal jump	6,11	4,86	11,45	**0,00**
Slide	6,92	5,15	23,86	**0,00**
Raw score	39,37	29,34	105,07	**0,00**
Balance	33,96	25,68	29,85	**0,00**

Table 1 contains the results of the univariate analysis of covariance (ANCOVA) of the differences in motor skills and balance between the experimental and control groups in the final measurement, with neutralization of the differences in the initial measurement. The results show a statistically significant difference in favor of the folklore group in all tests: run (F=8,18, p=0,01), gallop (F=35,02, p=0,00), hop (F=31,32, p=0,00), leap (F=97,78, p=0,00), horizontal jump (F=11,45, p=0,00), slide (F=23,86, p=0,00), overall result in the locomotor test (F=105,07, p=0,00) and balance (F=29,85, p=0,00).

Discussion

The results showed that the group that implemented folklore content for two months significantly improved balance and locomotor skills compared to the group that implemented the usual preschool program. The results can be explained by similar locomotor patterns of the test (TGMD-2), folklore dances, and children's games with singing. The children's folk dances of the Alpine and Pannonian zones contain locomotor movements of walking, running, galloping, and various jumps and hops. It can be assumed that the differences in running performance are enhanced by the influence of dynamic games. Furthermore, the dances (Na drvenom konjiću, Savila se bijela loza vinova) contain the motor movements of galloping forward, the dances Ančice Bančice and Lončići jumps on one leg, while jumps with both legs are performed in the dance U šumici zeko, and jumps from one leg to the other in Ivo i Mara and Jelena je kruha pekla. Significant differences in balance can be explained by movements in folk dances, where there are constant changes in the direction of movement and shifting the center of gravity of the body from one leg to the other, as well as the influence of folk dances such as Ciciljona, where the center of gravity of the body is on one leg, while the other leg moves to the side and forward. The results are in accordance with previous research that studied the effects of different dance programs based on locomotor movements of preschool and early school-age children. In the study by Tsompanaki (2019), where motor competence was assessed with a TGMD-2 (Urlich, 2000), an experimental group (EG) of 4-5-year-old preschoolers, who in a two-month creative dance-movement program significantly improved their locomotor abilities, while children from the control group (CG), who followed the usual preschool program, did not. After implementing a program that partially focused on motor creativity, Tsapakidou et al. (2014) noticed a significant improvement in locomotor skills in EG preschool children (3.5-5 years old) but not in CG (children tested with the locomotor subtest with TGMD-2). The results of the study with older children are analogous. In the study by Lykesas et al. (2014), after a creative, playful dance program, first and second-grade pupils who participated in EG significantly improved their locomotor skills (estimated with TGMD-2), in contrast to their peers from CG. The significant improvement in the balance test in this research is in accordance with the results of a two-month experimental study (Chatzihidiroglou et al., 2018) on a sample of 5-year-old children, which determined the impact of dance on sensorimotor synchronization (K-Rhythm Test), balance on one leg and speed of movement, and, compared to CG, the dance group (EG) showed statistically significantly better results in sensorimotor synchronization and balance. The authors also concluded that dance content should be included in preschool curricula due to its positive effect on sensorimotor synchronization and balance development. An interesting study was conducted by Fitri et al. (2017), who determined the influence of locomotor creative dance on children's motor skills development. The research was conducted on a population of 68 children in the third grade of elementary school, divided into two groups. The rhythmic activity group was treated by providing creative dance learning and other group by traditional game learning. Analyzing the results of the TGMD-2 test, the authors concluded that there are differences in motor skills between learning creative dance and activities that include games. Locomotor creative dance has a more significant influence on the improvement of gross motor skills, just as the results of this research showed that folklore content affects children's locomotor skills. The purpose of the research of dos Anjos & Ferraro (2018) was to compare the motor development of children who attended the educational dance with children who did not, and the results show that children who engage in educational dance, that is, folklore content, achieve significantly better results in motor development. Top et al. (2020) found the positive effects on manual and body coordination of a ten-week program of Turkish traditional dance on a sample of children aged 6 to 7 years. Furthermore, after a six-week experimental treatment of the influence of traditional Indian dances, significant differences were obtained in locomotor skills (TGMD-2) of children with Down syndrome compared to neuromuscular training (Raghupathy et al., 2022). Mesaroš Živkov et al. (2018) examined the impact of programmed exercise with an emphasis on traditional dancing and singing on the motor development of preschool children. The research included 43 preschool children divided into two groups, in which the EG attended programmed physical exercises twice a week for nine weeks. Children of the EG achieved better results in the sprint test, hand tapping, and standing on one leg, while in the tests of polygon backward or jumping, they did not show statistically significant results. The authors concluded that traditional dances and songs positively affect the development of basic motor skills, which is in accordance with the results of this research, confirming that folklore dance positively affect motor skills of preschool children. Research aiming to present the effects of dance education was conducted by Aldemir et al. (2011) on a sample of 114 children aged 11 to 14 years, where the results showed that dance plays a significant role in the motor development of children. A comparison of two groups proved that motor development was more stimulated in children of the dance group compared to children in CG. The results of the mentioned research are not in accordance with the research of Momčilović & Zdravković (2020), which studied the integration of physical and musical activities on the development of motor abilities of primary education pupils, where the participants of the EG attended additional physical education classes, while the participants of the CG attended regular classes of physical education and music education. In a study that lasted for eight weeks, the authors concluded that there was no statistically significant difference in motor abilities between the EG and CG. In the study of the effects of an eight-week creative dance and movement program on a sample of preschool children aged 4-6 years, no significant differences were obtained in motor competence, but only in motor creativity; therefore, the authors concluded that dance programs mainly focused on locomotor activities do not provide children enough opportunities to develop a wide range of motor skills (Thomaidou et al., 2021). An interesting study (Biber, 2016) of the impact of an eight-week program of Turkish folk dances on the social development of preschool children aged 5 to 6 years showed significantly greater development of social skills compared to the control group.

Conclusion

The results of this research lead us to the conclusion that the usual preschool education program is insufficient for children's adequate motor development, and programs that support it are needed. This study clearly indicated the advantages of folklore dance education. Folk dances can become part of daily practice in kindergarten, already from an early age. In the nursery age, the simplest movement patterns with singing can be applied, and in older groups, more complex dance structures that include lateral and back and forth movements in walking, running, as also galloping and various hops and jumps.

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ENHANCING PHYSICAL ACTIVITY LEVELS AND FITNESS IN THIRD-GRADE CHILDREN: A 12-WEEK INTERVENTION WITH STRUCTURED OUTDOOR GAMES

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Abstract
Regular physical activity (PA) is crucial for the holistic development of children, yet adherence to recommended activity levels remains low. This study evaluates the impact of a structured weekend intervention with outdoor games on physical fitness (PF) and PA levels in third graders.This quasi-experimental study involved 83 third graders from two schools who were divided into an experimental group (EXP) (n=51) and a control group (CON) (n=32). In addition to regular physical education (PE) classes, the EXP group participated in structured outdoor activities every weekend for 12 weeks. The CON group only participated in regular PE classes. PF and PA levels were assessed before and after the intervention using standardized fitness tests and accelerometry. After the intervention, the EXP group showed significant improvements in several PF parameters compared to the CON group: agility improved by an average of 0.30 seconds ($p < 0.05$), cardiorespiratory fitness increased by 2.50 laps ($p < 0.05$), abdominal endurance improved by 5 sit-ups ($p < 0.05$) and lower limb power increased by 3 cm ($p < 0.05$). In addition, sedentary activity decreased by 20 minutes per day ($p < 0.05$), and light PA increased by 30 minutes per day ($p < 0.05$). This study demonstrates the effectiveness of structured outdoor activities in significantly improving PF and PA levels in third graders. The intervention led to notable improvements in specific fitness scores and reductions in sedentary behavior, underscoring the benefits of regular, organized PA outside of school hours. These results emphasize the need for policy initiatives that promote the inclusion of such effective PA interventions in children's weekly routines to support long-term health benefits and active lifestyles.

Keywords: physical activity, child health, physical fitness, intervention study, outdoor education

Introduction

Involving children in physical activities from an early stage of development is a principle that is widely supported in the disciplines of developmental psychology (Stodden et al., 2023) and physical education (PE) (Lohmann et al., 2024), emphasizing its integral role in promoting overall health and well-being (Martín-Rodríguez et al., 2024). This principle is based on the premise that early and regular participation in physical activity (PA) not only provides immediate health benefits, but also establishes fundamental habits that promote long-term health and well-being (Bajamal et al., 2024; Zahner et al., 2006). Outdoor play, harnessing children's intrinsic motivation for movement and exploration, is proving to be a key strategy in promoting their overall development (Kiviranta et al., 2023).

The link between PA and aspects of physical fitness (PF), such as cardiovascular health, muscular endurance, flexibility and body composition, is well known (Cadenas-Sanchez et al., 2023; Haible et al., 2020; Lee et al., 2022; Müller et al., 2022). Structured outdoor games offer a holistic approach to promoting these fitness components (D'Anna et al., 2024; Shanahan et al., 2019). They provide a stimulating environment in which important motor skills such as coordination, balance and agility are challenged and encouraged (Pawlowski et al., 2023; Sollerhed et al., 2021), which is especially important in third grade when children are very receptive to developing new skills and behaviors (Ewell et al., 2024). Based on the principles of social cognitive theory, it is important to recognize that the social environment has a significant impact on the acquisition of movement behaviors in children (Y. He et al., 2024; Nasri et al., 2022). Structured outdoor play creates an enriching social environment that facilitates learning through observation, imitation and the adoption of positive movement behaviors (Karaba Bäckström et al., 2024; Loebach & Cox, 2020). This approach not only increases the physical benefits of the activity, but also promotes social skills and therefore a sense of belonging and community among participants (Eubank & DeVita, 2024; Gessiou, 2022; Jaiswal et al., 2022). In addition, self-determination theory assumes that the intrinsic motivation to engage in PA increases when the individual's needs for autonomy, competence and connectedness are satisfied (Kokkonen et al., 2020; Rodrigues et al., 2023). Structured outdoor games fulfill these psychological needs and thus sustainably promote interest in PA (Dunton et al., 2023; J. He et al., 2023; Santos-Pastor et al., 2022). By incorporating structured outdoor play into the children's weekly routine, the intervention not only conforms to bioecological models by promoting interactions within the various systems, but also enriches the developmental milieu by providing multiple opportunities for physical and social activities (Daskolia & Chouliara, 2024). This focus is critical, as research has shown that diverse and regular PA can significantly improve children's cognitive abilities and academic performance, as well as their physical health (Esteban-Cornejo et al., 2019; Hermassi et al., 2024; Sember et al., 2020). In addition, the inclusion of group activities in natural environments can further enhance these benefits by exposing children to diverse stimuli that promote their adaptability and resilience (Colding et al., 2020; Johnstone et al., 2022; Kassymova et al., 2023). Thus, structured outdoor games not only meets the developmental needs of children, but also creates a nurturing environment that promotes lifelong habits of health and social integration. By incorporating structured outdoor play into this context, the intervention aims to holistically support and improve children's engagement in PA and their overall fitness.

The present study attempts to synthesize these theoretical underpinnings into a comprehensive intervention strategy aimed at improving third graders' levels of PA and PF through structured outdoor games. The explicit aim of our study is to demonstrate the effectiveness of this approach in promoting an active lifestyle, thereby making a significant contribution to the existing body of research on PA interventions for children, with a focus on improving participants' levels of PA and PF.

Methods

Subjects

Two schools were asked to participate in a study focusing on the effects of structured outdoor PA games on the development of third graders. At these schools, six third grades were selected to participate and divided equally into an experimental (EXP) and a control (CON) group. The EXP group participated in an extracurricular program conducted on weekends from 9 a.m. to 1 p.m. that included a series of structured outdoor games designed to promote physical, cognitive and social skills. The initiative departed from traditional classroom activities and offered a novel approach to education by combining physical health with fun and engaging activities outside the traditional school environment. The participating schools and classes were selected with the aim of creating a balanced comparison between the EXP and CON groups to ensure a reliable evaluation of the program's effectiveness.

Once school participation was secured, the research team began communicating directly with the students and their parents or guardians. As part of this process, parents were invited to an information session where the aims, procedures and expected benefits of the study were explained in detail. The importance of informed consent was emphasized and that participation in the study would only be possible if the parents or guardians provided a signed consent form and the children provided an informed consent form.

The inclusion criteria for the study were clearly defined: Participants were not allowed to have any medical contraindications for participating in physical activities and were not allowed to participate in other similar programs. In addition, strict exclusion criteria applied, including the exclusion of children who were unable to cope with the physical demands of the program, who were taking medication that could affect the results of the study, or who were absent from the weekend events more than three times in a row.

Upon completion of the program, all participants received a personal report detailing their performance and the health effects of their participation. This feedback was intended to provide valuable insight into each child's development and encourage further PA. The final sample consisted of 83 students (51 in the EXP group and 32 in the CON group). A graphical representation of the process of participant selection and grouping was also included (Fig. 1) to provide a clear overview of the design and implementation of the study (Reis et al., 2024).

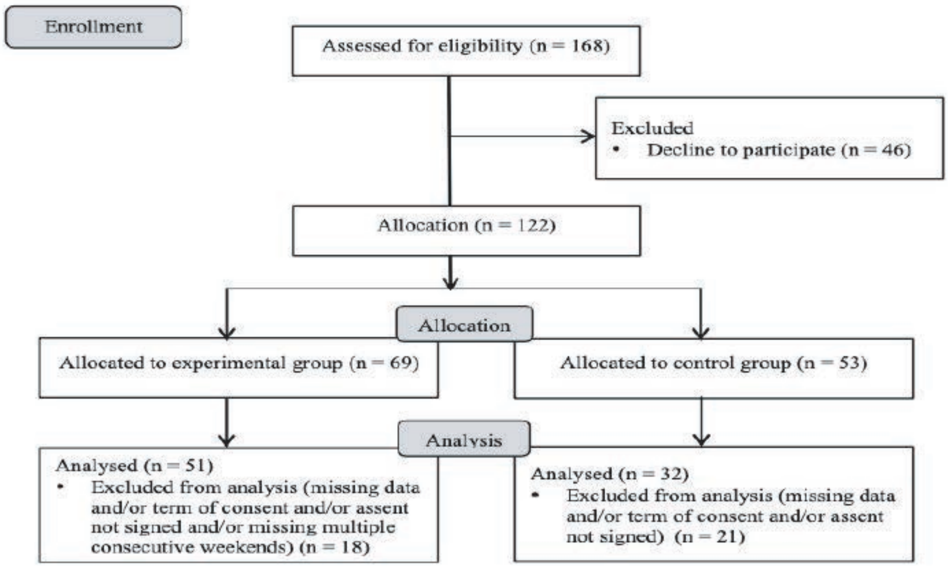

Figure 1: Sampling process

EXP group

The weekend outdoor intervention for third graders was a carefully planned outdoor activity program that took place every Saturday and Sunday from 9 a.m. to 1 p.m. for 12 weeks. This initiative was led by experienced PE teachers and child development experts and aimed to improve PF in areas such as abdominal muscular endurance, agility, cardiorespiratory fitness, flexibility, lower limbs power, speed and upper limbs power.

9:00-9:30 a.m.: Dynamic warm-up and flexibility

The program began with a half-hour dynamic warm-up in which playful aerobic movements and games gently prepared the body for the day's activities. This included stretching exercises, light jogging and games such as tag, designed to get the heart rate up, improve flexibility and mentally prepare the children for the session ahead.

9:30 a.m.-10:00 a.m.: Adventure Relay Races

After warming up, the children took part in adventure relay races for 30 minutes. These races, which were set up as obstacle courses with various physical challenges, aimed to improve agility, speed and teamwork. The obstacles included hurdles, balance beams and sprints, which the children had to complete as quickly and efficiently as possible.

10:00-10:45 a.m.: Strength and performance circuit

This 45-minute segment was dedicated to a strength and power circuit that used both the natural features of the outdoor area and portable equipment to encourage the children to be physically active. Stations were set up for activities such as push-ups, squat jumps, tug-of-war and other exercises aimed at building muscle strength and endurance in the upper body, core and lower body.

10:45 am-11:00 am: Short break

A 15-minute break was scheduled to allow the children to rest, drink water and have a snack to ensure they had the energy and hydration needed to continue the day's activities safely and effectively.

11:00-11:30: "Forest Frenzy" Game

The session continued with the "Forest Frenzy" game, a 30-minute activity that focused on agility and coordination. In this game, the children raced through an obstacle course modeled after a forest, developing their physical agility and quick decision-making skills as they moved through the course collecting objects or completing specific tasks.

11:30-12:00: "Mountain Movers" Game

Next on the program was 30 minutes of the game "Mountain Movers", which was all about teamwork and physical strength. The children worked in teams to complete tasks that simulated moving heavy objects. This included activities that required pushing, pulling and lifting, which built muscle strength and encouraged teamwork.

12:00 p.m.-12:30 p.m.:"River Rapids" Game
This game was designed to increase cardiorespiratory endurance through a series of high-intensity running intervals and rest periods that mimic the fast-paced and unpredictable nature of a rapids run. The activity lasted 30 minutes and focused on improving speed and endurance while providing a fun and challenging cardiovascular workout.

12:30-13:00: Flexibility and Mindfulness Cool Down
The last half hour was dedicated to flexibility and mindfulness. This included stretches and yoga-inspired poses to improve flexibility, followed by mindfulness and breathing exercises to calm the body and mind, bringing the day's activities to a close with a focus on relaxation and wellbeing.

CON group
CON group participated exclusively in normal PE classes, which took place three times a week during school hours, with no additional outdoor activities at weekends. The focus of these classes was on basic sports, gymnastics and fitness exercises to promote general health and motor skills. In contrast to the varied outdoor activities of the EXP group, the CON group's activities took place in traditional indoor or outdoor spaces and focused on traditional games and sports skill development. This provided a baseline for comparing the effects of the more dynamic weekend intervention.

Assessments
Assessments for the weekend outdoor activity program were conducted before and after the 12-week intervention period. Preliminary assessments were conducted by a team of trained evaluators over a one-month period for both the EXP and CON groups at their respective schools. During the first two weeks, anthropometric data were collected and PF was assessed. To monitor the level of PA outside the structured sessions, informational meetings were organized with parents or guardians, with detailed explanations given to those who could not attend. In consultation with parents or guardians, accelerometers were distributed and collected in the schools. These devices were used to accurately measure the children's PA throughout the intervention. Parents were given comprehensive instructions on how to use the accelerometers to ensure consistent and accurate data collection. The same procedures were carefully applied to the post-intervention assessments so that reliable comparisons could be made between the pre- and post-intervention data.

Anthropometrics
For the anthropometric measurements, the children were examined in light clothing and without shoes. Height was measured with a Filizola metal stadiometer with an accuracy of 1 mm, while body weight was measured with an analog-digital Filizola scale with an accuracy of 0.1 kg. Body mass index (BMI) was calculated by dividing body weight in kilograms by the square of height in meters.

Physical fitness
The assessment of abdominal muscular endurance, agility, cardiorespiratory fitness, flexibility, power in the lower and upper limbs, and speed were conducted according to the guidelines recommended by PROESP-BR. This series of tests is designed to assess physical health and performance indicators at minimal cost and with only simple equipment, ensuring compliance with standards for validity, reliability and objectivity.

To assess abdominal muscular endurance, the 1-minute sit-up test was used. Participants were asked to perform as many sit-ups as possible within one minute while lying on their back, knees bent at a 45-degree angle and arms crossed in front of their chest. An evaluator held the participant's ankles while they lifted their upper body and touched their elbows to their thighs before returning to the starting position.

Agility was measured using the square test, in which a 4-meter square was marked out with cones at each corner. Participants crossed the square as quickly as possible by touching each cone with their hands, moving diagonally across the square and then sideways before returning to the starting cone. Each child had two attempts, with the best time recorded to the nearest hundredth of a second.

Cardiorespiratory fitness was determined by a 6-minute run/walk test in which participants were asked to maintain a steady pace and run as much as possible without sudden starts or stops. The time checks were announced after 3 and 5 minutes, and the total distance covered in 6 minutes was determined by the number of laps and the partial distance of the last lap.
The flexibility test was performed using the sit-and-reach test. The participants, sitting without shoes, extended their legs and reached forward as far as possible, maintaining the position to allow measurement. The best of two attempts was recorded in centimeters.

The horizontal jump test measured the strength of the lower limbs. The participants stood behind a line and jumped with both feet at the same time, with a measuring tape laid out. The furthest distance jumped in two attempts was recorded in centimeters.Results

Table 1 presents the descriptive data of the participants prior to the implementation of the structured weekend intervention with outdoor games. No significant differences were found between the EXP group and the CON group in terms of age, body mass index (BMI) and flexibility. However, significant differences were found between the groups in baseline assessments of PF parameters. The EXP group performed better on agility ($p = 0.005$), abdominal muscular endurance ($p = 0.028$) and cardiorespiratory fitness ($p = 0.011$), indicating a higher baseline PF level compared to the CON group. Sedentary behavior also differed significantly ($p = 0.039$), with the EXP group being less sedentary.
To assess speed, a 20-meter running test was conducted in which the participants had to sprint across three parallel lines – a start line, a 20-meter line and a finish line 1 meter behind it, so that a complete sprint across the 20-meter mark was possible. The best time was recorded to the nearest hundredth of a second.

The power of the upper limbs was measured using the medicine ball throw. Participants sat against a wall with their legs outstretched and threw a medicine ball as far as they could while leaning back against the wall. The distance from the wall to the first point of contact with the floor was measured in centimeters, and the best of two attempts was recorded.

Physical activity
MMOXX1.07 (waterproof USB sensors for PA) were used to measure the children's PA. These devices were attached to the participants' hips at the mid-axillary line on the left side using a flexible belt. Participants were instructed to wear the accelerometers for a continuous period of seven days, which included both school days and weekends, from wake-up to bedtime. In the study, at least four days of wearing the accelerometer were considered sufficient to be included in the analysis, with at least one day of the weekend included, and the required wearing time was at least 10 hours per day, not including sleep periods. Analysis of the collected data was conducted using IDEEQ data acquisition and analysis software, with the initial data sampling rate set to 30 Hz. Data was recorded in one-second intervals and later summarized in 15-second blocks for detailed examination. For the analysis, the thresholds established by (Reis et al., 2024) were used to discriminate the level of PA: sedentary behavior was characterized by ≤ 25 counts per 15-second block (1 MET), light PA by counts between 101 and 573 per 15-second block (2 MET), and moderate to vigorous PA by counts of ≥ 574 per 15-second block (> 3 MET) (Matthews-Ewald et al., 2014).

Statistical analysis
Our analysis began with a baseline assessment to characterize participants' profiles at baseline and post-intervention. This involved determining central tendencies and dispersion for continuous variables by calculating mean and standard deviation, and quantifying categorical variables through counts and percentages. Following these descriptive statistics, we began a difference-in-differences (DiD) evaluation to understand the impact of the intervention over time. This involved calculating the change in scores for the variables of interest, where the change representing the difference between the scores at follow-up and baseline.

To examine the differences between the results of the EXP and CON groups, we performed an adjusted analysis of covariance (ANCOVA), taking into account differences due to gender, age and baseline values of the dependent variable. This analysis was supported by a bootstrapping approach in which 1,000 samples were selected and the bias-corrected and accelerated (BCa) bootstrap technique was applied to improve the precision of the estimation (Reis et al., 2024). Following the ANCOVA, we quantified the effect sizes using Cohen's d, setting benchmarks to categorize the magnitude of the observed effects: Values below 0.49 indicated small effects, values between 0.50 and 0.79 indicated medium effects, and values above 0.80 indicated large effects. This measure was also used to assess standardized differences in the initial group comparisons using Student's t-tests. The analyses were performed with the Statistical Package for the Social Sciences (SPSS version 23.0, IBM, Armonk, NY) and Jasp 0.18.3.0. To ensure the robustness of our results, we also performed post hoc power analyses using G*Power software (version 3.1.9.7), aiming for a power threshold of 80 for our models. The effect size for these analyses was determined using Cohen's f, calculated from the ratio of the variance to the unexplained variance, taking into account the degrees of freedom, group numbers and covariates in our analytic framework.

To obtain an accurate estimate of the effect of the intervention on treated individuals across different levels of PA and PF outcomes, we performed propensity score matching. This technique is invaluable in increasing the validity of causal inferences by mimicking the conditions of a randomized experiment. It calculates a participant's probability of receiving the intervention based on a logit model that includes covariates such as age, gender, BMI, and baseline values, with matching based on nearest neighbors. The average treatment effect for the treated (ATET) was determined by averaging the discrepancies between the actual and predicted outcomes for the EXP group. Propensity score matching and subsequent analyzes were performed using Stata version 17.0 (StatCorp., College Station, USA), with all significance tests set at the $p < 0.05$ level.

Results

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Table 1. Descriptive statistics

	EXP Group	CON Group	Total	p-value
Age (Pretest, years)	8.35 (± 1.10)	8.45 (± 1.15)	8.40 (± 1.12)	0.510
PF (Pretest)				
Abdominal (number of sit-ups)	30.10 (± 9.50)	20.85 (± 8.30)	25.48 (± 9.10)	**0.028***
Agility (seconds)	6.80 (± 0.90)	7.95 (± 1.00)	7.38 (± 0.95)	**0.005***
BMI (kg/m²)	17.65 (± 3.80)	18.40 (± 3.90)	18.03 (± 3.85)	0.152
Cardiorespiratory (laps)	7.10 (± 1.60)	6.40 (± 1.70)	6.75 (± 1.65)	**0.011***
Flexibility (cm)	36.80 (± 7.90)	35.50 (± 8.10)	36.15 (± 8.00)	0.324
Lower limbs (cm)	110.20 (± 18.20)	107.85 (± 17.70)	109.03 (± 17.95)	0.213
Speed (seconds)	4.25 (± 0.60)	4.80 (± 0.50)	4.53 (± 0.55)	0.054
Upper limbs (cm)	190.50 (± 50.30)	175.40 (± 45.20)	183.45 (± 47.75)	0.076
PA levels (Pretest, $min.day^{-1}.week^{-1}$)				
Sedentary behavior	410.60 (± 60.10)	445.90 (± 55.30)	428.25 (± 57.70)	**0.039***
Light PA	280.45 (± 85.30)	235.70 (± 90.20)	258.08 (± 87.75)	0.063
Moderate PA	38.85 (± 14.20)	46.10 (± 15.80)	42.48 (± 15.00)	0.097
Vigorous PA	23.10 (± 11.00)	19.70 (± 10.20)	21.40 (± 10.60)	0.221
Moderate-to-vigorous PA	61.95 (± 23.30)	65.80 (± 24.10)	63.88 (± 23.70)	0.158
Sex				
Male	18 (60.0 %)	8 (34.8 %)	26 (48.1 %)	**0.024***
Female	12 (40.0%)	15 (65.2 %)	27 (51.9 %)	**0.024***

Data are presented as mean and standard deviation (SD) for continuous variables and as absolute and relative frequencies for categorical variables. Group differences were assessed using the bootstrapping resampling procedure for the Student t-test for continuous variables. For categorical variables, Fisher's exact test was used to determine an unexpected distribution within certain cells of the contingency table for the association ($p < 0.05$).

Table 2 shows the difference-in-differences (DiD) analysis for PF and activity levels between the EXP and CON groups after the intervention. The results show that the EXP group had statistically significant improvements in cardiorespiratory fitness (ΔMean = 2.50 laps; $p < 0.05$) and agility (ΔMean = -0.30 s; $p < 0.05$) with a medium effect size, suggesting that the intervention effectively improved these specific fitness components. The analysis also shows a significant reduction in sedentary behavior (ΔMean = -20.00 $min.day^{-1}$.week-1; $p < 0.05$) and an increase in light PA (ΔMean = +30.00 $min.day^{-1}.week^{-1}$; $p < 0.05$) for the EXP group, indicating a positive shift towards more active behaviors.

Table 2. Difference-in-differences analysis between EXP and CON group

	EXP group Mean (SD)	CON Group Mean (SD)	Total	Cohen's d	R^2	Power
PF						
Δ Abdominal (number of sit-ups)	**+5.50 (± 2.50)**	**+1.00 (± 1.50)**	**+3.25**	**0.45**	**0.18**	**0.82**
Δ Agility (seconds)	**-0.30 (± 0.50)**	**+0.10 (± 0.40)**	**-0.10**	**0.50**	**0.25**	**0.85**
Δ BMI (kg/m²)	+0.10 (± 0.40)	+0.05 (± 0.30)	+0.075	0.12	0.02	0.15
Δ Cardiorespiratory (laps)	**+2.50 (± 1.00)**	**-0.50 (± 0.80)**	**+1.00**	**0.70**	**0.49**	**0.90**
Δ Flexibility (cm)	+1.50 (± 3.00)	-0.50 (± 2.00)	+0.50	0.25	0.06	0.42
Δ Lower limbs (cm)	+3.00 (± 2.00)	+0.00 (± 1.50)	+1.50	0.55	0.30	0.88
Δ Speed (seconds)	-0.10 (± 0.30)	+0.05 (± 0.20)	-0.025	0.35	0.12	0.68
Δ Upper limbs (cm)	+4.00 (± 5.00)	-1.00 (± 4.00)	+1.50	0.40	0.16	0.74
PA levels						
Δ Sedentary behavior	-20.00 (± 15.00)	+5.00 (± 10.00)	-7.50	0.60	0.36	0.82
Δ Light PA	+30.00 (± 20.00)	-10.00 (± 15.00)	+10.00	0.65	0.42	0.86
Δ Moderate PA	+5.00 (± 6.00)	-2.00 (± 5.00)	+1.50	0.30	0.09	0.58
Δ Vigorous PA	+2.00 (± 3.00)	-1.00 (± 2.50)	+0.50	0.30	0.09	0.58
Δ Moderate-to-vigorous PA	+7.00 (± 4.50)	-3.00 (± 4.00)	+2.00	0.50	0.25	0.82

Data are expressed as mean and standard deviation (SD). Δ indicates the changes in the dependent variable (posttest minus pretest results). The differences between the EXP and CON groups were determined using the bootstrapping resampling method for ANCOVA, adjusting for gender, age and the pretest outcome variable ($p < 0.05$)

Noteworthy abbreviations: AME Abdominalmuscular endurance; BMI Body mass index; CRF Cardiorespiratory fitness; LLP Lower limbs Power; ULP Upper limbs Power; SB Sedentary behavior; LPA Light physical activity; MPA Moderate physical activity; VPA Vigorous physical activity; MVPA Moderate to vigorous physical activity.

The results of the propensity score matching analysis for the PF variables are summarized in Table 3. The analysis showed a remarkable improvement in abdominal endurance with an ATET of +3.00 repetitions (95% CI: +0.50 to +5.50; p = 0.033) and a decrease in agility times of -0.25 seconds (95% CI: -0.45 to -0.05; p = 0.021). Cardiorespiratory fitness improved by +2.00 laps (95% CI: +0.80 to +3.20; p = 0.015), and lower limbs power increased by +3.50 cm (95% CI: +0.40 to +6.60; p = 0.048), indicating significant improvements in these areas after the intervention. No statistically significant changes were observed in flexibility (p = 0.210), speed (p = 0.125) and upper limbs power (p = 0.075).

Analysis of changes in PA levels, also shown in Table 3, revealed a significant reduction in sedentary behavior with an ATET of -12.00 min.day^{-1} (95% CI: -22.00 to -2.00; p = 0.024). Light PA experienced a significant increase of +18.00 min.day^{-1} (95% CI: +3.00 to +33.00; p = 0.045). The changes in moderate PA (p = 0.480), vigorous PA (p = 0.310) and moderate to vigorous PA (p = 0.110) were not statistically significant.

Table 3. Propensity score analysis

	ATET	95% CI	p-value
PF Outcomes			
Abdominal Endurance (number of sit-ups)	+3.00	+0.50 to +5.50	**0.033**
Agility (seconds)	-0.25	-0.45 to -0.05	**0.021**
Cardiorespiratory Fitness (laps)	+2.00	+0.80 to +3.20	**0.015**
Flexibility (cm)	+1.00	-1.00 to +3.00	0.210
Lower Limbs Power (cm)	+3.50	+0.40 to +6.60	**0.048**
Speed (seconds)	-0.08	-0.18 to +0.02	0.125
Upper Limbs Power (cm)	+4.50	-0.50 to +9.50	0.075
PA Levels			
Sedentary Behavior (min.day-1)	-12.00	-22.00 to -2.00	**0.024**
Light PA (min.day-1)	+18.00	+3.00 to +33.00	**0.045**
Moderate PA (min.day-1)	+1.50	-3.50 to +6.50	0.480
Vigorous PA (min.day-1)	+1.00	-2.00 to +4.00	0.310
Moderate-to-Vigorous PA (min.day-1)	+3.50	-0.50 to +7.50	0.110

ATET. Average treatment effect in treated individuals; adjusted for school affiliation, age, gender, BMI at baseline and outcome measures at baseline.

Discussion

The aim of this study was to investigate the effectiveness of a structured weekend intervention with outdoor games to increase PA and PF levels in third grade children over a 12-week period. The intervention resulted in significant improvements in agility, cardiorespiratory fitness, abdominal endurance, and lower limbs power, while decreasing sedentary behavior and increasing light PA. These results highlight the physiological and psychological adaptations that can occur when children participate in well-designed PA programs.

Based on the general improvements reported, the significant increase in abdominal endurance deserves special mention. This improvement is largely due to the challenging and varied activities of the weekend intervention, which required continuous and active use of the core muscles in particular. The intervention included games and activities that required not only brief, intense engagement of the core muscles, but also sustained engagement over longer periods of time. This sustained contraction is essential for building core muscle endurance.

Activities such as navigating obstacle courses, dynamic team games and adventurous relay races require participants to maintain balance, stabilize their core and manage rapid changes of direction. These dynamic movements ensure that the body's core is not only statically stressed, but also constantly adapts and reacts to different loads and demands. This type of functional training improves neuromuscular coordination, i.e. the efficient activation and synchronization of muscle contractions throughout the body, with the core muscles playing a central role.

In addition, the structured nature of the intervention likely ensured that these core-focused activities were performed regularly and with sufficient intensity to produce measurable improvements. Regular practice of these activities promotes muscular adaptation, i.e. muscle fibers become more efficient at sustaining prolonged periods of exercise without fatigue. This adaptation is crucial for the development of core endurance, which supports overall movement efficiency and stability. Research by Alqhtani et al. (2024); Gong et al., (2023); Khaledi & Gheitasi (2024) and Shalamzari et al. (2024) supports this finding, demonstrating that targeted, repetitive movements that engage the core can significantly improve endurance. These studies confirm that well-designed physical activities that emphasize core stability not only improve physical health but also enhance performance in a variety of activities, and this is exactly what was observed in our intervention. This approach to PE, which emphasizes core stability, provides children with a foundation for better general fitness and posture, reducing the risk of injury and improving their ability to perform everyday activities efficiently.

Building on the improved abdominal endurance, the EXP group also showed significant improvements in agility. This progress can be attributed to the specific activities of the intervention, which require advanced motor skills and a high degree of coordination.

Agility-oriented tasks such as sprinting through zig-zag patterns and jumping over hurdles specifically target neuromuscular coordination. This is a sophisticated interplay between the central nervous system and muscle groups that leads to efficient activation of motor units and precise synchronization of muscle contractions. Such activities improve the central nervous system's ability to process sensory information quickly, thus increasing reaction time and the accuracy of movements. Agility training goes beyond physical skills and improves cognitive functions that are crucial for quick decision making. This is particularly evident when participants must quickly assess and respond to changing physical and spatial demands in these dynamic environments. Research such as that by Haverkamp et al. (2021); Reigal et al. (2020); Selmi et al. (2024) and Shi & Feng (2022) supports these observations and shows that agility training can significantly improve cognitive functions in addition to physical agility. These studies illustrate how complex, coordinated activities that challenge both the body and the mind contribute to an overall improvement in agility and highlight the value of integrating such varied training into PE programs for children.

In addition to the clear progress in agility and abdominal endurance, the EXP group also showed significant improvements in cardiorespiratory fitness. This progress is directly related to the aerobic components of the weekend intervention. In particular, the high-intensity running intervals and the games that simulated the different pace of a sports game contributed to the improvement in cardiovascular and respiratory capacity. The activities to increase heart rate and respiratory efficiency led to a significant increase in stroke volume and an optimization of oxygen extraction at the muscle level. Continued participation in these strenuous aerobic exercises is key to significantly improving overall endurance and health. Supported by the findings of Baker et al. (2020) and Nguyen et al. (2023), our results reinforce the notion that regular, intense cardiovascular activity is essential for the development and maintenance of superior cardiorespiratory function. This structured approach to PA not only strengthens physical skills, but also emphasizes the importance of aerobic training for the long-term cardiorespiratory health of children.

Moreover, the intervention led to a statistically significant improvement in lower limbs power in the participants. This improvement is likely a direct result of the specific plyometric exercises and dynamic activities incorporated into the weekend program, such as jumping, squatting and various forms of sprinting. These exercises are known to increase muscle strength and explosive power in the legs by stimulating the fast-twitch muscle fibers that are critical for fast, powerful movements. The repetitive, high-intensity demands of these activities not only improve muscle condition, but also contribute to better performance in tasks that require fast and powerful leg movements. The improvements in lower limbs power observed in our study are consistent with the findings of Chen et al. (2023); Granacher et al. (2016); Kryeziu et al. (2023) and Marzouki et al. (2022), who reported similar improvements in athletic performance in adolescents following structured plyometric training. This aspect of physical development is essential for overall athletic performance and can significantly improve a child's competence in sports and other physically demanding activities.

In conjunction with the observed physical improvements, there was also a notable reduction in sedentary behavior and an increase in light PA among participants, further underscoring the comprehensive impact of the intervention. This change in daily activity patterns is not only evidence of the effectiveness of the program, but is also consistent with Asakura's et al. (2022) and Islam's et al. (2023), who emphasize the role of social-cognitive theory in behavior change. According to this theory, behavior change is facilitated by observational learning and social reinforcement. During the intervention, children were not only encouraged to engage in PA, but they also saw their peers actively participate, which created a positive feedback loop and reinforced active behavior. This environment encouraged an increase in light PA, which is essential to overcome prolonged periods of inactivity and mitigate the risks associated with a sedentary lifestyle. The success of these behavioral changes underscores the dual impact of the intervention on PF and daily behaviors that are critical to children's holistic development.

Building on the findings of this study, future research should extend beyond the school environment to examine the environmental and social factors that may impact the sustainability of behavior change initiated by interventions such as ours. It is crucial to assess the long-term impact of improved PF on children's daily PA and overall health, especially outside of school hours, e.g., weekends and vacations, to gain a comprehensive understanding of children's PA patterns.

This study is characterized by several strengths that highlight its contribution to the field of children's PA and health. One of the main strengths was the implementation of a socially engaging intervention that not only involved the children in physical activities, but also changed their activity patterns and preferences toward healthier behaviors. The use of advanced measurement tools such as accelerometry allowed for a detailed analysis of changes in sedentary behavior and PA levels. In addition, the use of propensity score matching addressed the challenges of non-randomization and strengthened the ability to demonstrate causal relationships between the intervention and the observed outcomes.

However, the study also has limitations that should be considered in future work. The non-randomized design and relatively small sample size may limit the generalizability of the results. By not accounting for variables such as sleep — a crucial component of 24-hour PA behavior— - important influences on children's health and activity levels may have been overlooked. Future studies should include a broader range of health behaviors, including sleep and dietary habits, to fully understand the effects and outcomes of PA interventions. In addition, while this study focused on immediate changes in PA and PF, these changes were not monitored over the long term or considered potential environmental or socioeconomic factors that could influence sustainability. Integrating a multidisciplinary approach that includes nutritional counseling in addition to physical activity could increase the effectiveness of interventions and support more substantial lifestyle changes.

Conclusion

This study confirms that structured weekend interventions with outdoor games are effective in improving PF and reducing sedentary behavior in third graders. Significant improvements in agility, cardiorespiratory fitness, abdominal endurance, and lower limb power underscore the potential of targeted physical activities to promote essential physical and cognitive skills. Although the results are promising, further research is needed to investigate the long-term sustainability of these behavioral changes and to incorporate additional lifestyle factors into intervention strategies. This research underscores the crucial role of dynamic and engaging PE in promoting healthy, active lifestyles in young children.

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THE IMPACT OF CLASSROOM-BASED PHYSICAL ACTIVITY ON STUDENT ACADEMIC PERFORMANCE AND ATTENDANCE RATES

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Abstract
The study examined the impact of physical activity during school hours on students' academic performance and attendance. It involved 293 students, with 186 in the experimental group and 107 in the control group. Active breaks lasting 5 minutes were introduced during classes such as Language, Mathematics, Foreign Language, and Science and Society, using multimedia content from the Brain Breaks® Physical Activity Solutions by HOPSports® platform. The study examined a range of factors, including academic performance at the end of the school year, subject-specific academic performance, and the attendance rate over the school year. Baseline participant characteristics were evaluated using univariate analysis of variance (ANOVA), while analysis of covariance (ANCOVA) was employed to compare the final measurements between the experimental and control groups. The study's results indicated that there were no significant differences in academic performance between the two groups after the experiment (p=0,721). Additionally, there was no significant variance in attendance rates (p=0,333). This underscores the potential benefits of integrating short physical activity breaks into the school day, highlighting that such breaks can be implemented without detriment to students' academic performance or attendance, while potentially enhancing their overall well-being.

Keywords: academic achievements, grades, active breaks, HOPSports®, school

Introduction
Physical activity is characterized as any bodily movement that requires energy and involves the use of skeletal muscles (Caspersen et al., 1985). According to the World Health Organization (WHO, 2022), children between the ages of 5 and 17 are advised to participate in an average of 60 minutes of moderate to intense physical activity daily throughout a week. They should incorporate vigorous-intensity aerobic activities, as well as activities that strengthen muscle and bone, into their routine at least 3 days a week (WHO, 2022). Unfortunately, only 21% of children and youth aged 6 to 17 in the USA meet the guideline of 60 minutes of physical activity every day (American Council on Exercise, 2022) and only between 27% and 33% of children and adolescents meet the recommended amount of moderate to vigorous physical activity (MVPA) necessary for maintaining ongoing health and well-being (Aubert et al., 2022).

Previous studies confirm that both extracurricular physical activity (Masini et al., 2019; Eime et al., 2013; Longmuir et al., 2014) and physical activity during classes have numerous positive effects (Masini et al., 2019; Daly-Smith, 2018; Watson et al., 2017; De Greeff et al., 2018). Additionally, physical activity in schools contributes to health, social interaction, and quality of life, aside from cognitive benefits (Loturco, et al., 2022; Marques, et al., 2017; Zach et al., 2017). There is a growing body of evidence linking physical activity with academic achievement (Loturco et al., 2022; Muntaner-Mas et al., 2023). This association could be attributed to the favorable effects of physical activity on cognitive functions, attention, the alleviation of depression and stress, and the enhancement of sleep quality, as suggested by Chang & Chen (2015) and Latorre et al. (2016). Consequently, increasing the amount of physical activity during the school day may lead to positive outcomes that extend beyond academic success, as noted by Marques et al. (2017). Furthermore, Ng et al. (2020) have confirmed a positive association between students' subjective assessment of school success and their participation in certain moderate to highly intensive physical activities.

Researchers have also incorporated active classroom breaks into their interventions (Masini et al., 2019; Daly-Smith et al., 2018; Watson et al., 2017). An active classroom break involves 5 to 15 minutes of moderate physical activity led by teachers. These active classroom breaks have a positive impact on attention, concentration, task performance (Masini et al., 2019; Buchele et al., 2018; Ma et al., 2015; De Greeff JW et al., 2018), and classroom behavior (Masini et al., 2019; Gathercole et al., 2003). Fedewa et al. (2018), as well as Howie et al. (2015), confirmed the positive influence of active breaks on reading outcomes and success in mathematical tasks.
Today's children are increasingly spending their free time in sedentary activities. Both in and out of school, they predominantly maintain a sitting posture, engaging in minimal physical movement (Nikšić et al., 2022). A sedentary lifestyle can lead to various chronic health problems later in life (Bull et al., 2021). Student absences from school have also become a growing issue (Daily et al., 2020), and regular attendance is crucial for academic success (Gentle-Genitty et al., 2020). Despite

the compulsory nature of education and the students' responsibility to attend and fulfill their duties, absenteeism and its causes are increasingly prevalent (Hancock et al., 2017). The level of physical inactivity in children increases with age, with younger students being more active and spending less time in a seated position compared to older peers (Tanaka et al., 2018). Additionally, studies suggest that student absenteeism can adversely affect educational accomplishments and undermine academic success (Winnifred et al., 2016). School absenteeism also serves as a risk factor for other associated issues. Students who do not regularly attend regular classes may develop issues in subject-specific classes and, ultimately, drop out of school (Birioukov, 2015; Daily et al., 2020). Physical activity, in addition to its numerous benefits, can also reduce school absenteeism, especially among students from lower socioeconomic backgrounds (D'Agostino et al., 2018). In a literature review, Watson et al. (2017) confirmed that physical activity during classes can increase children's physical activity levels and make classes more engaging. Therefore, it is plausible that physical activity breaks could improve students' attendance rates. Previous research has shown a positive impact of Brain Breaks® Physical Activity Solutions by HOPSports® (HOPSports, 2024) on self-efficacy in physical exercise (Glapa et al., 2018), level of physical fitness (Bonnema, Coetzee & Lennox, 2022) sattitudes and motivation towards physical activity (Popeska et al., 2018), and improved task focus during classes (Podnar et al., 2018). However, prior investigations have not delved into exploring the potential ramifications of utilizing the Brain Breaks® Physical Activity Solutions offered by HOPSports® (HOPSports, 2024) on overall academic performance and the impact on students' attendance rates hasn't been thoroughly examined. Therefore, the study's objectives are to assess the effects of using the Brain Breaks® platform on students' academic performance and attendance rates. It is hypothesized that the introduction of short, classroom-based physical activity breaks will positively impact students' grades and reduce the number of school days missed.

The study aims to investigate the impact of daily physical activity breaks during classroom instruction on primary school students in grades 2-4, focusing on overall school performance, subject-specific achievements, and class attendance. It hypothesizes that implementing these breaks will positively influence academic performance, particularly in subjects like Croatian language, Mathematics, English language, and Science and Society, and reduce the number of missed class hours for participating students.

Methods

Participants

The participant sample consisted of a convenience sample of students 8-10 years old students from one experimental and one control school. All participants and their parents signed informed consent prior to the study. In total, 293 students participated, with the experimental group comprising 186 students (49,5% female) across various age levels. The control group consisted of 107 students (47,7% female). At baseline, some significant differences were observed in the academic performance of female students ($p<0.05$). These statistically significant differences in grades should be noted, although they were relatively small, ranging from 0,11 for the average overall performance to 0,27 for the average Mathematics grade. Additionally, experimental and control groups had similar average attendance rates at baseline ($p=0,146$). The study was approved by the Committee for Scientific Research and Ethics on Faculty of Kinesiology, University of Zagreb.

Instruments and variables

With the approval of the school principal, data were collected on: (i) final school performance at the end of the previous school year, (ii) final school performance at the end of the current school year, (iii) school performance in the subjects of Language, Mathematics, Foreign Language, and Science and Society at the end of the previous school year, (iv) school performance in the subjects of Language, Mathematics, Foreign Language, and Science and Society at the end of the current school year, (v) data on absences during the current school year, (vi) the total number of absences during the 1st educational period, (vii) the total number of absences during the 2nd educational period.

Study protocol

The experiment involved students from the experimental group participating in physical activity breaks during Language, Mathematics, Foreign Language, and Science and Society classes, once per day for 12 weeks. The control group students received regular instruction without breaks. The experiment ran from February to May, and teachers were provided with detailed instructions on how to conduct the physical activity break. To access the necessary video clips for the experiment, teachers had to register on the Brain Breaks® Physical Activity Solutions by HOPSports® platform. Brain Breaks® Physical Activity Solutions by HOPSports® (HOPSports, 2024) is an online platform designed for teachers to use in the classroom. It includes short, dynamic activities aim to provide active breaks for children, promoting physical activity. The platform offers web games, videos, and animations lasting 3-20 minutes. The subjects' curriculum remained unchanged, and students attended all classes according to the regular schedule. In the experimental group, during a 45-minute class, a 5-minute active break was introduced after 20 minutes, followed by a return to regular class activities. Students were required to mimic movements from video animations displayed during these breaks. The content of the video animations was diverse, including various aerobic activities and exercises to strengthen and relax the body's muscles. During the 5-minute break, students achieved an average of 421,57 steps and spent an average of 3,83 minutes in physical activity requiring more than 4 METs, as estimated by the SenseWear Armband instrument (SWA-BodyMediaInc., Pittsburgh, PA, USA) over 5 days.

Statistical analyses

Univariate analysis of variance (ANOVA) was used to assess variations in students' baseline academic performance and attendance rates. Analysis of covariance (ANCOVA) including covariates academic performance at the end of the previous school year, and absences during the 1st educational period was employed to determine differences in the final measurement between the experimental and control groups.

Results

An analysis of covariance (ANCOVA) was conducted to assess the differences between the means of the experimental and control groups (Table 1). When the number of absences during the 1st educational period was included as a covariate, no statistically significant difference was found (F=0,269, p=0,605) in the number of missed class hours between the experimental group (27,01±1,53) and the control group (28,33±2,02).

Table 1. Adjusted means and variability between the control and experimental groups for the results of the final measurement (ANCOVA) including covariates academic performance at the end of the previous school year, and absences during the 1st educational period

	Experimental Group (Mean±SE)	Control Group (AS±SE)	F	p
Overall Success	4,753±0,014	4,745±0,018	0,192	0,662
Language	4,497±0,033	4,455±0,043	0,594	0,441
Mathematics	4,442±0,034	4,531±0,045	2,512	0,114
Foreign Language	4,63±0,032	4,653±0,042	0,193	0,661
Science and Society	4,655±0,028	4,656±0,037	0,001	0,982
2nd Educational Period attendance*	27,01±1,53	28,33±2,02	0,269	0,605

Mean - Arithmetic Mean, SE - Standard Error, *Average absent hours at the end of 2nd educational period - (covariate absences during the 1st educational period

When the academic performance at the end of the previous school year was included as a covariate, no statistically significant difference was found (F=0,192, p=0,662) for overall academic performance at the end of the school year (4,753±0,014 vs. 4,745±0,018). Additionally, when scrutinizing the subject-specific grades it can be noted that the experimental group had a higher average in Language compared to the control group (4,497±0,033 vs. 4,455±0,043). In Mathematics (4,442±0,034 vs. 4,531±0,045), Foreign Language (4,63±0,032 vs. 4,653±0,042), and Science and Society (4,655±0,028 vs. 4,656±0,037), students in the experimental group had lower averages compared to the control group. It's important to note that all these observed differences are not statistically significant (p>0,05), and upon closer examination of the actual values, these differences are relatively small and almost negligible.

Discussion

The goal of this study was to examine the influence of daily classroom physical activity breaks on various aspects of student performance, including overall academic performance at the end of the school year, performance in subjects like Language, Mathematics, Foreign Language, Science and Society, and the students' attendance rates. The study involved 8-10-year-old students from two primary schools. The experimental group, in contrast to the control group, engaged in physically active breaks. These breaks, lasting for 5 minutes and occurring midway through the class, involved participants imitating movements from video content provided by the Brain Breaks® Physical Activity Solutions on the HOPSports® platform (HOPSports, 2024).

The impact of physical activity on children's academic performance has been a subject of debate among scientists. Some argue that physical activity has no bearing on or doesn't enhance academic performance, while others believe it has a notably positive influence on children's academic achievements. A systematic review of evidence on the connection between in-school physical activity and academic performance has been published. Out of twelve articles included, seven indicated a positive association between physical activity and academic performance, four found no association, and one showed a positive association for third-grade students and a negative association for second-grade students (Marques et al., 2017). Upon analyzing these results in comparison with present study, it is evident that while some grades improved, others remained unchanged or experienced negligible alterations. A closer inspection of the grades reveals that they predominantly relate to students with high academic averages, indicating that it may be more challenging to enhance such grades than to diminish them. In conclusion, Marques et al. (2017) suggests that the results of their review support the thesis that physical activity positively affects children's academic performance. Drawing from the results of present research, it can be concluded that the incorporation of physical activity breaks did not yield a positive effect on student grades. Nonetheless, it is important to highlight that these breaks did not adversely affect the grades either.

Research suggests that advocating for healthier eating habits and increased physical activity among children significantly benefits their academic performance (Hiroshi, 2024; Donnelly et al., 2016). When examining studies that looked at the connection between physical activity and students' academic performance, we can conclude that academic performance is influenced by various factors, not just the physical activity conducted. Family circumstances, illness, class absences, fatigue, understanding of material for exams, classroom concentration, and healthy eating are just a few of the factors that can influence a student's academic success, whether positively or negatively (Kavi & Walvekar, 2020). Although, a report conducting a systematic review examining the association between physical activity in school and academic performance indicates that some findings do not provide substantial evidence of a significant impact on subjects like mathematics, reading, or problem-solving (Marques i sur., 2017), it is clear that physical exercise has a multiple positive effect on an individual's health, such as body weight control, fat reduction, improved cardiovascular and respiratory system function, and enhancement of the locomotor system's efficiency, i.e., voluntary muscles (Miko et al., 2020).

Students are increasingly absent from classes without valid reasons, leading to potential problems later in education (Mokhtari et al., 2021; Tripura, Das & Saha, 2015; Foldnes, 2017). The classroom-based physical activities could make classes much more enjoyable, simultaneously increasing their interest in physical activity, which can encourage students to attend classes regularly and improve attendance rates. Increasing the interest in physical activity and improving student's daily physical activity is important as data indicates that children with higher body weight are at a greater risk of missing school compared to children with normal body weight (An et al. 2017). In the present study, students exhibited a below-average absenteeism rate compared to the national average (MZO, 2024). Furthermore, students on average missed 46.6 hours of the school year, a rate of absenteeism similar to that in the USA, where about 14% of children and adolescents from kindergarten through 12th grade are chronically absent, defined as missing at least 10% of the school year, or about 18 days (Allen, Diamond-Myrsten, & Rollins, 2018; U.S. Department of Education, 2016).

The present study's limitations include not exploring the relationship between academic performance or attendance rates and body mass index (BMI) or socioeconomic status, which has been shown to potentially impact these factors. Additionally, we did not gather data on the reasons for absences, which could have been justified and not solely health-related. Future research should aim to conduct a longitudinal study to monitor the long-term impacts of consistent physical activity breaks on both academic performance and health outcomes. Additionally, further investigation may be necessary to determine the actual benefits and to optimize the duration and type of classroom-based physical activities.

Conclusion

The findings from the present research suggest that integrating classroom-based physical activities does not adversely impact students' academic performance or attendance rates. Teachers can confidently incorporate daily physical activities into classroom sessions without concern for a decline in students' grades or attendance due to diminished instructional time. This approach simultaneously offers students the advantages of engaging in physical activity.

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INTERACTION OF GROSS AND FINE MOTORS IN PRIMARY EDUCATION STUDENTS

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Abstract
Children's motor development is complex. It can be considered from the point of view of the development of gross motor skills (GMS) and fine motor skills (FMS). The aim of the research is to assess the relationship between the development of GMAS and FMS of students in primary education, also to assess the existence of differences in the GMS according to the level of results in the FMS.The research was conducted on a sample of 83 third and fourth grades students. Eight tests were used to assess the GMS: plate tapping tests, standing long jump, polygon backwards, sit up test, sit and reach test, flamingo balance test, and transferring sponges by running. FMS were assessed by stringing beads on thread in 60 seconds. Basic descriptive indicators were calculated. The relationship between the development of GMS and FMS was assessed by Pearson's correlation coefficient. The differences in the results of tests for the assessment of GMS with respect to the level of the FMS were assessed by univariate analysis of variance (Anova).Correlation analysis indicated that students who achieve a better result in the FMS also achieve a better result in tests for assessing flexibility (r=0.37), balance (r=0.40), coordination (r=-0, 27) and agility (r=-0.32). There is a statistically significant difference in tests for assessment of coordination, balance and agility with respect to the level of the achieved result in the FMS. The interaction of GMS and FMS is permanent, and its development should definitely be encouraged at school age.

Keywords: motor developement, motor skills, relationship, primary education

Introduction
A child's motor development is very complex and depends on the interaction of several factors. It can be considered from the point of view of the development of gross and fine motor skills. Gross motor skills include skills and movements that require the establishment of control over larger muscle groups and include locomotion, while fine motor skills include skills that require the activation of smaller muscles and the control of work such as manipulating objects, drawing or writing. Advances in the development of gross and fine motor skills are mostly complementary during development. Certain measures have been shown to correlate, but the study of interactions between these domains still requires further insights (Sorgente et al., 2021). Unfortunately, the motor abilities of children and young people, which define gross motor skills, according to numerous studies in recent decades, follow a negative trend in development (Eberhardt et al. 2020; Fühner et al. 2021). Petrić (2021) points out, for example, that today's children are 50% less coordinated, strong, flexible and precise than children in the 1950s. By the time children start school, they mostly have well-developed fine motor skills, but age-related differences have been found in the development of children's fine motor skills. In their research, Gaul and Issartel (2016) found that there is no gradual development of fine motor skills with increasing age, and that children's fine motor skills lag behind the expected norms. The level of movement has a great influence on motor development. Since the level of movement of children is significantly reduced with age, and access to tablets and other technology is increasing, this is certainly one of the causes of slower fine motor development (Lin et al., 2017; Martzog & Suggate, 2022). The aim of this research is to assess the gross and fine motor skills of students in the third and fourth grade of primary education and to assess the relationship between the development of students' fine and gross motor skills. Also the aim is to assess the existence of differences in gross motor skills with respect to the level of results achieved in the fine motor skills.

Methods
The research was conducted on a sample of 83 students of elementary urban schools from Zadar (43 third-grade students (of which 20 male and 23 female students), and 40 fourth-grade students (of which 18 male and 22 female students)). The research included only those students for whom parental consent was collected, and who voluntarily wanted to participate in the measurement. A total of 8 tests were used for the purpose of conducting research. To assess the gross motor skills of the participants, a standardized battery of tests was used to assess the following motor skills: plate tapping tests (PTT) to assess the speed of repetitive movements, standing long jump (SLJ) to assess the explosive strength, polygon backwards (PBT) to assess coordination, sit up test (SUP) to assess repetitive strength, and sit and reach test (SAR) to assess flexibility, flamingo balance test (FLB) to assess balance and transferring sponges by running to assess agility. Fine motor skills were assessed by the test of stringing beads on a 30 cm long string in a time of 60 seconds (the number of beads strung on a string in the given time is measured). Basic descriptive indicators were calculated: arithmetic mean, standard deviation, minimum

and maximum score, skewness and kurtosis. The normality of the distribution was tested with the Kolmogorov-Smirnov test. In order to assess the relationship between the development of fine and gross motor skills, the Pearson correlation coefficient was calculated. Differences in the achieved results of the tests for the assessment of gross motor skills with regard to the degree of development of fine motor skills were assessed by univariate analysis of variance (Anova).

Results

Table 1 shows the descriptive indicators of the variables for the assessment of fine and gross motor skills in the total sample of respondents. The average values of the examinee's measured variables in comparison with normative orientation values according to age (Findak et al., 1996; Vidranski, 2020) indicate that male and female students of the third grade achieve below-average results in the tests of plate tapping hand, polygon backwards and standing long jump, average results in the sit up test and moderately above-average results in the sit and reach test and transfering sponge by running test. Fourth-grade students achieve a below-average result in the plate tapping hand test, an average result in the standing long jump and transfering sponge by running test, and moderately above-average results in the polygon backwards test, sit up test and sit and reach test.

Table 1. Descriptive indicators of variables for the assessment of fine and gross motor skills on the total sample of respondents (N=83)

	Mean	Min	Max	SD	Skew	Kurt	Max D	K-S p
Plate tapping test	19.86	4.00	26.00	2.96	-1.88	9.23	0.13	p < .15
Sit up test	32.37	10.00	46.00	8.34	-0.58	-0.44	0.12	p < .20
Polygon backward test	21.74	8.06	53.00	9,50	1,15	1,00	0.14	p < .10
Sit and reach test	59.70	26.00	105.00	18.62	0.40	-0.34	0.09	p > .20
Flamingo balance test	102.71	7.00	305.00	76,71	1,13	0,69	0.15	p < .05*
Standing long jump test	145.20	79.00	194.00	23.50	-0.47	0.49	0.09	p > .20
Transferring sponges by running	13.47	10.24	21.00	2.74	1.11	0.19	0.22	p < .01*
Stringing beads	10.43	4.00	18.00	3.91	0.09	-1.04	0.12	p < .20

The values of the standard deviations indicate the greatest dispersion of the results in the flamingo balance test, standing long jump test, and sit and reach test. The normality of the distribution was tested with the Kolmogorov-Smirnov test. The values indicate a significant deviation from normality in the variables flamingo balance test and transferring sponge by running test, while in the other variables the distribution is normal.

Table 2. Pearson's correlation coefficient of the fine motor test with the gross motor tests

	Stringing beads
Plate tapping test	0.18
Sit up test	0.16
Polygon backward test	**-0.27***
Sit and reach test	**0.37***
Flamingo balance test	**0.40***
Standing long jump test	0.18
Transferring sponges by running	**-0.32***

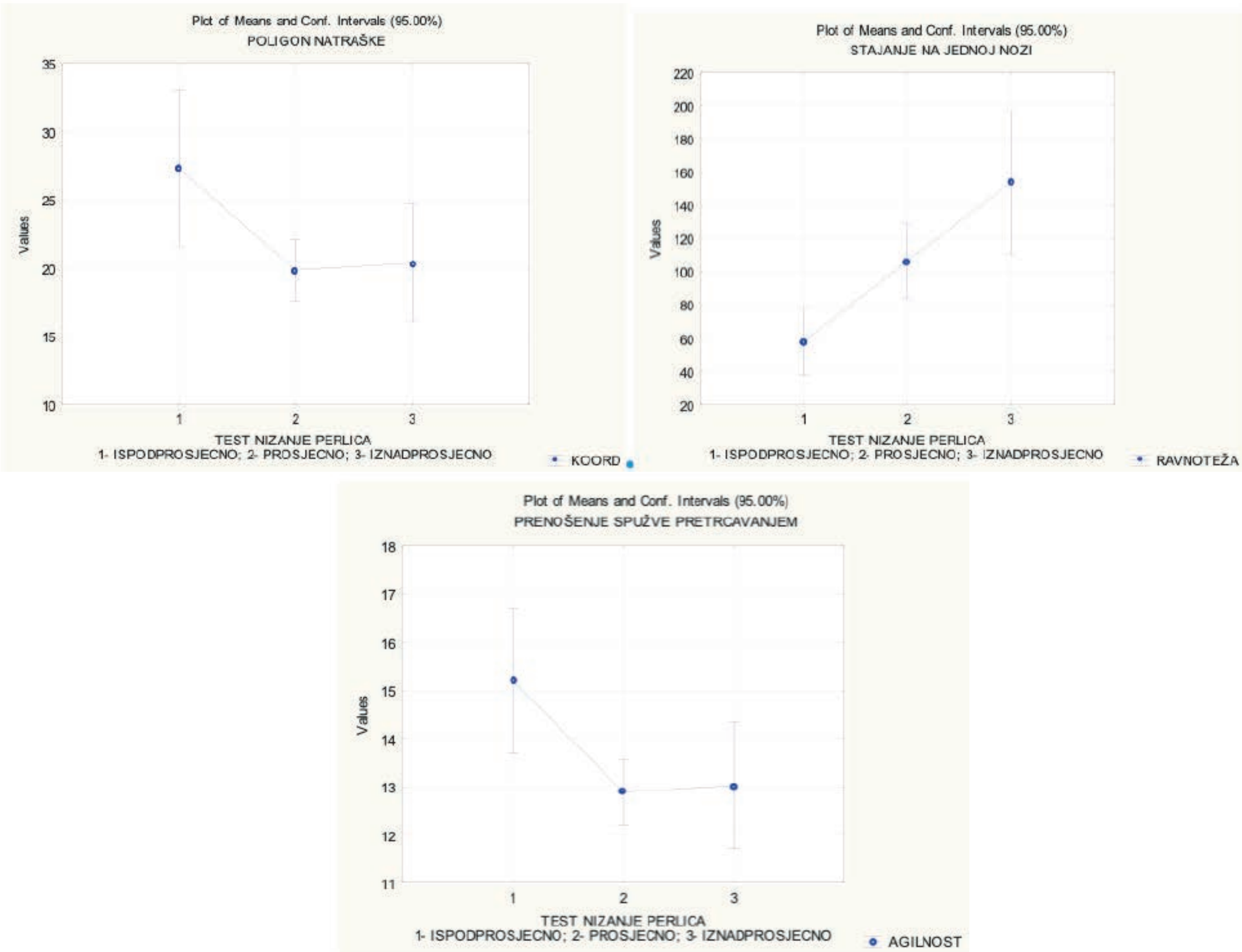
Correlation between the results of the test for the assessment of fine motor skills and the results of the tests for the assessment of gross motor skills was assessed by the Pearson correlation test. Significant positive correlations were obtained between the fine motor test and the tests for assessing flexibility and balance. There was also a significant negative correlation of the fine motor test with the tests for the assessment of coordination and agility, but since these are inversely scaled variables in which a lower value indicates a better result, the obtained negative correlation is interpreted as a logically positive one. Correlation analysis indicated that students who achieve a better result in the test of fine motor skills also achieve a better result in the tests for assessing flexibility, balance, coordination and agility. After establishing the interaction of fine and gross motor skills, we wanted to establish the existence of differences in gross motor skills tests with regard to the level of results achieved in the fine motor skills test. Based on the result achieved in the stringing beads test, the students were classified into the category of below average, average and above average results. The orientation norm for below-average results was obtained by subtracting the corresponding standard deviation from the arithmetic mean, and the orientation norm for above-average results was obtained by adding the corresponding standard deviation to the arithmetic mean. Based on the set criteria, 24.10% of the measured sample of respondents achieved a below-average result in the test for evaluating fine motor skills, 59.04% of the measured sample of respondents achieved an average result, and 16.87% of the measured sample of respondents achieved an above-average result.

Table 3. Analysis of variance of tests for assessing motor abilities with respect to the level of fine motor skills (significance level $p < 0.05$)

	SS Effect	df Effect	MS Effect	F	p
Plate tapping test	21.69	2	10.85	1.24	0.29
Sit up test	118.14	2	59.07	0.85	0.43
Polygon backward test	816.21	2	408.10	4.96	**0.01***
Sit and reach test	1894.86	2	947.43	2.86	0.06
Flamingo balance test	77356.40	2	38678.20	7.64	**0.00***
Standing long jump test	2403.79	2	1201.90	2.24	0.11
Transferring sponges by running	79.27	2	39.64	5.92	**0.00***

*statisticly significant

The analysis of variance (ANOVA) found that there is a statistically significant difference in the tests for the assessment of coordination, balance and agility with regard to the level of the achieved result in the fine motor skill test. No statistically significant differences were found in the other tests for the assessment of gross motor skills. The difference by group with regard to the achieved below-average, average or above-average result in the test for the assessment of fine motor skills in the tests for the assessment of gross motor skills is also visible in the presented graphs. Students who achieved a better result in the fine motor test also achieved a better result in the tests for assessing coordination, balance and agility, which once again confirmed the interaction of fine and gross motor skills.



Graph 1. Differences in tests for assessment of coordination, balance and agility with regard to the level of development of fine motor skills

Discussion

On the measured sample of respondents, the analysis indicated certain positive correlations of fine and gross motor tests. Students who achieve a better result in the fine motor skills test also achieve a better result in the tests for assessing flexibility, balance, coordination and agility. Numerous authors who investigated the relationship between gross and fine motor skills also obtained similar results (Dayem et al. 2015; Oberer et al. 2017; Sorgente et al. 2021). Oberer et al. (2017), for example, reported in their research on a positive correlation of fine motor skills with motor tasks that assess agility and balance. Similarly, research by Cameron et al. (2012) also indicated a positive correlation of fine motor skills with tests for assessing balance, agility and coordination. Tortelle et al. (2016) came to the opposite conclusions by assessing gross motor skills using precision and balance tests. The interaction of fine and gross motor skills is very complex and can change according to the age of children. The conflicting results of the relationship between fine and gross motor skills can be explained by different developmental trajectories. According to Sorgente et al. (2021) gross and fine motor skills follow different developmental paths. In addition, a different combination of assessment of gross and fine motor skills in different time intervals of growing up could give different results.

Despite the above, gross and fine motor skills are defined as motor domains that partially share the same cognitive processes (Oberer et al. 2017). The above can be partially explained by the fact that fine motor skills are crucial in many sports because they make small but often decisive adjustments in movements that are primarily produced by large muscle groups (Payne & Isaacs, 2017), for example specific gross motor activities include fine motor adjustments in driving the ball, hitting the ball with a bat, throwing at a target, etc. Although gross and fine motor domains can be functionally integrated to improve children's motor performance, further research is needed to clarify the effect of gross motor practice on fine motor performance (Sorgente et al. 2021).

Conclusion

The results of the research indicate the interaction of gross and fine motor skills in such a way that students who achieve a better result in the fine motor test also achieve a better result in the tests for assessing flexibility, balance, coordination and agility. The research contributes to the spread of knowledge about a better understanding of the relationship between fine and gross motor skills, but further research is needed to better clarify this relationship during the different phases of elementary school education. In order to more concisely explain the interaction of gross and fine motor skills, it would be useful through a longitudinal study monitor relationship between the development of gross and fine motor skills with increasing age and under different influences. Also in future research several different tests for the assessment of fine motor skills should definitely be applied. Studying relationships is important for knowing new strategies to improve motor development during childhood. The obtained positive correlation of the tests on the measured sample indicates that in educational practice should be implemented more integrated motor tasks that contribute to the development of fine and gross motor skills in parallel. For example, carrying small objects by running across space or, standing on one leg while moving small objects (pebbles, balls) from box to box with tweezer.

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CHANGES IN THE LEVEL OF ENDURANCE ABILITIES IN A SELECTED GROUP OF 11- TO 15-YEAR-OLD PUPILS RESULTING FROM THE COVID-19 PANDEMIC LOCKDOWNS IN THE CZECH REPUBLIC

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Abstract
During the global COVID-19 pandemic, there has been a long-term and unprecedented reduction in physical activities. The study describes specific changes in aerobic endurance performance after long-term mobility restrictions due to the COVID-19 pandemic in a group of 11- to 15-year-old children in the Czech Republic.The Czech children have experienced one of the most extended periods of closed schools and restricted sports and leisure activities worldwide. Material and Methods. A longitudinal study on a dependent group of second-grade students (nboys = 81, ngirls = 72). The level of physical performance was repeatedly tested during the regular regime without any restrictions and after their return to school. The conducted test was the 1000-metre endurance run. There was a significant decrease in endurance performance between the first and second lockdown restrictions by 10.6% (boys) and 19.9% (girls). In a normal environment (without pandemic restrictions), we would expect performance to increase in the year-on-year period, but there was a reduction of 3.5% (boys) and 5.5% (girls). The long-term restrictions of regular exercise regimes devastated vital components of endurance performance and health-oriented fitness.

Keywords: 1000-metre run, children, COVID-19, endurance, health-oriented fitness

Introduction

Recently, we have faced the COVID-19 pandemic. Today, the situation has returned to normal in all spheres of life. However, we still face the consequences which were caused by this period and its restrictions. To stop the spreading of the COVID-19 disease, there were many restrictions and lockdowns in public health and social measures (PHSM), so school attendance was significantly restricted. The Czech Republic belongs to countries where the length of online teaching was the most distinctive within Europe and the world. Organized and non-organized sports and activities were restricted to the same amount, as was the approach to movement activities (Škoda, 2021). The COVID-19 disease is not such a problem today. However, a comparable situation can repeat at any time. Children were the group which was affected the most. According to the national questionnaire survey (Pyšná et al., 2022; Štveráková et al., 2021), the movement regime has significantly changed in children and young people. The organized activities have been logically reduced, but this drop-out has not been replaced by non-organized sports activity. A significant change in the movement regime influences the unfinished development of children in many areas. Research has proven the rise of obesity (Chang et al., 2021; Stavridou et al., 2021; Wahl-Alexander & Camic, 2021) and changes in the mental area (López-Bueno et al., 2021). During the first pandemic attack in the Czech Republic in the spring of 2020, schools were closed for 11- to 15-year-old pupils from the 1st of March to the 26th of June. Restrictions were released during the summer of 2020, and the regime returned almost to normal. Other significant restrictions were not expected during summer and the start of the new school year in September 2020. However, the pandemic quickly worsened, and schools were locked down again from October 14th, 2020. Physical Education was not taught from the beginning of October. However, PE was replaced by outside walks. 11- to 15-year-old pupils observed in this study were taught online until the 24th of May 2021. After that, the school year returned to normal, and more widespread restrictions and lockdowns were not placed. Many studies (Table 1) either focused on concrete national environment (Béghin et al., 2022; López-Bueno et al., 2020; Zhou et al., 2022) or summarising studies (Stockwell et al., 2021), confirm a decrease in fitness caused by restrictions to stop spreading the COVID-19 disease. The authors have primarily used test batteries and motor tests to evaluate the physical fitness of children and young people. The most common motor test for testing endurance was the shuttle run test for 20 meters, in which the reached distance equal to the number of overruns (Basterfield et al., 2022; Chambonnière et al., 2021; Wahl-Alexander & Camic, 2021). The physiological parameter VO2max was set directly (Dayton et al., 2021) or indirectly (López-Bueno et al., 2020; Wolfe et al., 2023). The other tests used for measuring endurance performance were 600 (Jarnig et al., 2021; Morrison et al., 2021; Sunda et al., 2021), 800 and 1000 meters run (Hnízdil et al., 2022; Zhou et al., 2022) or 6 min endurance run (Eberhardt et al., 2022). To define changes in endurance (health-oriented fitness respectively), the authors have used the comparing methods. The results observed before and after restrictions were compared. The most common were the cross-sectional studies. These studies have concluded a decreased fitness in samples who went through restrictions (Dayton et al., 2021; Chambonnière et al., 2021; Lee et al., 2022). The same results were presented in the longitudinal studies of selected dependent samples (Basterfield et al., 2022; Zhou et al., 2022).

Table 1. Overview of selected studies discussing the impact of the COVID-19 pandemic on endurance performanceengage in PA increases when the individual's needs for autonomy, competence and connectedness are satisfied (Kokkonen

Study	*N*	Age	Measured parameters and results	Country
			Independent samples	
Dayton, 2021	10	14.85	VO_2max, direct measurement: –12.5%	USA
Chambonnière, 2021	206	9.65	SRT: –54.1%	FRA
Sunda, 2021	48	15.3 +0.3	600m ER: –10.4%	CRO
Béghin, 2022	532	16.5 ± 2.0	20-meter SRT for 6 min: –4.2%	FRA
Lee, 2022	9984	13–15	SRT: –18.5%	KOR
Eberhardt, 2022	999	7.98 ± 0.82	6min ER: no change	GER
			Dependent samples	
Wahl, 2021	264	9–14	SRT: –26.7%	USA
López-Bueno, 2021	89	13.3 ± 0.9	VO_2max from SRT: –0.64	ESP
Jarning, 2021	764	8.3 ± 0.7	600m ER: –7.2%	AUT
Sunda, 2021	66	15.6 ± 0.5	600m ER: –29.1%	CRO
Morrison, 2021	62	11.6 ± 1.5	600m ER: boys –5.8%, girls –2.8%	SLO
Zhou, 2022	265	14.1 ± 0.4	ER: boys (1000m) –6.6%, girls (800m) –9.1,	CHN
Basterfield, 2022	178	8–10	SRT: –9.5%	GBR
Hnízdil, 2022	52	8.3 ± 0.7	1000m ER: –14.6%	CZE
Wolfe, 2023	298	adolescents	SRT -4% , VO_{2max} - 1.8 $ml \cdot kg^{-1} \cdot min^{-1}$	USA

SRT – Shuttle Run Test; ER – Endurance Run
Note: Symbol „–" before the numerical value in the table indicates a decrease in endurance performance

The study's main aim was to determine how the applied restrictions and lockdowns related to COVID-19 affected PHSM, specifically endurance abilities in the selected group of 11- to 15-year-old pupils. Furthermore, the study aimed to determine which endurance changes appeared after getting to a regular daily routine

Methods
Procedures: This longitudinal study was realized during 2020 and 2021, repeated testing of the same selected group of 11- to 15-year-old pupils. We have used the running test for 1000 meters to measure aerobic endurance. Pupils of a selected school have run 1000 meters during their standard Physical Education lesson. The test was repeated thrice in the same group (Figure 1). The first measurements were realized after the first short lockdown (three months) in October 2020, close before the long eight-month online teaching. The following data collection was realized in the spring of 2021 after children returned to school. The third testing was realized in October 2021, after six months of regular school regime with unrestricted organized sports

Figure 1. Study schedule and school lockdowns in the Czech Republic

Participants:The sample counted 165 pupils, and the complete results were obtained from 153 pupils. Eighty-one boys and 72 girls aged 11 to 15 from Prague in the Czech Republic finished the tests.

Statistical analysis: We have declined the normal data distribution with the Shapiro-Wilk test of normality using the JAMOVI statistical software (v2.4.8). The Shapiro-Wilk test was chosen as it is a well-established method for assessing normality in smaller sample sizes like the one in this study. The results of this test indicated that the data did not follow a normal distribution, violating the assumptions for parametric tests. To determine the significance of changes between the three measurement periods, we therefore used the non-parametric Friedman ANOVA test for repeated measures. The Friedman ANOVA is suitable for analyzing differences across multiple related samples when the normality assumption is not met. For the post-hoc analysis to identify where the specific differences occurred, we conducted pairwise comparisons using the Durbin-Conover test. The Durbin-Conover test is a non-parametric alternative to the more common Bonferroni or Holm corrections, and does not require adjusting the p-values. The assumptions of the Friedman ANOVA, such as independence of observations and symmetry of the sampling distribution, were checked and confirmed to be met prior to conducting the analysis. The alpha level was set at 0.05 for all statistical significance testing

Results

Figure 2 shows the performance of tested pupils in the three periods in 2020 and 2021. The impact of COVID-19 restrictions and lockdowns on performance has been observed.

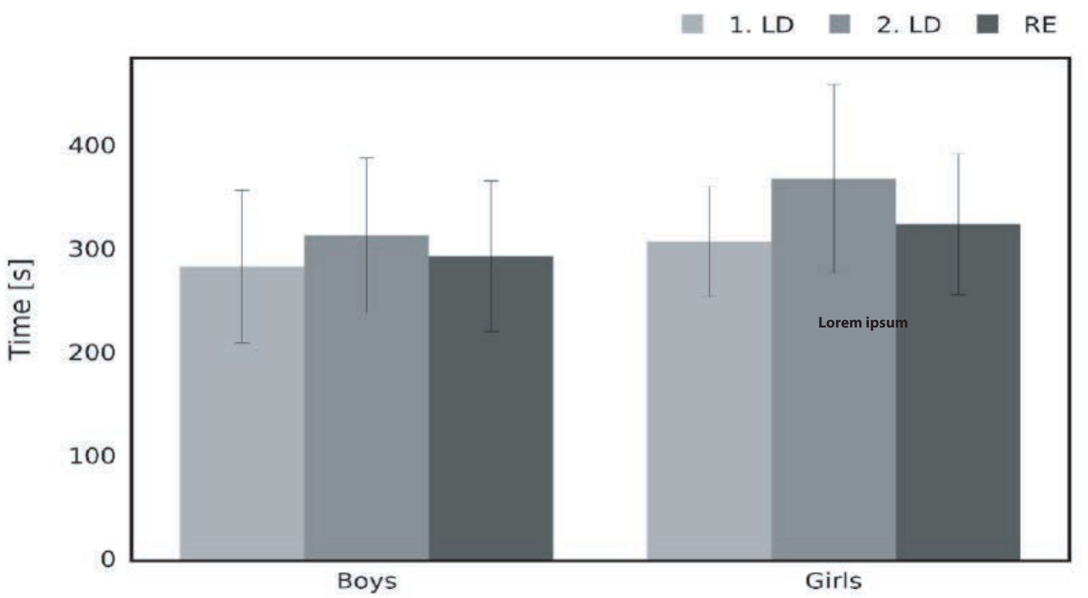

Figure 2. Descriptive statistics of performance in the running test for 1000 meters.Performance after the: 1. LD – first lockdown restrictions (three months); 2. LD – second lockdown restrictions (eight months); RE – six months in the regular environment

After the short Covid-19 lockdown (1. LD, three months), boys had reached the average time of 4:43 ± 1:14 and girls 5:00 ± 0:53. In the next period, after the long Covid-19 lockdown (2. LD, eight months) boys reached the time 5:13 ± 1:15, girls 6:08 ± 1:31. In the last observed period when children were not restricted for six months, boys reached the average time 4:53 ± 1:13 and girls 5:24 ± 1:08. When analysing differences between the observed data, a statistically significant difference has been found between the results of the repeated endurance measurement in boys ($\chi^2 = 67.9$, $p \leq 0.001$) and girls ($\chi^2 = 77.6$, $p \leq 0.001$). The post-hoc analysis of endurance parameters for both sexes is summarised in Table 2. The statistically significant differences have been confirmed after pairwise comparison of all periods, both in boys and girls.

Table 2. Post-hoc analysis of endurance performance (1000m run)

	Statistic	*p*	M_D	SD_D	M_D [%]
		1. LD vs. 2. LD			
Boys	10.64	< 0.001	30	1.7	–10.6
Girls	12.84	< 0.001	61	38.5	–19.9
		2. LD vs. RE			
Boys	6.63	< 0.001	–20	–2.3	6.8
Girls	5.55	< 0.001	–44	–22.7	13.6
		1. LD vs. RE			
Boys	4.01	< 0.001	10	–0.6	–3.5
Girls	7.34	< 0.001	17	15.8	–5.5

Performance after the: 1. LD – first lockdown restrictions (3 months); 2. LD – second lockdown restrictions (8 months); RE – 6 months in the regular environment

When comparing test results performed in the autumn of 2020 (1. LD – after the first lockdown restrictions) and in the spring of 2021 (2. LD – after the second lockdown restrictions, eight months of online teaching), we have found out the significant decrease in endurance performance. Boys' performance decreased by 30 seconds on average (10.6 %), and girls' performance was more than 1 minute worse after the lockdown, which is a decrease of 19.9%. After six months of the regular regime, results in tests in the autumn of 2021 showed better performance in testing endurance in the observed group of children than in spring. Boys improved on average by 20 seconds (6.8 %) and girls by 44 seconds (13.6 %). When we compare the results from the autumn of 2020 with those from the autumn of 2021, we can state a decrease in endurance abilities. Boys got worse in the year-on-year period by 10 seconds (3.5 %) and girls by 17 seconds (5.5 %) on average.

Discussion

The movement activity of 11- to 15-year-old children was insufficient before COVID-19 (Miklánková et al., 2013; Sigmundová & Sigmund, 2015). The fundamental component of health-oriented fitness is aerobic endurance. It is developed by sports activity, active movement regime, and everyday chores. These activities were during the COVID-19 pandemic restricted. The accepted anti-pandemic restrictions and lockdowns strengthened and directly encouraged a sedentary lifestyle and significantly restricted movement activities, both spontaneous and organised sports activities. These changes significantly and negatively influenced health and quality of life in the mental, physical, and social areas. There is a risk for children and young people that the accepted restrictions and lockdowns during the COVID-19 pandemic caused significant and probably irreversible changes in their health development. Many studies have tried to describe changes in components of health-oriented fitness. Results in the cross-sectional studies comparing independent samples could have been influenced by factors other than the accepted restrictions during COVID-19. The longitudinal studies, including ours, describe the sample before, during and after the pandemic restrictions. There are significantly fewer longitudinal studies than those cross-sectional ones. After the long-term lockdown (eight months of online teaching), the observed group of pupils saw significant changes in health-oriented endurance. That corresponds with the results of other studies (Béghin et al., 2022; Lee et al., 2022; Sunda et al., 2021; Zhou et al., 2022). Boys' performance in our study decreased by 10.6%, and girls' performance decreased by 19.9%. The lower decrease in boys' performance can be explained by the higher affinity of boys to movement activities compared to girls. Six months after the finish of COVID-19 restrictions, we measured the level of endurance abilities in the same group of pupils. The endurance performance has improved (boys by 6.8%, girls by 13.6%). However, results did not return to the previous year's former level. Boys got worse through the year by 3.5% and girls by 5.5%. Considering the maturation of tested persons, we would have expected performance improvement. Endurance typically improves in this age by 3% (Měkota et al., 1995). In this perspective, a decrease in endurance abilities throughout the year is even more significant in our study than the above-stated 3.5% and 5.5%, respectively. We do not have data about changes in other components of fitness in the observed sample, but we can expect, based on our results and other research, significant changes in body composition and flexibility (Hnízdil et al., 2022; Jarnig et al., 2021; Jurak et al., 2021; Sunda et al., 2021; Štveráková et al., 2021; Wahl-Alexander & Camic, 2021), and in the area of mental and social relationships (Armour et al., 2021; Cowie & Myers, 2021). Contrary to our findings are the results of work (Eberhardt et al., 2022), whose study did not show a change in the level of endurance abilities in nine-year-old children. In addition to the direct impact of the pandemic restrictions, there may have been other confounding factors that contributed to the observed changes in endurance performance. For example, individual differences in physical activity levels outside of the school setting, such as participation in unsupervised exercise or sports, could have influenced how much each child's fitness was affected. Dietary changes during the lockdown periods, including potentially less healthy eating habits, may have also played a role. Additionally, the psychological effects of the pandemic, including increased stress and anxiety, could have impacted the children's motivation and effort during the fitness testing (Marques de Miranda et al., 2020; Chawla et al., 2021). Future research should aim to better account for and control these potential confounding variables to more precisely isolate the effects of the pandemic restrictions.

Conclusion

Accepting COVID-19 restrictions and lockdowns, including restricted movement, absence of physical education, absence of leisure time organized activities and the unprecedented, forced change of overall movement regime had an extensive negative influence on the aerobic fitness of pupils. After the long-term lockdown and the change of movement regime, the general endurance significantly changed in the observed group of pupils. After the return to the regular regime, the observed group of pupils improved in performance. However, the level did not reach the entering values. All stakeholders responsible for the health and fitness of children and young people - including parents, educators, and public health institutions - should make maximal efforts to support the revival of physical activity habits and movement regimes in this population, at least returning to the pre-pandemic state. This is crucial not only for physical health, but also for mental well-being and social development. Specific recommendations for practice include:

1. Schools should prioritize the reinstatement of comprehensive physical education programs, with a focus on developing aerobic endurance through activities like running, cycling, and sports. Adequate time and resources should be dedicated to these efforts.
2. Policymakers should provide funding and infrastructure to expand access to organized sports and leisure-time physical activities for children and adolescents, both during and outside of school hours. This could include subsidies, increased facility availability, and community-based programming.
3. Health professionals should closely monitor the physical fitness levels of youth in the aftermath of the pandemic and develop targeted interventions to address deficits in aerobic capacity and other health-related components. Collaborations between schools, sports organizations, and the healthcare system will be crucial.
4. Parents should be educated on the importance of maintaining regular physical activity habits at home, encouraging their children to engage in both structured exercise and unstructured active play.

It is also an opportunity to learn from the mistakes during the pandemic and proceed differently next time a comparable situation arises, so the impact on children's physical and mental health is minimized. Doing sports activities, keeping everyday movement habits, and eating healthy food are necessary for the healthy development of this population.

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DIVERSITY IN ACADEMIC JOURNEYS: EXPLORING THE VARIED COLLEGE EXPERIENCES OF STUDENTS IN PHYSICAL EDUCATION INSTITUTIONS

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Abstract
Understanding students' college experiences is crucial for evaluating and enhancing the quality of higher education in physical education institutions. Using Beijing Sport University as a case study, this research explores the overall and group characteristics of students' college experiences at the institution. It analyzes the impact of these experiences on goal management and value selection. Utilizing a survey approach, the study engages 1,023 undergraduates, examining their experiences across seven dimensions: perception of interpersonal environment, life support, teacher support, academic support, student association participation, and interactions with both teachers and peers. Findings reveal that students generally perceive positive support from the campus environment but experience weaker student-faculty interaction, potentially due to the unique dynamics of sports disciplines. Significant differences in college experiences were identified based on gender, grade, discipline type, political status, and participation in student associations. Notably, students specializing in sports, particularly males, reported higher experience scores than academic students, highlighting the impact of personality traits and self-regulation skills. Grade level differences suggest freshmen and sophomores feel more engaged than juniors. Students' academic experiences have a significant impact on their goal management and value selection. Based on these insights, recommendations are made to enhance teacher-student interactions, foster peer interactions through strengthened student association construction, provide personalized support and optimize physical education courses etc.

Keywords: students' college experience, campus environmental support, student-faculty interaction, student organizational involvement

Introduction
Students' college experience encompasses their recognition and experience with the interactions among people, events, and objects within the college environment, encapsulating both academic and extracurricular engagements. It represents a unification of the processes and outcomes of student-centered cognitive and behavioral activities, constituting a significant aspect of students' meaning-making and self-education. Furthermore, it serves as vital material for educators to understand students' reactions to their educational actions and to refine their teaching strategies accordingly (Zhou, 2023). Integrating students' college experience as a crucial basis for monitoring and assessing the quality of higher education holds significant importance for achieving the objectives of higher education quality assessments.

Presently, international academic research on the university experience of students predominantly focuses on comprehensive universities through macro-level and holistic surveys. The student training model in physical education institutions differs from other comprehensive universities. The college experience of students in physical education institutions is not only vital for enhancing the individual comprehensive quality and realizing self-meaning of university students but also relates to the reserve force of high-quality sports talents for physical education institutions and the nation. This study concentrates on the overall and group characteristics of students' college experience at Beijing Sport University, especially the impact of factors such as gender, discipline, grade, involvement in student associations, and academic performance. By delving into these differences, the aim is to uncover the educational experiences of students from diverse backgrounds, assess the quality of education, and provide targeted educational improvement strategies for physical education institutions. The significance of this research lies in aiding physical education institutions in better understanding student needs, optimizing talent training programs, enhancing educational outcomes, and thus cultivating high-quality sports talents that meet the demands of the era.

Methods
This study primarily utilized a survey method, the survey objects are 1,023 undergraduate students at Beijing Sport University. To ensure the representativeness of the selected sample in this study, a stratified sampling method was employed, considering key factors such as grade level, gender, and ethnicity. The gender ratio is 1:1.4(599:424), with students specializing in sports accounting for 65.5% of the sample. The majority of the participants are from sports-related

majors, comprising 71.1% of the sample. Ethnic minorities represent 14.6% of the sample. The sample structure closely mirrors the distribution of the student population at the university, indicating good representativeness.

The research tool employed was the "Sport College Student Experience Questionnaire" (SCSEQ)which was revised in 2020 by us. The questionnaire is divided into two parts: the first part is about background information, including such as gender, grade, discipline type, and academic performance. The second part focuses on the students' college experience, asking students to self-assess their experiences across seven dimensions, including three aspects: perceived Campus Environment Support, Student-Faculty interaction, and Student Organizational Involvement. Campus Environment Support refers to students' perceptions of the school environment related to learning and personal development. This includes the extent to which the college innovates conditions and environments to engage students in various learning experiences and skill enhancement. The support categories include interpersonal environment support (3 items), living support (3 items), teacher support (4 items), and academic support (5 items). These questions are rated on a scale from 1 (strongly disagree) to 7 (strongly agree).

Student-Faculty Interaction refers to the experiences students have with teachers and peers during their university years, rated on a scale from 1 (never) to 7 (often). Experiences with faculty (4 items) specifically include discussions about academics, life philosophies, career planning, and emotional exchanges. Peer interaction experiences (3 items) involve interactions with peers of different values, disciplines, and ethnicities. Student organizational involvement includes 3 items, detailing student participation in college clubs, external organizations, and party or youth league organizations.

The overall internal consistency coefficient (Cronbach's alpha) for the SCSEQ is 0.968. The Cronbach's alpha for the Campus Environment Support scale is 0.968, for the Student-Faculty Interaction scale is 0.939, and for the Student Organizational Involvement scale is 0.843, indicating good reliability and that the scales measure a single construct. A confirmatory factor analysis was conducted on the SCSEQ. The model fit indices for the Campus Environment Support scale were as follows: X2/df = 7.436, RMR = 0.053, GFI = 0.923, NFI = 0.962, IFI = 0.967, TLI = 0.957, CFI = 0.967, and RMSEA = 0.079. For the Student-Faculty Interaction scale, the model fit indices were: X2/df = 6.093, RMR = 0.047, GFI = 0.981, NFI = 0.989, IFI = 0.991, TLI = 0.984, CFI = 0.991, and RMSEA = 0.071. These indices all meet acceptable levels, indicating that the model fit is good and the scales have good construct validity.

Results

Overall Characteristics of Students' College Experience

Students rated their perception of the interpersonal environment as the highest, while their experiences of interacting with teachers received the lowest scores. Specific dimensions ranked as follows: life support, teacher support, academic support, student association participation, and interaction with peers. The majority of students were fairly satisfied with the academic support, particularly in terms of emphasis on professional skill development and the provision of practical platforms, yet satisfaction with opportunities for internships at enterprises and institutions was relatively low. In terms of life support, students were more satisfied with financial support from the college and encouragement of interactions among students from different ethnic backgrounds, but felt that the college offered limited help in dealing with interpersonal and emotional issues. Regarding teacher support, while most students were satisfied, some felt the absence of targeted guidance for learning difficulties or believed that teachers lacked care and proper guidance. The frequency and depth of discussions between students and teachers on learning, life philosophies, career plans, and emotional and social issues were found to be lacking, indicating both strengths and weaknesses in the campus environment support and communication experience. Strengths were noted in their perception of the interpersonal environment, especially relationships with peers and involvement in student association.

In the realms of academic, life, and teacher support, most students felt satisfied, especially with career skills and professional capacity development, as well as the availability of practical platforms. However, the drawbacks of these experiences included limited communication with teachers, particularly in discussing course content, life values, career planning, and emotional and social issues. Furthermore, despite the overall high satisfaction with life support, students felt the assistance provided by the college in dealing with interpersonal and emotional issues was insufficient. These findings highlight areas for improvement in colleges, such as enhancing teacher-peer interaction, increasing internship opportunities, and providing greater support for students' emotional and interpersonal issues. Increasing the frequency and quality of interactions between teachers and peers, as well as strengthening support for students facing difficulties in life, may be key to enhancing the overall educational experience for students.

Group Characteristics of Students' College Experience

This study found significant differences in college experiences among students based on gender, grade, discipline type, political status, and student association participation, while the mode of admission, academic performance, and family structure did not show significant variance. Male students generally scored higher in their college experiences than female students. There were notable differences in the college experiences of students from different grades, particularly where freshmen and sophomores scored higher across multiple dimensions than juniors. Students specializing in sports reported higher college experience scores than those in academic disciplines. Students admitted through individual recruitment scored significantly higher in academic support and teacher interaction experiences compared to those admitted through general enrollment. Members of the Communist Party had higher experiences in teacher interaction and student association participation, than students with other political affiliations. Students who held positions in student organizations or sports teams scored higher across most dimensions than those who did not. Students with excellent grades had significantly higher scores in student association participation, than their lower-performing peers. These results reveal the diversity and complexity of college experiences among students, emphasizing the varied impact of educational experiences on students from different backgrounds.

Analysis of the Impact of College Students' Academic Experiences on Goal Management and Value Selection
Based on the regression analysis results, the seven independent variables collectively explain 51.4% of the variance in goal management. The ANOVA results show that the p-value for the F-test is less than 0.001, indicating a significant correlation between the selected independent variables and the dependent variable, with a good model fit. Specifically, students' perceptions of academic support, teacher support, interpersonal environment, experiences with peers, and participation in student organizations all have a significant positive impact on their goal management. Among the five significant standardized regression coefficients, the interpersonal environment has the largest absolute β coefficient, suggesting that this variable has the highest explanatory power for goal management. Thus, positive academic experiences can help college students clarify their career goals, and effectively plan for the short, medium, and long term, thereby promoting their overall development. This finding partially validates the model of factors influencing university student development, which posits that peer relationships, student-faculty interaction, and institutional conditions affect student development (Kuh, 2007).

The regression analysis results show that the p-value for the F-test is less than 0.001, indicating a good model fit. The seven independent variables collectively explain 50.5% of the variance in value selection. Among these, academic support, living support, interpersonal environment, and student organizational involvement have a significant positive impact on value selection. Among the five significant standardized regression coefficients, the interpersonal environment has the largest absolute β coefficient, indicating that this variable has the highest explanatory power for value selection. Hence, positive academic experiences can help university students form correct values and enhance their sense of social responsibility and commitment.

Discussion
Firstly, the overall characteristics of students' college experiences indicate a positive perception of campus environment support, but weaker in teacher-peer interaction experiences. This could be due to the education model in physical education institutions often emphasizing practical and skill training over traditional cultural or academic studies (Jiang & Gao, 2021), potentially leading to less interaction between teachers and students in traditional academic discourse, with a relative lack of in-depth exchanges on academic discussions, career planning, and personal development. Secondly, the study found that gender, discipline type, grade, political status, and student association participation significantly influence college experiences. Students specializing in sports, particularly males, tend to have higher scores in terms of college experience, reflecting their optimistic and outgoing personalities and strong capabilities for self-regulation (Oleg & Peter,2010).

Notably, differences in grade significantly affected students' college experiences, with freshmen and sophomores generally scoring higher than juniors, possibly related to their expectations and engagement levels with college life. The relative dip in juniors' experiences could reflect the confusion and adaptation challenges faced at this stage, while seniors' experience scores recover, likely due to clearer future plans and goals. Moreover, party members scored higher in certain dimensions of college experience, suggesting more involvement and positive interactions in campus life within these groups. Students who served as leaders or organizers in student associations also showed higher college experience scores, likely due to the leadership roles they played and enhanced social interactions boosting their campus experience.

Overall, these findings highlight the diversity and complexity of college experiences among students, identifying key factors affecting their educational experiences and offering insights for enhancing student satisfaction and educational quality. Specifically for students in sports disciplines, strengthening teacher-peer communication and understanding students' unique needs is particularly important.

Conclusion

The research indicates that Beijing Sport University students exhibit variances in their development across seven dimensions: perception of the interpersonal environment, life support, teacher support, academic support, student association participation, and interactions with peers and teachers, generally scoring at an above-average level. Factors such as gender, grade, discipline type, political affiliation, and organizational experience significantly influence students' college experiences. Based on these findings, the following recommendations are proposed: First, enhance teacher-student interaction and support by increasing the frequency and quality of interactions, creating platforms for exchange, fostering environments conducive to the development of teacher-student relationships, promoting undergraduate mentorship programs, and encouraging comprehensive guidance and support from teachers. Second, facilitate peer interaction by strengthening the construction of student associations, offering diverse opportunities for communication, and promoting positive interactions among students, thereby improving interpersonal skills and self-awareness. Third, pay attention to the differences in student development and provide personalized support. The college should offer targeted support and interventions based on students' gender, grade, and discipline, with special focus on female students, juniors, non-party member students, and those in academic disciplines, catering to their specific needs and challenges .Lastly, optimize physical education courses to promote physical and mental health by leveraging the advantages of sports institutions, enhancing physical education for academic discipline students, providing ample opportunities for physical activity, and fostering teamwork and social skills. These strategies aim to improve the overall educational experience and holistic development of students at Beijing Sport University, contributing valuable insights into the education quality assessment of physical education institutions.

Limitations

This empirical study, based on college student development theory, reveals the academic experiences of students at Beijing Sport University. However, there are several limitations that highlight areas for future in-depth research. This study surveyed cross-sectional data on the academic experiences of students at Beijing Sport University, reflecting their current experiences. However, student academic experiences are dynamic and evolving. Future research could conduct longitudinal studies to further explore the developmental trajectory of college students' academic experiences in sports institutions. This would allow for a more reliable analysis of academic experiences and broaden the scope of the research.

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CURRENT TRENDS AND INNOVATIONS IN KINESIOLOGY RESEARCH: PROCEEDINGS

RESEARCH METHODOLOGIES, DATA SCIENCE AND EMERGING RESEARCH METHODS

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ANALYZING AND PREDICTING CAREER TRAJECTORY OF MALE ELITE JUNIOR TENNIS PLAYERS: A MACHINE LEARNING APPROACH

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Abstract
This study explores the intricate dynamics of the Junior-to-Senior (JTS) transition phase in elite tennis. Focusing on challenges faced by young talents, the research aims to unveil factors influencing successful transitions and the role of elite junior tournaments. In a retrospective-predictive analysis, 240 male tennis players from national teams in the World Junior Tennis Finals (2012-2016) were studied. The cleaned dataset (n = 2847) underwent statistical analyses, including Chi-square tests, Cramer's V, Bayesian approaches, and Multinomial Logistic Regression (MLR). Artificial Intelligence (AI) models, using supervised learning classification, were applied. Results revealed 62.08% elite junior participants in the Association of Tennis Professionals (ATP) database, emphasizing the significance of team nominations and tournament results in predicting ATP status. Inferential and Bayesian statistics confirmed robustness, with MLR highlighting tournament results' importance. The most accurate AI model (2.1) achieved 84.5% testing accuracy and a 0.76 AUC, suggesting practical application. Findings underscore JTS complexities, emphasizing the pivotal roles of participation, national team nominations, and tournament results. The study recommends comprehensive player development programs, urging strategic team selections by national federations and academies. Coaches, stakeholders, and organizations should prioritize monitoring these variables for early talent identification and support. These measures collectively aim to optimize success trajectories, navigating the critical JTS phase in junior tennis players' sporting careers.

Keywords: *JTS, boys, senior, professional, sport, talent, Artificial Intelligence.*

Introduction
In not only tennis but also across all sports, there is an urgent need to scrutinize the transition from junior to professional categories for both genders and address issues such as Burnout, Transitions, or dual careers (Devine, 2022; Lambrich & Muehlbauer, 2022; Tessitore et al., 2021). Therefore, alongside monitoring performance characteristics, there is a growing focus on studies that delve into the junior-to-senior transition (JST), recognized as a pivotal phase in the development of young, promising, or elite athletes (Drew et al., 2019). This scrutiny allows for a better understanding, prediction, or reduction of Burnout or premature termination of a sports career before reaching peak performance, often associated with a disdain for physical activity as well (Alfermann, 2014; van Sluijs et al., 2021).

The JST phase is crucial in the development of young, promising, or elite athletes, signifying the shift from junior/youth age categories to the professional level (Røynesdal et al., 2018). Typically lasting between one and four years, this phase is characterized by non-linear processes, presenting a dynamic and complex developmental stage accompanied by sociocultural barriers and heightened expectations (Mills et al., 2012; Storm et al., 2012). Athletes navigate this transitional phase amidst elevated psychological stress, emotional, moral, and performance-related standards, making it the most challenging and critical period in their sporting careers (Røynesdal et al., 2018; Stambulova, 2017).

In tennis Artificial Intelligence (AI) techniques such as Machine Learning and Neural Networks enable us to handle large volumes of data (Kovalchik & Reid, 2017; Takahashi et al., 2022). By leveraging various AI methods and techniques, we can collect, analyse, evaluate, and predict game performance, strategies, and tactics (Cui et al., 2018, 2020; Damani et al., 2020; Kovalchik & Reid, 2017; Makino et al., 2020), either traditionally or in relation to performance over the years and the impact of age on player rankings (Grambow et al., 2020; Kim et al., 2015). Traditional statistical analysis, which often simplifies individual factors analysed separately to enhance interpretability and Power, tends to minimise the complexity of the phenomena observed, thereby missing many non-linear relationships (Family et al., 2014) characteristic of the JTS transition. Consequently, AI techniques (in combination with classical statistical methods) are suitable for uncovering hidden relationships, which, in the case of female tennis players and their JTS transition, has proven to be an appropriate approach warranting further exploration (Bozděch & Zháněl, 2023).

Therefore, the aim of this research was to investigate the complexities of the JTS transition in elite tennis, focusing on identifying key factors that influence successful transitions from elite junior to professional levels. The study seeks to assess the predictive value of participation in elite junior tournaments, particularly the World Junior Tennis Finals, on future professional status in the ATP. By employing advanced statistical analyses and AI models, the research intends to develop and validate models for predicting ATP status and career rankings.

Methods

Participants

Tennis players from national representative teams who advanced to The World Junior Tennis Final (WJTF) tournament between 2012 and 2016 were participants in this retrospective-predictive study. This time frame was intentionally selected to allow participants the opportunity to reach their peak performance age (around 24 years) during the data collection year (Allen & Hopkins, 2015). Subsequently, these materials were supplemented with information related to the sports career, acquired from the official publicly accessible Association of Tennis Professionals (ATP) website (https://www.atptour.com/en/). Specifically, players were individually searched and classified by ATP status in single; Not Found, registered without points, and Found (updated as of the last week of the 2022 season). Data were validated and cleaned of outliers. The research adhered to the principles outlined in the Declaration of Helsinki and received approval from the Masaryk University Research Ethics Committee (EVK-2021-006).

Statistical analysis

A priory to AI modelling initial statistical analysis included methods from inferential statistics (Chi-square; $\chi2$), effect size (Cramer's V), Bayesian statistics (BF), Regression analysis (Multinomial logistic regression, MLR). This provided a better insight into data and the issue before applying various ML algorithms. For all generated AI models, predictors and responses were categorical data. The dataset included a total of 2847 data points and was randomly split into training and testing data. For greater consistency and verification of identified trends, two licensed software packages were used: MATLAB (R2022a, with Deep Learning and Statistics and Machine Learning Toolboxes, Cross-Validation, folds 5; Training algorithm was Levenberg-Marquardt) and IBM SPSS (version 29.0.0). Only the most valid of the six different models from these programs are included in this study (Table 1). For each of these six models, 25 different types of models were generated, with only the best one selected based on training and testing accuracy. For the best-performing algorithm from these six models, it was further selected based on reliability results, ROC (Receiver operating characteristic), AUC (area under the ROC curve) value, and logically justifiable Importance input variables for fine-tuning hyperparameters and parameters. Network information and Synaptic weight estimation are available in Supplementary material 1 and 2 (Bozděch, 2024b, 2024a).

Results

Among the 240 participants in the elite junior tournament, 195 were identified in the official ATP database. However, 46 were merely registered and did not acquire any points, while 149 (62.08%) earned official ranking points. Of these 149 players, 64 (42.95%) achieved a position within the top 500 in their tennis careers, 40 (26.85%) achieved places in the 501-1000 rank, 29 (19.46%) achieved in the 1001-1500 rank category, and 16 (10.74%) attained rankings of 15001 and above. This suggests a negative association between player frequency and their best career rankings. In other words, participants in the elite tournament more frequently achieved higher career ranking. Upon a closer examination within 100-rank intervals, it was observed that the majority (n = 18) of elite tournament participants reached the 201-300 rank, constituting 7.50% of the entire research sample and 12.08% from those who earns enough ATP points for ranking.

The aforementioned insights facilitated an improved modeling process for advanced supervised machine learning methods. Algorithms were generated following predefined procedures for predetermined categorical predictors and response variables. For each of the six types of ML models, which were based on the response and predictor variables they encompass, 25 different algorithms suitable for categorical data were generated. Only the best-performing models are presented in Table 1. The model demonstrating the highest achieved validation, preferably in the testing phase, underwent additional fine-tuning.

Table 1. An Overview of Best Performing AI Models

No.	Response	Predictor	Classification		Validation (%)		AUC
			Model	Type	Training	Test	
[1]	ATP status (F/NF)	2 variables	NN	MLP	81.0%	82.0%	F = 0.52 NF = 0.52
[2]	ATP status (F/NF)	6 variables	NN	MLP	79.8%	84.4%	F = 0.75 NF = 0.75
[3]	ATP status (F/R/NF)	6 variables	NN	MLP	66.1%	65.3%	# = 0.71 0 = 0.59 NF = 0.74
[4]	ATP Rank (Pentacentile)	6 variables	SVM	Linear	46.7%	35.7%	Lowest (2) = 0.51 Highest (3) = 0.59
[5]	ATP Rank (Tricentile)	6 variables	Naïve Bayes	Gaussian	30.8%	33.3%	Lowest (4) = 0.36** Highest (5) = 0.73
[6]	ATP Rank (Hekatentile)	6 variables	KNN	Medium	15.0%	14.3%	Lowest (12) = 0.23* Highest (5) = 0.87

Note: Predictor (2 variables) = Nominations (ordinal), WJTF results (ordinal); Predictor (6 variables) = Year of the tournament (nominal), Nominations (ordinal), Continent (nominal), Birth quarter (nominal), Birth year (nominal), WJTF results (ordinal); F = Found at ATP; NF = Not Fount at ATP; * = unable ROC curve for 5 classes 7, 9, 10, 13, 19; ** = unable ROC curve for 1 class 7; # = tennis players who participated in the WJTF and were found in the ATP database with points earned; 0 = tennis players who participated in the WJTF and were only registered in the ATP database; Not found = tennis players who participated in the WJTF but were not found in the ATP database

Model 1, which included only relevant variables for predicting ATP status based on previous calculations, exhibited relatively satisfactory test validity values (82.0%). This can be considered a satisfactory result considering the number of different variables that could theoretically influence the chosen response. However, Model 1 achieved an unsatisfactory ROC test quality; F = 0.52, FN = 0.52. Although Model 2 included the same response (fount or not found at ATP database), the fact that it encompassed all 6 examined categorical variables as predictors (compared to Model 1, which included only 2) resulted in both higher test validity (84.4%) and, more importantly, satisfactory AUC levels (F = 0.75, NF = 0.75). Due to these attributes, this model was selected for the second phase of fine-tuning.

After fine-tuning various iterations of Model 2, the most successful version, Model 2.1, exhibited a training accuracy of 80.5% and a testing accuracy of 84.5%, along with a .756 AUC for both the Found and Not Found predicted categories. Model 2.1, the ultimate iteration, was a Multilayer Perceptron characterized by a two-hidden-layer architecture, Sigmoid activation function, Softmax Output layer, Online training type, and Gradient Descent as the optimization algorithm. This outcome was achieved by excluding the least significant predictor (Birth year). Among the generated models, this was the sole one demonstrating improvement in both the training and testing phases, as evidenced by the AUC results.

Discussion

This study emphasizes the formidable challenges inherent in the transition from elite junior tennis to ATP, particularly highlighting the pivotal JST phase. Findings underscore the importance of elite junior tournament participation, with an unexpectedly high percentage of players making it to the professional association. Nominations in team also play a significant role, as individuals with better nominations, although the national team was not successful in the tournament, exhibit a heightened likelihood of successful transitions to professional senior association. Inferential statistics (χ2, ES, BF) confirm these trends, but a divergence is noted in the case of MLR, where players with a worse team position, albeit negligibly, have a greater chance of entering the ATP.

A parallel study (Bozděch & Zháněl, 2023) focusing on elite junior female tennis players transitioning to the professional Women's Tennis Association (WTA) found that out of 240 participants, 58.75% gained points in the WTA ranking. This slightly lags behind the male counterpart (diff 3.33%), suggesting a stronger trend of JTS for male players. Both studies revealed a lower dropout rate (boys = 37.92%; girls = 41.25%) than reported by Franck et al. (2018); up to two-thirds (75%) dropout rate among junior athletes. Suggesting that participation in elite junior tournaments plays a crucial role in JTS transition. Further, study indicates that elite junior tournament participants commonly achieve rankings in the 201-300 range in their best career ATP ranking. This aligns with Balliauw et al. (2023) assertion that players ranked worse than the top 250 face financial challenges, making this a crucial professional threshold. Coaches, players, associations, and stakeholders should be aware of these findings for informed decision-making in players' career trajectories.

This study faces several limitations. The exclusive focus on male players from national teams introduces gender and selection bias, limiting generalizability. The retrospective design may lead to recall bias and hampers causal inference. Expanding the dataset to include a more diverse range of players and tournaments, and incorporating a broader set of variables, is essential for enhancing the explanatory power and applicability of the predictive models. Additionally, the models might omit crucial variables such as psychological resilience and socio-economic factors, affecting predictive accuracy. Technological constraints of AI models, coupled with the study's reliance on historical data from 2012-2016, further restrict the findings' applicability to current contexts. Lastly, while recommendations for monitoring and support strategies are provided, their practical effectiveness remains untested and requires further empirical validation.

Conclusion

This study delves into the challenges of transitioning from elite junior to professional tennis, emphasizing non-linear processes within the JTS Transition. Key findings underscore the predictive power of participating in the Elite Junior Tennis Tournament, revealing that 62.08% of 240 elite junior participants progressed to actively participate in the ATP. Team nomination at the elite junior tournament, and particularly tournament results, emerge as crucial predictors for future professional status.

The study introduces AI models to automate ATP status prediction, with the latest version (Model 2.1) demonstrating an 84.5% testing accuracy. While a valid model for overall ATP status prediction is achieved, generating a credible model for detailed career ranking analysis proves challenging due to the JTS complexity and susceptibility to Type I error. Expanding the number and type of variables in this model is advisable for enhanced explanatory value.

In conclusion, coaches, scouts, and tennis organizations should prioritize monitoring elite junior tournament results for early talent identification. Incorporating advanced machine learning models, especially those with multiple categorical variables, proves effective in predicting JTS transition results. To support athletes during the challenging JST phase, establishing a robust longitudinal monitoring system is recommended. Collaborative efforts among tennis organizations, coaches, stakeholders, and sports scientists can facilitate tracking players' progress for timely interventions and support. Additionally, implementing educational programs addressing unique stressors and challenges associated with JST is crucial.

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PERFORMANCE ANALYSIS IN HIGH LEVEL VOLLEYBALL: PROBLEM OF DEFINING THE SET SCORE

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Abstract
In performance analysis in volleyball the set score is defined in various manners, e.g. victory / defeat, a point difference etc. The purpose of this study was to introduce the relative point difference as a more appropriate variation of defining the set score in volleyball. For this purpose, 40 volleyball sets were randomly selected (Men's European Volleyball League, 2011 and 2012). The predictor variables were efficiency coefficients of the serve, reception, spike, block and dig. A criterion variable was the set score. The set score was defined in four different ways, relative point difference, the point difference, the category according to the range of point difference, and victory / defeat. Four multiple linear regression analyses were conducted to determine the relationship between the efficiency coefficients of the volleyball game phases and the set score, one for each manner of defining the set score. The results showed that victory / defeat was the variation with the lowest amount of explained variance of the set score, only 47.5%. Next was the category with 69.0%, then the point difference with 70.7%. The relative point difference was the variation of the set score that had the highest amount of common variance with the efficiency of the game phases, 75.2%. Relative point difference differentiates the sets with the two point difference but different total numbers of rallies played in a set. The set score that is not adequately defined could enable the determination of the existing phenomenon.

Keywords: *volleyball, performance analysis, multiple linear regression, set score*

Introduction
A performance indicator in sport is a selection, or combination, of action variables that aims to define some or all aspects of a performance (Hughes, 2004). A selection of performance indicators has its specificities according to the sport and the aim of the analysis. It is generally known that every element of the game, if performed excellently, has a positive impact on the final score. The extent of impact on the score of one performance indicator is less obvious when multiple performance indicators are considered.

Multiple regression analysis is a set of statistical processes for estimating the relationship between a dependent variable (criterion) and independent variables (predictors). It's often used in performance analysis in volleyball to determine various relationships between the performance indicators and their predictive potential. The match score in general is used as a criterion to predict impact of observed elements. But in previous research, the match score had many variants when used as the criterion, according to the scoring system.

According to the volleyball scoring system, authors often use victory / defeat of the set or the match as the criterion (Monteiro et al, 2009; Pena et al, 2013; Silva et al, 2016). Final team rank in a competition is used to define one final outcome in a series of matches of one team. Drikos, et al. (2019) divided 12 ranks into 6 groups of 2 ranks as a criterion. In another study, Drikos, et al. (2021) divided 24 ranks into 3 groups of 6 ranks.

Some researchers conduct a discriminant analysis to determine differences between winning and losing teams (Marelić et al, 2004; Drikos et al, 2020). In this manner, when only two groups are observed, they actually determine a relationship between predictors and a dichotomously defined criterion similar to regression analysis (Morris & Huberty, 1988). Score difference in a set was rarely used as a criterion unlike victory / defeat. Grgantov, et al. (2005) used a score difference in a beach volleyball set as the criterion to determine a relationship with efficiency coefficients of game phases. Garcia-de-Alcaraz, et al. (2019) used total number of points (per match or per set) and average point difference (of all sets in a match) as two variables (not criterion) in analysis of variance.

The authors of this study consider that the same point difference in a set does not represent the same outcome when the set score is 13:15, 23:25 or 29:31. For that reason, the set score was defined as a relative point difference. No previous research considered the set score as a relative point difference. The aim of this study was to determine the relationship between situational efficiency of volleyball game phases and the set score defined in four different manners, victory/defeat, category according to the range of point difference, the point difference and the relative point difference.

Methods

Set of entities

The set of entities were 40 randomly selected volleyball sets from matches played in the Men's European Volleyball League in 2011 and 2012. In order to avoid the dependence of the entities, only the data from one set of a match and only one team were selected.

Set of variables

The predictor variables were the efficiency coefficients of five phases of the volleyball game: the serve, reception, spike, block, and dig. The efficiency coefficient was defined as the arithmetic mean of scores of all performed technical skills within a particular phase in one set. Each performed skill was evaluated with a score 1 – 4. The score 1 was an error, 2 was an advantage for the opponent, 3 was an advantage for the team being evaluated, and 4 was an ideal performance (reception, dig) or a point won (serve, spike, block). The criterion variables were the set score defined in for different manners, victory/defeat, the category according to the range of point difference, point difference and the relative point difference. Victory/defeat is a binomial variable (0/1) according to the set outcome. Category was a variable of 6 different categories according to the point difference in the set, 1 (2 - 4 points), 2 (5 – 7 points) and 3 (8 and more points). A point difference variable was the point difference in the set. A relative point difference was the total point difference in the set divided by the total number of points (rallies) in the set. If the evaluated team won the set, the result in category, point difference and relative point difference was positive and conversely, if they lost the set, it was negative.

The data were obtained from the existing videos of volleyball matches. It was done by the first author. The reliability analysis was conducted with the help of an expert with multiannual playing, coaching and notational analysis work experience.

Statistical analysis

A reliability analysis was conducted on a sample of 3 randomly selected sets. Spearman's rank correlation determined the degree of agreement between the two different measurements (the first author and the expert) and two different measurements of the same measurer (the first author) at intervals of 4 – 6 weeks (test-retest method). Four separate multiple regression analyses were conducted to determine the relationship between the efficiency coefficients of the five phases of the volleyball game and the four various manners of defining the set score. Statistically insignificant predictors were gradually excluded (backward selection) from the initial regression models and only significant predictors remained in each model. The collected data were analyzed with the computer program Statistica for Windows 13.3 (TIBCO Software Inc.).

Results

Reliability analysis results indicated a high correlation between the two measurements of the same measurer conducted at two-time points ($R = 0.91$, $p < 0.05$) and the two different measurers ($R = 0.92$, $p < 0.05$).

A change in distribution of values is presented when a point difference is divided with the total number of points.

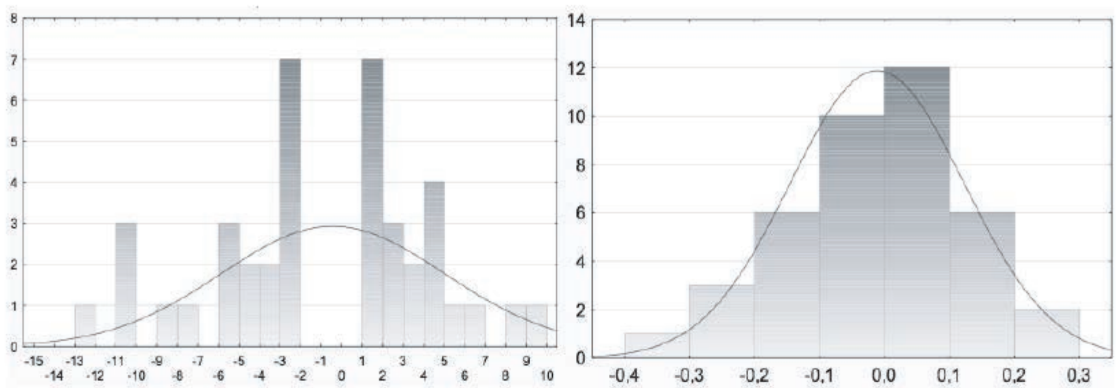

Figure 1. Histogram of the point difference (left) and the relative point difference (right).

Four separate multiple regression analyses were conducted to determine the relationship between the efficiency coefficients of the five phases of the volleyball game and the four various manners of defining the set score.

Table 1. Results of the four separate regression analyses.

	Rel. score difference		Score difference		Category		Victory/defeat	
R	0.87		0.84		0.83		0.69	
R^2 (%)	75.2		70.7		69.0		47.5	
$R2_{adj}$ (%)	72.4		67.4		65.5		43.1	
F	26.3		20.2		17.5		9.4	
p	<0.01		<0.01		<0.01		<0.01	
	β	$R^2_{part.}$	β	$R^2_{part.}$	β	$R^2_{part.}$	β	$R^2_{part.}$
EC – serve	0.38	18.2 **	0.38	18.2 **	0.38	18.2 **	0.38	18.2 **
EC – reception	0.26	11.4 **	0.26	11.4 **	0.26	11.4 **	0.26	11.4 **
EC – spike	0.52	35.4 **	0.52	35.4 **	0.52	35.4 **	0.52	35.4 **
EC – block	/	/	/	/	/	/	/	/
EC – dig	0.32	10.6 **	0.32	10.6 **	0.32	10.6 **	0.32	10.6 **

EC: efficiency coefficient, R: coefficient of multiple correlation, R2: coefficient of determination, R2: adjusted coefficient of determination, F: F-test value, β: standardized regression coefficient, R2part: coefficient of partial determination (%), /: variable removed from the model; *: $p < 0.05$; **: $p < 0.01$

Results of four separate regression analyses showed that the efficiency coefficients explained the most variance of the set score when defined as the relative point difference ($R2 = 75.2$, $p < 0.01$).

Discussion

The methodological approach with defining the set score as the relative point difference was assumed to be the most appropriate according to the aim. Four multiple regression analyses determined a statistically significant relationship between the efficiency coefficients of volleyball game phases and the set score defined in all four manners. But not all five game phases were significantly related to the set score. The relationship of the block and the set score was too low and was removed from all four models. Efficiency coefficients of remaining phases, serve, reception, spike and dig explained 75.2% ($p < 0.01$) of variance of the relative point difference. The amount of the explained variance of the set score was lower when it was defined in other three manners, 70.7% ($p < 0.01$) when defined as a score difference, 69.0 % ($p < 0.01$) as categories and 47.5% ($p < 0.01$) when victory / defeat. When the set score was defined as victory/defeat the reception was also statistically insignificant and was removed from the model. Not many studies are suitable for comparison of the results because of the applied methodology. Grgantov, et al (2005) in their study in beach volleyball also selected the same game phases' efficiency coefficients as predictors but the criterion was the point difference in a set. They determined 72% ($p < 0.01$) of common variance between the efficiency coefficients and the set score.

Multiple regression analysis is an analysis that determines the relationship between the predictors and the criterion (Field, 2009). The relationship is determined if there is an existence of the systematic variation between the predictor and the criterion. So if there is variation in one variable but not the other, the relationship between them is assumed to be lower. But it isn't necessarily the case. If the variable is defined in a manner that doesn't differentiate the entities sufficiently, the existing relationship will not be determined. The set score defined as a victory / defeat is a dichotomous variable, it has only two values. By separating a continuous variable by the median into two categorical variables, significant information is lost and a probability of proving the effect when it exists is reduced (Aiken & West, 1991). That is the reason why the common variance between game phases and victory / defeat was the lowest of all four manners. The set score defined as the category in this study had 6 different values so it differentiates the sets better than victory / defeat. Furthermore, the set score defined as a score difference has 48 theoretical values. From minimal difference of 2 points to maximum difference of 25 points multiplied by two for possible positive and negative value. In this study the score difference had 16 different values ranging from -12 to 10 points. But 7 volleyball sets had the value -2 and another 7 sets had the value 2, meaning there was no variation within each group of 7 sets (Figure 1). Other 26 sets had 14 different values.

When the score difference is divided with the total number of points the variation between the sets was higher. The score difference of -2 and 2 transformed into four different values each so the total number of values increased from 16 to 24. The number of sets with the same value decreased from 7 to 4. Also the normality was improved ($p = 0.26$; $p = 0.51$). The consequence was that the amount of variance of the score increased from 70.7% ($p < 0.01$) to 75.2% ($p < 0.01$).

Furthermore, when the variation between the sets was insufficient, another incidence occurred (Table 1). The relationship between efficiency coefficients of spike and the score was lower. The partial coefficient of determination was 16.1% ($p < 0.01$) compared to 35.4% ($p < 0.01$) (the relative point difference). When the set score was victory / defeat the relationship of efficiency coefficient of reception was statistically insignificant and had to be removed from the model. According to that model, neither the reception nor the block had a significant relationship with the set score. Shares of each game phase's impact on the score were very different according to the victory / defeat model. Serve had the highest impact on the score (20.2%, $p < 0.01$). In the model with the relative point difference as the criterion, spike had almost two times higher impact on the score than the serve. And spike is known to be the phase with the highest impact on the victory in a volleyball match (Drikos et al, 2019; Drikos et al, 2020; Drikos et al, 2021; Marelic et al, 2004; Monteiro et al, 2009; Yu et al, 2018). This methodological approach presents that inadequately defined set score with insufficient variation between the sets could enable the determination of the phenomenon that actually exists.

Conclusion

The relative point difference as a set score is a methodological solution to achieve higher variation between the volleyball sets in high level volleyball. That enables the determination of a higher impact of the game phases' performance on the score. The results of this study show that the dichotomous variable victory/defeat is the least adequate manner of defining the set score in volleyball. If possible, the score should be defined in a manner that enables distinction between the entities. The relative point difference is determined as a set score that determines the highest variance between volleyball sets.

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RELIABILITY AND VALIDITY OF THE EASYFORCE DYNAMOMETER FOR ASSESSING MAXIMAL HIP MUSCLE STRENGTH IN YOUTH FOOTBALL PLAYERS

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Abstract
This study evaluates the reliability and validity of the EasyForce digital dynamometer for assessing maximal isometric strength in hip muscles. The sample consisted of 109 male youth athletes (mean age: 16.33±1.87 years) from Croatian football clubs. Measurements of quadriceps and hamstring muscles isometric strength were taken using the EasyForce dynamometer, following the manufacturer's recommendations. Three trials for each muscle group were recorded, with participants performing maximal isometric contractions. The study demonstrated high reliability, with intraclass correlation coefficients (ICC) indicating excellent reliability for quadriceps muscles (0.935-0.939) and good reliability for hamstrings (0.840-0.876). Validity was established by significant differences in strength between dominant and non-dominant leg muscles, confirmed through single-sample t-tests ($p<0.001$ for both quadriceps and hamstrings). These findings align with previous research on belt-stabilized hand-held dynamometers. The EasyForce dynamometer's high reliability and validity make it a practical tool for sports performance assessment and rehabilitation, suitable for field testing and clinical environments. However, the study's limitation includes a 45-second rest interval between trials, potentially insufficient for complete muscle recovery. Future research should explore longer rest intervals and include diverse populations to enhance generalizability.

Keywords: *isometric strength, handheld dynamometer, dominant and non-dominant leg*

Introduction

Muscle strength in both sport performance and rehabilitation is commonly a major point of interest for sport scientists and coaches since it has direct impact on performance. Both isometric and isokinetic strength levels can determine the performance output or successfully applied rehabilitation protocol. Isokinetic dynamometers are considered gold standard for assessing muscle strength (Dvir & Müller, 2020; Stark et al., 2011). Hand-held dynamometry (HHD) is a viable alternative that provides reasonably reliable and valid measurements of muscle strength (Chamorro et al., 2017; González-Rosalén et al., 2021; Schrama et al., 2014). Even more so, other studies showed that HHD stabilized with a belt offer great to excellent reliability and usability (Pinto-Ramos et al., 2022; Florencioet et al., 2019; Sung et al., 2019). HHD stabilized with the belt demonstrated better reliability especially on the larger muscle groups where the force of the participant might be too high for an examiner to hold which could potentially lead to incongruent and inaccurate results. Also, the forces demonstrated using the belt stabilised HHD were significantly higher than forces demonstrated with HHD (Bohannon et al. 2012). EasyForce is a new and effective tool for the measurement of muscle force production specifically designed for belt-stabilized HHD (Trajković et al., 2022). The EasyForce dynamometer can be considered a reliable tool for assessing shoulder IR and abduction, knee extension and flexion, as well as hip abduction and adduction strength (Trajković et al., 2022; Kosinc et al., 2021). Objectives of the study are: To evaluate the reliability of the EasyForce hand dynamometer by conducting repeated measurements with a single rater; To assess the validity of the EasyForce hand dynamometer by testing the difference in strength between the muscle groups of the dominant and non-dominant leg, demonstrating the instrument's ability to distinguish strength between it.

Methods

The sample was composed of 109 male youth athletes (age: 16.33±1.87) from Croatian football clubs that have been competing in 1st division of national championship. Twenty two players had a left leg as a dominant leg and 87 of them had right leg as dominant leg. To be included in the study the athletes had to meet the following criteria: 1) no history of unresolved pain or severe trauma in either knee hip or ankle; 2) no reported injuries in the period of last 6 months or more from the date of testing procedure; 3) period of practice more than five years so the adaptations caused by the training stimulus were presented. All athletes received information and clarification of the testing and signed consent form where all the stated conditions were noted. Parents or legal guardians signed the informed consent for participants under the age of 18. The Ethical Board of the University of Split, Faculty of Kinesiology, Split, Croatia, approved the study (Ref. no:2181-205-02-05-22-001, Date of approval: 05/01/2022).

Measurements of quadriceps and hamstrings muscles isometric strength levels were taken with the EasyForce dynamometer and have been conducted according to the manufacturer's recommendations. All measurements were taken by two examiners with a background in muscle testing who were familiarized with the device and the procedures before measurements. Three trials of each motion were recorded. The examiner gave verbal instructions, demonstrated the test and set each participant in an appropriate position.

The testing procedure was initiated by the patient medical screening and assessment of physical features followed by the predetermined 15-minute warm up. The warm up consisted of dynamic leg swings, skipping and running followed by bodyweight exercises for the core and lower extremities (squats, lunges, front and side planks). Following the warm up procedure subjects received information about the testing protocol and was given a warm up trial at submaximal intensity to familiarize themselves with the task prior to executing at maximal intensity. The participant executed three maximal isometric contractions with the rest of 45 seconds between the attempts. Maximal force produced in each of the attempts was noted. During the measurement the instruction was to gradually build up force in the muscle to highest possible and sustain it for 3 seconds.

Quadriceps testing procedure was conducted by the participants sitting on a physiotherapy table 90 cm high and the testing device was connected to both an unmovable object and the patient's ankle using the strap band. Additional straps were tightened between the lower part of the trunk and thigh to stabilize and allow maximal isometric contraction without movement of other parts of the body. The hip and knee were positioned at the 90° degree angle and the patient was allowed to hold on the edge of the table to stabilize the body. The subject executed three maximal isometric contractions with the rest of 45 seconds between the attempts. Maximal force produced in each of the attempts was noted in Newtons.

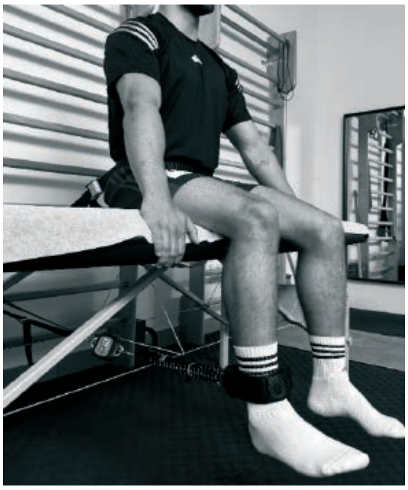


Figure 1. Quadriceps testing set up

Hamstring isometric testing protocol was initiated by the participant sitting on the bench 60 cm high. The device was connected using the strap bands to the unmovable object in front and the ankle of the subject. The hip and knee were positioned in the 90° angle and the patient was allowed to hold on the edge of the bench to stabilize the body. The subject executed three maximal isometric contractions with the rest of 45 seconds between the attempts. Maximal force produced in each of the attempts was noted in Newtons.

Figure 2. Hamstring testing set up

Intraclass correlation coefficient (ICC (3,1)). The ICC values were interpreted according to the classification of Koo and Li (2016), ICC < 0.50 = poor, 0.50–0.75 = moderate, 0.75–0.90 = good, and 0.90 –1.00 = excellent. A 95% confidence interval was calculated for the true difference to check if there were any systematic differences between the measurements (Bruton, et al., 2000). Descriptive statistics and single sample t-test was performed to determinate differences between muscle strength of dominant and non-dominant leg. All data were analyzed by IBM SPSS version 23.

Results

Descriptive statistics of all measured variables are presented in Table 1. The first thing what can be noticed is that quadriceps muscle isometric strength is two times higher than the hamstrings muscle isometric strength. The range of isometric peak strength of quadriceps muscle is from 608.71 N to 666.45 N, while the peak strength of hamstrings muscles is from 309.79 N to 344.83 N. Also it is evident that we have slightly decreasing of the isometric strength in second and third attempt in both tested muscles.

Table 1. Descriptive statistics with number of cases (n=109), arithmetic mean (Mean) and Standard deviation (SD) for left(L) and right (R) leg muscle

Variables	$Mean_L$	SD	$Mean_R$	SD_R	Variables	$Mean_L$	SD	$Mean_R$	SD_R
QUAD_1	621.96	127.54	666.45	133.19	HAMS_1	313.47	60.21	344.83	63.24
QUAD_2	618.81	122.00	648.61	124.48	HAMS_2	313.95	64.18	335.50	62.54
QUAD_3	608.71	115.97	629.08	117.54	HAMS_3	309.79	60.28	324.95	59.84

Reliability of measurement procedure with digital dynamometer was described in Table 2. Same evaluator tested all three repeated measures. Reliability coefficient ICC (3,1) was established. According to the Koo & Li (2016) ICC(3,1) of quadriceps muscle repeated measures is excellent (0.935-0.939), while for hamstring muscles repeated measures ICC(3,1) is good quality (0.840-0.876). The inter-item correlations show that the first and third items had a smaller correlation coefficient compared to the coefficient between the first and second repeated measures. This pattern was observed consistently across all tested muscle groups.

Table 2. Reliability – intraclass correlation coefficient (ICC) of three measurements of each variable (quadriceps left and right, hamstrings muscles left and right)

Variables	QUAD_L_1	QUAD_L_2	QUAD_L_3	ICC (3,1)	Variables	QUAD_R	QUAD_R_2	QUAD_R_3	ICC (3,1)
QUAD_L_1	1.000	.953	.923		QUAD_R_1	_1	.947	.911	
QUAD_L_2		1.000	.948		QUAD_R_2	1.000	1.000	.958	
QUAD_L_3			1.000	.939	QUAD_R_3			1.000	.935

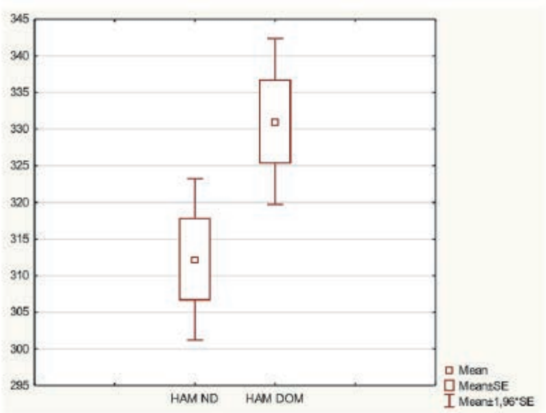
Variables	HAMS_L_1	HAMS_L_2	HAMS_L_3	ICC (3.1)	Variables	HAMS_R	HAMS_R_2	HAMS_R_3	ICC (3.1)
HAMS_L_1	1.000	.832	.781		HAMS_R_1	_1	.901	.846	
HAMS_L_2		1.000	.906		HAMS_R_2	1.000	1.000	.883	
HAMS_L_3			1.000	.840	HAMS_R_3			1.000	.876

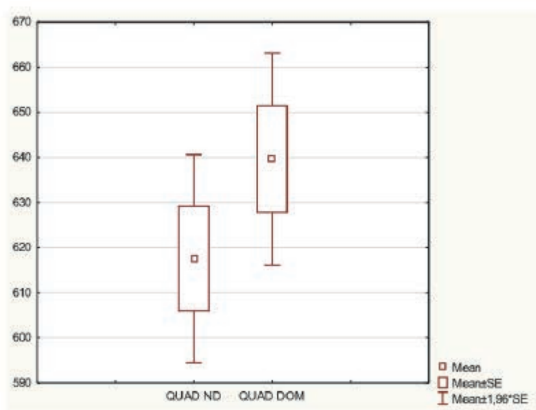
Differences in the strength of the same muscle on the dominant and non-dominant legs can indicate the validity of the EasyForce digital dynamometer. Every force measurement device should be able to distinguish the difference between the strength of the dominant and non-dominant leg. The validity of the EasyForce device is shown in Figures 3. A T-test for a single sample established a significant difference between the strength of the quadriceps muscle ($p < 0.001$) and the hamstrings muscle ($p < 0.001$) on the dominant and non-dominant legs.

Discussion

The primary hypothesis of this study was that the EasyForce hand dynamometer would demonstrate both high reliability and validity in assessing maximal hip muscle strength. The results of this study confirmed this hypothesis. The reliability of the EasyForce hand dynamometer was established through repeated measurements by a single rater, with intraclass correlation coefficient (ICC) values indicating excellent reliability for quadriceps muscle testing (0.935-0.939) and good reliability for hamstring muscles (0.840-0.876). These findings are consistent with previous studies that have shown high reliability for belt-stabilized hand-held dynamometers (Pinto-Ramos et al., 2022; Florencio et al., 2019; Sung et al., 2019). In terms of validity, the EasyForce dynamometer successfully distinguished between the strength of the dominant and non-dominatn leg muscle groups, with significant differences noted in both quadriceps and hamstring muscles ($p<0.001$). This finding supports the instrument's ability to differentiate between varying muscle strengths, further corroborating its validity. These results are in line with prior research indicating the effectiveness of hand-held dynamometers in measuring muscle strength accurately (Chamorro et al., 2017; Wang et al., 2021). The differences observed between our results and those of other studies may be attributed to variations in the testing protocols, sample characteristics, and specific dynamometers used. For instance, some studies used different warm-up protocols or rest intervals, which could affect the maximal force output. The EasyForce hand dynamometer is a practical tool for both sports performance assessment and rehabilitation settings. Its portability and ease of use make it suitable for field testing and clinical environments where quick and reliable muscle strength assessments are needed. The high reliability and validity of the EasyForce hand dynamometer suggest that it can be confidently used by practitioners to monitor muscle strength, track rehabilitation progress, and make informed decisions regarding training and treatment plans. One limitation of this study is the 45-second rest interval between trials, which may not have been sufficient for complete muscle recovery. Future studies should consider longer rest intervals to mitigate the potential effects of muscle fatigue. Additionally, the study sample was limited to male youth athletes, which may affect the generalizability of the results to other populations.

Figures 3. Validity (Box Plot) of differences between muscle strength (N) of dominant (DOM) and non-dominant (ND) leg: hamstrings (HAM) and quadriceps muscle group (QUAD).





Conclusion

In conclusion, the EasyForce hand dynamometer demonstrates high reliability and validity for assessing maximal hip muscle strength. Its ability to differentiate between the strength of the left and right leg muscles further supports its use as a reliable tool in both sports and rehabilitation contexts. The findings of this study contribute to the growing body of evidence supporting the use of hand-held dynamometers in muscle strength assessment.

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CURRENT TRENDS AND INNOVATIONS IN KINESIOLOGY RESEARCH: PROCEEDINGS

SOCIAL SCIENCES AND HUMANITIES

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THE POSITION OF FEMALE ATHLETES IN CROATIAN SOCIETY: WHEN WOMEN'S SPORT "SUFFERS"

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Abstract
Given the deeply rooted patriarchal culture in Croatian society, gender inequality is also assumed to be ingrained in the field of sports. To determine the experiences and attitudes of students at the Faculty of Kinesiology in Zagreb regarding gender (in)equality in sports in Croatian society, 20 semi-structured in-depth interviews were conducted. A thematic analysis of participants' statements determined that Croatian society exclusively highlights and values top results in sport and that gender stereotypes are present in attitudes towards women in sport; this results in the significant subordination of women in sport at all levels, as well as an unawareness of the need to promote the development of women's sport.

Keywords: *Croatian society, gender equality in sport, women in sport*

Introduction
In contemporary society, sports are traditionally considered part of the male domain; most sports are typified as male, while only a few belong to the female domain (Chınurum et al., 2014; Plaza et al., 2017). This division between "male" and "female" sports is a result of stereotypical perceptions of gender roles. Despite efforts to ensure equality in sports, there are still significant differences in the approach to activities that are traditionally gender-typed. Women are considered the 'weaker sex'—physically, mentally, and emotionally. They are expected to be feminine and not to display characteristics defined as masculine. When women 'cross the line' and show 'masculine traits', their gender identity, sexual orientation, values, and social roles are often questioned (Constantinou et al., 2009).

Women are increasingly participating in and trying their hand at 'male' sports in order to integrate with and adapt to the norms and values that dominate these sports; meanwhile, male interest in typically 'female' sports is negligible (Pfister, 2011). The aim of this study is to determine the experiences and attitudes of participants regarding gender equality in sports within Croatian society. In the field of sports, equality primarily refers to establishing equal opportunities and access to resources for both men and women, regardless of who is 'faster, taller, stronger,' or who achieves better results (Antekolović, 2023).

Methods
During June 2022, 20 semi-structured in-depth interviews were conducted with second- and third-year students of the Faculty of Kinesiology in Zagreb. The resulting data describing the participants' experiences with and attitudes toward the role of sports and the position of female athletes in Croatian society were analysed. The interviews were conducted by the research author at the Faculty of Kinesiology in Zagreb, using the face-to-face method; they ranged in duration from 14 to 36 minutes. The interviews were transcribed verbatim and then coded using the MAXQDA2022 qualitative data analysis software. The thematic analysis method was used to code and interpret the participants' statements.

Sport in Croatian society
The research participants recognise that "... sport has an influence on society" (LPN: 11) and plays an important role in the health of the population, as participation in sports and an active lifestyle provide a range of positive effects on individual health and "*helps us develop society*" (PAN: 12).

Sport and physical activity are essential for human and societal development as they permeate all aspects of life, affect physical and mental well-being, and improve quality of life. Child and youth participation in sports activities lays the foundation for physical and mental health in adulthood. Interviewee BCRG:12 particularly emphasises the importance of sports "in the upbringing of children when they watch some of their idols". As idols, athletes serve as a motivating example by which children decide to take part in sports, as interviewee PJRG:11 states: "many people have idols in sports to look up to, not only in sports, but also in how to live life and think, they draw inspiration from that. I think those 'athletes' from any sport are quite respectable and encourage young people to take part in sports."

Despite the numerous benefits of sport that the interviewees recognise, they still believe that sport and athletes are not adequately appreciated in Croatian society, that knowledge about sport is very superficial, and that the absence of top results leads to the public rejection and mockery of athletes. Traditionally, sport is seen in the context of competition aimed at achieving the best possible result. In society, sport is considered a means of affirmation and validation:

"*I think society mostly looks only at success, how good you are (...). Somehow, they don't understand that you can't be on the same level every year, in the same form, and there are injuries, there are psychological issues, things that happen in the lives of these athletes. And the change of generations has a big impact... how the team gets along, the atmosphere in sports*." (AIN: 19)

Sport and women in sport

Research shows that Croatian society is still patriarchal in many dimensions of gender relations on all levels (Tomić-Koludrović & Kunac, 2000; Topolčić, 2001). Galić (2004, 2012) also emphasises that sexism is particularly common in Croatia among the older population, those with lower levels of education, and men, among whom patriarchal, non-sexist models of thinking and prejudices about gender identity and gender groups still dominate. Changes are evident among young people who increasingly support egalitarian partner relationships and the division of labour within the family (Galić, 2012; Klasnić, 2017).

Sport reflects society; in patriarchal societies, the assumption has always been that the primary role of women is to be mothers, and all other relationships are measured against this role (Galić, 2006). We may thus assume that discrimination against women exists in Croatia in the field of sports. A European Commission report (2022) confirms that Croatia is below the European Union average in almost all parameters regarding frequency of exercise or participation in sports. Women are significantly less active than men in all age groups. The difference between men and women is especially apparent in the 15-24 age group, where 19% of men report "never or rarely" exercising or participating in sports as compared to 54% of women. This indicates that women are systemically insufficiently encouraged to engage in physical activities; the responsibility for this lies with family upbringing and habits, the education system, and the functioning of Croatian society, where women are not perceived as equal actors in the field of sports (Ombudsperson for Gender Equality, 2023).

Although studies in Croatia addressing gender (in)equality, discrimination, and sexism in sports are rare, the underrepresentation of women is clearly evident at all levels: women are underrepresented in media coverage of women's sports; fewer women hold leadership positions within sports organisations; fewer women participate in sports activities, and their conditions for participating are poorer; female athletes have lower earnings and receive less value in compensation and rewards; additionally, they are at risk of exposure to sexism or gender-based violence, including sexual harassment (Agency for Electronic Media, 2019; ALL IN, 2019; European Commission, 2022; Greblo Jurakić et al., 2021, 2022).

Our interviewees note the subordination of female athletes on multiple levels. They believe that male athletes are more greatly valued, receive higher compensation than female athletes, and have more media exposure; they also believe that their sporting achievements are not equally valued, that male athletes have better training conditions, and that women are not sufficiently represented in leading positions in clubs and associations. Thus, the interviewees say: "Men are more appreciated" (MMN: 23), "No one talks about women's sports at all" (MPRG: 28), "*In Croatia, people talk more about a man bringing home a trophy than a woman*" (LKNRG: 25).

A participant with experience working in a women's handball club encounters unequal treatment between male and female clubs on a daily basis: "*When something is important for male clubs, everything gets done for them, while women's sports suffer... If they were given support, they wouldn't have to work in addition to studying and training. If they were financially supported by the club, association, or city, if they had scholarships... most of the players in the first league are high school students or university students. Here, a few girls work, so they rush from work to matches and training*" (MPRG: 25: 27).

Despite the changes that are occurring, sport largely retains and continues its conservative role in gender relations (Messner, 2002). The representation of women in higher coaching, refereeing, and managerial positions in sports organizations is extremely rare. Women employed in positions such as sports directors or head coaches raise suspicions about how they came to their positions of power and how they might use that power, as noted by our interviewees: "*Usually, women in clubs are like secretaries, and mostly the top positions are held by men" (FMN: 29). On the other hand, if women try to alleviate suspicions by "fitting in*" with the system or behaving like men, they are seen as manipulative and undeserving of the positions they hold. This seriously hinders women's careers both in coaching and in administration (Coakley, 2021).

Men hold leading positions in Croatian sports. In Olympic sports, four sports organisations have female presidents (11%) and one female vice president (2%). A total of 11% of national sports federations of Olympic sports in Croatia have female presidents, 13% have elite sport coaches who are women, while 22% have recreational sports coaches who are women (ALL IN, 2019).

The successes of female athletes are often neglected or subordinated to the achievements of their male counterparts (Fink, 2015; Greblo Jurakić et al., 2021). Compared to female athletes, male athletes receive higher cash rewards at sports competitions, in addition to having higher salaries and more lucrative contracts with sponsors (Flake et al., 2012; Wicker et al., 2021).

"*It's terrible for women. (...) My XY achieved huge results, she gets the bare minimum of everything, while in the meantime her male colleague got a flat from the government. It has absolutely nothing to do with the results being different because they're almost identical, but if it's a man they'll say 'Well done, congratulations', or whatever, but if it's a woman, they say 'Oh bravo, you managed it!' As if it were miracle that she succeeded? It's terrible!*" (VDRG: 24)

The interviewee, a former athlete, strongly wants the female voice to be heard and the needs of all stakeholders in sports to be equalised: "*We're not asking to be treated with kid gloves... just – we're here, we're the same as you, we're here!*" (SRG: 10). Such responses are a clear indication of gender inequality in Croatian sport. Prejudices and stereotypes about women in sport are still widespread, and women visibly struggle to progress in all traditionally "male" areas of work and public life (Antekolović, 2023). Only gradual, continuous, diligent work can lead to the deconstruction of entrenched gender stereotypes in sports and change the perception of the role of women in sports (Ombudsperson for Gender Equality, 2023). It is of paramount importance to develop social awareness about providing equal support, access to resources, and opportunities for competition and professional development for all stakeholders. The development of modern society is possible through the establishment of gender equality in society and sport.

Conclusion

The aim of this study was to understand the experiences and attitudes of interviewees regarding gender (in)equality in sport in Croatian society. To achieve this goal, 20 students from the Faculty of Kinesiology in Zagreb were interviewed. A thematic analysis of the interviewees' statements resulted in two main themes: Sport in Croatian Society and Women in Sport.
The interviewees observe that sport is an "integral part of society" and that "sport influences society" to achieve a healthier nation. As students of kinesiology, they are aware of the positive effects of sports and an active lifestyle on physical and mental health. Similarly, they believe that athletes can significantly influence children's decisions to participate in sports by setting an example. However, Croatian society undervalues athletes, fails to understand their real needs, and quickly discards them in the absence of top sporting results.

The interviewees recognise the subordination of women in Croatian sports on multiple levels. They are underrepresented in leadership positions in federations and clubs, and the achievements of women in sports are not given the same value as those of their male counterparts, even though they are achieved on the same level of competition. Furthermore, male athletes are paid better than female athletes, receive more media exposure, and have better training conditions. This makes it evident that Croatian society can still be considered traditional and patriarchal.

Since research on gender equality in sport is very rare in Croatia, it is necessary to conduct research, publish results, and raise awareness about the need for equal opportunities and access to resources for all stakeholders. Developing social awareness about gender issues, deconstructing gender stereotypes, and changing entrenched patriarchal patterns represent paths toward the development of more egalitarian sport and society.

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CADET WRESTLERS' ATTITUDE TOWARDS CLUB COACHES AND PEERS

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Abstract
The objective of the research was to determine younger wrestlers' attitude towards club coaches and peers, their involvement in motivation and support for engaging in wrestling, as well as intercorrelation of wrestling-related variables such as training experience, weekly training load and placement at the national championship with the social attitudes. The sample consisted of 43 Croatian wrestlers aged 16 to 17, who are classified as cadet wrestlers (U17) based on their age group in accordance with international wrestling rules. A questionnaire was used to measure athletes' social orientation towards coaches and peers. The obtained results demonstrated that the most important thing for the cadet wrestlers is coach praise, followed by friendship between club peers, and peer acceptance. The results also show that there is no statistically significant correlation between the sports variables related to wrestling and the questionnaire items. However, the sports variables related to wrestling and the items of the questionnaire are statistically significantly correlated with each other. Under the positive influence of the social environment, the cadet wrestlers will recognise wrestling as a sporting activity that gives them a sense of satisfaction, which is why they will continue doing it. As wrestling has a strong positive influence on a large number of different anthropological characteristics, this research is of great importance because it shows which and to what extent social factors can motivate cadet wrestlers to continue wrestling. The research is part of a PhD thesis titled Social Environment and Youth Participation in Wrestling by Ivica Biletić (2022).

Keywords: *motivation, support, Greco-Roman style, sport, social orientation*

Introduction

Social environment is known to greatly affect young people's motivation to do sports (Stuntz & Weiss, 2003; Weiss & Williams, 2004; Petošić, 2007; Ullrich-French & Smith, 2009; Weiss, 2013; Crnjac, 2017; Biletić, 2022; Biletić et al., 2024), and it is understood that a traditional and popular sport in a country significantly affects the number of young athletes engaged in that sport. This research studies the cadet wrestlers' attitude towards coaches and peers in the wrestling club, as well as their influence on the cadet wrestlers' motivation to engage in sport, i.e. wrestling. The Social Orientation Questionnaire (Stuntz & Weiss, 2003) used in the research was translated into Croatian and modified into a version with 18 items (Crnjac, 2017; Biletić, 2022). In order to continue wrestling, young wrestlers must be satisfied and positively value their personal abilities and achievements. If they feel excluded from their sports team and if they are at odds with the coach, they quit sports (Šilić, 2014; Biletić, 2022; Biletić et al., 2023; Biletić et al., 2024). According to Stuntz and Weiss (2003), good relationships in the team, support from peers in the club, and friendship are major sources of sport enjoyment and motivation, as well as further participation in sports. The social influence of coaches on children is of the utmost importance because of the effort and satisfaction, which is one of the most important reasons for children and young people to do sports (Lee et al., 2000; Weiss & Williams, 2004; Sit & Lindner, 2006). Crnjac (2017), states that "coaching support is related to satisfaction in sports, and that young athletes with a high level of social orientation towards their peers are more dedicated to and satisfied in their sport and have a higher level of intrinsic motivation". Considering the quality and character of the sports experience, coaches in a sports organization have a strong influence on young people. "If the coach constantly complains and criticizes a child's work, the child will lose self-esteem and self-confidence, which will greatly affect his/her sports results" (Goričanec Obadić, 2015). "A child chooses a sport previously chosen by his/her peers, he/she behaves in accordance with the rules unconsciously defined by his/her peers, children imitate, want to be like their peers, etc. Often, the child's motivation to do sports depends primarily on his/her friends - the child trains as long as he/she has company in the club. When a friend stops training, the child also stops doing sports" (Petošić, 2007). According to Biletić (2022) and Biletić et al., (2024), club peers influence the motivational climate, i.e. they determine whether the atmosphere at training will be negative or positive, which will consequently affect the child's further engagement in wrestling.

Methods

The analysed sample comprises 43 respondents aged 16 to 17 from the majority of Croatian wrestling clubs, who are classified as cadet wrestlers (U17) based on their age group according to international wrestling rules. The Social Goal Orientation Questionnaire (Stuntz & Weiss, 2003) was used to determine the cadet wrestlers' social orientation towards coaches and peers. In 2017, Crnjac translated the respective questionnaire into Croatian and modified it, adding 3 items to increase reliability. Internal consistency reliability was checked by Cronbach's Alpha (α), which was excellent (Taber, 2018; Novak, 2020), amounting to 0.92. Therefore, we can conclude that the Croatian version of the questionnaire is an extremely reliable measuring instrument providing a really good assessment of the impact of the social environment on the cadet wrestlers. The questionnaire has two dimensions. "Coach praise" as the first dimension consisting of six items refers to the coach's support for the athlete. "Peers" as the second dimension has two sub-dimensions, each containing six items, and it is related to peers ("friendship" and "peer acceptance"). The correlation of wrestling-related variables such as training experience, weekly training load and placement at the Croatian Championship with the dimensions of the questionnaire was analysed as well. The respondents' ranking at the national championship was divided into 4 categories: 1st – 3rd place was category 1, 3rd – 5th place was category 2, 5th – 10thplace was category 3, and any raking above 10th place was category 4.

Descriptive statistics, i.e. median, mode and mode frequency, were calculated for all variables. Normality of the distribution was tested using the Kolmogorov–Smirnov test. Since each set of variables contains one variable that does not have a normal data distribution, further data processing was done using non-parametric statistical methods. Correlation between the sports-related variables and the dimensions, including the sub-dimensions of the questionnaire, was calculated using Spearman Rank Order Correlations.

Results

Table 1. Descriptive statistical parameters of the Social Orientation Questionnaire for cadet wrestlers (N = 43)

Items	A.M.	Min.	Max.	S.D.	Skewness	Kurtosis
My coach praises my performance.	3.95	2	5	0.87	– 0.13	– 1.18
My coach praises me.	4.05	3	5	0.82	– 0.09	– 1.49
My coach is often in a good mood and encourages me.	4.70	3	5	0.56	– 1.72	2.17
When I do well, my coach tells me that I have done a great job.	4.60	3	5	0.62	– 1.35	0.81
When I am good at my sport, the coach is very pleased.	4.77	4	5	0.43	– 1.31	– 0.29
When I have a bad day, the coach helps me to be better.	4.51	2	5	0.77	– 1.53	1.76
I have teammates who care how I feel.	4.37	3	5	0.72	– 0.71	– 0.74
I have teammates who really understand me.	4.35	2	5	0.78	– 1.03	0.51
My sport friends take care of me.	4.35	2	5	0.75	– 1.04	0.87
I share my experience with my teammates.	4.37	2	5	0.87	– 1.27	0.79
My teammates encourage me when I make a mistake.	4.47	2	5	0.83	– 1.61	2.09
The guys from my club would never walk out on me.	4.47	1	5	0.93	– 2.19	4.88
Most of my colleagues in the club want to be friends with me.	3.93	2	5	0.83	– 0.13	– 0.93
The children from my club listen attentively to what I say.	3.58	1	5	0.93	– 0.34	0.19
My teammates from the club want to spend time with me.	4.02	1	5	0.86	– 0.99	2.09
My teammates often invite me to hang out with them.	4.07	1	5	0.91	– 1.14	1.88
I celebrate my birthdays with my friends from the club.	3.63	1	5	1.29	– 0.51	– 0.86
When I need company to go to the cinema or a partner to play video games, I can easily find someone from the club.	3.95	1	5	1.17	– 0.83	– 0.46

Legend: A.M. – arithmetic mean of a response to an item; Min. – minimum value of a response to an item; Max. maximum value of a response to an item; S.D. – standard deviation of a response to an item; Skewness – the coefficient of the asymmetry of distribution of a response to an item; Kurtosis – the coefficient of the tail of distribution of a response to an item

The obtained results have been foreseen and anticipated with regard to the form and the items used. In the first dimension of the questionnaire, "coach praise", the cadet wrestlers on average give the highest values to the following items: "When I am good at my sport, the coach is very pleased" and "My coach is often in a good mood and encourages me". The analysis has shown that the items valued the least by the respondents in this dimension are the following: "My coach praises my performance" and "My coach praises me". Although valued the least, the mentioned items still obtained very high results with values of 3.95 and 4.05. For that reason, attention should be focused on them because it could be interpreted that the respondents think the coaches do not praise them or support them enough, which can cause dissatisfaction and lack of motivation among young wrestlers. As regards the items in the second dimension that measure the social sub-dimension "friendship", the items that were given the highest values are "My teammates encourage me when I make a mistake" and "The guys from my club would never walk out on me", followed by the items "I share my experience with my teammates" and "I have teammates who care how I feel". Although the respondents in the first sub-dimension of the second dimension, rated the item "My sport friends take care of me" and the item "I have teammates who really understand me" the lowest, these items still received a very high average value of 4.35. It can thus be concluded that friendship is a very important factor for wrestlers of this age. In the second sub-dimension of the second dimension, i.e. "peer acceptance", the following items were given on average the highest values: "My teammates often invite me to hang out with them" and "My teammates from the club want to spend time with me". The items of the second sub-dimension of the second dimension that are valued the least include "The children from my club listen attentively to what I say" and "I celebrate my birthdays with my friends from the club. It is evident that once again the lowest values still provide very high results, of 3.58 and 3.63, which yet again emphasizes and confirms the importance of peer teammates from the club and defines the importance the cadet wrestlers give to peer acceptance.

Table 2. Descriptive statistical parameters (median, mode and mode frequency) and normality of distribution tested using the Kolmogorov-Smirnov test (max D and KS p)

Items	N	Median	Mode	F mode	max D	K-S
Training experience	43	5.00	5.00	5.00	0.10	p > .20
Weekly training load (min)	43	480.00	450.00	9.00	0.15	p > .20
Placement at the national championship	43	1.00	1.00	27.00	0.38	p < .01
Coach praise	43	4.50	5.00	11.00	0.14	p > .20
Peers	43	4.17	Multiple	4.00	0.11	p > .20
Friendship	43	4.67	5.00	18.00	0.23	p < .05
Peer acceptance	43	4.00	4.17	5.00	0.10	p > .20

Legend: Median – arithmetic mean of a response to an item; Mode – value of the highest frequency of a response to an item; F mode – mode frequency ; max D – maximum distance between the cumulative frequency of the normal distribution and the cumulative frequency of the empirical distribution calculated using the Kolmogorov– Smirnov test; K-S – the Kolmogorov–Smirnov test; p – level of statistical significance

As evident from the obtained results presented in Table 2, in two variables there is a significant statistical deviation of data distribution from the normal distribution. (Multiple – there are multiple variables with the highest frequency).

Table 3. Matrix of intercorrelations between wrestling-related variables and the questionnaire dimensions, including the sub-dimensions of the second dimension

Variables	Training experience	Weekly training load (min)	Placement at the national championship	Coach praise	Peers	Friendship	Peer acceptance
Training experience	1.00	0.31*	-0.51*	0.20	0.10	0.06	0.12
Weekly training load (min)	0.31*	1.00	-0.41*	0.23	0.27	0.18	0.24
Placement at the national championship	-0.51*	-0.41*	1.00	-0.16	-0.12	-0.19	-0.09
Coach praise	0.20	0.23	-0.16	1.00	**0.74***	**0.63***	**0.75***
Peers	0.10	0.27	-0.12	**0.74***	1.00	**0.90***	**0.93***
Friendship	0.06	0.18	-0.19	**0.63***	0.90*	1.00	**0.70***
Peer acceptance	0.12	0.24	-0.09	**0.75***	0.93*	**0.70***	1.00

The results presented in Table 3 show the correlation between the sports-related variables and the dimensions of the questionnaire (Coach praise and Peers), including the sub-dimensions of the second dimension "Peers" (Friendship and Peer acceptance). It is evident from Table 3 that, in terms of statistics, the sports variables related to wrestling are not significantly correlated either with the dimensions or with the sub-dimensions of the Social Goal Orientation Questionnaire, but are all significantly intercorrelated. The situation is the same with the dimensions and sub-dimensions of the questionnaire, which are in a statistically significant and very high mutual intercorrelation ranging from r = 0.63 to r = 0.93.

Discussion

In the Social Orientation Questionnaire, the item "When I am good at my sport, the coach is very pleased" from the first dimension of the questionnaire, i.e. "coach praise", obtained the highest average value of 4.77. The foregoing shows the respondents understand that the coach appreciates their involvement in training, as well as in the competition, which has a very motivating effect on their perseverance in wrestling. As regards the results of the second dimension, in the first sub-dimension ("friendship"), on average the most valued items (both 4.47) are the ones that indicate a feeling of support and trust in teammates, i.e. the items "My teammates encourage me when I make a mistake" and "The guys from the club would never walk out on me". Particularly compelling items in the second sub-dimension of the second dimension of the questionnaire, i.e. "peer acceptance", are the items "My teammates often invite me to hang out with them" and "My teammates from the club want to spend time with me", which were given on average the highest values of 4.07 and 4.02. This perfectly shows the importance of friendship with peers from the club. Similar conclusions have been stated in other research by several authors (Hartup, 1993; Hartup, 1999; Berndt et al., 1999; Ladd et al., 1996; Crnjac, 2017, Biletić 2022; Biletić et al., 2023; Biletić et al., 2024) who especially emphasize the importance of friendly relations and trust among friends. The results of the research showed that the majority of young boy wrestlers believe that the guys from the club would never walk out on them, claim that their teammates understand them and that their friends from the club take care of them (average values 4.47, 4.35 and 4.35). That being said, the responses to the items about celebrating birthdays together and about most colleagues in the club wanting to be friends with them are really varied, and the distribution of scores is close to normal. Stuntz and Weiss (2003) determine the concept of social goal orientation and define three social goals, i.e. peer acceptance, friendship and coach praise, which is common with this research in which the most prominent items are related to coach praise. The coach's influence is highlighted in research by several authors (Lee et al., 2000; Weiss & Williams, 2004; Sit & Lindner, 2006; Biletić, 2022; Biletić et al., 2023; Biletić et al., 2024), where researchers confirm the coach's strong social influence on young athletes, and the satisfaction in sports is related to the coach's support. Smoll et al. (2011) state in their study that coaches and peers are very important in social interactions, and such conclusions can also be reached based on the results of this research. Several authors (Smith & Smoll, 2005; Smith et al., 2007; Crnjac, 2017; Biletić, 2022; Biletić et al., 2023; Biletić et al., 2024) also emphasize the positive atmosphere of the social environment (coaches and peers) as a key factor in a young athlete's continued engagement in a sporting activity. It is quite logical that the sports variables are interrelated because the cadet wrestlers who have been training longer have more training sessions per week and thus rank better at national championships. It is not surprising that the variables of the questionnaire are highly interrelated. Wrestlers who are praised by the coach are well accepted by their peers and develop deep friendships. It is obvious that placement, experience and amount of training do not have to be related to the wrestler's social environment.

Conclusion

All previous studies were conducted on the respondents who participated in team sports, and the results reflect the attitudes of the respondents from team sports, not the respondents from individual sports, especially not from wrestling. Since we have recently noticed children and young people's increased involvement in wrestling, as well as their noticeable quitting of wrestling, this topic is really interesting. Therefore, it is surprising to realise that there is no systematic research on this issue. This is precisely why this research is an exceptional move in that direction and is of great importance for understanding the reasons for quitting wrestling. The cadet wrestlers in this research describe the social environment defined by their peers and club friends as motivating because they love their teammates and they like spending time with them. Based on the analysis of the obtained results, according to the arithmetic means of the valuated items of the three sub-dimensions of social orientation, it can be stated that the most important thing for the cadet wrestlers is coach praise followed by friendship with peers/teammates in the club, and after that, the sense of belonging and peer acceptance. Under the positive influence of the social environment, the cadet wrestlers will recognise wrestling as a sporting activity that gives them a sense of satisfaction, and for that reason they will continue doing it. Considering the strong positive impact of wrestling on a large number of various anthropological features, this research is of great importance as it shows which and to what extent social factors can motivate cadet wrestlers to continue wrestling.

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ANALYSIS OF SCIENTIFIC PRODUCTION ON RHYTHMIC GYMNASTICS

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Abstract
This study uses bibliometric analysis to study rhythmic gymnastics literature, with the objective of understanding its growth, identifying key contributors, and main research areas. The analysis of data from the Web of Science database covering 1987 to 2023 shows a rise in scientific publications, predominantly comprising articles. While Spain leads in contributions of publication volume, Brazil is underrepresented among top authors. Furthermore, specific journals, notably the Science of Gymnastics Journal, are highlighted for their pivotal roles in disseminating rhythmic gymnastics research. Different research areas are identified, encompassing investigations into body composition dynamics and injury prevalence. This study helps us grasp the trends and contributors in rhythmic gymnastics research, facilitating collaboration and further exploration in the field.

Keywords: *bibliometrics, bibliometric mapping, scientific production, sport, rhythmic gymnastics*

Introduction
Rhythmic gymnastics is the juncture of sport and art, heavily influenced by ballet and modern dance, in which gymnasts, either as individuals or in groups, amaze audiences with their astonishing skill as they execute enormously difficult maneuvers with hand-held apparatus: hoop, ball, clubs, ribbon and rope (Federation Internationale de Gimnastique, n.d.). To reach elite level, girls begin the intensive training at early age (Sabeti et al., 2014) and only those who pursue maximum difficulty and perfectionism of performance and manage to conquer the audience with virtuosity and artistry can qualify for a prestigious ranking in this sport (Ivanova, 2022). As there are expectations from the relatively young gymnasts to perform their competitive routines perfectly in many aspects: technically, artistically, musically, and expressively (Gantcheva et al, 2021), high-performance gymnastics involves a high degree of physiological adaptation (Kyselovičova et al., 2023). That is one of the main reasons why the amount of research is growing rapidly, especially in motor skills, injuries and body composition. Bibliometrics quantifies scientific output and provides insights beyond traditional literature reviews, complementing academic research rather than replacing it. Bibliometric analysis is a well-established procedure employed to assess both qualitative and quantitative shifts in academic publications by employing mathematical methodologies (Huertas González-Serrano et al., 2020). There are two main methodologies: performance analysis and bibliometric mapping. Performance analysis examines output based on factors like documents and authors, while bibliometric mapping visualizes connections between research structures, generating networked structures with clusters and nodes (Jiménez-García et al., 2020). Two types of bibliometric maps are utilized in assessing organizational innovation: bibliometric term maps visualize latent topics, while co-citation networks of authors unveil the intellectual landscape. These maps are created using Vosviewer software, portraying scientific structure and its evolution (Van Eck & Waltman, 2014; Van Eck & Waltman, 2010).

Methods
Data was extracted from the Web of Science database, a globally acclaimed scientific citation search and analytical platform by Clarivate Analytics. It serves as both a research tool and dataset for extensive data-driven studies, noted by Li et al. (2018). This study, focused on rhythmic gymnastics literature, utilized the Web of Science Core Collection database for data extraction, spanning 1987 to 2023. Types of documents, author information, journal details, document titles, and keywords were compiled in March 2024 using Excel 2016 software.

Results
Performance analysis
A total of 450 publications were included based on the selection criteria. The publications comprised four main document types: articles (394), representing 87.56% of the total, followed by proceeding papers (44), accounting for 9.78%, review articles (11), accounting for 2.44%, and meeting abstracts 1.11% (5). The annual publication count typically averages around 15, with some notable exceptions: 2019 (40), 2020 (45), reaching a peak of 49 in 2022, and concluding the study period with 27 publications in 2023 demonstrating growing trend in scientific literature production over time (see Figure 1). English accounts for most of the scientific output, representing 77.56% (349), with the remaining publications appearing in various languages including Spanish, Russian, Portuguese, Ukrainian, French, Japanese, Latvian, German, Italian, Latin, and Polish.

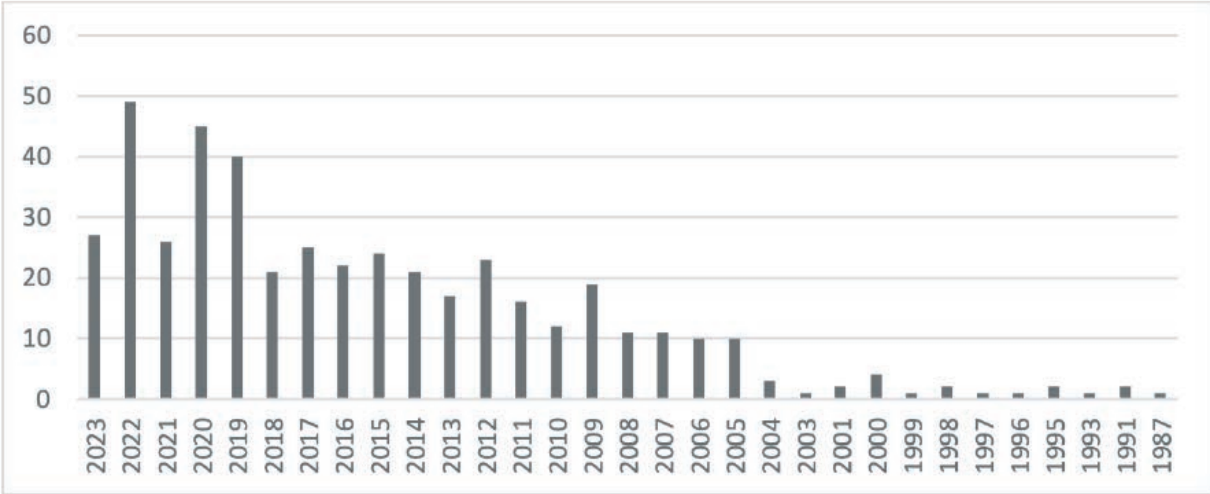

Figure 2. Articles and conference papers

Figure 3 illustrates the most prolific countries in terms of scientific output. This chart presents the top 15 contributing countries, which collectively represent 88.67% of scientific production. Leading the list is Spain, contributing 81 scientific publications, accounting for 18.01% of the global information shared over the past four decades of research. Brazil follows closely with 53 publications (11.78%), trailed by Italy (48; 10.67%), Greece (36; 8%), the People's Republic of China (27; 6%), Portugal (25; 5.56%), Ukraine (20; 4.44%), Russia (19; 4.22%), Croatia (15; 3.33%), and England (14; 3.11%). These countries represent the top ten most productive nations in research while Romania, France, Japan, the United States of America, and Bulgaria occupy the eleventh to fifteenth positions, respectively.

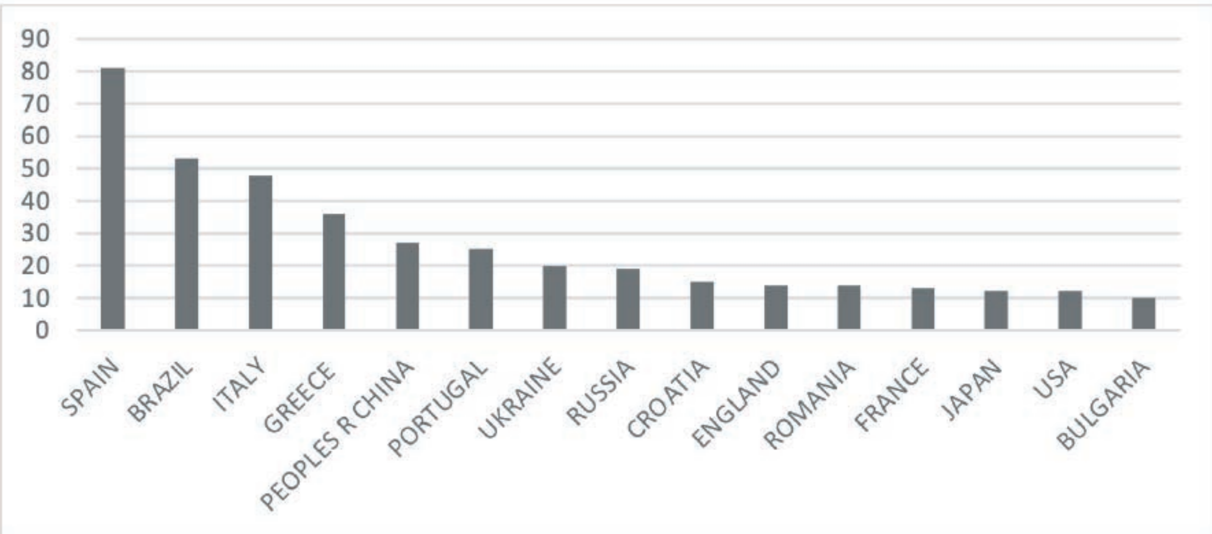

Figure 3. Productivity by country

This analysis provides a broad understanding of the journals where the studied documents are published, offering insight into how the topic of rhythmic gymnastics is approached, whether from a medical, sports, or educational perspective. Table 1 presents ten journals organized by their productivity, along with their respective journal impact factor (IF). The standout journals include the Science of Gymnastics Journal, leading with 54 publications, and the Pedagogics Psychology Medical Biological Problems of Physical Training and Sports in second place with 19 publications. Both are indexed in the Journal Citation Report Emerging Sources Citation Index. Considering the prestige of journals (IF), notable publications include Medicine and Science in Sports and Exercise and International Journal of Environmental Research and Public Health and Journal of sports sciences. Notably, 30% of the papers listed in Table 1 were published in the Science of Gymnastics Journal. Overall, it is evident that research on rhythmic gymnastics has been significantly influenced by these journals, with European research institutions playing a pivotal role in its expansion.

Table 1. The ten most important publication sources

Journal title	Number of documents	Journal IF	Publisher	Country
Science of Gymnastics Journal	54	0.6	University of Ljubljana - Univerza v Ljubljani	Ljubljana
Pedagogics Psychology Medical Biological Problems of Physical Training and Sports	19	0.13	Iermakov S S	Ukraine
Journal of Sports Medicine and Physical Fitness	12	1.7	Edizioni Minerva Medica	Italy
Human Sport Medicine	9	0.2	South Ural State University	Russia
Apunts Educacion Fisica y Deportes	8	1.6	Instituto Nacional de Educación Física de Cataluña	Spain
Journal of Human Sport and Exercise	8	0.5	University of Alicante	Spain
International Journal of Environmental Research and Public Health	7	4.614	MDPI	Switzerland
Journal of Sports Sciences	7	3.4	Taylor & Francis LTD	England
Retos Nuevas Tendencias en Educacion Fisica Deporte y Recreacion	7	1.2	Federación Española de Asociaciones de Docentes de Educación Física (FEADEF)	Spain
Medicine and Science in Sports and Exercise	5	5.411	Lippincott Williams & Wilkins	Philadelphia

Table 2 presents nineteen authors who have made significant contributions to organizational innovation, along with additional details such as their institution, country, and the number of publications on rhythmic gymnastics. The H-Index, “serving as a measure of individual scientific production and impact on the academic community” (Hirsch, 2005), is also included, reflecting the significance of their research endeavors. It's worth noting that this table highlights authors with the most substantial contributions in rhythmic gymnastics.

Table 2. Ten most productive authors

Authors	Number of documents	Institution	Country	H-Index
Avila-Carvalho, Maria de Lurdes Tristão	14	Universidade de Coimbra	Portugal	6
Piazza, Maria	13	University of Padua	Italy	32
di Cagno, Alessandra	12	Foro Italico University of Rome	Italy	18
Sierra-Palmeiro, Elena	10	Universidade da Coruña	Spain	5
Battaglia, C.	8	Veterans Affairs Medical Center - Denver	United States	15
Baldari, Cosima T. (Baldari, Carlo)	7	Foro Italico University of Rome	Italy	51
Bobo-Arce, Marta	7	Universidade da Coruña	Spain	6
Guidetti, Laura	7	Foro Italico University of Rome	Italy	28
Batista, Amanda	6	University of Porto Faculty of Sport	Portugal	4
Giannitsopoulou, Evgenia	6	Aristotle University of Thessaloniki Faculty of Physical Education and Sport Sciences	Greece	4

Maria de Lurdes Tristão Avila-Carvalho, hailing from the Universidade de Coimbra in Portugal, emerges as the foremost author in the field of rhythmic gymnastics, boasting the highest number of publications, followed closely by Maria Piazza (University of Padua) and Alessandra di Cagno (Foro Italico University of Rome). It's notable that despite Brazil being the second most prolific country in terms of publications, none of its authors rank among the leading contributors. This observation suggests that the prominence of authors doesn't always align with the productivity of their respective countries. Moreover, it implies that countries with greater contributions tend to have a more diversified output, while those with fewer contributions concentrate rhythmic gymnastics articles among a select few authors.

Bibliometric mapping

This segment introduces the cognitive framework and its evolution within the domain of organizational innovation studies. To accomplish this, the presented science maps illustrate its development. During the creation of this web map, terms sourced from the database were derived from a combination of nouns and adjectives. On the map, the distances between terms indicate the frequency of their co-occurrence. Terms extracted from titles, abstracts, and keywords serve as the units of analysis, adhering to the methodology proposed by Van Eck and Waltman (2010, 2014). Consequently, a minimum of 10 occurrences was set for the study period, with 29 terms meeting this criterion. Figure 5 displays the bibliometric term map, which encompasses four clusters grouping the primary topics examined in this research field. Descriptions of these clusters are provided in the subsequent paragraphs.

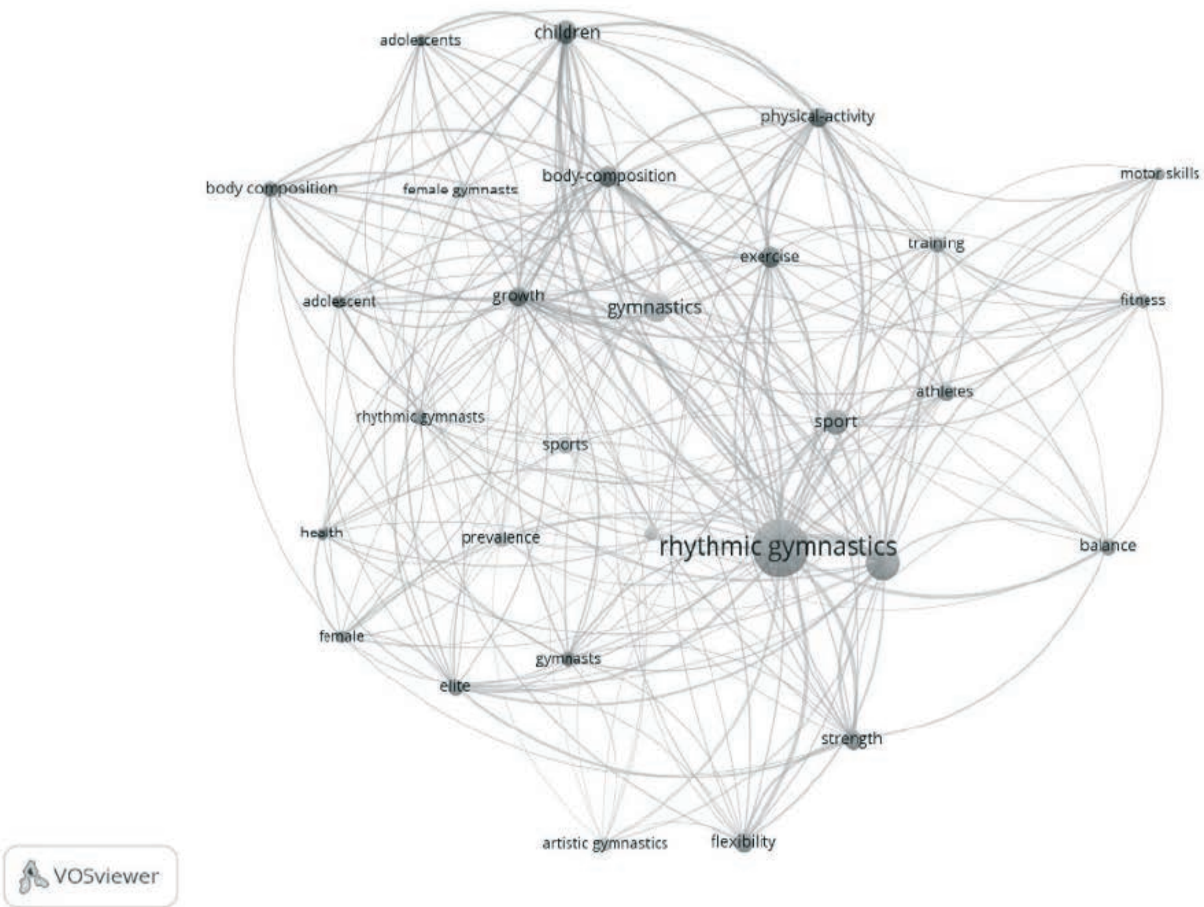

Figure 4. Bibliometric Map of Terms

Cluster 1 represents the impact of gymnastics on adolescent body composition and growth, identified as the foremost research front due to its significance and the number of keywords, totaling 9. Positioned at the top left of Figure 4, it centers around the nucleus term “Children”, with additional terms including Adolescent, Adolescents, Body Composition, Exercise, Growth, Gymnasts, and Physical Activity.

Cluster 2, situated in the top right quadrant of Figure 4, focuses on athlete performance through motor skills training in rhythmic gymnastics. This cluster features a core of 8 items, surrounded by 13 peripheral elements. The central terms include Athletes, Balance, Fitness, Motor Skills, Performance, Rhythmic Gymnastics, Sport, and Training. The themes within this cluster relate to Motor Skills and Balance Development, Fitness and Performance Enhancement, and Sport-Specific Training and Injury Prevention.

Cluster 3, located in the lower left side of Figure 4, concentrates on optimizing strength and flexibility in elite female rhythmic gymnasts. The main terms in this cluster are Elite, Female, Flexibility, Rhythmic Gymnast, and Strength. Cluster 4, representing articles about injury prevalence in female artistic gymnastics and sports safety studies, includes the main terms Artistic Gymnastics, Female Gymnastics, Gymnastics, Injuries, Prevalence, and Sports.

Conclusion

In conclusion, this study utilized bibliometric analysis to delve into the realm of rhythmic gymnastics literature, shedding light on its evolution and key contributors. Through the exploration of various methodologies, including performance analysis and bibliometric mapping, we gained valuable insights into the scientific output and the intellectual landscape within this field. The dataset sourced from the Web of Science database provided a comprehensive overview of publications spanning from 1987 to 2023, revealing a growth in scientific literature production over time. Notably, articles emerged as the primary document type, with significant contributions from various countries.

Our findings underscore the importance of international collaboration and the dissemination of research findings through reputable journals. While certain countries, such as Spain and Brazil, emerged as major contributors, it's essential to acknowledge that authorship representation may not always correlate with national productivity. Furthermore, the bibliometric mapping of terms unveiled distinct research clusters, ranging from adolescent body composition and growth to injury prevalence in artistic gymnastics. These clusters reflect the diverse research interests and focal points within the domain of rhythmic gymnastics.

Overall, this study not only provides a comprehensive overview of scientific output but also highlights areas for further exploration and collaboration within the rhythmic gymnastics research community. By leveraging bibliometric analysis, researchers can continue to advance their understanding of this dynamic field and contribute to its ongoing development and innovation.

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"PHYSICAL EDUCATION IN ELEMENTARY SCHOOLS" BY ANDRIJA HAJDINJAK PUBLISHED IN 1875 - FIRST TEXTBOOK FOR PHYSICAL EDUCATION WRITTEN IN THE CROATIAN LANGUAGE

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Abstract
The introduction of compulsory Physical Education (PE) in Croatian elementary schools began in 1874 with the Act on the constitution of primary schools and teacher training schools in Croatia and Slavonia. Before this, PE was mostly optional and taught by foreign instructors following German and Czech gymnastic systems. The need for qualified PE teachers led to the establishment of a training system in 1875. However, there was a significant lack of literature and textbooks for PE, and most teachers had minimal knowledge of conducting PE classes. This study aims to analyze the first Croatian Physical Education textbook, "Physical Education in Elementary Schools" by Andrija Hajdinjak, published in 1875. Hajdinjak's book, published shortly after the enactment of compulsory PE, addressed the lack of literature and teacher training in Croatian schools. The book provided a guide for teachers on methodically teaching exercises and games. It was financed by Hajdinjak himself and was based on his theoretical engagement with physical exercise. The book has four chapters: a Brief history of physical exercise, the Benefits and necessity of physical exercise, Simple exercises, and Some strengthening games. Hajdinjak's work was influenced by the German system of physical exercise, particularly the works of Adolph Spiess. Despite its brief length, Hajdinjak's manual is significant in the history of PE and kinesiology literature. It follows contemporary approaches to physical exercise in German-speaking countries and aligns with the Austrian and Prussian PE programs of the time. The German system of physical exercise influenced Croatian school practice until the 1908 law changes, after which Sokol principles became more prominent, especially following the arrival of Czech František Hochmann in Zagreb in 1876.

Keywords: *Andrija Hajdinjak, Physical Education, textbook, history of Physical Education, Croatia*

Introduction

Physical Education (PE) as obligatory part of elementary school curriculum was introduced in Croatia in 1874 with the first Croatian Act on Education – Zakon ob ustroju pučkih školah i preparandijah za pučko učiteljstvo u kraljevinah Hrvatskoj i Slavoniji [Act of the constitution of primary schools and primary-teacher training schools in the Kingdoms of Croatia and Slavonia. In Croatian.]. (Grgić & Čustonja, 2011) Before that PE was mainly optional and delivered by foreign gymnastic and PE teachers (Germans, Austrians, Czechs), who implemented the principles of the German and later Czech gymnastic system. (Bobić & Čustonja, 2005) After 1874 and the introduction of obligatory PE the need for PE teachers increased and engagement couple of foreign exercise professionals was not enough. Therefore, a training and education system for Physical Education teachers was established in Croatia in 1875. (Čustonja & Škegro, 2015) However, one big issue was literature and textbooks for conducting PE. Most elementary schools teachers did not have even minimal knowledge with regard to conducting PE classes, nor did any reference or literature exist from which they might attain a basic knowledge regarding the prescribed PE curriculum. (Čustonja & Škegro, 2014)

The first books, textbooks, and manuals for physical education instruction appeared after the introduction of compulsory physical education in primary schools in 1874. These publications are also the oldest monographic editions in the field of kinesiology in the Croatian language and represent the beginnings of kinesiology and sports publishing in Croatia. Approximately 30 books in the field of physical education were published before the First World War. These books primarily arose from the need for literature in the Croatian language and later from the everyday practice of teachers in primary and secondary schools in conducting physical education classes. Therefore, most publications relate to methodological instructions and descriptions of exercises and games from the physical education curriculum. A smaller portion of the publications pertains to the historical development of physical education, the construction of facilities for physical education classes and their equipment with apparatus and other aids, the specifics of physical education for girls, physical education for children with special needs, and one work on the physiology of physical education. Most of these publications were used at various times as literature for the subject of gymnastics in teacher training schools and courses for training and exams for gymnastics teachers in secondary schools. In a few cases, they are translations of foreign literature into Croatian, but most publications were the result of the work of local authors.

Analyzing the most important books, textbooks, and manuals used in physical education instruction before the First World War reveals the complexity of the development of this field. Besides legal acts, regulations, and other formal documents, as well as generally brief and formulaic reports on physical education classes in individual schools, the most comprehensive primary material for studying the history of physical education consists of books, textbooks, and manuals. Analyzing these materials makes it possible to draw quality conclusions about the various social and political influences on physical education instruction, ideas and ideologies, foreign models, and different changes that occurred in the understanding of the role and goals of physical education instruction up to the First World War.

The aim of this study is to analyse first textbook on Physical Education ever written in Croatian language – "Physical Education in Elementary Schools" by Andrija Hajdinjak published in 1875.

Andrija Hajdinjak

Andrija Hajdinjak (1847-1885) is the author of the first book on physical education and the first kinesiology text in the Croatian language—"Physical Education in Elementary Schools," published in 1875. He was born near Sisak, in the village of Prelišćica. He completed his secondary education at the Real Gymnasium in Petrinja and graduated from the Teacher Training Academy in Zagreb. Hajdinjak worked as a teacher in Zagreb and Karlovac, and from 1875, he was employed at the Teachers Training Academy in Zagreb. In addition to publishing several books, he contributed to journals such as "Narod," "Napredak," and "Smilje." For a time, he was also the editor of the humorous magazine "Vrabec." He was one of the founders and the secretary of the humanitarian society "Dobrotvor" (Jajčević, 1987). Collaborating with Miroslav (Friedrich) Singer, the first physical education teacher in Zagreb, he organized the first PE courses for elementary school teachers in 1874. Hajdinjak authored the first gymnastic manuals and books, laying the foundations for Croatian physical education terminology: "German-Croatian Terminology for Physical Exercise" and "Terminology for Fencing" (1875). In 1878, he and Franjo Hochman launched "Sokol," a bi-weekly publication on physical exercise, which was the first periodical in the field of kinesiology in the Croatian language. He was also one of the founders of the first physical exercise society, "Hrvatski Sokol" in 1874. As an author, Hajdinjak covered various topics in kinesiology, such as exercise methodology, school gymnasium and playground design, the shortcomings of modern education, the influence of family, home, and school on youth development, education systems in other countries, and women's education (Frntić, 2002).

"Physical Education in Elementary Schools," 1875

Andrija Hajdinjak's textbook and manual, "Physical Education in Elementary Schools," was published ten months after the enactment of the first education law, which introduced obligatory physical education in elementary schools, and just before the start of the 1875/1876 school year, when the instruction in PE was to begin. A serious problem faced by teachers at that time was the lack of experience and training in physical education, which Hajdinjak highlights in the book's preface:

"The benefits of physical exercise and its significant importance for bodily development and health, and thus for education itself, have been recognized, leading to the inclusion of physical exercise in the curriculum of elementary schools by the law of October 14, 1874... From October 1 of this year (1875), in accordance with the law, physical education instruction must begin in elementary schools, and every teacher, regardless of their previous lack of opportunity to prepare for this instruction, will be obligated to promote it as best as possible." (Hajdinjak, 1875: preface)

The book's greatest value lies in addressing the serious issue of the lack of literature and minimal teacher training in physical education in Croatian elementary schools. It aimed to serve as a guide for teachers on how to methodically teach simple exercises and games in physical education classes:

"Since there are practically no books on this subject (physical education), which could at least partially educate our teachers, I have decided to share what I have gathered through my theoretical engagement with physical exercise over time. My small work will provide my colleagues with a guide, which will surely be useful where there is almost nothing else available." (Hajdinjak, 1875: preface)

Hajdinjak financed the book himself and noted that it contained only a portion of the material he had collected:

"If I had the means or any help from somewhere, I would have undertaken to compile a more comprehensive work with extensive explanations and necessary illustrations; I could have embarked on such a task more easily since I have already gathered enough material for it." (Hajdinjak, 1875: preface)

In the preface, Hajdinjak thanks Miroslav Friedrich Singer, the physical education teacher at the Royal Gymnasium and Realschule in Zagreb, the first physical education teacher in Croatia, and the leader of the newly founded "Hrvatski Sokol" society in Zagreb, for his help in preparing the book.

The book has four chapters: "A Brief History of Physical Exercise," "On the Benefits and Necessity of Physical Exercise in

General," "Simple Exercises," and "Some Strengthening Games." In the first part, Hajdinjak provides a brief overview of the development of physical education, beginning with ancient Greece and Rome, followed by medieval German chivalry, and then physical education in modern Germany and Austria. He briefly mentions physical education in other European countries, most likely based on the German literature available at the time, although he does not specifically cite any sources or models for his writing. The most widespread and influential books on physical education at that time were the works of the German organizer of physical education instruction, Adolph Spiess (1810-1858), "Die Lehre der Turnkunst" and "Turnbuch für Schulen." (Naul, 2002) The influence of Spiess, as well as his successors Konrad Koch (1846-1911) and August Hermann (1835-1906), is evident in other parts of Hajdinjak's book. Regarding the history of physical education in Croatia, Hajdinjak merely stated that "physical exercise was also cultivated in our major cities, especially in military Croatia and Slavonia," (Hajdinjak, 1875:18) and that it had been taught in Zagreb since 1858 by Friedrich Miroslav Singer "of course in German, as we have so far lacked Croatian writings and instructions for this subject." (Hajdinjak, 1875:18)

In the second chapter, Hajdinjak explains the benefits of physical education or physical exercise: "From the historical development of physical exercise, one can already conclude that it is beneficial and necessary for humanity." By "benefit," Hajdinjak means the positive impact on health:

"Anatomical and physiological knowledge has proven, especially through the work of scholars and physicians, the beneficial and salutary influence of physical exercise on human health, on the strength of bodily limbs, on a firm and graceful posture, and in general, on the development of the human body." (Hajdinjak, 1875:18)

Hajdinjak continues to explain the benefits of physical exercise on the muscular system, posture, gait, and cardiovascular system. This section also reflects the influence of the German school of physical exercise, which after Spiess's death (1858), came under the influence of the Swedish system of Pehr Henrik Ling, who began to associate physical exercise with health and insisted that the main benefit of physical exercise was the improvement of health status.

Under the "necessity" for physical exercise, Hajdinjak primarily considers the educational potential that physical education has for young people:

"In everyday life today, there is a tendency towards softness and aversion to work. Laziness is spreading like a plague: it is thought that work is a punishment inflicted by cruel fate... Such prejudices, which unfortunately are all too common, need to be eradicated, and the importance of physical labor must be emphasized, showing how idleness is detestable and harmful to our mental health..." (Hajdinjak, 1875:20)

Hajdinjak particularly emphasizes that "for national identity and social life, physical exercise is a great help — it awakens national consciousness and patriotism, fosters friendship, unity, and brotherly harmony." (Hajdinjak, 1875:21) The educational potential of organized physical exercise, particularly in terms of developing national consciousness, was one of the key incentives for the development and spread of physical education in German states in the 19th century. The same motivation for developing a system of physical exercise existed among the Czechs, and the Sokol system of physical education appeared in Croatia in 1874.

Hajdinjak systematically organized physical exercise and physical activities entirely following Spiess's system. He divided physical exercise based on its targeted orientation into "school or pedagogical, health, and military," (Hajdinjak, 1875:22) with school physical education being the most important. He emphasized that "a special section of school physical exercise is constituted by female or girls' strengthening exercises," and that "women are specially taught this subject." (Hajdinjak, 1875:22) Physical exercises were divided into: regular or simple exercises, exercises with apparatus, and exercises on apparatus. He stressed that the most important were simple exercises: "Without simple exercises, there is no true strengthening skill." (Hajdinjak, 1875:32)

The third and fourth chapters provide methodological instructions for performing physical exercises. The third chapter deals with simple exercises, which Hajdinjak describes in detail, explaining the method of demonstration, sequence of exercises, number of repetitions, etc.:

"Simple exercises must follow one another, and the teacher must ensure this if they want their pupils to become skilled in physical exercise, especially when the students are not yet sufficiently enthusiastic about physical exercise; but never should simple exercises be skipped." (Hajdinjak, 1875:52)

In the fourth chapter, Hajdinjak explains games and their role in physical education classes:

"By 'game,' we understand the free, unforced activity of the mind or body, and the purpose of games is to refresh, cheer, and pleasantly entertain. The youth want to play, but the teacher must supervise so that there is no disorder or foolishness. Games for girls should develop and promote pleasant and graceful agility and some elegance." (Hajdinjak, 1875:52)

Hajdinjak permits and anticipates games in the physical education curriculum but, following Spiess's influence, limits the importance and representation of games in teaching:

"...for proper physical exercise (simple exercises), we would allow two hours, and for playing only one, as they can play elsewhere outside the gymnasium." (Hajdinjak, 1875:32)

Games, especially later sports games, gained significant importance in physical education only at the end of the 19th century, when Franjo Bučar introduced them into the curriculum, influenced by the Swedish system that preferred games over mechanical movements of simple exercises.

Conclusion

Although Hajdinjak's manual was only 56 pages long, it is an exceptionally significant work in the history of physical education instruction and kinesiology literature in general. Hajdinjak had no formal education in physical education, nor, as far as we know, any practical experience with physical exercise. Despite this, the book was written in line with contemporary approaches to physical exercise present in German-speaking countries. Although Hajdinjak does not cite literature or models for his writing, it is evident that his book was modeled on the works of Adolph Spiess (1810-1858), the German organizer of physical education instruction, "Die Lehre der Turnkunst" and "Turnbuch für Schulen." Despite not referring to the physical education curriculum, his book closely follows the program, which was based on Austrian and earlier Prussian physical education programs, largely shaped by Spiess. Therefore, it is logical that, among other reasons, Spiess and the German system of physical exercise served as Hajdinjak's model. The German system of physical exercise formally persisted in Croatian school practice until the 1908 law changes and the introduction of new curricula that moved away from German influence, adopting Czech physical education principles. In practice, however, the Sokol principles prevailed, especially after 1879 with the publication of Czech A. J. Löffler's textbook "Gymnastics for Elementary School Teachers and Teacher Trainees" and the arrival of Czech František Hochmann as a physical education teacher at the Teacher Training School in Zagreb in 1876.

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INFLUENCE OF THE COURSE "SPORTS JOURNALISM" ON THE ATTITUDE OF FEMALE STUDENTS ABOUT WOMEN IN SPORTS JOURNALISM

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Abstract
In the past few decades, with the development of technology and digital media, sport has experienced a period of great expansion, popularization, commercialization and globalization. In this process, sports journalists, as mediators between athletes in the sports courts and spectators, have an important role to inform but also to educate the audience. In other words, they are an important element in the development of sports as a social phenomenon. Although sports journalism is still considered primarily a male activity, and men's and women's sports are not equally represented in the media, gender equality policies dictate a change in this area. The first step in that direction is the provision of high-quality education for female sports journalists. Therefore, this study deals with the analysis of sports education female students of journalism at the Faculty of Political Science, University of Zagreb (FPZG). For five academic years, specifically from 2018 /2019 to 2022/2023, an elective course named "Sports Journalism" was part of the curriculum of the study programme of journalism at the Faculty of Political Science in Zagreb. In the course, students learned about different ways of reporting, writing and commenting on sports events, and the topics included ethical and professional principles and professional criteria of sports journalism. During this period, the course was attended by a total of 220 students, of whom there were as many as 167 female students. The survey that was conducted using a sample of 97 female students reveals that it was because of their interest in sports and sports journalism that most of them opted for the "Sports Journalism" course. The results show that attending this course changed their concept of sports journalism and interest in it. FPZG students believe that women are not sufficiently represented in sports journalism, and that courses like this can significantly change the current situation.

Keywords: sports journalism, women, sports, education

Introduction

Sport and media are closely intertwined, and their relationship began to be intensively built up with the advent of electronic media, primarily with the development of television in the mid-sixties of the last century (Whannel, 2009). Over the years, the media have changed the general view of sport by making it more dynamic and attractive to viewers. Sport provides the media with a diverse range of content, including entertainment, news, and the market, while the media give rise to popularity, visibility, and interest in sport and athletes in society (Braumüller et al., 2020). According to Pfister (2010), the media create perceptions about a particular sport and contribute significantly to the reproduction of gender differences. However, men's and women's sports are not equally represented in the media. For example, women received coverage only when representing the home nation at an Olympic event (Antunovic & Bartoluci, 2022). Previous research indicated a trend of lack of coverage of women's sports in the media, lower representation of live broadcasts on television, and asymmetry in coverage of the same sport for women and men (Cooky et al., 2021). In a 2005 study that included more than 10,000 articles from 37 newspapers in ten countries covered by the survey, only 6% of the articles were about female athletes (Schultz-Jorgensen, 2005), and a British study which compares the period before and after the 2012 Olympic Games (O'Neill & Mulready, 2015) shows that there has been no change in the perception of women's sports and that female athletes are still neglected in the British media compared to their male fellow athletes. Even during the pandemic, when sports were less represented in the media in general, women were left out in equal measure. Journalists automatically returned to their routine practices of creating sports content, which suggests that dominant reporting of men's sport is much more deeply rooted and that it is emanated from the media (Symons et al., 2021: 13-14).

Sports journalists are an important segment in linking media and sport, they are intermediaries who transmit events from the sports arena to indirect spectators, that is, readers, listeners or viewers. Yet, there is no equal proportion of men and women in sports journalism. Despite statistics showing that there are more women in sports journalism than there were 50 years ago, this number is still significantly lower than the number of their male counterparts (Zbigniew et al., 2019). Reich (2014) maintains that "the overall picture regarding status indicators suggests that discrimination of female reporters did not disappear but simply migrated to less overt and observable places". For example, the barrier to women's promotion on TV and printed news is virtually inconsiderable compared to online media and radio, where females heavily gain prominence (Reich, 2014). For example, the Croatian Association of Sports Journalists (HZSN) has 131 members, among whom only ten are women (HZSN, 2024). Although membership of the HZSN is not mandatory, it is an indicator of the current state of Croatian sports journalism. The Office for Gender Equality, the Electronic Media Agency, the Croatian Journalists' Association, and the Union of Journalists of Croatia are taking various actions to increase the proportion of women in journalism. Attitudes about women involved in sports journalism are changing hard and slowly. Increasing the share of female sports journalists is important because that would lead to the further development of sports journalism; new "voices" would certainly change the sports reporting discourse and improve professional competences. Furthermore, this would also change the public perception of sports journalism and the image of female athletes in the media, which would in turn change the established models and attitudes about women in sports in general. Therefore, efforts need to be made at all levels, including education itself. This is why this paper investigates the influence of the course "Sport Journalism' on the attitudes of female students of journalism at the Faculty of Political Science of the University of Zagreb towards sports journalism, with the hypothesis that "the 'Sports Journalism' course positively changes the attitudes of FPZG female students towards this profession". Lectures in the course dealt with different ways of reporting, writing and commenting on sports events, and a significant part of the syllabus was devoted to the professional criteria of sports journalism, as well as ethical and professional principles and the influence of the media on the perception of sports. Since sports journalism is a kind of "genre" within journalism, students were acquainted with its specific features. They also acquired knowledge and skills that sports journalists must develop in order to convey reliable and verified information to the audience as credibly as possible and to interpret it in an appropriate way.

Methods

For the purposes of this paper, the survey method was used. "The survey method is a special form of non-experimental research that uses as a primary source of data a personal statement of opinions, beliefs, attitudes and behaviours, obtained through an appropriate standardized set of questions" (Milas, 2005: 395). The respondents were asked the following questions: (1) Why did you decide to enrol "Sports Journalism"? (2) Did you change your attitude towards sports journalism after attending the course? (3) Do you think that women are sufficiently represented in sports journalism in Croatia? and (4) Does the course "Sports Journalism" provide relevant knowledge for working as a sports journalist? The survey questions were answered by female students who attended the course "Sports Journalism" in the period from 2018 to 2023. The survey was conducted from the 30 October 2023 to 30 November 2023. The questionnaire was sent to the e-mail addresses of 164 female students, and 97 (59%) of them responded.

Results

The demographic questions of this survey confirm that the surveyed female students were born between December 1991 and February 2002. Of these, 43.3% (42) have a master's degree in journalism and 56.7% (55) have a bachelor's degree.

When asked why they decided to take the "Sports Journalism" course, as many as 50.5% (49) respond that from the very beginning they have been interested in sport and sports journalism. At the FPZG, there is a certain deficit of journalism courses and that is why 39.2% (38) opted for this course. Four students responded that they enrolled in this course "because it seemed easy to them", while individual responses were: "it was the only option", "because of their interest in sport and journalism", "to gain general knowledge about sport and sports journalism", "because it is a discipline-specific journalism course that seemed easy" and "because it fitted their weekly schedule best".

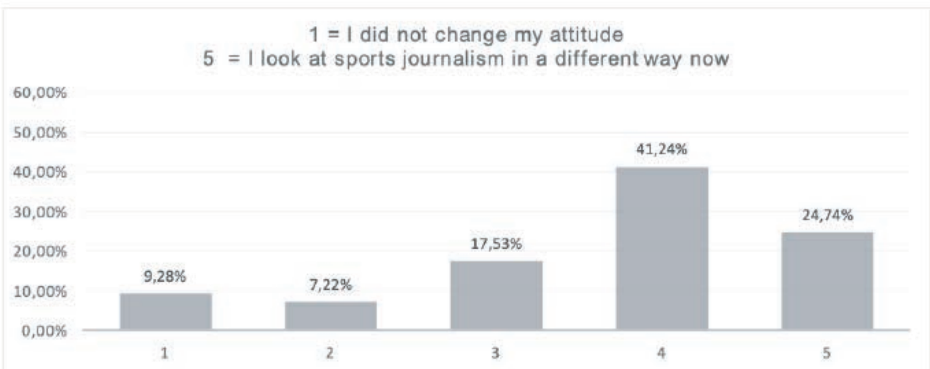

Figure 1. Answers to the survey question

Did you change your attitude towards sports journalism after attending the course?
When asked if their attitude towards sports journalism was changed after attending the course (Figure 1), as many as 24.74% (24) claim that they now view sports journalism in a completely different way, and 41.24% (40) significantly changed their attitude towards sports journalism. On the other hand, 9.28% (9) did not change their attitude in the least, and 7.22% (7) only minimally changed their attitude, while 17.53% (17) do not have a clear opinion, i.e., they do not have a clear attitude towards sports journalism.

When asked about the proportion of women in sports journalism (Figure 2), as many as 78.4% (76) respond that women are fully underrepresented or insufficiently represented, and only 8.3% (8) believe that there is already a sufficient number of female journalists in the media today, while 13.4% do not have a clearly defined position on this.

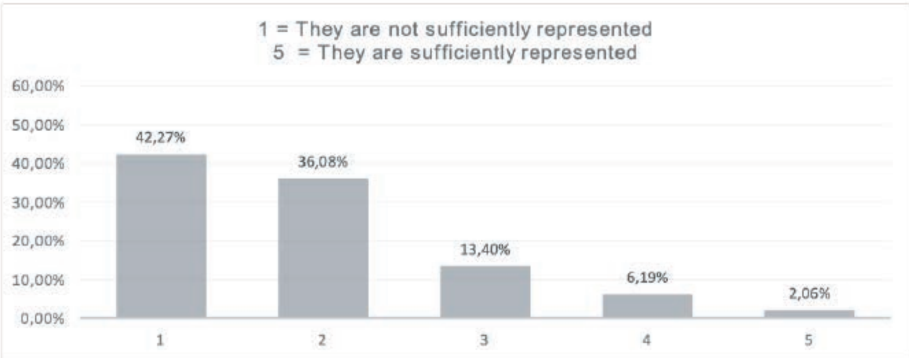

Figure 2. Answers to the survey question

Do you think that women are sufficiently represented in sports journalism in Croatia?
As many as 55.67% (54) believe that the course "Sports Journalism" has fully provided them with the necessary knowledge to potentially to engage in this type of journalism, and 32.99% (32) assert that they have acquired some knowledge about sports journalism. Only 2.06% (2) feel to some extent that they have not gained new knowledge, while 9.28% (9) do not have a clearly defined opinion on this issue (Figure 3).

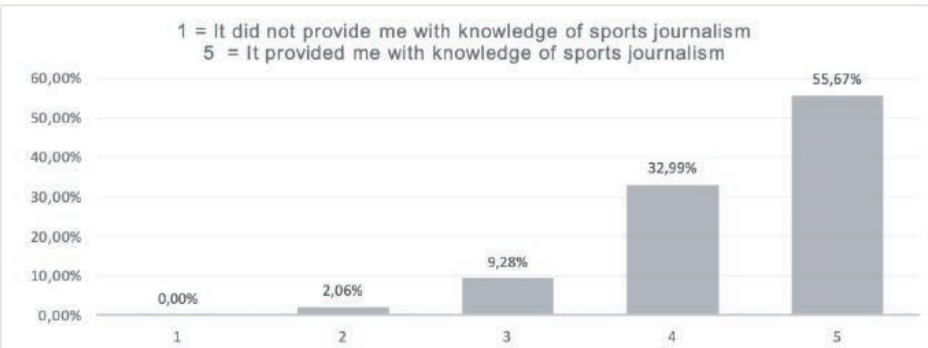

Figure 3. Answers to the survey question

Does the course "Sports Journalism" provide relevant knowledge for working as a sports journalist?
However, by answering the last question, the respondents expressed their views more clearly. As many as 51.5% (50) believe that the "Sports Journalism" course has not changed their desire to pursue sports journalism professionally. 20.6% (20) have changed their professional ambitions after attending the course and want to pursue sports journalism in the future, and 27.8% (27) believe that this course may have changed their views of sports journalism.

Discussion
The initial attitudes of FPZG female students are an important indicator because half of them express an interest in sports and sports journalism, i.e., the students do not have an a priori negative attitude towards sport and sports journalism. The survey of female students showed that the lack of interest in sports journalism is not the reason for the lack of women in sports journalism. As prescribed by the "Sports Journalism" course syllabus, students get acquainted with the social aspect of sport and the importance of sport in society. This also changes the perception of sports journalists who have a potentially important and great influence on social phenomena, because sport is part of everyday life. Only a little more than 16% of the

respondents did not change their attitude about sports journalism after attending the course. This is also an indicator of how education can positively influence attitudes, confirming the importance of education in journalism, especially in sports journalism, so that future journalists get a broader picture of sport.

The survey shows that FPZG students are aware of the deficit of women in sports journalism. Since the sample consisted of young, educated women, the percentage of those who believe that there is not a sufficient number of female journalists in this journalistic genre today is very indicative of gender-based perception of sports journalism. They are in fact in opposition to conservative currents that take the position that women have no place in sport and sports journalism. Most female students of journalism at the FPZG believe that the theoretical and practical knowledge acquired in the course "Sports Journalism" can be used later in their professional journalistic career. The answer to the last question can be viewed as somewhat concerning. It indicates that more than half of the female journalism students surveyed have not changed their mind about doing sports journalism in their professional careers after attending the course. Female students are interested in this field of work, and they are aware that there is not a sufficient number of women in this area of journalism. Furthermore, they have acquired elementary knowledge for doing sports journalism, and yet they have not changed their attitude about entering the world of sports journalism. If at least a fifth of the respondents who claim that they have changed their attitude about sports journalismt after attending the course (in addition to the fact that a little more than a quarter may be ready to work in sports journalism) actually pursue this career path, it will be a big step towards achieving gender equality in this professional field which is currently dominated by male journalists.

Conclusion

Women are still a rarity in sports journalism. This deficit certainly cannot be quickly eliminated, and gender equality in this area of journalism cannot be achieved through simple and quick solutions, yet any action that leads to this goal is important. This research confirmed the hypothesis that the course "Sports Journalism" positively changes the attitudes of FPZG female students about the genre of sports journalism. The survey confirmed the importance of education in journalism, as a course combining scientific and practical principles helped female students to acquire new knowledge about a profession that is still perceived as 'male'. As established by this survey, almost every fifth female student (perhaps, one in four) leaves open the possibility of doing sports journalism after graduation. This finding indicates a great potential for the development of a critical mass of female sports journalists, which could change the current egregiously uneven ratio of men and women in the profession in the future. Unfortunately, the "Sports Journalism" course within the study programme of journalism at the FPZG was frozen in the academic year 2023/2024, after only five years of its activity.

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THE RELATIONSHIP BETWEEN SELF-EFFICACY, GOAL ORIENTATIONS, AND INTRINSIC MOTIVATION IN ELEMENTARY PHYSICAL EDUCATION PUPILS

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Abstract
Intrinsically motivated behavior refers to participation in an activity for the satisfaction that derives from that participation. This self-determined form of motivation is associated with greater investment of effort in the activities, greater satisfaction, and higher effectiveness of exercise in Physical Education (PE) classes. Self-efficacy and goal orientation are some of the constructs related to intrinsic motivation in the context of sports and physical exercise. This research examines the contribution of physical exercise self-efficacy and task and ego goal orientations in explaining the variance of intrinsic motivation in PE classes in a sample of seventh and eighth-grade pupils (N = 118). The results of the hierarchical regression analysis showed that based on this set of predictors it is possible to explain 37% of the variance in intrinsic motivation, with task goal orientation and physical exercise self-efficacy being statistically significant positive predictors. The practical implications of the present study suggest that PE teachers should strive to create a mastery motivational climate given that some theories suggest that situational cues can reinforce or override the expression of dispositional tendencies. Furthermore, it is important that teachers set realistic and attainable goals for each pupil and give positive feedback on pupils' activity and progress to strengthen their belief in the capacity to perform specific PE tasks and possibly to contribute to them enjoying the PE classes more.

Keywords: self-determined motivation; goal orientations, self-efficacy, PE classes

Introduction

Motivation is a psychological construct that helps us explain why people behave in a certain way at a certain moment. Self-determination theory (Ryan & Deci, 2000) is an approach to human motivation that proposes that various types of motivated behaviors can be ordered along a continuum of self-determination moving from amotivation, through different types of extrinsic motivation to intrinsic motivation. Intrinsic motivation refers to participation in an activity for the pleasure that activity brings (Ryan & Deci, 2000). Intrinsic motivation is shown to be positively related to adaptive outcomes in PE settings (e.g. investment of effort in the activity; Ntoumanis, 2001). To understand someone's behavior, it is also important to consider the goals one is pursuing in different contexts. Differences in behaviors can be explained, not only by the level of self-determination of the motivation but also by differences in goal setting between people. Nicholls (1989) suggests that in achievement settings people tend to be task or ego-oriented. This orientation towards certain goals in a specific achievement context (e.g. PE classes) is determined by the complex interaction between the dispositional goal orientations (intrapersonal level) and the broader motivational climate (situational level) created by relevant social agents (e.g. PE teacher; Dweck & Leggett, 1988). On a dispositional level, dominantly task-oriented people judge their competence in comparison to their past performances in a certain task or by the progress achieved. For them, the basic criterion of success is the subjective feeling of mastering a task (Nicholls, 1989). Unlike them, people who are dominantly ego-oriented rate their success by social comparison, and being successful for them means establishing superiority over others (Nicholls, 1989). Previous research showed that task orientation is positively related to intrinsic motivation in PE (Standage & Treasure, 2002), while ego-goal orientation is often shown to be unrelated to intrinsic motivation for exercise (Boyd et al., 2002) or in PE (Standage & Treasure, 2002). While goal orientations indicate different reasons for engaging in the activity, another psychological construct closely related to motivation, self-efficacy, indicates a belief in one's capacity to produce a certain level of performance (Bandura, 1997). Children who consider themselves more capable of performing PE tasks will set more challenging goals and be more persistent in achieving them. They will not give up when encountering obstacles but will make an extra effort to overcome them. Such children attribute the achieved success to their abilities and efforts, and they also attribute any failure to themselves, i.e. to the insufficient investment of effort in the activity (Barić, 2012). Children with a lower level of self-efficacy regularly choose goals too easy or too difficult because in such circumstances the outcome of their behavior is often known in advance. In the case of choosing a goal that is too easy, they confirm their competence, and in the case of choosing a goal that is too difficult, they attribute the failure to the difficulty of the task, so that their sense of competence remains relatively preserved (Barić, 2012). Previous research indicates a positive correlation between motor self-efficacy and enjoyment in PE (Morales-Sánchez et al., 2021). Based on previously described theoretical frameworks and results of empirical research it is hypothesized that task goal orientation and physical exercise self-efficacy will be statistically significant positive predictors of intrinsic motivation in PE classes.

Methods

Participants

The participants (N = 118) were seventh (N = 57) and eighth-grade (N = 61) pupils who attended an elementary school in Zagreb, Croatia. The average age of the participants was 13.69 years (SD = 0.58). Most of the participants were males (N = 70), and a smaller part were females (N = 48). Also, 83 of the surveyed pupils participate in organized sports outside the school.

Instruments

Intrinsic motivation in PE classes was measured with the interest/enjoyment subscale from the adapted Croatian version (Štimac, 2000) of the Intrinsic Motivation Inventory (IMI; McAuley et al., 1989). The interest/enjoyment subscale (e.g. "I enjoy this exercise very much.") is considered a measure of intrinsic motivation, while the other subscales of the IMI are considered antecedents or outcomes of intrinsic motivation rather than intrinsic motivation per se (Clancy et al., 2017). The participants were asked to assess the degree of agreement with the statements on a Likert-type scale (1-strongly disagree, 5-strongly agree). A higher score indicates a higher level of intrinsic motivation. For the present research, one item was modified[1]. The inversely[2] phrased item: "This exercise does not hold my attention." was transformed to: "This exercise holds my attention." Cronbach's reliability coefficient (α = .91) was calculated. The satisfactory reliability of the subscale is in line with the results of previous research (Jakobek & Ljubotina, 2022). Physical exercise self-efficacy was measured with the Self-efficacy for Exercise Behaviors Scale (Sallis et al., 1988). The original questionnaire contains 12 items and a total score indicating self-efficacy for physical exercise can be calculated (Lauš, 2019). Participants were asked to rate how confident they were that they could motivate themself to do different exercise-related behaviors consistently for at least six months on a Likert-type scale (1-sure I could not do it, 5-sure I could do it) with a higher score representing a higher perceived self-efficacy. In this research items (e.g. "Get up earlier to exercise.") presented in Lauš (2019) were used. Some items were modified to be suitable for elementary school pupils (e.g. demands at work were reworded to demands at school). Given that to the best of our knowledge, no paper investigating a factorial structure of the Croatian version of the scale was published and some modifications have been made, PAF analysis was performed to inspect whether the unidimensional solution is interpretable. 12 items were entered into analyses. The values of Kaiser-Meyer-Olkin (.91) and Bartlett's (χ^2 (66, *N* = 118) = 736.35; $p < .01$) tests indicate that data were appropriate for factor analysis. Two factors whose eigenvalues (λ_1 = 6.27, λ_2 = 1.05) are greater than 1 were extracted. The differences between the primary and alternative factor loadings were then inspected. All items had a greater loading on the first factor with the lowest loading on that factor being .54. Some authors (Howard, 2016) suggest that items should demonstrate a difference of at least .20 between their primary and alternative factor loadings. Only one item[3] (the one with the lowest loading on the first factor) did not demonstrate a difference at least that high and was excluded from the subsequent analyses[4]. We re-run the analysis without the aforementioned item and one factor with an eigenvalue (λ = 5.98) greater than 1 explaining 54.38% of the variance in the results was extracted. The lowest factor loading was .57. Satisfactory Cronbach's reliability coefficient (α = .91) calculated on the 11 items is in line with previous findings (Lauš, 2019). Goal orientation was measured with the Croatian version (Barić et al., 2002) of the Task and Ego Orientation in Sport Questionnaire (TEOSQ; Duda, 1989). The questionnaire contains a total of 13 items that are divided into two subscales: task goal orientation (e.g., "I feel most successful in PE classes when I work hard.") and ego goal orientation (e.g. "I feel most successful in PE classes when I am the best."). The participant's task was to choose the degree of agreement with a certain statement on a Likert-type scale (1-strongly disagree, 5-strongly agree). A higher score indicates a higher level of certain goal orientation. Cronbach's alpha coefficients of the subscales (0.94 for task orientation, 0.89 for ego orientation) indicate satisfactory reliability which is in line with the results of previous research on the same population (Barić et al., 2014).

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[1] Given that some modifications to the subscale were made, principal axis factoring (PAF) analysis was performed to inspect whether the unidimensional solution is interpretable. 5 items measuring interest/enjoyment were entered into the analyses. The values of Kaiser-Meyer-Olkin (.87) and Bartlett's (χ^2 (10, N = 118) = 398.67; $p < .01$) tests indicate that data is appropriate for factor analysis. One factor whose eigenvalue (λ = 3.68) is greater than 1 was extracted which explained 73.62% of variance in results. The lowest factor loading was .65. The PAF analysis suggests that the unidimensional solution is interpretable.

[2] Krosnick and Presser (2018) state that reversely worded items based on a negation word are particularly cognitively burdensome for participants, which is why they contribute to an increase in measurement error.

[3] Item: "Set aside time for a physical activity program, that is, walking, jogging, swimming, biking or other continuous activities for at least 30 min three times per week."

[4] There was no difference in the significance of Pearson's r or β coefficients of the self-efficacy variable whether the item was excluded or not. However, considering PAF analysis results, we decided to exclude the item from further analyses.

Procedure

The research was conducted in May 2023 via an online survey created in LimeSurvey software. Informed written consent signed by the parents was collected for all participants. The consent paper, as well as the opening page of the questionnaire, contained information about participation in research being anonymous and withdrawal from participation possible at any time during the research. Parents and children were informed that collected data was going to be used for scientific purposes exclusively. The research design was in line with the Code of Ethics for Research Involving Children (Ajduković & Keresteš, 2020). The gathered data was analyzed via SPSS 26 software.

Results

The descriptive data of the variables used in this research are presented in Table 1. The subscale results are expressed as the average values on items indicating respective dimensions.

Table 1. Descriptive statistics (N = 118)

	M	*SD*	*Skew*	*Kurt*
Ego goal orientation	3.30	1.06	-0.45	-0.41
Task goal orientation	3.54	1.05	-0.76	-0.15
Physical exercise self-efficacy	3.64	0.96	-0.63	-0.13
Intrinsic motivation	3.30	1.07	-0.27	-0.73

Legend: M – mean; SD – standard deviation; Skew – skewness; Kurt – kurtosis

The normality of the distributions of variables was inspected via skewness and kurtosis indices. Based on those parameters the distributions can be considered normal, and the application of parametric statistical procedures is justified (Ryu, 2011). Table 2 presents the bivariate Pearson's correlation coefficients between the variables. A high positive statistically significant correlation was found between task and ego goal orientations. Also, relatively high positive correlations between intrinsic motivation and task goal orientation and intrinsic motivation and self-efficacy were obtained. A moderately high positive correlation emerged between intrinsic motivation and ego goal orientation.

Table 2. - Correlation matrix (N = 118)

	1.	2.	3.	4.
1. Ego goal orientation		.59**	.08	.28**
2. Task goal orientation			.16	.45**
3. Physical exercise self-efficacy				.47**
4. Intrinsic motivation				

Legend: ** p < .01

A hierarchical regression analysis with intrinsic motivation as a criterion was performed. Before the analysis, collinearity diagnostics were run. The lowest tolerance was .64 and the highest variance inflation factor was 1.56, meaning no multicollinearity issues should be present (Miles, 2014). Goal orientations were included in the first block and self-efficacy in the second. Based on the first block of predictors, 21% of the variance in intrinsic motivation could be explained with task orientation being a statistically significant positive predictor. With self-efficacy included in the second block, an additional 16% of the variance in the criterion variable was explained. Task orientation and self-efficacy shown to be significant positive predictors of intrinsic motivation.

Table 3. Results of hierarchical regression analysis with intrinsic motivation as a criterion

	*β*M1	*β*M2
Task orientation	.44**	.37**
Ego orientation	.02	.03
Physical exercise self-efficacy		.41**
R^2	.21	.37
F	14.96	22.44
p	< .01	< .01
ΔR^2		.16
$F\Delta R^2$		29.88
$p\Delta R^2$		< .01

Legend: β-the value of the standardized regression coefficient; M1, M2-models in hierarchical regression analysis; R^2-the total contribution to the explained variance; F-the F-ratio value; p-significance level of the model; ΔR^2-the contribution of the additional group of predictors to the explained variance; $F\Delta R^2$-the F-ratio value for the additional group of predictors; p ΔR^2-the significance level of the increase in the explained criterion variance with the inclusion of an additional group of predictors; **p < .01.

Discussion

This research aimed to determine the contribution of task and ego goal orientations and physical exercise self-efficacy in explaining the variance of intrinsic motivation in PE among seventh and eighth-grade elementary school pupils. The results of hierarchical regression analysis showed that 37% of the variance in the criterion variable could be explained, with task goal orientation and physical exercise self-efficacy being statistically significant positive predictors. Ego goal orientation did not prove to be a significant predictor of intrinsic motivation and this finding is in line with some other empirical research (Boyd et al., 2002). The insignificance of the regression coefficient of ego goal orientation, although the variable is shown to be related to intrinsic motivation at the level of a simple correlation, could be explained by the relatively high correlation between ego and task goal orientations. The results of the present study could be of particular interest to PE teachers. Achievement goal theory suggests that key social agents could shape the social-psychological environment, called motivational climate, in an achievement context (e.g. PE teachers can shape motivational climate in PE classes; Duda & Balaguer, 2007). There are two main types of motivational climate, mastery and performance. A mastery motivational climate is shaped when the teacher emphasizes self-referenced improvement and effort, and success is defined as an improvement of one's personal best achievements. On the other hand, a performance climate is created when the teacher encourages normative comparisons and the pupil's success is evaluated in comparison to the performance of others (Ames, 1992). Achievement goal theorists suggest that the interplay between goal orientations and motivational climate influences the likelihood of pupils being task- or ego-involved in PE. When mastery or performance situational cues are not salient, one's dispositional goal orientation should predict achievement-oriented behavior. However, strong situational cues could override dispositional goal orientations, or further reinforce them if they are compatible, so it can be expected that more pupils will behave similarly in specific achievement contexts, which emphasizes the importance of creating a mastery climate in PE (Dweck & Leggett, 1988). To promote a mastery climate, Ames (1992) proposes that the task, authority, recognition, grouping, evaluation, and time structures (TARGET) should be manipulated by the teachers. Designing tasks within the lessons should emphasize mastery goals, variety, and novelty. Pupils should be involved in the learning process via the provision of choices and decision-making opportunities. Recognition and evaluation should focus on individual effort and improvement and be given privately whenever possible, providing opportunities for success for all pupils. The grouping structure within the lesson should focus on cooperative group learning using heterogeneous (in terms of abilities) and diverse groupings. Learning time should be maximized and flexible so the pupils have enough time to complete the assignments (Ames, 1992). By implementing aforementioned teaching strategies PE teachers could create mastery-oriented situational cues and increase the likelihood of pupils being task-involved in PE classes. Being task-involved in an activity is often discussed to be motivationally adaptive in a sports context. Task goal orientation is positively related to enjoyment, satisfaction, and perceived physical competence (Boyd et al., 2002). In the present study individuals who reported higher scores in task orientation variable also reported higher levels of intrinsic motivation, which makes fostering task orientation in the PE context even more important. Intrinsically motivated pupils find PE classes more interesting, and challenging, it gives them a sense of satisfaction, and they are investing the effort in the activity for its own sake, and not because of external factors (Boyd et al., 2002). Self-efficacy, the belief that our capacities are sufficient to produce a certain level of performance (Bandura, 1977), has also been shown to be positively predictive of intrinsic motivation in the present study. Therefore, to increase the possibility of pupils being intrinsically involved in PE classes, PE teachers should also strive to increase pupils' perceived physical exercise self-efficacy. Four sources of information, including past performance, vicarious experience, verbal persuasion that one possesses certain qualities, and physiological/affective states, are the basis of one's self-efficacy judgment. Teachers should try to capitalize on these sources (e.g. draw pupils' attention to their improvement and praise their performance of specific skills; use pupil models to demonstrate the performance of particular skills to show pupils that their peers of similar characteristics can master the lessons) to produce pupils who are more confident in their physical exercise skills (Siegle & McCoach, 2007). Based on the results of the present and previous studies implications arise in the suggestion for PE teachers that fostering a master climate and working towards increasing pupils' physical exercise self-efficacy could contribute to pupils' intrinsic motivation in PE classes. The main limitation of the present study stems from the correlational nature of its design. Therefore, it cannot be concluded that relations between variables are causal. Other limitations include a relatively small sample size, data obtained by self-assessment (which can be subject to bias), and the focus exclusively on intrinsic motivation. Future research should include pupils of a broader age range and from a wider geographical area to ensure greater external validity of the findings.

Conclusion

The results of the present study showed that task goal orientation and physical exercise self-efficacy are statistically significant predictors of intrinsic motivation in PE classes. It was discussed that PE teachers should strive to create a mastery motivational climate (to reinforce task orientation in pupils) and increase physical exercise self-efficacy in pupils, possibly contributing to them enjoying PE classes more.

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WHO'S AFRAID OF WOMEN IN SPORTS?

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Abstract
This paper explores the underrepresentation of women in sports media by analyzing the frequency of coverage of women's sports disciplines on popular Croatian news websites - Jutarnji.hr, Večernji.hr, and Index.hr. Furthermore, it applies qualitative discourse analysis within the context of critical theory to locate ideological structures that uphold a biased power imbalance based on biological differences between men and women. Sport does not exist in a vacuum; it reflects the social issues that surround it. Just one look at the results of the quantitative analysis is enough to dispel the fallacy that suffrage has achieved equality and that feminism is pointless in the 21st century.

Keywords: *sports media, women's sports, feminism, Croatia*

Introduction

The 1990s were an especially prolific decade for works that criticized structures that upheld our society's androcentric distribution of power. Riding on the shoulders of trailblazing authors when it comes to the systemic marginalization of women, Judith Butler (1988) published her revolutionary work on the topic of the performative nature of gender identity. Her work ignited a discourse on gender politics that is still used as the foundation for critical analyses of systems that sustain the current cultural status quo. Gender politics, systemic marginalization, and distribution of power, all seem to be heavily loaded words for an environment so light-hearted as sport. Yet, the structures that maintain this multibillion-dollar landscape remain as problematic as ever. In the decades past, abounding research has been done on the topic of underrepresentation of women in sports media. Adrian Beard, Lawrence Wenner, and Linda Fuller all published or edited multiple works on the topic of the treatment of women in sports and the corresponding media content. The premise of Beard's work, for example, rests on the idea that "if there are gender issues in our society, then these issues are likely to appear in sport" (1998, p.17). In the gender binary, that which is feminine is weak, less worthy, less than, and lastly, the other. On the other hand, that which is masculine is preferable, powerful, positive, and the default. Ironic when one takes biology and the stages of prenatal development into account. In the introduction of her work, Linda Fuller confirms the findings of Beard's, then already a decade old, research by noting that sportscasters focus on female athletes' sex appeal and emphasize "female frailties rather than performance" (2006, p. 6). Nevertheless, the question that overlays this complex tapestry of issues is simple - why? Who or what comes to benefit from such a state of affairs? If culture is a system consisting of values, ideas, and beliefs, then the one in control of that trifecta is in control of those who maintain its elements. Allowing those who are oppressed to enter the playing grounds and equate themselves with the identity markers of those who oppress, poses a threat to the image of the powerful masculine. Studying sports through the lens of identity politics allows for a better understanding of the mechanisms of power and their location. Therefore, relying on critical theory to assess the social structures upheld by the content that surrounds sports is a valuable resource for combating misogyny and marginalization.

Methods

This paper tackled the issue of underrepresentation of women in sports media. It aimed to support this blatant inequality by way of analyzing the frequency of the coverage of women's sports disciplines in the sports segments of the popular Croatian news websites - Jutarnji.hr, Večernji.hr, and Index.hr. All analyzed articles were strictly sports-related. The mentioned websites were visited for three consecutive days (from Wednesday May 8 to Friday May 10, 2024) between 9 a.m. and noon, and the articles' (N=540) content was surveyed for the presence of news covering women in sports (totaling 22). The subject matter of the articles was surmised from their titles and subtitles, and it received more elaborate attention in the Discussion part of the paper, in that some titles and subtitles were mentioned to indicate and touch upon the presence of androcentrism and machismo. The percentage of articles covering women in sports within the identified timeframe was calculated. Ultimately, the analysis was used as a methodological framework to discuss gender roles and how, even in sports, or more accurately, by way of sports, misogyny bordering gender bias is instrumental for the preservation of the patriarchal status quo.

Results

In total, there were 540 sports articles surveyed, out of which only 22 in some way, shape or form, mentioned women in sports (Table 1). In a span of three days and across all three news websites, that comprised a mere 4.07% of sports articles that covered news about women in sports, not even female athletes necessarily, just women.

Table 1. The frequency of articles covering women in sports on three consecutive days per website and total

	DAY 1 - WEDNESDAY, MAY 8, 2024			
NEWS WEBSITE	Sportske novosti (Jutarnji.hr)	Večernji.hr	Index.hr	TOTAL
N. OF ARTICLES	80	53	51	184
WOMEN IN SPORTS	1	4	2	7
PERCENTAGE	1.25%	7.55%	3.92%	3.80%
	DAY 2 - THURSDAY, MAY 9, 2024			
NEWS WEBSITE	Sportske novosti (Jutarnji.hr)	Večernji.hr	Index.hr	
N. OF ARTICLES	75	52	50	177
WOMEN IN SPORTS	1	2	3	6
PERCENTAGE	1.33%	3.85%	6%	3.39%
	DAY 3 - FRIDAY, MAY 10, 2024			
NEWS WEBSITE	Sportske novosti (Jutarnji.hr)	Večernji.hr	Index.hr	
N. OF ARTICLES	75	53	51	179
WOMEN IN SPORTS	1	4	4	9
PERCENTAGE	1.33%	7.55%	7.84%	5.03%
	TOTAL FOR EACH WEBSITE			
NEWS WEBSITE	Sportske novosti (Jutarnji.hr)	Večernji.hr	Index.hr	
N. OF ARTICLES	230	158	152	**540**
WOMEN IN SPORTS	3	10	9	**22**
PCT. WOMEN IN SPORTS	1.30%	6.33%	5.92%	**4.07%**

This means that articles about women in sports comprised a mere 3.8% of all the sports articles for that day. Jutarnji.hr was at the forefront regarding content quantity, with 80 articles in total. However, only one of the said articles marginally touched upon the topic of women in sports. The word marginally is used very loosely here, given that the article actually informs the reader about the death of one Štefica Borjan – the grandmother of the controversial goalkeeper Milan Borjan (Urukalo, 2024). Nevertheless, a woman has been mentioned within the context of sports, which means that 1.25% of the articles in the sports segment of Jutarnji.hr represent women in sports. Večernji.hr follows suit with 53 articles in total and four, or 7.55%, of them mentioning women. The most notable name mentioned in these four articles is that of Blanka Vlašić. The ratio of articles on Index.hr was no different. Out of 51 articles, 3.92% provided the reader with some kind of news about women in sports. However, one of the two articles did not convey information about sports results. Rather, it focused on the physical transformation of a former tennis player. On the final day of research, Index.hr had the highest ratio of articles of women in sports to the total number of sports articles (7.84%). Out of 51 articles, Index.hr had 4 articles covering women in sports. Summing up all three days together, Večernji.hr had the largest number of articles mentioning women in sports (6.33%), whereas Jutarnji.hr had the largest number of total sports articles (230) but only 1.3% (3) of them dealt with women in sports. The most fruitful day regarding the number of women's sports articles was Friday, with 5.03% of articles covering such news or themes.

Discussion

With the underrepresentation of women in sports media being quantitatively substantiated, this part of the paper ventures into qualitative discourse analysis and its implications within the context of critical theory. In addition to the number of articles dealing with women in sports being scarce, the language and the themes covering such news are also conspicuously negative. Articles covering women in sports tend to focus on: "the appearance, parental figures, and/or spouse/family involvement of women athletes rather than strictly on their athleticism and in-game play" (Darvin, 2023). The idea that women in sports are "gazed at as sex objects" (Fuller, 2006, p. 6) is confirmed by an Index.hr article examined on the last day of research where an Italian tennis player Camila Giorgi was blatantly subjected to the male gaze. The article consists of six sentences, two of which briefly recount her successes, and the rest of the article depicts her Instagram posts in which she models underwear ("Tenisačica s 32 godine završava karijeru da bi se posvetila biznisu s donjim rubljem" ["Tennis player at 32 ends her career to focus on lingerie business"], 2024). Another example covered by this research includes an Index.hr article about a former tennis player. The focus of this article is not on her athletic career, but on her physical transformation after she gave birth ("FOTO Nekad 4. tenisačica svijeta oduševila fizičkom transformacijom nakon dva poroda", 2024). It is interesting to note here that the subject matter of the article could easily have been a recounting of the athlete's successes in her long career. Instead, two things are at the article's forefront, the first being the athlete's physical appearance, while the second is the fulfillment of her main role as a woman - that of motherhood. As Beard indicates: "It is as though women have an inferred status that is only fully realised through their role relationships with men" (1998, p. 27). Such "discriminatory stereotyped descriptions of female athletes are motivated by an ideological stance aiming to confine women to behavior consonant with, and assertive of, hegemonic masculinity" (Ponterotto, 2014, p. 97). As already mentioned, articles focusing on women's bodies in sports abound, so much so that out of four articles that cover news about women in sports on the final day of research on Večernji.hr, one of them features a woman who has nothing to do with athleticism. To be precise, the article in question notifies the reader that this year Ivana Knoll, a Miss Croatia World 2016 finalist, best known for her busty appearance in the 2022 FIFA World Cup, is returning to the stands of various stadiums. On the one hand, news covering men in sports usually range from unbiased reports on their scores to portraying them in a more favorable light as "the dominator; the playboy; or the lovable, big clown" (Burris, 2006, p. 86). On the other hand, when not depicted through the lens of their physical appearance, women are typecast as "emotionally troubled, unfulfilled, and torn by role conflict" (Hillard 1984, as cited in Bissel, 2006, p. 174). Even in the short amount of time during which this paper's research has been conducted, there was a title focusing on a female American player's tantrum at a WTA tournament in Rome ("VIDEO Amerikanka napravila skandal u Rimu! Bacala stvari pa počela psovati publiku" ["VIDEO American woman caused a scandal in Rome! Threw things and swore at the audience"], 2024). This delineation of identity markers "is frighteningly consistent with stereotypical hegemony" in which various structures are implemented throughout different social landscapes to preserve the androcentric distribution of positions of power (Hallmark, 2006, p. 166). The instrumental structure in this case is language which in sports traditionally "includes a great number of vocabulary items related to military and warfare" (Kowalkowa, 2009, p. 65). In other words, language in sports "tends to be militaristic, sexual, even violent" (Fuller, 2006, p. 7). What better instrument to use to emanate power than that of mass destruction? The military is the ultimate symbol of the strength of a given nation. It is used to subjugate and oppress the enemies of the state and to maintain state sovereignty. To exude power one must be strong, indomitable, and unyielding, all the qualities used to preserve the idea of masculine hegemony, i.e. to leave the cultural positions of power under the rule of men. In a system where strength is used as the denominator that determines one's position, "it is the biological differences between men's and women's bodies that underpin the inequality that is (re) produced and legitimated in contemporary society" (Cooky, 2006, p. 101). If women were allowed to enter these systems of power, the (im)balance of privilege determined by biological differences becomes glaringly obvious. This disrupts the superficial idea of equality and misogyny rises to the surface of the carefully layered tapestry of society. In other words, this breach of femininity into a predominantly masculine landscape disrupts the ideological structures that maintain hegemonic masculinity, i.e. the androcentric systems of power. "The public is not ready to see women in these roles" of performative masculinity because women are on the opposite side of the gender binary (Burris, 2006, p. 88). Following that line of reasoning, "by using traditional definitions of 'female' and 'femininity' as the antithesis of 'athlete' and 'athletic,' the de facto norm or standard against which performance is measured becomes maleness or 'masculinity'" (Creedon, 2002, p. 90). Therefore, an athlete cannot be a woman, or, put simply, to be a woman means to be "what a man is not" (Wachs, 2006, p. 44). However, the reason as to why women are underrepresented in sports media needs not to be that serious. Maybe there is a lack of sports media content covering women simply because women's games are boring and they can't play on the same explosive level as men (Burris, 2006, p. 88). "Women's athletes are simply not as 'fun' to watch" (Burris, 2006, p. 88). Since they are not entertaining, they fail to build an audience large enough that would be profitable for advertisers. Following that train of thought, it would be folly not to consider market factors as crucial components that affect news judgment (Creedon, 2002, p. 89). Therefore, the reason for not including women in sports news may simply be the lack of profit. But which comes first – the lack of profit or the lack of interest? Cooky and Antunovic (2022, p. 39) argue that the responsibility for "building and sustaining audiences for sport" lies in the sports media themselves. In other words, the audience does "not think they like women's sports, because the media has not convinced them that they should" (Burris, 2006, p 88).

Conclusion

The underrepresentation of women in sports media has been a global point of contention for over three decades. Starting in the 1990s, with the dawn of the Internet and the late-stage capitalism assuming its modern form, sports have remained a landscape dominated by masculinity. Gender equality is an issue omnipresent in our society that repeatedly proves its resistance to erasure. The findings of the research undertaken for this paper align with the global trends of underrepresentation, as well as topic selection and language bias sterotypes. Across the three most popular news websites in Croatia, the percentage of sports articles covering women was less than 10%. The reasons for this abound and range from market profitability to insidious and covert misogyny to deeply rooted cultural practices that uphold power dynamics in favor of hegemonic masculinity.

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CONTRIBUTIONS OF SPECIFIC TRAITS AND COPING STRATEGIES OF ATHLETES TO PSYCHOLOGICAL DISTRESS DURING THE COVID-19 PANDEMIC

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Abstract
The COVID-19 pandemic has disrupted sporting activities worldwide and impacted athletes' mental health due to training interruptions and competition cancellations. This study aimed to investigate how certain personality traits and coping strategies contribute to athletes' psychological distress during the pandemic. The results showed that fear of a new COVID-19 wave, maladaptive perfectionism, and the use of non-adaptive coping strategies were associated with increased distress in athletes. Conversely, adaptive coping strategies did not significantly reduce distress. Poorer health perception was also associated with higher distress. These findings emphasize the importance of considering maladaptive coping strategies and perfectionism in the treatment of athletes' mental health during and after a pandemic. Further research is needed to investigate these dynamics longitudinally and in different sports.

Keywords: *athletes, competition cancellations, adaptive coping, personality traits*

Introduction
The COVID-19 pandemic has presented the world of sport with unprecedented challenges. The consequences of prolonged isolation and reduced training had an impact on the athletes' mental well-being. They manifested themselves in the form of depression (Pillay et al., 2020) anxiety symptoms (Iancheva et al., 2020), fatigue, and an increased perception of stress (Leguizamo et al., 2020). Well-developed coping mechanisms were needed to deal with the stressors of this sudden and unprecedented situation (Schinke et al., 2017). Athletes are used to dealing with stressful and uncertain situations due to the nature of their activities (Boat, 2016; Toering & Jordet, 2015). Di Fronso et al. (2020) found that elite athletes successfully utilized their advanced coping skills during the COVID-19 pandemic by managing isolation measures more effectively and reporting lower perceived stress levels and higher levels of functional psychosocial states than lower-ranked athletes. This suggests that not all athletes have equally developed coping mechanisms. Some athletes had previously established effective coping methods or developed them efficiently in response to the challenges of the pandemic. In contrast, others had diminished resources and ineffective strategies for coping with the crisis (Stambulova et al., 2020). In addition, athletes faced further challenges as the work of coaches, staff, and sports organizations involved in managing their activities had to be reorganized. Coping with all these stressors requires well-developed coping mechanisms (Schinke et al., 2017), which raises the question of which strategies are most effective and what potential benefits they have for athletes' mental health. Pete et al. (2020) identified four coping profiles in athletes based on the use of different coping strategies in response to the pandemic. Athletes who utilized high levels of cognitive restructuring, problem-solving, moderate levels of distraction (engaged profile), and high levels of cognitive restructuring, problem-solving, distraction, and moderate levels of help-seeking (active and social profile) experienced the lowest levels of stress and anxiety. Conversely, athletes who predominantly used avoidance strategies (avoidance profile) experienced higher levels of stress and anxiety. Perfectionism can also influence the stress levels of athletes (VandenBos, 2007). The psychological dictionary defines perfectionism as the tendency to demand exceptionally high or flawless performance from oneself or others that exceeds the demands of the situation. Perfectionism has been linked to depression, anxiety, eating disorders, and other mental problems, making it a critical psychological variable that affects the cognitive, behavioral, and emotional functioning of athletes (Hamachek, 1998). Enns and Cox (2002) distinguish between adaptive perfectionism characterized by organization and personal standards and maladaptive perfectionism characterized by worries about mistakes, parental expectations, parental criticism, and doubts about actions. Iancheva et al. (2020) investigated the relationship between these dimensions of perfectionism and psychological states in physical education students from Bulgaria and Russia and found that adaptive perfectionism was predominant among the students. They also reported significant associations between maladaptive perfectionism and increased levels of tension, fatigue, anger, and depression. During the pandemic, numerous factors could influence the mental health of athletes. It is important to understand the background and factors that contribute to or hinder a person's mental well-being. Therefore, the main objective of this study was to investigate the contribution of certain personality traits and coping strategies to the overall distress of athletes during the COVID-19 pandemic. This study aimed to investigate variables significantly associated with athletes' mental health and to determine their contribution to athletes' overall psychological distress.

Methods

Participants

A total of 398 athletes (65.9% recreational and 34.1% professional), aged 12 to 70 (M=30.05, SD=11.21), participated in the research. The respondents were athletes from Croatia (n=210, 52.7%) and Bosnia and Herzegovina (n=188, 47.3%), with 46.5% female and 53.5% male.

Instruments

Sociodemographic data, health status, use of relaxation techniques, and changes in training frequency were collected. *The Brief COPE (Coping Orientation to Problems Experienced) inventory (Carver, 1997), adapted to Croatian by Mirjanić & Milas (2011)*, was used to assess stress coping strategies. The questionnaire contains 28 items divided into two subscales: adaptive (α=.78) and non-adaptive coping strategies (α=.78). The subscale of adaptive coping strategies has 16 items, and the subscale of non-adaptive strategies has 12 items. Respondents are asked to recall stressful situations that occurred in the past few months and to indicate how often they assess the frequency of their behavior in a given way, to overcome stress. The answers to the questionnaire range from 1 to 4, (1 = I did not do it at all, 4 = I did it often). The scores on the subscales are calculated as a linear combination of the corresponding particles, with a higher score indicating more frequent use of that stress-coping strategy. In this study, the reliability of the internal consistency type for adaptive ones is α=,78, and for non-adaptive α=,75. *The Depression, Anxiety, and Stress Scale (DASS-21; Lovibond & Lovibond, 1995), adapted to Croatian by Jokić-Begić, Jakšić, Ivezić, & Suranyi (2012)*, was used to assess symptoms of depression, anxiety, and stress. The DASS-21 scale consists of 21 items that are divided into three scales. Each scale contains seven items and measures the level of negative emotional states - depression, anxiety, and stress. The depression scale includes symptoms of dysphoria, hopelessness, self-devaluation, apathy, and lack of interest. Respondents were asked to rate how they felt in the last week on a 4-point Likert scale (0 = not at all to 3 = mostly or almost always). In this research, based on earlier literature (Zanon et al., 2021) and due to high correlations between subscales, the questionnaire was used as a unidimensional measure of general psychological distress (α=.95). Scores on the scale are calculated as a linear combination of particle responses, with a higher score indicating more severe symptoms. In this study, the reliability of the internal consistency type for the overall scale is α =,95. *Perfectionism (Burns scale of perfectionism, Burns, 1980; according to Ivanov and Penezić, 2004)*. The Burns scale of perfectionism consists of 10 items that the participants evaluated on a 5-point Likert scale (1 = do not agree at all, 5 = completely agree). The scores on the scale are calculated as a linear combination of responses on the particles, with a higher score indicating more pronounced perfectionism (α=.70). The reliability of the scale in this study is α=,70.

Procedure

The research was conducted online using a Google form. The invitation letter, including research details and an access link, was sent via social media and email to sports clubs and athletes. To participate, respondents under 18 years of age first had to obtain parental consent to meet ethical principles. They were informed that participation is voluntary and anonymous and that the results were analyzed at the group level. The data collection period lasted from May 29 to August 5, 2020. Since the research was voluntary and anonymous, participants could withdraw from participation at any time. The questionnaire included the aforementioned instruments. IBM SPSS Statistics 23 was used for data analysis, including descriptive, correlation, and multiple regression analyses.

Results

Before the statistical data analysis, the prerequisites for their implementation were checked. The values of symmetry and flattening were calculated, which should be within the range of -3 to 3 (Kline, 2016) for the use of the aforementioned statistical analyses. Although the Kolmogorov-Smirnov test indicates that the data of the variables are not normally distributed, the criteria of the index of flatness and symmetry indicate that these criteria of normality are satisfied. Also, with a sufficiently large sample, regression analysis models are robust to the violated assumption of normality and it is possible to perform regression analysis, that is, the use of planned parametric statistical procedures is justified (Schmidt and Finan, 2018). Table 1 contains all the descriptive data of the variables used in the research.

Table 1. Descriptive data of the variables examined

	Min	*Max*	*M*	*SD*	*α*
Psychological distress	0,00	63,00	15,59	14,09	0,95
Perfectionism	10,00	46,00	30,46	6,03	0,70
Adaptive strategies	28,00	64,00	46,83	6,46	0,78
Non-adaptive strategies	14,00	48,00	23,86	4,97	0,75
Health status	3,00	15,00	8,70	1,92	0,74

Pearson's and Spearman's correlation coefficients were used to examine the existence of a statistically significant relationship between variables. The presentation of these values can be seen in Table 2. General distress is significantly positively related to non-adaptive coping strategies (r=.50, p<.01), perfectionism (r=.24, p<.01), fear from the renewed wave of COVID-19 (r=.20, p<.01), and changes in body weight during the pandemic (r=14, p<.05) and significantly negatively related to self-assessment of overall health (r=-.30, p <.01). At the same time, it is not significantly associated with gender, age and adaptive coping strategies.

Table 2. Presentation of the intercorrelation matrix of all examined variables

	2	3	4	5	6	7	8
1. Distress	,09	-,05	,27**	,07	,54**	-,29**	,22**
2. Gender	1	,09	-,04	,19	,14	-,08	,16
3. Age		1	-,20**	-,05	-,04	-,01	,03
4. Perfectionism			1	,13*	,25**	-,05	,22**
5. Adaptive strategies				1	,26**	-,14*	,04
6. Non-adaptive strategies					1	-,27**	,20**
7. Health status						1	-,14**
8. Fear of a new wave							1

*p<0,05, ** p<0,01

To answer the first research problem, multiple regression analysis was used. Table 3 presents the results showing the contribution of maladaptive coping strategies, self-rated overall health, perfectionism, fear of a resurgence of COVID-19, and weight change during the pandemic to explaining the variance of general neuroticism. Non-adaptive coping strategies (ß=.42, p<.01), perfectionism (ß=.19, p<.01), and fear of another wave of COVID-19 (ß=.10) were found to be significant positive predictors of psychological distress, p<.05). Self-assessment of overall health was found to be a negative predictor of general distress (ß=-.15, p<.05). This model explained 33.8% of the variance of the criterion variable of psychological distress.

Table 3. Presentation of the results of the predictive contribution of coping strategies, self-assessment of health status, perfectionism, and fear of the new wave of psychological distress

	Non-standardized coefficients		Standardized coefficients	t	p
	B	SP	β		
Constant	-17,88	5,40		-3,32	0,001
Non-adaptive strategies	1,14	,14	,42	8,33	<,001
Health status	-1,03	,34	-,15	-3,01	<,05
Perfectionism	,41	,11	,19	3,85	<,001
Fear of a new wave	1,12	,54	,10	2,02	<,05
R=,581, p<,01; R²=,338, p<,01; adj. R=,329					

Discussion

This study aimed to examine the contributions of specific personality traits and coping strategies to the psychological distress experienced by athletes during the COVID-19 pandemic. The results indicate that neither gender nor age is significantly associated with the level of psychological distress among athletes, although previous literature (Nolen-Hoeksema & Aldao, 2011; Nurullah, 2010) suggests that younger individuals and females might be more prone to higher levels of distress. In contrast, the results suggest that athletes who express a greater fear of a new wave of COVID-19 report more pronounced symptoms of distress. Given that the pandemic situation and restrictive measures are closely related to the possibility of engaging in sports activities (Stambulova et al., 2020), athletes who fear a new wave may be not only concerned about the risk of infection and illness but also about their ability to continue their sports careers. Therefore, their fear of a new wave may be associated with both health uncertainty and the uncertainty of their sports career, which amplifies their experience of distress. Furthermore, the results indicate that athletes with higher levels of perfectionism experience greater psychological distress, consistent with initial expectations and previous literature (Hamachek, 1998; Iancheva et al., 2020), which suggests that perfectionism affects the cognitive, behavioral, and affective functionality of athletes. Given that this study measured maladaptive perfectionism, which is linked to poorer mental health in the literature (Hamachek, 1998), athletes prone to worrying about mistakes and setting high expectations for themselves (both professionally and personally) are likely to experience symptoms such as depression, stress, and tension. In line with these findings, our study also found that professional athletes reported higher levels of perfectionism and greater use of relaxation techniques compared to recreational athletes. This suggests that the unique demands and pressures of professional sports may contribute to these differences in psychological characteristics and coping mechanisms (Kuna et al., 2023). The study also found that general distress is significantly positively associated with the use of maladaptive coping strategies, which are positive predictors of distress. This finding aligns with previous literature (Pete et al., 2020), suggesting that athletes who frequently use maladaptive coping strategies experience higher levels of stress and anxiety. These strategies, which include avoidance, rumination, denial, withdrawal, self-blame, and substance abuse (Thompson et al., 2010), are linked to increased stress. Maladaptive coping mechanisms prevent individuals from fully processing emotional events, leading to feelings of inefficacy and helplessness (Wolfe et al., 1993), which can further exacerbate distress symptoms. For athletes, using such strategies may make coping with the pandemic and changes in sports activities more difficult. Additionally, it was found that athletes who perceive their health as poorer are more likely to report higher levels of distress. Participation in sports, especially through physical activity, has many benefits for health and well-being (Breslin et al., 2017). Physical activity and mental resilience are consistently positively associated with positive mood and well-being, while poorer health perception is associated with negative outcomes (Biddle & Mutrie, 2015). Therefore, athletes who perceive their mental, physical, and conditioning state as weaker may feel that life stressors, including professional challenges, exceed their capacities, supporting symptoms such as anxiety and depression. Nevertheless, this study provided new insights into how athletes experienced the COVID-19 pandemic and identified variables contributing to psychological distress in athletes. The findings also have practical applications. Given the results regarding coping strategies and distress symptoms, it would be beneficial to develop interventions that educate athletes about the negative effects of maladaptive coping strategies and the positive effects of adaptive strategies, especially concerning professional adaptation to the pandemic and post-pandemic periods.

Conclusion

This study highlights the complex interplay of fear, perfectionism, coping strategies, and health perception in athletes' psychological distress during the COVID-19 pandemic. Future research should investigate these relationships longitudinally and in specific sports contexts.

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GENDER TYPING OF VOLLEYBALL IN CROATIA

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Abstract
Volleyball is one of the most widespread team sports today, enjoying global popularity among both men and women. The aim of this research was to determine whether students at the Faculty of Kinesiology, University of Zagreb perceive volleyball as a male, female, or equally male and female sport. The study was conducted on a sample of first-year students at the Faculty of Kinesiology, University of Zagreb (N=230; mean age=19.2). For the purpose of analysis, the sample was stratified by gender and previous experience in volleyball. Female students perceive volleyball as a female sport, while male students perceive it as a sport equally for men and women. The group of respondents who are not volleyball players also perceive volleyball as a female sport. The group of volleyball players considers volleyball equally as a male and female sport. In none of the conducted analyses do men or women perceive volleyball as a male sport.

Keywords: *volleyball, male sport, female sport, perception, gender typing*

Introduction
In countries with democratic systems, some traditionally men-dominated occupations have been taken over by women (and vice versa). Examples include teaching, dentistry, or general practice medicine (Cockerham, 2017). Similarly, we can observe these changes in sports. According to the first known categorization (Metheny, 1965), volleyball was the only team sport considered suitable for women. One of the main reasons for the perceived "suitability" of volleyball for women (as opposed to other team sports such as basketball or handball) stemmed from the medical myth about the female body. This myth held that intense sports, especially contact sports, were inappropriate for "fragile female bodies" or even dangerous for their general or reproductive health (Coakley, 2015). The categorization of sports in terms of their masculinity or femininity was based on criteria such as physical contact, aesthetics, competition, and face-to-face competition. We can surmise that volleyball was put on the list because it was a team sport in which women could compete on an international level and the fact that the sport was much less physical in the 1960s compared to other team sports.

Changes in the popularity of volleyball among women began in the 1980sIn the United States, the passage of the Title IX in 1972 had a profound impact on women's sports. Title IX prohibited gender discrimination in educational programs and activities, including athletics. This led to increased support and funding for women's sports programs in high schools and colleges, significantly boosting the popularity of volleyball among women (Stevenson, 2007). The 1980s saw a rise in media coverage of women's sports, including volleyball. Televised matches of internation competitions, backed by significant social changes, including a growing emphasis on gender equality and women's rights, played a crucial role in promoting volleyball and inspiring young girls to take up the sport (George & Epstein, 1990).

At the 1984 Summer Olympics in Los Angeles, female athletes from Team USA won a total of 57 medals. This impressive haul included 15 gold medals, 23 silver medals, and 19 bronze medals, highlighting the impact of Title IX and the growing support for women's sports in the United States during that era. One reason for this success was the increasing demand for greater rights and gender equality for women in society and sports.

Due to its characteristics, volleyball is often the first choice of sport for girls and/or their parents. This preference is reflected in the number of registered players. In many countries, the number of female players is double that of male players. Of the total number of registered players in the United States, 78.1% are registered female volleyball players, and 21.9% are registered male volleyball players (Zippia, n. d.). Similar ratios are found in Italy, where 77% are female volleyball players and 23% are male volleyball players (Dire Agenzia di stampa Nationale, 2019). In Croatia, this ratio is mirrored in the number of clubs, with 92 (71%) women's and 37 (29%) men's clubs officially competing in the 2023/2024 competitive season (Croatian Volleyball Federation, 2024). Therefore, the ratio of registered female to male volleyball players could be similar to that of the United States or Italy.

According to previous research (Koivula, 1995; Fontayne et al., 2001; Koivula, 2001; Riemer & Visio, 2003; Plaza et al., 2017; Xu et al., 2021), volleyball is considered a gender-neutral sport. However, based on certain variables used in some of the studies, it can be considered "gentler and more aesthetic" compared to team contact sports such as soccer and basketball. In some scientific studies, respondents perceive volleyball as more "feminine" than "masculine." Gymnastics, aerobics, volleyball, and figure skating, which involve aesthetics, grace, and beauty or are dominated by women, are perceived as more feminine (Hardin & Greer, 2009; Antekolović, 2023). The perception of volleyball as a women's sport may be more pronounced in countries with greater gender inequality (Ozaydin, 2022), suggesting that social norms direct girls and women toward sports considered more suitable for them. European countries with greater gender inequality are relatively more successful in women's sports, such as volleyball (Ozaydin, 2022). Media can also influence sex-typing and perceptions about sports (Jones & Greer, 2011). Recent research found that men showed less interest when female athlete appearance was incongruent with the sport's stereotype, particularly favoring feminine athletes in feminine sports like volleyball. Conversely, women showed higher interest in masculine-appearing female athletes regardless of sport type.

Volleyball is the only team sport (to the author's knowledge) where the top female player (Zhu Ting, earning $1.6 million per season) is paid better than the top male player (Wilfredo Leon, earning $1.4 million per season) (Soliu, 2023).

The path for women's volleyball to reach its current status and popularity has been long. One hundred twenty-nine years ago, an enthusiast and visionary invented an entertaining game suitable for both genders. In the early days, volleyball was mostly played by men—businessmen who would prefer it over the then well-known basketball. The reason was that there was no physical contact, reducing the risk of injury. Considering the characteristics of volleyball, women began to play very quickly. The most influential organization in popularizing and spreading the game in the United States was the YMCA (Young Men's Christian Association), aiming to spread Christian values through the development of a healthy body, mind, and spirit. Later, the leading role was taken over by the American military, spreading volleyball especially during World War I. After World War I, Dr. George J. Fisher, secretary of the YMCA war office, introduced volleyball as part of the mandatory program in military camps and sent 16,000 volleyballs and hundreds of volleyball nets to American camps.

Initially, men's volleyball "led" women's volleyball. In 1948, the first European championship for men was organized, and the following year, one was organized for women. A similar "maneuver" occurred with the first World Championships. The first Men's World Championship was held in 1949, and three years later, in 1952, women participated. In the former Yugoslavia, a federal league was introduced for men in 1949, and one year later for women. Until the 1980s, men's volleyball was more popular than women's, so the Italian Volleyball Federation (FIPAV) at that time had more registered male volleyball players than female players (Di Cesidio, 2019). Men's volleyball experienced incredible popularity during those years, such as in 1983, when a match between the USSR and Brazil was played at the Maracanã Stadium in front of more than 90,000 spectators. This match was a rematch in which the Brazilian team sought redemption for their defeat against the USSR at the World Cup held a year earlier. The match was played in the rain at a football stadium and has not been surpassed in terms of the number of spectators to this day.

Men's volleyball remains popular today. This is confirmed by the fact that at the opening of major competitions such as the World Cup or the European Championship, matches are played in football stadiums in front of a large number of spectators. The opening match of the 2014 World Cup was played in front of about 63,000 spectators. The final of that World Cup was held in a hall in front of 12,000 spectators, while 10,000 spectators watched the match on the video wall outside the hall.

Women's volleyball is even more popular. Somehow, the event from 2023 went under the media's radar when the university women's teams from Nebraska and Omaha played a match at a football stadium (Memorial Stadium - Lincoln/Nebraska/USA) in front of 92,003 spectators (data published by the NCAA). This match was recorded as the women's sports event with the highest number of spectators in history, surpassing the UEFA Women's Champions League match between Barcelona and Wolfsburg played in 2022 (Camp Nou Stadium - Barcelona/Spain) in front of 91,648 spectators.

We must note, in hopes of preempting some criticisms regarding the use of language to define gender or sex terms in this paper, that we encountered a significant amount of "noise" in linguistic terms, both in Croatian and English. Sports is currently one of the only activities in contemporary liberal cultures in which sex segregation is expected, accepted, and mandatory in nearly all competitive events (Coakley, 2011). This introduces quite a few problems and ambiguities when attempting to research and write about gender differences in sports, especially when considering the proper differentiation in the use of gender terms. The authors have strived to adhere to guidelines for the correct reporting of gender terms (Boston Medical Center, n. d.). Even if some noise is introduced with sex-related terms arising from sports terminology, the authors hereby note that this paper primarily investigates and interprets gender (social) rather than sex (biological) differences.

Research Methods

The research was conducted in 2023 on a sample of 205 students from the Faculty of Kinesiology, University of Zagreb (130 male, 75 female; mean age=19.2 years). The research was carried out using a questionnaire constructed specifically for this study. The questionnaire included an introductory text (cover letter) that included informed consent from the participants. The measurement instrument contained a list of sports and three statements expressing the perception of the sport as "male," "female," or "equally male and female." For the purposes of this study, only data related to volleyball were analyzed. As an additional control variable, the previous experience in volleyball was measured using a binary code (with previous experience/without previous experience). The author's assumption was that previous experience in volleyball (students who currently practice or have practiced volleyball) may influence a different perception of volleyball as a "male," "female," or "equally male and female" sport.

Descriptive statistics were calculated, and the significance of differences in the perception of volleyball between man and women and those with different previous experience in volleyball was tested using the Chi-square test, along with the calculation of the strength of association between variables (Cramer's V). A significance level of α=0.05 was used for assessing statistical significance. The analysis was conducted using IBM SPSS Statistics 26 software.

Results

A total of 205 students were surveyed, of which 130 were male (63.4%) and 75 were female (36.6%). Table 1 shows the perception of volleyball as a "male," "female," or "equally male and female" sport in the overall sample. Overall, respondents predominantly perceive volleyball as equally a "male and female" sport (64.4%). However, one-third (33.2%) consider volleyball a female sport, while a small number of respondents (2.4%) perceive volleyball as a male sport.

Table 1. Perception of Volleyball in the Overall Sample of Respondents

Perception of Volleyball	n	%
Volleyball is male sport	5	2.4
Volleyball is an equally male and female sport	132	64.4
Volleyball is female sport	68	33.2
Total	205	100.0

Chi-square test of independence (Table 2) showed a statistically significant association between gender and perception of volleyball, where women were more inclined to perceive volleyball as a female or equally male and female sport, compared to men who perceive volleyball predominantly as an equally male and female sport, χ^2 (1, N=205) = 13.55, p<0.01, Cramer's V = 0.26 with a small to medium effect size.

Table 2. Association between Gender and Perception of Volleyball

Gender	Volleyball is male sport	Volleyball is an equally male and female sport	Volleyball is female sport	X^2, df, *p*
	n (%)	n (%)	n (%)	
Men	5 (3.8)	93 (71.5)	32 (24.6)	13.55, 1, 0.00**
Women	0 (0.0)	39 (52.0)	36 (48.0)	
Total	5 (2.4)	132 (64.4)	68 (33.2)	

**p<0.01

In Table 3, the results of the χ^2 test are shown when a control variable - previous experience in volleyball - was applied to the sample for better interpretation and control of the obtained results. The Chi-square test of independence (Table 3) revealed a statistically significant association between gender and perception of volleyball among those respondents who do not have experience in volleyball, with women more likely than men to perceive volleyball as a female sport, χ^2 (1, n=182) = 13.34, p<0.01, Cramer's V=0.28 with a small to medium effect size. However, in the group of respondents who have previous experience in volleyball, there is no difference in the perception of volleyball (p=0.87), meaning that male and female volleyball players primarily perceive volleyball as equally a male and female sport.

Table 3. Association between Gender and Perception of Volleyball by Previous Experience in Volleyball

Previous experience in volleyball	Gender	Volleyball is male sport	Volleyball is an equally male and female sport	Volleyball is female sport	X^2, df, p
		n (%)	n (%)	n (%)	
No	Men	5 (4.1)	86 (71.1)	30 (24.8)	14.34, 1, 0.00**
	Women	0 (0.0)	29 (48.3)	31 (51.7)	
	Total	5 (2.8)	116 (63.5)	61 (33.7)	
Yes	Men	0 (0.0)	7 (77.8)	2 (22.2)	0.34, 1, 0.87
	Women	0 (0.0)	10 (66.7)	5 (33.3)	
	Total	0 (0.0)	17 (70.8)	7 (29.2)	

**p<0,01

Discussion and Conclusion

The majority of respondents (64%) perceive volleyball as an equally male and female sport, with the fewest respondents considering volleyball as a male sport (only 2.4%). It is important to note that due to the uneven gender distribution in the sample, the choice of one-third of respondents (33.2%) perceiving volleyball as a "female" sport was likely made by women, who accounted for 36.6% of the total sample.

Considering that the respondents (students) were familiarized with historical facts about the origin and development of volleyball worldwide, in Europe, and in Croatia, as well as with the achievements of Croatian volleyball players, and key facts from the domain of kinesiological and anthropological analysis of volleyball, it can be said that the results were expected – the majority, 64.4%, perceive volleyball as equally a male and female sport, which, considering that men accounted for 63.4% of the sample, can be interpreted as the choice of the male population in the total sample.

When the sample was stratified by gender using the Chi-square test of independence, statistically significant differences in respondents' perceptions were found. Despite being familiar with historical facts, women perceive volleyball as a "female" sport, unlike men, who perceive it as equally male and female sport. However, the strength of association (Cramer's V) indicates a weak to moderate association between variables.

By introducing the control variable "Previous experience in volleyball," results were obtained specifically for the population in the sample who did not have previous experience in volleyball – let's call them "non-volleyball players", and the population with previous experience in volleyball – let's call them "volleyball players". Among "non-volleyball players," there is a statistically significant difference in the perception of volleyball between men and women, with women more likely than men to perceive volleyball as a female sport. Since the population of "non-volleyball players" comprises as many as 182 respondents (89% of the total sample), it is logical that the results of the total sample will be reflected in the population of "non-volleyball players" as well. However, among "volleyball players," there was no statistically significant difference in the perception of volleyball. It is interesting that this result occurs in both male and female populations of "volleyball players." The assumption is that these respondents are more familiar with the characteristics of volleyball and its current position at the national and international levels. In none of the conducted analyses do men or women perceive volleyball as a male sport.

It should be noted with caution that the perception of respondents may have been influenced by the fact that women's representative volleyball in Croatia has achieved greater success on the international scene than men's volleyball (winning 3 silver medals at European Championships, participation of female volleyball players in the Sydney 2000 Olympic Games, winning 2 club Champions League titles). It is also important to consider the findings of some previous studies conducted in some European countries, which emphasize that greater gender inequality can promote the success of women's volleyball, as volleyball is considered an acceptable sports activity for women (Özaydın, 2022).

Studying gender typing in volleyball among all team sports is particularly interesting and valuable because volleyball has a history both as a sport for women and as a domain of male dominance. It presents a unique economic situation where it leads in gender equality regarding athletes' earnings. Additionally, the gender typing of volleyball offers equally compelling arguments for being perceived as a male, female, or equally male and female sport, making the study of volleyball's perception a potential indicator of general gender perceptions in sports within the investigated population.

In further research, it would be interesting to conduct a survey before and after the respondents are informed about a certain sport through the educational process and to determine whether this new knowledge affects their perception of the sport as "male," "female," or "neutral." Since the perception (experience) of a sport change under various influences; cultural, religious, traditional, gender relations, dominant patterns of patriarchal culture, media coverage, etc., it would also be interesting in future research to conduct similar studies in those European countries where men's volleyball has better sports results than women's volleyball.

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CONNECTION BETWEEN MODERATED PHYSICAL ACTIVITY ON VITALITY AND MENTAL HEALTH OF STUDENTS

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Abstract
The aim of this study was to determine the effect of moderated physical activity on the mental health and vitality of students at the Faculty of Traffic Sciences. By increasing physical activity with an additional 3000 steps above their baseline level, three times a week, participants in the experimental group were expected to achieve this over a period of 20 weeks. The study was conducted on a sample of 79 participants who were divided into two groups, Experimental group (EG) and Control group (CG). In the EG, there were 45 participants, and in the CG, there were 34 participants. To determine differences between groups in initial and final measurements, the Mann-Whitney U test was used at a significance level of p=0.05. The results showed that increasing physical activity from their baseline level by 3000 steps three times a week can lead to positive changes in the area of mental health and vitality. The results provide information that may be useful for future research and implementation of kinesiological interventions among students.

Keywords: *physical activity, vitality, mental health, students*

Introduction

Students worldwide face significant difficulties in the domain of mental health and vitality, with one in five university students experiencing mental health-related issues (Herbert, et al., 2020). Mental health is a state of mental well-being that enables people to connect, function, cope with stress, realize their potential and contribute to their community (WHO, 2022.). Many studies aim to further explore the impact of regular physical activity on vitality, or the lack thereof (feeling of fatigue and low energy), partly due to the fact that almost one quarter of the population experiences prolonged and disabling fatigue (Coakley et al., 1998). Subjective vitality is a positive and phe nomenologically accessible state of feeling alive and having energy available to the self (Ryan & Deci, 2001.). Feeling a low level of vitality is associated with a wide range of different physical and mental conditions, such as cardiovascular problems (Quittan et al., 1999), strokes and cancers (Dimeo et al., 1999), obesity (Kesavayuth and Zikos, 2024), sleep difficulties (Mahindru et al., 2023), as well as lower self-esteem and a diminished sense of life satisfaction (Rodrigues et al., 2022). Concerning are the results of individual studies showing that almost half of young people do not meet the WHO recommendations for exercise to achieve health benefits (Cocca et al., 2014), and one of the reasons students cite is overcrowded schedules and time constraints, as well as the fact that the transition from high school to college also means a decrease in overall physical activity levels (Irwin, 2007). There is an increasing number of studies documenting the beneficial effects of physical activity on mental health by examining the effects of exercise cycles and the duration of activity periods (Mahindru et al., 2023). Previous studies have found that continuous physical activity can positively impact mental health and vitality (Ruegsegger & Booth, 2018). However, they raise questions regarding the amount of physical activity on health as well as on future recommendations for kinesiological intervention programs. Various international studies have shown significant effects of exercises such as walking, swimming, and cycling at aerobic intensity on mental health. However, it should be noted that the intensity, frequency, and duration of exercise that impact mental health vary greatly among studies. Some studies indicate that moderate physical activity, between 30 and 60 minutes, 3 to 5 times a week, has the most favorable effect on mental health and vitality, while extreme and intensive exercise longer than 90 minutes or more than 23 times per month is associated with worsening health (Große et al., 2021). These results indicate the need for prompt and quality physical activity intervention among university students with the aim of increasing mental health and vitality levels. Vitality and mental health levels are strongly linked to the quality of student life (Herbert et al. 2020.). A better understanding of the relationship between moderated physical activity and health can ultimately contribute to improving the quality of life of young people. The aim of this study was to investigate the impact of physical activity on the vitality and mental health of students through an intervention program to increase 3000 steps three times a week for 20 weeks.

Methods

This study is based on data collected from students of the Faculty of Traffic Sciences, University of Zagreb (N=79; 26 female and 53 male participants). The participants were divided into two groups, Experimental group (EG) consisting of 45 participants (average age 20.96 years) and Control group (CG) consisting of 34 participants (average age=20.79 years). All participants in this study were selected through systematic random sampling. The inclusion criteria for participants in the study were: a) students of the Faculty of Transport and Traffic Science; b) students with normal health status; c) voluntary participation in the study. The exclusion criteria for participants were withdrawal from participation in the study during the research, non-participation in the final measurement, and non-compliance with the intervention program. To assess mental health, the Croatian version of the Short Form-5 Health Survey (MHI-5) (Slišković, 2020.) and the Health Status Questionnaire (SF-36) were used, from which variables for the vitality dimension were extracted. The level of physical activity was measured using the Yamax digi-walker SW-200 pedometer, which has been shown to be reliable and suitable for scientific research (Schneider et al., 2004). The study was conducted over a period of five months during which participants wore the pedometer and were tasked with walking 3000 steps three times a week more than their initially determined step count. The initial level of physical activity was measured by the pedometer over 4 days (3 workdays + 1 weekend day) recording their number of steps taken throughout the entire measurement period. Here, the variable is the number of steps. For the purpose of statistical analysis, the average number of steps per day was calculated for each participant.

To test the normality of the distribution, the Kolmogorov-Smirnov test was used, indicating that the data significantly deviate from normal distribution for all variables. To determine differences between groups in initial and final measurements, the Mann-Whitney U test was used at a significance level of p=0.05. The study presents basic statistical parameters and results of differences between measurements within individual groups. The data were analyzed using the IBM SPSS Statistics version 25 software package.

Results
Descriptive statistics and differences between EG and CG in initial and final measurements are presented in Table 1. The results show that the respondents are of equal age (EG=20.96±1.35 for IM and 20.96±1.41 for FM; CG=20.79±1.20 for IM and 20.79±1.20 for FM) body weight (EG=76.15±13.59 for IM and 76.59±13.16); CG=77.35±13.92 for IM and 77.85±13.61 for FM) and height (EG=179.24±10.37 for IM and 178.87±10.63 for FM; CG=179 ,19±9.22 for IM and 178.85±9.27 for FM), which confirms the almost equal distribution of respondents according to anthropological characteristics. Subjects of the experimental group differ significantly in the number of steps taken by EG in IM (4870.71±2845.08) and FM (6170.53±2980.54), which indicates the positive effects of the implemented intervention program over a period of 20 weeks.

Table 1. Descriptive Statistics and Differences by Groups and Measurements

	EXPERIMENTAL GROUP (N=45)				CONTROL GROUP (N=34)			
	IM		FM		IM		FM	
VARIABLE	Mean	St.Dev.	Mean	St.Dev.	Mean	St.Dev.	Mean	St.Dev.
Age (years)	20,96	1,35	20,96	1,41	20,79	1,20	20,79	1,20
Height (cm)	179,24	10,37	178,87	10,63	179,19	9,22	178,85	9,27
Weight (kg)	76,15	13,59	76,59	13,16	77,35	13,92	77,85	13,61
Steps (number)	4870,71	2845,08	6170,53	2980,54	4750,55	2735,12	4832,21	2531,21

Abbreviations: EG – experimental group; CG – control group; IM – initial measurement; FM – final measurement; St. Dev – Standard Deviation

Post -hoc test with Bonferroni correction was applied for the multiple testing and p value correcting. Controlling the false discovery rate (FWR) with the Bonferroni correction, using 0,05/2=0,025. The results of the Mann-Whitney U test in the area of mental health (Table 2) indicate statistically significant differences between initial and final measurements in EG for three variables measuring the dimension of psychological distress (MH_NERVOUS, p=0,001; MH_DOWN, p= 0,002; MH_DISHEARTEND_AND_BLUE, p=0,007), while no such difference was found for CG. Differences for variables measuring the dimension of psychological well-being (MH_CALM _AND_PEACEFUL, p=0.147; MH_HAPPY, p=0.230) were not statistically significant in EG or CG. According to the results, after the program, the subjects of the experimental group felt less down in the dumps that nothing could cheer them up, less nervous as well as less downhearted and blue comparing with control group subjects.

Table 2. Differences between initially and finally measurement in component of mental health (Mann-Whitney U test results) for the experimental and control groups

	EXPERIMENTALNA GRUPA				KONTROLNA GRUPA			
VARIABLE	Mann-Whitney U	Wilcoxon W	Z	Asimpa. Sig. (2-tailed)	Mann-Whitney U	Wilcoxon W	Z	Asimpa. Sig. (2-tailed)
MH_NERVOUS	626,000	1661,000	-3,316	0,001	497,500	1092,500	-1,050	0,294
MH_CALM_AND_PEACEFUL	841,500	1876,500	-1,449	0,147	496,000	1091,000	-1,060	0,289
MH_ DOWN	656,500	1691,500	-3,048	0,002	574,500	1169,500	-0,045	0,964
MH_DISHEARTEND_AND_BLUE	709,000	1744,000	-2,705	0,007	543,500	1138,500	-0,481	0,631
MH_HAPPY	872,000	1907,000	-1,201	0,230	531,500	1126,500	-0,607	0,544

LEGEND: MH_NERVOUS - Have you been a very nervous person?; MH_CALM_AN_PEACEFUL - Have you felt calm and peaceful?; MH_DOWN - Have you felt so down in the dumps that nothing could cheer you up?; MH_DOWNHEARTED_AND_BLUE - Have you felt downhearted and blue?; MH_HAPPY - Have you been a happy person?

Differences in the domain of vitality (results of the Mann-Whitney U test) in IM and FM (Table 3) were confirmed and statistically significant in all four variables from the vitality domain for EG (FEEL_FULL, $p = 0.015$; LOT_OF_ENERG, $p = 0.019$; FEEL_WORN_OUT, $p = 0.009$; FEEL_TIRED, $p = 0.002$), while for CG, statistical significance between IM and FM was not confirmed for any variable. According to the results, the subjects of the experimental group felt less worried and less tired after the program feel full of pep and had lot of energy after.

Table 3. Differences between initially and finally measurement in component of vitalnost (Mann-Whitney U test results) for the experimental and control groups

	EXPERIMENTAL GROUP				CONTROL GROUP			
VARIABLE	Mann-Whitney U	Wilcoxon W	Z	Asimpa. Sig. (2-tailed)	Mann-Whitney U	Wilcoxon W	Z	Asimpa. Sig. (2-tailed)
VT_FEEL_FULL	724,00	1759,00	-2,423	0,015	523,50	1118,50	-0,695	0,487
VT_LOT_OF_ENERG	731,50	1766,50	-2,353	0,019	515,50	1110,50	-0,802	0,423
VT_FEEL_WORN_OUT	702,00	1737,00	-2,612	0,009	433,00	1028,00	-1,856	0,063
VT_FEEL_TIRED	650,50	1685,50	-3,092	0,002	483,50	1078,50	-1,221	0,222

LEGEND: VT_FEEL_FULL - Did you feel full of pep?; VT_LOT_OF_ENERG - Did you have a lot of energy?; VT_FEEL_WORN_OUT - Did you feel worn out?; VT_FEEL_TIRED - Did you feel tired?

Discussion

This study investigated the impact of moderated physical activity on the subjective experience of vitality and mental health among students. The results show that increasing by 3,000 steps three days a week over 20 weeks leads to an increase in vitality and mental health levels, consistent with the current WHO findings (WHO, 2020) that increasing moderate-intensity physical activity contributes to better health. The results of this study demonstrate the dosage of physical activity expressed through the number of achieved steps that would be sufficient for certain changes in the areas of vitality and mental health. The dosing of physical activity through increasing steps per day is also described in other studies (Tudor-Locke et al., 2011.), but not through the objectification of measurement in the student population.

In terms of mental health, the results highlight the impact of walking as a physical activity on improvements in the area of psychological distress, with participants feeling less nervous, discouraged, sad, and less depressed after the intervention program. Physical activity can help improve mood, reduce stress, increase self-confidence, improve sleep quality, and treat mental health disorders such as depression and anxiety, thereby positively impacting overall quality of life (Endrawan et al., 2023.), as demonstrated by this study.

Most research shows positive relationships between physical activity and vitality (Van Woudenberg et al., 2020.). One possible explanation may be the activation of endorphins during physical activity, which can stimulate feelings of energy, alertness, and good mood. Endorphins are released during sports activities and contribute to feelings of happiness and satisfaction, increased energy, and better physique (Chaput et al., 2011.). However, it is difficult to conclude from existing research what dose of physical activity is necessary to achieve mental well-being.

Statistically significant differences related to all four variables describing the level of vitality indicate that participants felt fulfilled, experienced an increase in energy levels, and were less exhausted and tired after the program. Based on these results, we can conclude that increasing by 3000 steps per day, three times a week, led to a comprehensive improvement in vitality.

We believe that this study can contribute to understanding the relationship between moderated physical activity, mental health, and the sense of vitality among students. This research also has its limitations, reflected in the fact that the intensity of exercise was not defined, which would be useful in future research to define in the direction of determining the time required to pass an additional 3000 steps per day. The results of this study provide information that can be very useful for further strategies promoting physical activity among students.

Conclusion

The results of this study have shown that moderated and individualized increases in physical activity of 3000 steps three times a week can lead to positive changes in the aspect of mental health and vitality. As previous studies have emphasized, physical activity is one of the key factors in the prevention of mental health issues and promoting vitality, highlighting the importance of developing moderated kinesiological intervention programs and promoting physical activity among student populations.

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BALKAN ULTRAS - AN INSIGHT INTO THE CONCAVITY OF ULTRAS AS SUBCULTURAL ACTORS

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Abstract
Radical football fans in Yugoslavia began forming ultra groups in the early 1980s, influenced by English and Italian fan cultures, creating a distinct subcultural scene. This paper investigates the concept of concavity within the football *ultras* subculture in the context of the former Yugoslavia, focusing on the inside-of-the-scene dynamics and relationship with the mainstream. We analyze comments from the "Balkanski navijači" Instagram page to understand how *ultras* perceive legitimate behavior and values. Utilizing Hannerz's concave subcultural pattern (2015), which examines intra-subcultural variations and the interplay between subculture and mainstream culture, the study reveals criticisms directed at groups displaying disorganization, lack of seriousness, and dependence on external entities. The research employs ethnographic content analysis to examine 424 comments from 500 posts, sampled between January and May 2024, that speak of *ultras*' perceptions of rituals, particularly the theft of rival banners. Main findings highlight tensions within the ultras community regarding adherence to subcultural norms, with criticism directed towards actions seen as deviating from the traditional codes of conduct and exhibiting shallowness, complacency, and dependence, as delineated by the concave subcultural pattern.

Keywords: *Ultras; Instagram; Ethnographic Content Analysis; Concave Subcultural Pattern*

Introduction

Radical football fans in Yugoslavia began to organize themselves into ultra groups in the early 1980s, increasingly following the trends of English and Italian fans, and gradually creating their subcultural scene. Social scientists have been following their development since the beginning, using various methodological and theoretical tools (Buzov et al., 1988; Lalić, 1993; Vrcan, 2003; Perasović and Mustapić, 2013, etc.), but largely overlooked the need for concrete insight into the new forms of sociality within fan communities - on websites, specialized forums, and social media groups. Another problem is the extraction of collective identity determinants of *ultras* groups at different locations within the countries of the former Yugoslavia. These are *ultras* groups that shared the same scene for a period and even today often refer to each other, creating a special collective identity. Due to the difficulty of entering such, often deviant, communities and the complicated relationships between groups, we consider that researching *ultras* on social networks is a unique way to understand today's fandom within regional frameworks. The absence of more frequent research into *ultras* communities on internet forums and social media is surprising given that *ultras* are predominantly a young population who grew up in an era marked by internet platforms. There are rare domestic studies that utilize the virtual domain among *ultras* using forum posts (Šantek, Zečević, and Nuredinović, 2020), internet photo galleries (Nuredinović and Vukušić, 2021), but do not use this content to describe general code of conduct using *ultras* perspective. The vehement social changes determined by globalization and the Internet have defined new information and communication platforms for *ultras* (Doidge and Lieser, 2017). What were once fanzines are now internet portals, forums, and social networks. Today, we can talk about the abandonment of international *ultras* forums and the increasing importance of Instagram and TikTok. Incorporating different determinants of several styles begins to spread faster and easier among the *ultras* population. For example, ultras began to dress similarly, and use techniques of foreign ultras groups. It is enough to look at the changes happening to ultras regarding opposition to modern football to realize the real force of information transfer, strategies, and techniques used in ultras groups from distant countries or other continents. The theoretical concept of subculture has been used in research on ultras in former Yugoslavia since the late 1980s (Perasović, 1989). Although there have been tectonic changes in post-Yugoslav societies since then (Perasović and Mustapić, 2013), we believe that this concept is crucial for understanding the differences in the identification of what ultras perceive as their values from values they consider part of mass or pop culture (mainstream). Although the existence of a common collective identity of all ultras groups in the former Yugoslavia is impossible to determine, primarily due to contextual differences (but also methodological limitations), this paper deals with different forms of perceptions communicated in comments on the Instagram page "Balkanski navijači" (Balkan ultras). The paper aims to study ultras' perceptions of different practices concerning the relationships within the scene. We explore this using the theoretical concept of a concave pattern of subcultural identification that differs from the perceived mainstream (Hannerz, 2015), using ethnographic content analysis of comments on Instagram posts. Our main research question was: How do ultras communicate through comments what constitutes legitimate (ultras) behavior and what does not? In this paper we provide only analysis of one ultras ritual – one that concerns a theft of a rival banner.

Theoretical framework

Although a lot has been done by now in investigating various dimensions of social phenomenon of football ultras, in this work we underpin the main finding of the works done by sociologists in domestic context that underline ultras groups as a distinctive subculture. That is why we will address their code of honor through subcultural theory that concerns itself with subcultural identification.

According to Hannerz (2015), subculture represents a quest for the sacred. The sacred must be protected from the secular and from all those who attempt to degrade it. Subcultural dynamics manifest through two basic dimensions. The first dimension, called convex, emphasizes the distinction between subculture and mainstream, while the second dimension, known as concave, explores variations within the subculture itself (Hannerz, 2015). The author highlights the importance of considering different perceptions of the mainstream because these perceptions shape diverse interpretations within subcultural communities. Hannerz (2015) describes this process as the convex subcultural pattern, where relationships to the mainstream are viewed as homogeneous but also undefined masses that provoke subcultural identification through their implicit threats and attempts at assimilation. On the other hand, the concave subcultural pattern focuses on intra-subcultural differences and similarities, as well as on how individuals within the subculture position themselves and their colleagues concerning the mainstream. This dimension, although already encompassed by subcultural identity, examines how different participants in the subcultural community perceive their relationships with the mainstream and how these relationships manifest in practice. The *concave* dimension views the mainstream as *shallow, complacent* and *dependent*.

Shallow mainstream is defined as a lack of awareness of the essence of the subcultural world. The difference with shallow mainstream arises from the effort, sacrifice, renunciation, and education needed to understand subcultural identity. There is no inherent characteristic that automatically links an individual to what is "different," so active efforts are needed to differentiate and understand the subcultural world. Development in this context means moving away from mainstream interests and emphasizing internal subcultural identity to maintain the scene's vitality. *Complacent* mainstream refers to hedonistic behavior within the subculture that is inherently contrary to subcultural behavior and degrades it. In contrast, freedom is manifested in ambition and activities where the individual subordinates themselves to the collective and subcultural norms of behavior. Creating specific spaces, regulated by rules and separated from the mainstream, is crucial for preserving subcultural identity. Freedom is not an internal feeling but a constant effort to maintain the scene "clean" from superficiality and self-sufficiency. *Dependent* mainstream is perceived as passive, irresponsible, and incapable of achieving anything independently. Subcultural actors, on the contrary, are independent, self-financed, self-organized, and give meaning to their actions themselves. Passivity is considered a threat to the functioning of the scene because it leads to dependency. Therefore, it is crucial to reject external assistance and rely on one's own organization to maintain the authenticity and integrity of the subcultural community. Selling out is not only perceived as a loss of one's own integrity but also as a betrayal of the sacred ideals of the scene.

Method

In this study, we utilize ethnographic content analysis (Altheide, 1987), leveraging the interpretative power granted by researchers' extensive prior knowledge of the phenomenon under investigation (Vukušić and Hrstić, 2022; Nuredinović and Vukušić, 2021; Nuredinović, 2019), as "insiders." ECA is partly quantitative analysis but in greater part a qualitative analysis. In this paper we did ECA to establish similarities in perceptions of similar praxis and rituals of Balkan ultra groups. We examine the "Balkanski navijači" (Balkan ultras) page on Instagram, boasting 14,800 posts and 79,100 followers (May 2024), focusing on ultras scenes in the former Yugoslavia, with occasional coverage of Greece and Bulgaria. Sampling 500 posts from January 1, 2024, to May 10, 2024, we analyzed comments addressing "ultra' values," yielding 424 comments on posts (by 137 users) for analysis. Comments were sorted according to the different ultras rituals they comment. Afterwards we thematically analyzed comments by theoretical matrix of the three dimensions of concave subcultural pattern to explore relationships within the scene. Identifying "valid" subcultural actors presented a methodological problem and a challenge for this research due to the top-down nature of this practice, raising uncertainties about the real depth of actors' subcultural experiences. However we tried to subsequently eliminate "superficial" comments or parts of comments from the analysis - those that did not comment on the "essence of a subcultural ritual or practice" (that did not answer to how it should be done or why was it done wrong). Due to the inherent limitations of this paper, we focus on the analysis of results pertaining to a singular ritual, yet one of significant importance within the regional ultras scene – the theft of main banners perpetrated by rival ultras groups in Mostar (Ultras Zrinski Mostar and Red Army Mostar). Notably, these groups are entrenched as rivals not only in the context of football but also as a result of historical events and thriving ethnic tensions.

Results and discussion
Taking into account the theoretical framework, here we will present only a part of the results related to all three dimensions of concavity, based on one fan ritual - stealing banners of rival groups. This practice is deeply rooted in regional fandom, as well as in *ultras* culture in general. Confiscating rival banners has several important ritual features that must be followed for the "fall" of the banner to be legitimized in the scene. The stolen banner is usually displayed upside down and ritually burned in the stands to humiliate opposing ultras groups. After the fall of the banner, the ultras group is expected to be "extinguished" and to cease activity under that name or seek revenge against the rival group:

"When one flag falls, the group has two options. Either to steal the strongest flag of the enemy or to extinguish itself. There is no third option." (antisplicanin)

Although there are significant contextual differences, these elements can be seen as common to all groups that follow the ultras way of life. However, the context surrounding the "making," "keeping," "falling," and "burning" of banners is significantly conditioned by understanding the code of conduct. In this chapter, we will present an example of understanding the ultras code through different perceptions of two recent and very significant events of banner theft between rival fan groups in Mostar (Red Army Mostar and Ultras Zrinski Mostar).

The first event concerns the confiscation of 9 Ultras banners by the Red Army. Members of the Red Army, disguised as construction workers, followed and awaited one Ultras member in front of his apartment after a home match of HŠK Zrinjski, caused him injuries in front of his family and confiscated the main banners of Ultras Zrinjski. After the confiscation of the banners, they were displayed upside down in a video that started circulating on ultras channels. Ultras Zrinjski appeared at the next match with banners "Ljudi od puta" (People with purpose) and "Borba" (Struggle), thus vowing revenge, which soon followed. Namely, Ultras Zrinjski allegedly used a drone to track where Red Army kept their banners and then broke into the house and forcibly stole a large number of banners from Red Army - including almost all banners of that ultras group. A video circulating on ultras communication channels shows the banners upside down. The development of events between these two rival groups has not yet fully unfolded, and the situation in Mostar is very tense, with the police still on high alert. A large number of comments on posts have been made about these two events, which are considered the most significant events among *ultras* of former Yugoslav countries.

A large part of the analyzed content implied that fans in the comments often criticize the shallow understanding of the code and norms of ultras behavior. Comments mostly went in the direction of wrong behavior, that which is contrary or illogical for the "subcultural", for the essence of fandom itself and ultras culture. Namely, the theft of banners in these two events was seen as premeditated, calculated, malicious action, while in the "true" mentality, it is constructed as the "fall" of the banner in a liminal, spontaneous, and fair showdown of groups. If the action is contrary to the perceived code, then it deviates from the proclaimed "honor" of the group. Shallowness is evident in the simplification of the rituals, moving away from what it should be because the banner is considered the personification of the group in its fullness. Without the existence of conflicts between groups, the mere theft of the banner is not enough. However, in the results of the analysis, the presence of "revenge" as a motive is differently conceptualized because it may imply the same form of behavior - although it is "not-*ultra'*":

> *"Both actions are contrary to the code. Only banners and flags that fall in a fight are considered taken in a chivalrous way. Here both actions were done "viciously" and do not serve to the honour of the actors (...)." (nitkoinistabp)*
> *"You're an idiot if you don't understand that a fair fight where no flag falls is worth a hundred times more than this "action". Although I'm not for that either, at least people from the group collectively measure strength, there is something in that, without fools who have no connection with ultras and no police anywhere near." (amurtiger36)*
> *"The Ultras (Ultras Zrinjski) officially return under their banners. The only correct way of coming back - revenge. Since they lost unfairly, they returned unfairly. The only fact even though I hate both sides." (barigro)*

The second element of the concave framework is complacent mainstream. Criticism of the hedonistic view of subculture was least represented in our results because most comments could still be attributed to certain immersed ultras actors. This issue arises from the fact that referring to non-adherence to the ultra' rules, or the subordination of individuals to the collective, did not stem from hedonistic behavior but from lack of seriousness, disorganization, and relaxed behavior when reasoning about *ultras* rituals. When specifically talking about the "fall" of banners, in both cases, fan groups were criticized for a lack of focus on keeping the banners safe:

> *"(…) The point is to defend the flag until the safe zone, i.e., until the person enters the house... It wouldn't be fair if they broke into his home like this... Why wasn't the group with him... There is no time for rest... (…)" (pmc.mokranjac)*

> *"Wow, people, what's the story that one guy carried all these flags? Even if he did, with the man who carries the flags, there are at least 3 to 4 people... This is a rotten story that one dude carried it(...)" (5ar.m13)*
> *"The Ultras showed themselves as amateurs and disorganized where they gave the main banners to a child to carry them alone, that's their problem and amateurism (...) Would Torcida allow a child to carry their banners home alone? (...)" (jasaaaaaaaaaaredarmy)*

The last characteristic of the internal mainstream is also seen as the worst in the ultras world and refers to dependence. Independence from politics, police, the club, stewards, and other groups are the most common motives for ultras autonomy. Criticism of dependence in comments on posts related to the theft of banners of Mostar groups mostly referred to the betrayal of the ideals of subcultural sanctity by giving part of their sovereignty to someone else:

> *"Come on, gypsies (Red Star Ultras), be quiet. (...) And the police secure your banners." (bokiblackpfc)*
> *"After that, Zrinjski called Torcida and BBB to help them, but they didn't respond. Only regular Herzegovinians came, imagine how weak they are that they had to call others for help instead of responding themselves. Imagine Torcida calling ultras to help them against BBB, that's humiliation." (jasaaaaaaaaaaredarmy)*

Conclusion

Since this paper does not deal with data quantification but separates three themes of the concave pattern to grasp the subcultural essence of fandom regarding one ritual, here we can summarize several conclusions. Social networks are an important channel of communication and replace former forms of subcultural communication such as fanzines and forums. By studying these platforms, we can learn more about collective codes and their similar and different understandings. Based on the perception of distance from the mainstream, the relationships between these understandings are encompassed by the concave dimension of subcultural identity (Hannerz, 2015), where ultras practices differ in terms of shallowness, complacency, and dependence. *Ultras* perceive deviations from proclaimed "chivalry" ("sneaky" theft of banners, fights involving a much larger number of people on one side than the other, or any other form of what they see as "unethical behavior") as superficial. Independence is highly valued in the ultras world, and therefore, the lack of independence of a group leads to its delegitimization within the subcultural scene. From the analysis of the results, we can conclude that ultras most often criticize other groups for collaborating with the police, politics, certain actors of civil society, or various forms of "sponsoring" their support. Finally, self-sufficiency is perceived as a delegitimizing factor for groups when in the eyes of other fans, that group neglects the primary tenets of subcultural behavior, or is seen as "unserious," "disorganized," "hedonistically oriented", and "unprepared for action".

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GENDER DIFFERENCES IN METACOGNITIVE AWARENESS LEVELS AND L2 LISTENING SKILLS IN KINESIOLOGY STUDENTS

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This study explores whether there are gender differences in metacognitive awareness of listening strategies and L2 listening skills among kinesiology students. A sample of N=91 kinesiology students (NM=38, NF=53) completed the Metacognitive Awareness Listening Questionnaire (MALQ), which consisted of 21 items. The data were analyzed using a between-subjects t-test, revealing significant differences ($p<0.05$) in six MALQ items. These findings suggest that gender is a partial predictor of metacognitive awareness. The results of the study clearly indicate that females utilize more metacognitive skills while listening than males. Additionally, the results show significant differences between genders in latent dimensions representing Problem-solving, Planning and evaluation, and Mental transition. The findings of the study have implications for multidimensional educational assessment in kinesiology students, and future research in this area is highly recommended.

Keywords: *listening skills, non-native speaker, metacognitive strategies, gender, academic success*

Introduction

Listening skills that incorporate listener's attention, cognitive skills, perception, and memory, along with the listener's prior linguistic knowledge (Hamouda, 2013; Vandergrift & Baker, 2015), represent one of the most complex mental processes. Proficient listening skills enable L2 students (non-native English speakers who listen to English texts as a second language) to successfully cope with academic demands (Huang, 2005; Deb, 2020). However, there are several factors that make students' listening comprehension challenging: poor vocabulary, inappropriate teaching styles and dialects (Schoonmaker-Gates, 2017), different speech speeds and pronunciations, (Hamouda, 2013), and students' lack of background knowledge. Studies (Goh, 2013; Moradi, 2013; Gilakjani & Sabouri, 2016) have shown that these difficulties can be overcome by using listening strategies: cognitive strategies, metacognitive strategies, and socio-affective strategies. This research focuses on the correlation between metacognitive strategies, the most prominent learning skill relevant to students' listening comprehension, problem-solving skills, attention, self-regulation, and autonomy (Baleghizadeh & Rahimi, 2011; Tavakoli, Shahraki, & Rezazadeh, 2012; Goh & Hu, 2013) and gender as one of the distinctive factors in determining the proficiency of language skills (Deliany & Cahyono, 2020). While some studies have suggested that women, in general, have higher metacognitive awareness and tend to utilize metacognitive strategies more frequently (Fayyaz & Kamal, 2014) when compared to men (Akin, 2016; Ciascai & Lavinia, 2011; Alami, 2016; Liliana & Laviania, 2011), Onat (2012) found no difference in metacognitive listening awareness activity between genders. In addition, Thomas and Gadbois (2007) highlighted that, in the field of scientific education, male students used more advanced metacognitive strategies which ultimately led to better academic achievements. Therefore, the aim of this study is to determine whether there are gender differences in metacognitive awareness of listening strategies and L2 listening skills among kinesiology students.

Methods

The sample consisted of a total of 91 undergraduate students of kinesiology (M = 38, F = 53; age 21.1 ± 1.9) from a public university in Croatia. Inclusion criteria required that they had learned English since primary school and completed one mandatory English language course as part of their program. The study was conducted from December 2022 to February 2023. Data were collected using the Metacognitive Awareness Listening Questionnaire (MALQ) (Vandergrift et al., 2006). The questionnaire consisted of 21 standardized MALQ items, grouped into five factors related to L2 listening comprehension processes: problem-solving (PS), planning and evaluation (PE), mental translation (MT), person knowledge (PK), and directed attention (DA). Questions were answered using a six-point Likert scale (1 = Strongly disagree, 6 = Strongly agree). The questionnaire, administered in English, was distributed through the Google One Drive platform. Participants were assured of anonymity and voluntary participation, with no time restrictions. The study adhered to the Declaration of Helsinki guidelines.

Data were presented as mean and standard deviation for each gender, along with additional descriptive statistics: median, minimum and maximum values, skewness, and kurtosis. The Kolmogorov-Smirnov test was used to assess normality. Levine's test checked for homogeneity of variances, and a t-test for independent samples determined gender differences in questionnaire items. Cohen's d was used as an effect size assessment. It was interpreted as small if $d \leq 0.25$, medium if $0.25 < d \leq 0.55$, moderate to high if $0.55 < d \leq 0.80$, and high if $d > 0.80$. Type I error was set at $p < 0.05$. Statistical analysis was performed using Statistica 14.0 software (Cloud Software Group, Inc. (2023). Data Science Workbench, ver 14.).

Results

Prior to the statistical analysis, the Kolmogorov-Smirnov test revealed that most of the items had a distribution that did not deviate significantly from a normal distribution ($p > 0.20$), so parametric analysis was used. Descriptive parameters have been presented in Table 1.

Table 1. Descriptive statistics of the MALQ items in male subsample

Variable	M±SD	Med	Min	Max	Skewness	Kurtosis
1. Before I start to listen, I have a plan in my head for how I am going to listen	3.63±1.24	4.00	1.00	6.00	-0.46	-0.40
2. I focus harder on the text when I have trouble understanding	4.16±1.24	4.00	1.00	6.00	-0.53	-0.25
3. I find that listening in English is more difficult than reading, speaking, or writing in English	3.40±1.59	4.00	1.00	6.00	0.06	-1.03
4. I translate in my head as I listen	3.71±1.59	4.00	1.00	6.00	-0.18	-1.15
5. I use the words I understand to guess the meaning of the words I don't understand	4.32 ±1.21	4.00	1.00	6.00	-0.37	-0.09
6. When my mind wanders, I recover my concentration right away	3.90±1.18	4.00	2.00	6.00	0.07	-0.83
7. As I listen, I compare what I understand with what I know about the topic	3.98±1.19	4.00	1.00	6.00	-0.27	-0.37
8. I feel that listening comprehension in English is a challenge for me	3.23±1.22	3.00	1.00	6.00	0.22	-0.44
9. I use my experience and knowledge to help me understand	4.47±1.18	5.00	2.00	6.00	-0.50	-0.46
10. Before listening, I think of similar texts that I may have listened to	3.53±1.20	4.00	1.00	6.00	-0.02	-0.48
11. I translate key words as I listen	3.94±1.47	4.00	1.00	6.00	-0.24	-1.07
12. I try to get back on track when I lose concentration	4.40±1.12	4.50	2.00	6.00	-0.50	-0.22
13. As I listen, I quickly adjust my interpretation if I realize that it is not correct	3.90±1.07	4.00	2.00	6.00	-0.14	-0.61
14. After listening, I think back to how I listened, and about what I might do differently next time	3.85±1.33	4.00	1.00	6.00	-0.16	-0.45
15. I don't feel nervous when I listen to English	4.42±1.37	4.50	1.00	6.00	-0.65	-0.22
16. When I have difficulty understanding what I hear, I give up and stop listening	2.95±1.50	3.00	1.00	6.00	0.24	-1.13
17. I use the general idea of the text to help me guess the meaning of the words that I don't understand	4.02±1.25	4.00	2.00	6.00	0.13	-0.93
18. I translate word by word, as I listen	3.10±1.41	3.00	1.00	6.00	0.11	-0.80
19. When I guess the meaning of a word, I think back to everything else that I have heard, to see if my guess makes sense	3.94±1.17	4.00	2.00	6.00	-0.12	-0.55
20. As I listen, I periodically ask myself if I am satisfied with my level of comprehension	3.77±1.23	4.00	2.00	6.00	0.01	-0.93
21. I have a goal in mind as I listen	4.06±1.14	4.00	2.00	6.00	-0.20	-0.63

Note. Male sample = 38. M±SD-Mean and Standard Deviation; Med-Median; Min-Minimum: Max-Maximum

The results of descriptive statistics for a subsample of male students indicate that they are using metacognitive skills to a great extent. It is noteworthy that the maximum value of six remains constant for all questionnaire items, while the minimum value ranges from one to two across all items. Skewness and kurtosis also suggest that the data is normally distributed. Additionally, Table 2 presents the results of descriptive statistics for the female subsample.

Table 2. Descriptive statistics of the MALQ items in female subsample

Variable	M±SD	Med	Min	Max	Skewness	Kurtosis
1. Before I start to listen, I have a plan in my head for how I am going to listen	4.10±1.29	4.00	1.00	6.00	-0.65	0.11
2. I focus harder on the text when I have trouble understanding	4.52±1.19	5.00	1.00	6.00	-0.59	0.16
3. I find that listening in English is more difficult than reading, speaking, or writing in English	3.81±1.69	4.00	1.00	6.00	-0.23	-1.13
4. I translate in my head as I listen	4.66±1.36	5.00	1.00	6.00	-0.91	0.05
5. I use the words I understand to guess the meaning of the words I don't understand	4.84±1.09	5.00	1.00	6.00	-1.03	1.68
6. When my mind wanders, I recover my concentration right away	3.84±1.21	4.00	1.00	6.00	-0.18	0.00
7. As I listen, I compare what I understand with what I know about the topic	4.17±1.14	4.00	1.00	6.00	-0.28	0.08
8. I feel that listening comprehension in English is a challenge for me	3.55±1.45	4.00	1.00	6.00	-0.12	-1.04
9. I use my experience and knowledge to help me understand	4.67±1.08	5.00	1.00	6.00	-0.76	1.20
10. Before listening, I think of similar texts that I may have listened to	3.38±1.57	3.00	1.00	6.00	0.30	-0.98
11. I translate key words as I listen	4.50±1.35	5.00	1.00	6.00	-1.08	0.81
12. I try to get back on track when I lose concentration	4.47±1.20	5.00	1.00	6.00	-0.61	-0.06
13. As I listen, I quickly adjust my interpretation if I realize that it is not correct	4.34±1.15	4.00	1.00	6.00	-0.43	0.13
14. After listening, I think back to how I listened, and about what I might do differently next time	3.91±1.27	4.00	1.00	6.00	-0.25	-0.45
15. I don't feel nervous when I listen to English	4.19±1.46	4.00	1.00	6.00	-0.27	-1.14
16. When I have difficulty understanding what I hear, I give up and stop listening	3.05±1.37	3.00	1.00	6.00	0.29	-0.30
17. I use the general idea of the text to help me guess the meaning of the words that I don't understand	4.29±1.11	4.00	2.00	6.00	-0.05	-0.59
18. I translate word by word, as I listen	3.72±1.50	3.50	1.00	6.00	0.00	-1.15
19. When I guess the meaning of a word, I think back to everything else that I have heard, to see if my guess makes sense	4.10±1.19	4.00	1.00	6.00	-0.21	-0.29
20. As I listen, I periodically ask myself if I am satisfied with my level of comprehension	4.05±1.38	4.00	1.00	6.00	-0.26	-0.75
21. I have a goal in mind as I listen	4.12±1.19	4.00	1.00	6.00	-0.11	-0.26

Note. M±SD-Mean ± Standard Deviation; Med-Median; Min-Minimum: Max-Maximum

The results of descriptive statistics for the female subsample also indicate that they are using metacognitive skills in high quantities. Similarly, to their male colleagues, the maximum value remains constant and the minimum value increases from one to two. It is interesting to note that the maximum value of 6 is constant for all questionnaire items, while the minimum value rises from one to two in all items. Similarly, the parameters describing the distribution are consistent with the male group. Finally, Table 3 consists of t-test results for independent samples. Levene's test for homogeneity of variances was applied.

Table 3. Gender differences in the MALQ items (test statistics- t value, level of statistical significance- p, test statistics for homogeneity of variance- f ratio, level of statistical significance for Levene's test- p Levene).

Variable	Female M±SD	Male M±SD	t-value	p	F-ratio	p
1. Before I start to listen, I have a plan in my head for how I am going to listen	4.10±1.29	3.63±1.24	2.05	0.04	1.08	0.76
2. I focus harder on the text when I have trouble understanding	4.52±1.19	4.16±1.24	1.60	0.11	1.10	0.73
3. I find that listening in English is more difficult than reading, speaking, or writing in English	3.81±1.69	3.40±1.59	1.36	0.18	1.13	0.65
4. I translate in my head as I listen	4.66±1.36	3.71±1.59	3.49	<0.01	1.38	0.23
5. I use the words I understand to guess the meaning of the words I don't understand	4.84±1.09	4.32±1.21	2.48	0.01	1.24	0.42
6. When my mind wanders, I recover my concentration right away	3.84±1.21	3.90±1.18	-0.27	0.79	1.05	0.86
7. As I listen, I compare what I understand with what I know about the topic	4.17±1.14	3.98±1.19	0.88	0.38	1.09	0.73
8. I feel that listening comprehension in English is a challenge for me	3.55±1.45	3.23±1.22	1.33	0.18	1.42	0.18
9. I use my experience and knowledge to help me understand	4.67±1.08	4.47±1.18	0.99	0.33	1.20	0.50
10. Before listening, I think of similar texts that I may have listened to	3.38±1.57	3.53±1.20	-0.60	0.55	1.71	0.04
11. I translate key words as I listen	4.50±1.35	3.94±1.47	2.18	0.03	1.18	0.53
12. I try to get back on track when I lose concentration	4.47±1.20	4.40±1.12	0.29	0.77	1.15	0.60
13. As I listen, I quickly adjust my interpretation if I realize that it is not correct	4.34±1.15	3.90±1.07	2.18	0.03	1.16	0.57
14. After listening, I think back to how I listened, and about what I might do differently next time	3.91±1.27	3.85±1.33	0.25	0.80	1.09	0.75
15. I don't feel nervous when I listen to English	4.19±1.46	4.42±1.37	-0.89	0.38	1.12	0.65
16. When I have difficulty understanding what I hear, I give up and stop listening	3.05±1.37	2.95±1.50	0.38	0.70	1.20	0.49
17. I use the general idea of the text to help me guess the meaning of the words that I don't understand	4.29±1.11	4.02±1.25	1.28	0.20	1.27	0.37
18. I translate word by word, as I listen	3.72±1.50	3.10±1.41	2.36	0.02	1.12	0.65
19. When I guess the meaning of a word, I think back to everything else that I have heard, to see if my guess makes sense	4.10±1.19	3.94±1.17	0.78	0.44	1.04	0.88
20. As I listen, I periodically ask myself if I am satisfied with my level of comprehension	4.05±1.38	3.77±1.23	1.16	0.25	1.25	0.38
21. I have a goal in mind as I listen	4.12±1.19	4.06±1.14	0.26	0.79	1.08	0.78

Note. M±SD-Mean ± Standard Deviation

It has been calculated that Cohen's d ranged from 0.37 to 0.76 for all the observed items, indicating a moderate to high practical significance of the variables. Moreover, it can be noted that differences are identified in variables 1, 4, 5, 11, 13, and 18, which are representative of the latent dimensions named: Problem-solving, Planning and Evaluation, and Mental Translation.

Discussion

From the obtained results, we read that female students, whose awareness is higher than male students, used metacognitive listening strategies more frequently. This finding is consistent with other research studies (Baleghizadeh and Rahimi, 2011; Jinhong, 2011; Chang, 2012) that pointed out to the same gender differences and their correlation to L2 listening skills comprehension and better academic results. On the other hand, researchers found that students' use of metacognitive strategies did not have any significant correlation with their listening performance (Buchari, 2015). However, gender-related differences are identified in variables related to factors such as Problem-solving, Planning and evaluation, and Mental translation. These findings provide additional information for the growing scientific debate on the issue (Tavakoli, Shahraki, & Rezazadeh, 2012; Goh & Hu, 2013). The findings of the study can be used to structure of gender-dependent L2 language teaching and assessment in student populations. Also, our results will help to understand the similarities and differences in L2 language use between genders.

Conclusion

We conclude that gender provides information on L2 listening skills. The results could help English teachers understand better their students' needs regarding listening skills and academic lecture comprehension, regardless of students' gender. Moreover, we believe that the study's results will assist university authorities in becoming more aware of student challenges and the need for support systems for students at all levels.

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"BY THE PEOPLE FOR THE PEOPLE" - EMOTIONS AND THE ULTRAS' BATTLE AGAINST MODERN FOOTBALL IN AUSTRALIA AND CROATIA[1]

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Abstract
This study delves into the emotional dynamics and collective identities of football ultras, focusing on the Bad Blue Boys (BBB) of GNK Dinamo Zagreb and Sydney United Supporters (SUS) of Sydney United 58 (previously also called Bad Blue Boys). Through an examination of modern football practices, including name changes, financial malpractices, and corruption, it explores how these factors have fractured the collective identities of ultras, leading to emotional detachment and revolt. By identifying the main enemies faced by these groups, the research sheds light on the broader themes of resistance against the commercialization and de-ethnicization of football. Through 19 semi-structured interviews, the study uncovers how both groups utilize emotional practices concerning identity fractures. These findings underscore the significance of emotional engagement in supporter communities and contribute to a deeper understanding of the alienation and opposition faced by ultras worldwide.

Keywords: *ultras, emotions, modern football, Sydney United Supporters; Bad Blue Boys*

Introduction
Football supporters often express a collective understanding of club communities by invoking "we" during games of the teams they support. During each football match, there is a whole range of emotions present (Doidge, Kossakowski & Mintert, 2020). However, depending on the context, emotions can transcend events characteristic of football matches or tournaments. They can be triggered by the "breaking down" of supporters communities (Taylor, 1971). Current supporters' research follows emotions as one of the most important identity components (Vukušić & Hrstić, 2022; Doidge et al. 2020). Collective identity is constructed during the rehearsal of ultras rituals through constant performance while emotional energy achieves a sense of homogeneity and togetherness (Doidge et al. 2020).

We focus on the Bad Blue Boys (BBB), ultras of GNK Dinamo Zagreb and Sydney United Supporters (SUS),[2] ultras of Sydney United 58. Both groups have gone through different phases in their history and have found themselves in a "battle" with various aspects associated with modern football, their bond, among else, being the specific struggle related to the club's name change "from above".

In the case of Sydney United 58, formerly known as Croatia Sydney, the name change came as a result of the decision by the Australian Football Federation to ban the use of ethnic motifs and symbols of clubs (James, 2023). This decision was based on two seemingly separate matters (to calm ethnic tensions and to popularize football), yet ultimately with a common goal, which is to form a profitable league that will attract a wider audience, generate revenue, and promote football in a country without a significant football tradition. It's important to mention that Australian clubs with ethnic affiliations represent a much broader social structure (James, 2023). Their presence in the local (ethnic) community served as a cohesive factor for that community, a gathering place, and ultimately a way to manifest their minority (ethnic) identity (James, 2023; Hughson, 1997). Previous research so far indicated the existence of an ethnic community as a mobilization base and the football club as a forum for expressing their minority demands and political stances toward the Australian and Croatian (Yugoslavian) political situation (James, 2023; Hughson, 1997). However, a work done by Drapač and Hrstić (2023) resists such claims. Authors say that such "ethnic" clubs helped Croats achieve greater inclusion in Australian society. They forward their thesis with the recollection of various social networks made through clubs' communities. Following this, "everyday multiculturalism" is more contextual and dependent on the actors themselves and not only the political product of a powerful institution. It seems Croats, through their football clubs actually find ways to integrate. The study shows on multiple occasions how Croats but also Australians and other minorities were involved in building "Croatian" football clubs.

[1] This work is the result of research conducted as part of the project "Exploring emotions in the (re)construction of diaspora identity: Croats in Australia and New Zealand (1945-1991)" (UIP-2020-02-1283) financed by the Croatian Science Foundation.
[2] Previously, the Sydney United Supporters were known as Bad Blue Boys Sydney (modelled after the Zagreb supporters' group). The fact that some older members were part of the Croatian Bad Blue Boys is very important. It highlights continuous ethnic but also subcultural relation with Dinamo Zagreb supporters.

This by no means erase the fact that there were changes made that hurt identity of the Croats supporting their clubs. Resistance arises as a product of the de-ethnicization of football in Australia through repression of their ethnic supporter subculture and ethnic clubs in general (Hughson, 1997).

The other researched group in this paper are the Bad Blue Boys, supporters of GNK Dinamo Zagreb, who have also fought several 'battles' throughout their history, one of which was motivated by a name change of the club. The idea of the state authorities in the 1990s was to distance Dinamo from its "communist legacy" and promote the newly formed state abroad by renaming it Croatia Zagreb (Nuredinovi & Vukušić, 2021). The supporters never reconciled with such an interpretation because for them, the name Dinamo represented a national "beacon" in the times of Yugoslavia, and the arbitrary action of the state president Franjo Tuđman was seen as a radical attack on the basis of their identity (Vrcan, 2003). Once the supporters succeeded in reclaiming the name Dinamo, a new battle began, similar to the one mentioned in the Australian case, which concerns opposition to the creation of a club devoid of any identity solely for the purpose of making money (Šantek, Zečević & Nuredinović, 2020). The supporters' struggle was marked by resistance to the control of the club by one man (Zdravko Mamić), the draining of money from Dinamo, and ultimately the prevention of the participatory role of supporters in the decision-making process related to the club.

Despite extensive research on both groups, specific academic attention has not been paid to the enemies of the movement through the prism of emotional detachment from modern football. Modern football is intricately intertwined with political, financial, and other interests. Therefore, in this paper, we observe local and supralocal specificities of the emotional response to the disruptions of collective identities through external factors influencing already established collective identities of ultras communities. Our research question is: who are the enemies of the ultras movement today?

Theoretical and empirical background

Today's "world of football" is described by at least three postmodern processes, such as commercialization, globalization, and individualization (Brandt, Krugliak & Warnecke, 2023). Researchers of ultras phenomena have already highlighted the issue of the dispersion of supporter communities as a result of the internationalization and professionalization of football (Taylor, 1971). Changes in club names, kit colors, emblems, sports and financial policies, surveillance and repression, increasing ticket prices, rescheduling matches for television broadcasters, and so on, become problems addressed in supporter demands for the return of the "true" club identity. The battle against modern football, characterized by the struggle for a nostalgic club identity (Numerato, 2018), has become one of the most important foundations for the demands and activities of ultras worldwide (Doidge et al., 2020). The performance of supporter groups represents an established ritual from which we can read group values and solidarity (Nuredinović & Vukušić, 2021; Doidge et al., 2020). Randall Collins (2008) introduced the concept of interaction ritual into the sociology of emotions, which builds group solidarity through mutual synchronization, focus, stereotyped formalities, similar language, bodily movements, and more. The positive emotional energy that arises during the performance of such rituals leads to commonly experienced emotional states that fill the meaning of group interaction. By inventing common symbols (such as words, phrases, emblems, slang, objects, etc.), the significance of the group is established, and a particular cultural capital full of shared experiences (memories, narratives, etc.) is built. Particular cultural capital and symbols circulate among group members (Turner, 2009) and become the 'moral' of the group. "Should they be violated by members or those outside the group, righteous anger will be aroused" (Turner, 2009: 347).

Methods

Through contacts established during ethnographic research on Bad Blue Boys (2019-2023), a second research stage was achieved - semi-structured interviews with the core members of the Sydney United Supporters. Fifteen semi-structured interviews were conducted in person with the BBB, while four semi-structured interviews were conducted online with the SUS. The difference in the sample is explained by the fact that SUS is a significantly smaller group (compared to BBB) consisting of only about 50 members. While many topics were addressed in the interviews, this work focuses solely on the emotional perceptions of "external" enemies in the form of structures of modern football or national institutions they conflict with. This approach has its limitations, primarily manifested in the inability to conduct long-term field research on SUS members, within which emotions and attitudes of respondents regarding the topic could be more precisely recorded. However, this analysis can provide answers to fundamental questions about the relationship of ultras to various aspects of contemporary football.

Results

Emotions are experienced through ongoing subcultural rituals that demonstrate the division of the world between "ours" (our team, our ultras, our community, our league) and "theirs" (big clubs, other ultras, other ethnic communities, A-League football). Participants offered their perspectives on the importance of Sydney United 58 in the context of various dimensions that do not solely relate to football but also to their everyday lives, i.e., social relationships that go beyond mere sports fandom and evolve into a sense of belonging to the community:

It is tattooed on me, and on my heart. My friends are there, my family is there (...). (**V., 27, SUS**).

Pride, celebration. All of our friends and family have met through football, church, our clubs and festivals. (**B., 34, SUS**).

From these quotes, we see that different expressions of emotional states are attributed to both the football club and the formation of identity (personal and collective). Similarly, we can observe in the case of respondents from the ranks of the BBB who describe the importance of the football club they support and around which they build their identity in a similar manner:

A football club that is more than that, a football club that is a symbol of a city, a state, a community, socializing, travelling, much more than a club, a social phenomenon. (**S, 38, BBB**).

It is also important to mention the existence of an intergenerational component, the transmission of emotions and heritage to younger generations:

From grandfather to father to son. It's a club that runs from generation to generation. Without the young ones, we don't have Sydney Croatia. (**Z, 23, SUS**)

Ultimately, one of the respondents from Australia summed up most of what we have presented in this section when expressing his opinion on how he sees the importance of the club in the community, what its role is, and how it should function:

By the people for the people. The club was built by the community and that's how it should be. (**B, 34, SUS**)

Local specificities related to the impact of external factors on Sydney United 58, and thus its ultras, primarily relate to the decision of the Australian Football Federation to ban ethnic motifs, which for our respondents represents an 'attack' to the symbolic foundations of their club, and therefore to them as ultras.

It was always known that Croatia was playing on Sunday afternoon. Unfortunately, ever since the clubs had to change their name, fewer and fewer people follow the football of our football clubs in Australia. (**Z, 23, SUS**).

We see that the name change has affected the interest in following the club and reduced attendance at matches, thus undermining the 'tradition' emphasized by our respondents. The 'tradition' of going to the stadium on Sunday afternoon is much more than watching a match; it includes socializing, connecting, and ultimately the ritual dimension of celebrating the collective identity of the group. Some reasons cited by respondents relate to the existence of prejudices and open discrimination (even violence) against them as members of an ethnic minority in Australian society. Therefore, they see the name changes and the prevention of competing in the A-League as an attempt to erase the identity of Croats in Australia or to delegitimize them:

The name change happened in early 90s. the older generations hated the change. Australian football federation tried to kill our name and colours off. To make us more Australian. (**B, 34, SUS**)

They always look at us as a corrupt people, as if we were some 'Fascists' or 'Nazis'. (**V, 27, SUS**)

Bad Blue Boys faced similar structural pressures when then-president Franjo Tuđman and the ruling party Croatian Democratic Union decided to change clubs' name from Dinamo to Croatia Zagreb in 1993. The position of the Bad Blue Boys, who did not agree with that change and openly rebelled using their distinctive methods (boycotts, flares, banners, graffiti), as well as social activism (protests, public forums, theater performances), was delegitimized during that period of the war-torn nineties by associating them with phrases like "Agents of Belgrade." Conflict with the authorities during the wartime and post-war years resulted in increased repression, decreased match attendance, and distancing of fans from the club:

Especially when few people went to away matches, that was the era of Tuđman's Croatia. There was a boycott (of home matches). When there were 40-50 of us, that was a big number. I remember we went to Vinkovci once, I counted 47 people on the train. We literally congratulated ourselves because that was a number. So fewer people went, at least in those years, until the name was restored. (**G, 42, BBB**)

After the final return of the name, the Bad Blue Boys had a new enemy. According to our respondents, the intertwining of modern football and chronic capitalism resulted in a political-criminal hybrid at the helm of Dinamo and the Croatian Football Federation, with which fans simply could not emotionally identify:

I think it's the worst thing that happened to Dinamo since its existence as a club. I think they killed the emotion and love for the club for the vast majority of fans, sympathizers, and people living in Zagreb. (**L, 44, BBB**)

During that period, the Bad Blue Boys protested against the club's management, the top of the Croatian Football Federation, and political figures. The identity crisis is so present that respondents speak of cheering against the club they live for:

> People didn't root for that club. I go to the match and I root for them to lose... Because I know that when they lose, it's another nail in Mamić's coffin, and when they win, I know all that money goes to him…(**L, 44, BBB**)

Respondents from Croatia and Australia mostly speak of hatred towards the mentioned structures, which they see not only as enemies of the fans but also as enemies of the football community - the football clubs as they should be:

> Police, HNS, FIFA, and UEFA. Money governs everything and most of all football, which has turned from a sport for the poor into a spectacle and theater for the rich. I think we must not allow that. They want to kill the passion for football, which without true fans is no longer the same. (**J, 33, BBB**)
>
> The football federation, governments, police, and all those who hate football. (**V, 27, SUS**)

According to Australian ultras, there is almost a systematic erasure of the identity of their football club and its community. Different forms of injustice, now perceived through the club management's manipulation for profit from the brand, lack of transparency, and the absence of cooperation between the club and the fans, have aroused the anger of the fans and resulted in resistance:

> The club president has taken our club like it's his own now. He is like Mamić when he was in Dinamo. He uses the club for his own money and gain. (**B, 34, SUS**)
>
> A lot of information is being hidden. We have people in the management who are also in the management of another club. There shouldn't be such a conflict of interest. There should be an annual general meeting for all members, but that hasn't happened for a long time. The management should be defending the club and the fans (...). (**V, 27, SUS**)

Discussion and conclusion

The most significant findings suggest that there are enduring, violent, and deeply emotional practices of revolt against the forces of modern football on a supralocal level, as well as domestic policies that have tactlessly extinguished collective understandings of club identities. It is interesting to observe how references to ethnic and national identity in both cases are based on the discrediting of supporter bases. SUS are discredited based on their ethnic identity where national symbolism is forcibly removed from the symbolic world of the football club. In addition, BBB were discredited for lacking a proclaimed Croatian identity, which is forcibly removed during a name change to one of greater political significance. Both cases also demonstrate consistent fractures of collective identities through financial malpractices, damaging relationships with supporters, and corruption. These fractures result in the deterrence or revolt of supporters through reduced attendance, activism, and fan riots. Most importantly, such practices affect the emotional sphere of fandom, with supporters primarily speaking about the absence of emotion towards the clubs they support. Emotional practices are encapsulated in the "struggle" to return football to the community from which it originated. These practices are common to SUS and BBB and can also be observed among other ultras worldwide, and they must be further studied and compared. In this regard, Ian Taylor's work (1971) on the bourgeoisification of football, which undermines local supporter communities and deprives them of participation, is of great significance for studying the alienation and resistance of supporter communities today.

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THE EVOLVING LANDSCAPE OF HIGH-PERFORMANCE COACHING: A SYNTHESIS OF RESEARCH ON GENERAL AND CONTEXT-SPECIFIC ISSUES

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Abstract
The article critically evaluates high-performance coaching, underscoring its capacity to cultivate accountability and self-awareness for peak individual performance. It discusses obstacles including identity shifts, and work-life equilibrium, which disproportionately impact marginalized sectors, championing the need for additional scholarly investigation in this field.

Keywords: *High-performance coaching, Gender discrimination, The disabled, Career challenges*

Introduction
High-performance coaching represents a scientific approach to management that prioritizes a human-centric and sustainable perspective. It is adept at adapting to diverse contexts and environmental shifts, and it excels in aggregating knowledge and fostering innovation. Compared to traditional team models, high-performance coaching is characterized by its efficiency and reliability, generating greater amounts of value (Mo, 2018). High-performance coaching is a multifaceted role that extends far beyond the mere instruction of skills and drills. Coaches are tasked with managing and leading various human elements that are crucial for enabling peak performance.

Nonetheless, the high-performance coaching, whether conceptualized as a technical strategy or embodied by an individual—a coach of high performance—one invariably encounters a spectrum of challenges. The adage "The higher one climbs, the colder it gets" rings true in the realm of greater complexity and elevated performance, which demand a commensurate sacrifice. Regarding the special cases of vulnerable groups in the field high-performance coaching, such as people with disabilities, it has been suggested that sport provides a context that can challenge and influence the social and cultural perceptions of disability and disabled people (Howe & Silva, 2016). Besides, the relatively weaker female group, the gender and sports coaching literature evidence that all groups of women are more likely to experience discrimination in the coaching workplace than men across most sports, performance domains, and at all points on the coaching pathway (Burton & LaVoi, 2016; Carter-Francique & Olushola, 2016; Kenttä, Bentzen, Dieffenbach, & Olusoga, 2020). In a broader view of this field, most professionals confront a spectrum of career hurdles, including transitioning roles, burnout, crises, reclaiming wellness, and maintaining work-life balance.

Given this position, this article provides an overview of the current limited knowledge of high-performance coaching and demonstrates the need for further research in this space.

The Underprivileged in High-Performance Coaching
Women in high-performance coaching - Australian case: *Numbers are up, but top talent is scarce*
The participation and media coverage of women in sports has seen a gradual uptrend globally over recent year. However, this increased involvement has not been reflected in a significant boost in the number of women assuming coaching roles, especially at the high-performance level. Take Australia as an example, where women account for a mere 15% of high-performance coaching positions (Damien et al., 2023).

In a qualitative Australian study, it uniquely emphasizes facilitating women's entry into high-performance coaching rather than just focusing on barriers, suggesting a positive approach for future studies.

Women encounter both overt and subtle gender discrimination in high-performance coaching. For instance, a study conducted by Donna and Popi in 2018, grounded in constructionism and critical feminism, revealed gender-based differentiation in coaching practices among 10 international male elite rowing coaches through semi-structured interviews and thematic analysis. Findings indicated that coaches' behaviors subtly discriminate against female athletes in training intensity, opportunities, encouragement, and expectations, potentially hindering their athletic development and competitiveness.

Disabled individuals in high-performance coaching

In sport, the disabled body is, as Edwards and Imrie (2003: 240) argued, a 'site of contestation' where impairment and its effects (physical and intellectual) can 'function as distinctive signs and as signs of distinction, positive or negative' (Bourdieu, 1989:20). These distinctions can be shaped by the structures of the field, and thus the use of the work of Bourdieu can highlight the cultural resources and frameworks drawn upon in practice and the meanings attributed to disability across coaching in disability sport.

Thus, coaching research requires the application of sociology to reveal and challenge dominant values and ideologies that influence disability sport, and by extension, the way disability can be understood and reconstructed in society.

The Unique Challenges Encountered by the High-Performance Coaching - Identities & Transition

While developments in the mainstream literature have contributed to an increased sociological understanding of 'precarious work' and 'insecure workers' (Kalleberg, 2009, p. 1) in neo-liberal societies, there remains a paucity of such inquiry within sporting contexts.

In a study (Christopher et al., 2020), it delves into how top male athletes from English and Welsh football and rugby union teams forge their coaching identities following their athletic careers, grappling with the challenge of differentiating their playing philosophies from coaching ones, highlighting an imperative for educational programs that help coaches delineate between their roles as players and mentors. As you can see, the study underscores the significant investment and introspection required for high performance coaches to redefine themselves professionally and establish a clear identity that encapsulates both their athletic background and coaching aspirations.

Work-Family Balance

In a field where time is a precious commodity and the rhythm of work is often at odds with conventional hours, the challenge for coaches in the high-performance coaching is profound. In our common logic, the difficulty of work-family balance can lead to just negative consequence, however, in a study examines how high-performance sport coaches combine their professional and family lives, the results of the participants who involved in the preparation of the French teams for the Olympic Games in Rio (2016), Pyeongchang (2018) and/or Tokyo (2020) showed different answers, for some coaches, they can't have both, for others, family life is a protection for their work. More interestingly the coaches interviewed have one thing in common: They do not consider stopping their careers. It is even the opposite, as a coach puts it: ''If I were asked to stop today, it would be terrible'' (Christine). Which gives us an insight to look at the question at another angle.

Future Directions - The Vulnerable Minority

As women's representation in pivotal coaching roles is still alarmingly low. Closing this gap necessitates a targeted push for best practices that advance gender equity in coaching, guaranteeing a clear pathway from grassroots to high-performance levels for women. It is also important to recognise that "one" woman in a highly visibly, powerful role is not enough, more attention should be put to engage more women in higher position in the field of high-performance coaching.

For disabled people, coaches are guided to home in on the capabilities of athletes, aiming to push and refine their talents, yet the distinction between disability and sport can sometimes be exploited for symbolic gain. It's essential to explore how societal norms and cultural values shape coaching methodologies. Moreover, the creation and assessment of coaching strategies that are inclusive and centered on the diverse requirements of athletes with disabilities should be a priority.

The General Majority

Given the multifaceted challenges faced by high-performance coaching, it should investigate power dynamics and symbolic violence influencing coaching, especially in the development of professional identity and the overlap between playing and coaching ideologies. Research should also tackle the work-family balance, examining how coaches navigate their professional and personal spheres amidst demanding schedules and travel.

Given the predominance of qualitative interview-based studies, there's a need for more cross-cultural and cross-racial research. Future studies should aim to diversify by including data from a broader range of sports.

Conclusion

This article shines a light on the complex hurdles within high-performance coaching. The finding stresses the importance of organizational initiatives to bolster women's coaching careers and expose the nuanced biases they and disabled coaches often face. Additionally, the demanding aspects of high-performance coaching can result in burnout and challenges to balancing work and family. The coaching sector must enact substantial reforms to tackle these concerns and foster a fairer, more sustainable coaching culture.

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THE CHILD-CENTERED OR SUBJECT-CENTERED: THE PLACEMENT OF PHYSICAL EDUCATION IN THE NEW SCHOOL CURRICULUM REFORM IN SLOVENIA

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Abstract
This paper highlighted the ongoing discussions about the new school reform in Slovenia related to the placement of physical education and extracurricular physical/sports activities in a new school curriculum. This area is addressed in the 2nd priority area of the National Programme of Upbringing and Education for the Period 2023-2033, dedicated to ensuring a safe and supportive environment for the optimal development of every child in school. Following the findings of our scoping review, the leisure pedagogy seems to be a promising approach to support child-centred holistic development, inclusion, interests, freedom of choice and autonomy for all school children in a classroom. Future analysis of various roles and values of physical education and physical activity are needed in the new school curriculum reform.

Keywords: *sport, physical activity, education system, wellbeing, leisure pedagogy*

Introduction
The discussions about new school reform in Slovenia have recently taken priority in the educational sector. In January 2024, a National Programme of Upbringing and Education for the Period 2023-2033 (Ministry of Education, 2024) was introduced to the public to establish contemporary directions for the education system in Slovenia for a new decade. The document explains the strategic goals and measures for their implementation in school practice among the six priority areas focused on: 1) Development of the society and the role of education; 2) Ensuring safety and supportive environment for the optimal development of an individual; 3) Teaching, learning, progress monitoring, and evaluation and assessment of the knowledge; 4) Professional and career development of the staff in education; 5) Evaluating and ensuring quality system; and 6) Education system.

Although physical education and extracurricular physical/sports activities, like other school subjects, are not particularly mentioned in these priority areas of the National Programme of Education, they are addressed in the strategic goals within the particular priority areas. Encouraging physical and sports activities is part of the 2nd priority area, dedicated to ensuring safety and a supportive environment for the optimal development of every child in the school system. This priority area is one of the crucial foundations of the reform and enables all other goals (e.g. only a healthy child is willing to learn). It consists of four strategic goals, and the last one is supporting the development of a healthy lifestyle, including encouraging physical activity, restricting sedentary time, developing healthy eating and sleep habits, providing leisure time and time to rest, and avoiding any risk behaviours or addictions (Ministry of Education, 2024). However, some experts in the field of kinesiology are critical to the National Programme and pointed out that despite receiving intense support at numerous meetings and boards, everyday physical activity in school is not sufficiently represented in the final document (Jurak, 2023). Therefore, the group of experts from universities, secondary and primary schools, and kindergartens developed additional guidelines for the placement of physical activity in everyday school life, emphasising the school environment that encourages physical activity and development of teachers' competences to know how to use physical activity in their teaching. They advocate five hours of physical education per week (Jurak et al., 2023).

Similar concerns were emphasised by Štremfel (2023), who found relations between Slovenian national educational reform processes and the Europeanisation of education. Štremfel characterised the current education reform as more likely the result of passive Europeanisation, which is happening under the pressure of a European funding timeline with insufficient national considerations and broader, more time-demanding national consensus. Such openness and enthusiasm towards the implementation of EU values, policies, and international comparisons are particularly distinctive to European post-socialist countries (Silova, 2009). Therefore, Kodelja (2023) warns that the new school reform could be a path to a more equitable and quality education system, but only if these aspects are part of the crucial goals of the reform. Unfortunately, Kodelja see the National Programme of Education for the Period 2023-2033 with good emphasis on establishing the quality of the education system, but with the lack of measures to ensure that the reformed education system will also be as fair as possible for all schoolchildren. From that perspective, physical education and extracurricular physical/sports activities should be available and accessible to all students regardless of gender, social status, religion, nationality, or mental or physical disability.

However, to reach the goal of justified and consensually accepted school reform, many discussions among educational experts from various disciplines are still needed. In this paper, we aimed to look more closely at the strategical goal of the reform addressing the conditions for providing good mental and physical health to school children with increased concerns for the learning environment that encourages physical activity and restricts continuous sitting, implements physical activity in everyday teaching across school subjects and provides extracurricular activities that support physical and mental well-being of children (Ministry of Education, 2024). This study aimed to: 1) contribute to the ongoing discussion on the new school curriculum reform in Slovenia from the aspect of physical education and extracurricular physical/sports activities; 2) to critically analyse the benefits as well as shortcomings of physical activity in the education system; 3) to discuss how physical education and extracurricular physical/sports activities could benefit from the leisure pedagogy.

Methodology

This study is based on a qualitative literature review. Following the typology of reviews by Grant & Booth (2009), we used a scoping review to identify the nature and extent of available research evidence related to the discussion of the new school curriculum reform in Slovenia from the aspect of placement of physical education and extracurricular physical/sports activities in the education system. From that point of view, all published material was evaluated, such as scientific publications (articles, books, conference proceedings), professional papers, policy documents and television broadcasts of the National Assembly.

The benefits of physical education and physical activity for children

The ongoing discussions about the importance of physical activity in education should be understood from the perspective of scientific evidence about the correlations between a child's physical activity and holistic development (Pišot & Zurc, 2005). The previous studies undeniably showed that the amount and intensity of physical activity a pupil is involved in - in and out of school - is an essential contributor to better school performance (Booth et al., 2014; Zurc & Planinšec, 2022; Tomporowski et al., 2008) and the management of behavioural problems in school (Zurc et al., 2022). Moreover, one of the main goals of physical education and extracurricular physical/sports activities at school is to develop a positive attitude towards regular physical activity participation throughout the lifespan by raising students' awareness of the importance of lifelong physical activity to maintain health (Lahti et al., 2018; Štemberger & Zurc, 2024). Despite the convincing arguments, the insufficient level of physical activity in the adult population (WHO, 2020) shows that this ambitious educational goal is not fully realised.

Despite numerous studies on the impact of physical activity on a child's development, we still don't have one general model of what kind of physical activity is the most suitable for children. Nevertheless, child happiness and interest in physical activity seem to be the strongest predictors of continuing participation. One of the most important factors is to support or diminish intrinsic motivation for physical activity and school assessment. Based on the findings of two focus groups with primary school teachers, Štemberger & Zurc (2024) emphasised that teacher's attitudes towards physical activity and child-centered approach are more important than numerical assessment in determining a child's attitude to and interest in physical activity/sports. Therefore, the importance of assessing pupils' progress but not motor skills and talents should continue to be emphasised in physical education and extracurricular physical/sports activities, alongside the long-term goal of physical education classes, which is lifelong participation in physical activity and sports to maintain and enhance health.

The concept of leisure time pedagogy

Leisure pedagogy is an integral and systemically organised scientific-pedagogical and practice-oriented discipline in upbringing and education, revealing the regularities of the pedagogical process and socio-cultural aspects in the field of leisure. The special mission of leisure pedagogy is to provide conditions for the formation of an individual's ability to self-develop in the field of leisure and increase their own leisure competence (Chernikov, 2020). The unique task of leisure pedagogy also referred to as "education for freedom" (Svobodová, 2023), is to create the conditions for the formation of the individual's ability for self-development and to increase their leisure competence (Chernikov, 2020). Leisure pedagogy is based on non-directive methods with the main goal of developing a free person who is responsible for freely chosen actions related to personal freedom. In order for students to grow in their freedom and responsibility, they need education (Svobodová, 2023). Therefore, it is not surprising that many EU countries focus intensively on leisure centres for children aged 6–10 years. However, there are differences in the research of leisure pedagogy. For example, Danish research on leisure pedagogy focuses on collaboration between schoolteachers and leisure-time pedagogues, while Swedish researchers are interested in the professional identity of leisure-time pedagogues (Ringskou et al., 2022).

The leisure pedagogy focuses on an individual's actions in time and space where human freedom and responsibility are performed and seeks to nurture an individual in such a way that life in this time and environment is as worthy of the human person as possible. In addition, the pedagogy of leisure offers humanity, justice, partnership, inclusion, enhancing interests, reflection, freedom of choice, autonomy, and similar methods that can be used (Svobodová, 2023). We can conclude that the involvement of children, especially from marginalised groups, in leisure time activities could be recognised as an important factor of education. School extracurricular physical/sports activities provide crucial opportunities for child-centered holistic development, supporting his/her interests, freedom of choice and autonomy.

Conclusion

The Ministry of Education, the Ministry of Higher Education, Science and Innovation, the National Education Institute of Slovenia, primary and secondary schools, kindergartners, parents' associations and civil society is contributing their views in numerous written and live discussions on education that should be the best for Slovenian children and youth in the next decade 2023-2033. The established Slovenian pedagogues emphasised different perspectives, why school reform is needed and what it should be, mention the e.g. equity and justice in education (Kodelja, 2023), children's participation in decision-making and expressing their views on issues relevant to them (Kodele & Lesar, 2023), lack of teachers and strategies to keeping them in the education profession (Bogdan Zupančič & Gavriloski Tretjak, 2023).

Even though ongoing discussions contribute valuable insights for all school subjects, among them also for the physical education, there is a lack of comprehensive studies dedicated to physical education and physical activity in the school curriculum reform. With this paper, we contribute to this gap and provide some starting points for further discussions about the strategic aims, values and didactical approaches that should be developed and implemented in physical education and extracurricular physical/sports activities within a new school reform. Following the findings of our scoping review, the leisure pedagogy seems to be a promising approach to support child-centered holistic development, inclusion, interests, freedom of choice and autonomy for all school children.

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CURRENT TRENDS AND INNOVATIONS IN KINESIOLOGY RESEARCH: PROCEEDINGS

SPORTS RECREATION

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EFFECTS OF EXERGAMES ON PHYSICAL FITNESS VARIABLES OF OVERWEIGHT AND OBESE YOUNGSTERS: A SYSTEMATIC REVIEW

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Abstract
Technology has been explored as a potential source of fostering physical activity (PA) levels, mainly through exergames. This study provides an overall view of the literature on the effects of exergaming on physical fitness components among overweight and obese children and adolescents. A systematic review following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines was performed in the PubMed, Web of Science, and Scopus databases. Among the 618 articles identified at the first screening stage, 24 were retained for analysis. The results indicate positive effects of exergaming interventions in body composition outcomes, cardiorespiratory fitness, muscular strength, and skills performance. The duration of the programs ranged between four and 24 weeks, and the most common intervention period corresponded to 12 weeks (n = 6). Most interventions were based on 3 weekly sessions ranging between 45 and 60 min (n = 9), using dance (n = 15), sports (n = 13), and adventure (n = 7) games designed for the PlayStation, Xbox 360, and Nintendo Wii. Virtual reality was deployed in one study, while another investigation used a mobile serious game to promote behavioral lifestyle changes. Exergames showed high levels of enjoyment and attractiveness among participants, representing a powerful complementary tool to foster daily PA recommendations. However, considering the diversity of methods employed, limited generalizations could be made, and future research is still needed to define the most effective approaches.

Keywords: *active video games; body composition; fitness; physical activity*

Introduction

The prevalence of low physical activity (PA) levels and increased sedentary behavior among adolescents have become major public concerns worldwide, with an estimated 81% not meeting recommended activity levels (WHO, 2021). This trend often persists from childhood and adolescence into adulthood, contributing to rising rates of overweight and obesity and escalating risk for non-communicable diseases (i.e., hypertension, coronary heart disease, and type 2 diabetes) (Abrignani et al., 2019).

The literature has described overweight and obesity as related to low physical fitness levels, which is described as a set of attributes that allows individuals to carry out daily tasks without undue fatigue and with enough energy to enjoy leisure time (Caspersen et al., 1985). The health-related components of physical fitness include cardiorespiratory fitness, muscular strength and endurance, flexibility, and body composition (Caspersen et al., 1985).

Increased technology usage has exacerbated sedentary behavior among youth, but it also presents an opportunity to promote healthy lifestyles through exergames. These games leverage young people's interest in gaming to increase PA levels (Gao & Chen, 2014). Previous research has demonstrated the potential benefits of exergaming, including improved activity levels, weight loss, and increased enjoyment (Foley & Maddison, 2010; Gao & Chen, 2014). However, significant knowledge gaps remain regarding the long-term effects, comparative effectiveness against traditional exercise interventions, and adherence and sustainability of exergaming, especially among overweight and obese children and adolescents. Therefore, to address these important issues, this review aimed to provide a comprehensive view of the literature on the effects of exergaming on physical fitness components among overweight and obese children and adolescents.

Methods

Study design

The research followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines.

Before the literature search, the study protocol was registered with PROSPERO (reference: 439081).

Search strategy
Three comprehensive electronic databases (PubMed, Web of Science, and Scopus) were screened by two independent authors (C.F. and S.A.) for articles published until 1st of June of 2023. The following terms were used to search in the title/abstract level: “serious games”, “exergam*”, “active video game”, “child*”, “adolescent”, “youth”, “obesity”, and “overweight”, combined with the Boolean operators “OR” and “AND”.

Study quality and risk of bias
The quality assessment was based on the Effective Public Health Practice Project (EPHPP), determining an overall score defined as “weak”, “moderate”, or “strong”.

Results
Study selection
Figure 1 represents the flowchart of the study selection procedure. A total of 618 articles were identified at the first stage of the database search. After removing duplicate entries, 454 articles were analyzed by title and abstract. Of those, 93 remained for full-text reading. After full-text evaluation, 69 articles were excluded based on inclusion and exclusion criteria, resulting in a final sample of 24 articles for analysis.

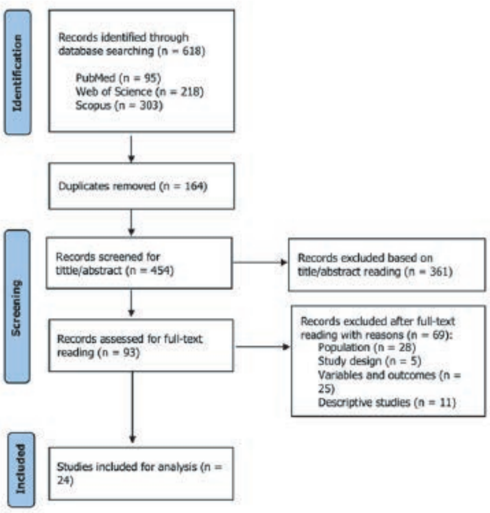

Figure 1. Flowchart representing studies’ selection.

Study quality and risk of bias
Concerning methodological quality, nine studies were classified as strong, 10 were scored as moderate, and five as weak.

Main results
Body composition
Eight studies reported a significant reduction in body weight and BMI in the intervention group (IG) compared to the control group (CG). In contrast, weight and BMI increases were seen in the IG and CG following a 12-week home-based exergaming program. In two interventions, weight was reduced in the IG and CG, although the decrease was more significant in the IG than in the CG (Trost et al., 2014; Zarkogianni et al., 2023).

Cardiorespiratory fitness
Three investigations reported increased cardiorespiratory fitness among the IG (Christison & Khan, 2012; Comeras-Chueca, Villalba-Heredia, Perez-Lasierra, Marin-Puyalto, et al., 2022; Murphy et al., 2009). In contrast, no changes were described in the IG or the CG after 24 weeks of home-based exergaming (Maloney et al., 2012). In another study, the number of step-ups was used to assess endurance, with a substantial increase of a mean of 30 repetitions being described from pre- to post-intervention (Flynn et al., 2018).

Muscular strength
Significant improvements were seen in knee extension maximal isometric strength, handgrip strength, and vertical jumping height after 20 weeks of intervention (Comeras-Chueca, Villalba-Heredia, Perez-Lasierra, Marin-Puyalto, et al., 2022), while a substantial increase of a mean of five repetitions in the sit-ups test was described after six weeks of exergaming with the Nintendo Wii (Flynn et al., 2018).

Skills
Cognitive skills improvement was reported in the IG, including a competition mode that increased their testing score seven times more than the CG (Staiano et al., 2012). On the other hand, 20 weeks of exergaming has contributed to significant increases in locomotor and object control domain testing scores (Comeras-Chueca, Villalba-Heredia, Perez-Lasierra, Marin-Puyalto, et al., 2022).

Enjoyment and attractiveness
Among the sample analyzed, only three investigations have reported data concerning the participants' enjoyment and/or attractiveness while playing exergames. All studies summarized high levels of enjoyment and attractiveness while using different exergames in single (Polechonski et al., 2020) or multiple sessions (Flynn et al., 2018; Staiano et al., 2012).

Discussion
The review aimed to assess the impact of exergaming on physical fitness components among children and adolescents with obesity. Overall, findings indicate positive effects of exergaming interventions on body composition, cardiorespiratory fitness, muscular strength, and motor skills performance. Interventions typically lasted four to 24 weeks, with most programs consisting of three weekly sessions lasting 45 to 60 minutes, mainly conducted at home.

Regarding body composition, exergaming interventions resulted in decreases in weight, BMI, waist circumference, and fat mass percentage (Christison & Khan, 2012; Christison et al., 2016; del Rio et al., 2018; Foley et al., 2014). Cardiovascular fitness and muscular strength also improved following exergaming interventions, potentially mitigating the negative health effects of sedentary behavior and obesity (Christison & Khan, 2012; Comeras-Chueca, Villalba-Heredia, Perez-Lasierra, Lozano-Berges, et al., 2022; Flynn et al., 2018).

Limited research on motor skills performance showed promising results, suggesting exergaming's potential to enhance fundamental motor skills among children and adolescents. Participants ' high levels of enjoyment and attractiveness support exergaming as a valuable tool for promoting physical activity, particularly among those who may lack interest in traditional forms of exercise.

However, exergaming should complement rather than substitute traditional physical activity, as it may not sustain long-term motivation for exercise. Additionally, the review acknowledges limitations in study methods, such as the diversity of intervention approaches and the need for more research to strengthen the evidence base.

Overall, while exergaming shows promise in improving physical fitness components among children and adolescents with obesity, further high-quality research is needed to fully understand its effectiveness and integration into comprehensive physical activity interventions.

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PRELIMINARY INSIGHTS INTO PHYSICAL ACTIVITY LEVELS AND THEIR ASSOCIATION WITH OBESITY INDICATORS AMONG ADOLESCENTS AGED 15-18 YEARS IN EASTERN SLAVONIA

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Abstract
Adolescence can be described as a period of life that passes quickly, yet it plays a crucial role in transitioning from a child dependent on others to an adult who is independent. Developing an unhealthy lifestyle during adolescence is now a global health challenge because such habits can ultimately manifest as cardiovascular complications and obesity, which can also impact longevity and quality of life. The aim of this study is to investigate the relationship between physical parameters, such as body mass index, percentage of body fat, and percentage of muscle, and the physical activity of adolescents. A total of 65 adolescents participated in this study, and the results indicate that the participants in this study generally have satisfactory body composition parameters. However, the level of physical activity is significantly higher compared to similar studies using International Physical Activity Questionnaire. Additionally, significant differences in energy expenditure were found regarding gender, favoring male adolescents. Based on the results, general guidelines suggest the necessity for additional education and involvement of adolescents, especially females, in extra physical activities to prevent poorer quality of life and improve health status.

Keywords: *physical activity, adolescents, energy expenditure*

Introduction

The World Health Organization has defined health as a state of complete physical, social, and mental well-being, and not merely the absence of disease (Sartorius, 2006). One of the most important and accessible factors that can positively impact an individual's health status is appropriate and tailored physical activity. There is a plethora of evidence on the positive effects on human health caused by frequent participation in physical activities (Biddle et.al., 2004). Adolescence is a period in which young people develop their personalities and identities. It is a period in which key processes such as psychological, physical, and social maturation occur, guiding young people towards the next phase of their lives, adulthood (Cachón-Zagalaz et al., 2023). All of these changes have a significant impact on a person's quality of life. Overall, these changes in anthropological status can influence healthy habits such as balanced nutrition, quality sleep, and engagement in various forms of physical activity. Therefore, it is the task of all society, who have the ability to influence young people, to lead by example and guide them towards making informed decisions about adopting healthy lifestyle habits (El-Qudah, 2014). However, the increasingly prevalent adoption of unhealthy habits and lifestyles during adolescence today represents one of the leading health challenges globally. In addition to the increased risk of developing diseases within the metabolic syndrome spectrum, such a lifestyle often reflects in later ages, thereby setting a negative example for young people, who view their parents as role models (Hayes et al., 2019). Unhealthy living, characterized by poor dietary habits, insufficient physical activity, and thus inadequate energy expenditure, coupled with increased nutritional energy intake, is most commonly the result of the growing obesity among adolescents, the emergence of type II diabetes mellitus, musculoskeletal disorders, cardiometabolic disorders, mental disorders, etc. (Bhatti et al., 2020; Babic, 2022; Sluijs et al., 2021). This is particularly important due to the fact that the risk of developing cardiovascular diseases and their consequences is significantly higher in Eastern Slavonia compared to other regional parts of the Republic of Croatia (Kern et al., 2009). It is crucial to emphasize that the issue of insufficient physical activity is not a problem that emerged solely in the modern era; this problem existed even before technological advancements. Today's sedentary lifestyle is further exacerbated by prolonged sitting in school desks, extended hours spent sitting in front of the television or computer. Additionally, urban environments contribute to this lifestyle due to limitations in engaging in physical activities, such as reliance on public transportation in daily life, lack of playgrounds in certain urban areas, etc. (Misigoj-Durakovic, 2018). With the modernization of technology, access to smartphones, computers, and other high-tech devices increases, further exacerbating the underlying cause of adolescents' lack of physical activity. Such unfavorable trends, especially in the area of Eastern Slavonia, where the highest rate of physical inactivity and sedentary lifestyle among children, especially those who gravitate towards rural areas, is recorded, represents an additional risk for the development of various diseases from the spectrum of metabolic syndrome (Vukelja et.al., 2022) The aforementioned factors may contribute to adolescents' diminished interest in physical activity. In the daily battle against sedentary lifestyles, as previously mentioned, parents and teachers must provide encouragement and motivation for children to engage in physical activities for at least 30 minutes a day, or preferably more (Gula & Sumayang, 2022). Therefore, the primary aim of this study is to assess physical activity and energy expenditure among high school adolescents, while the secondary aim is to examine the relationship and influence of anthropological status factors on the primary objectives.

Methods

A total of 65 high school students participated in this study, including 29 male and 36 female students, aged 15 to 18 years. Before the study commenced, all participants provided informed consent to participate in the research and agreed to the use of their data for the purpose of conducting this study. Participants under the age of 18 provided informed consent from their parents/guardians. The International Physical Activity Questionnaire (IPAQ) was used to assess physical activity and energy

expenditure, from which values of metabolic energy expenditure (MET) expressed in minute per week were later calculated. After completing the questionnaire, basic anthropometric parameters were measured for the participants; body height using a Lange anthropometer, and body weight, body mass index, body fat percentage, and muscle mass percentage using a digital Omron BF511 scale (Kyoto, Japan). Descriptive statistics were expressed using minimum and maximum values, arithmetic means, and standard deviations. Pearson correlation was used to examine the relationship between predictor variables and IPAQ. An independent samples t-test was used to assess differences by gender in the observed variables. Statistical significance was set at $p = 0.05$ and $p = 0.01$. All aforementioned analyses were performed using the statistical software SPSS (ver. 22.0, SPSS Inc., Chicago, IL, USA).

Results

Table 1. Basic descriptive information about the participants

n = 65	MEAN	MIN	MAX	Std. Dev.
BH	175.13	149.10	195.40	10.44
BW	72.59	46.20	123.70	16.91
BMI	23.61	17.60	42.30	4.99
MM	35.46	20.20	45.20	6.68
BF	24.00	5.40	54.30	10.99
IPAQ	4615.33	375.00	11916.50	2904.66
SITT	2465.77	420.00	6480.00	1144.88

LEGEND: n; number of respondents, MIN; minimal value; MAX; maximal value, BH; body height, BW; body weight, BMI; body mass index, MM; muscle mass, BF; body fat, IPAQ; value of energy expenditure described in MET minutes per week, SITT; total time spent sitting expressed in minutes

Table 2. The Pearson coefficient of correlation between predictor and criterion variables

n = 65		BH	BW	BMI	MM	BF	IPAQ	SITT
BH	r	1	0.46**	-0.05	0.67**	-0.53**	0.36**	-0.25*
	p		0.00	0.68	0.00	0.00	0.00	0.05
BW	r	0.46**	1	0.86**	-0.11	0.38**	0.17	-0.21
	p	0.00		0.00	0.39	0.00	0.18	0.10
BMI	r	-0.05	0.86**	1	-0.50**	0.73**	-0.02	-0.06
	p	0.68	0.00		0.00	0.00	0.90	0.62
MM	r	0.67**	-0.11	-0.50**	1	-0.92**	0.43**	-0.18
	p	0.00	0.39	0.00		0.00	0.00	0.14
BF	r	-0.53**	0.38**	0.73**	-0.92**	1	-0.33**	0.16
	p	0.00	0.00	0.00	0.00		0.01	0.21
IPAQ	r	0.36**	0.17	-0.02	0.43**	-0.33**	1	-0.34**
	p	0.00	0.18	0.90	0.00	0.01		0.01
SITT	r	-0.25*	-0.21	-0.06	-0.18	0.16	-0.34*	1
	p	0.05	0.10	0.62	0.14	0.21	0.01	

LEGEND: n; number of respondents, r; Pearson correlation coefficient, p*; statistical significance < 0.05, p**; statistical significance < 0.01, MIN; minimal value; MAX; maximal value, BH; body height, BW; body weight, BMI; body mass index, MM; muscle mass, BF; body fat, IPAQ; value of energy expenditure described in MET minutes per week, SITT; total week time spent sitting expressed in minutes

Table 3. T-test analysis by gender

	GENDER	n	MEAN	Std. Dev.	*p*
BH	M	29	182.39	6.36	0.00**
	F	36	166.12	6.84	
BW	M	29	77.71	14.83	0.01**
	F	36	66.24	17.41	
BMI	M	29	23.34	4.18	0.64
	F	36	23.94	5.90	
MM	M	29	40.27	3.66	0.00**
	F	36	29.49	4.30	
BF	M	29	17.88	7.88	0.00**
	F	36	31.59	9.52	
IPAQ	M	29	5855.82	2627.58	0.00**
	F	36	3075.40	2494.00	
SITT	M	29	2160.42	1206.21	0.01**
	F	36	2844.83	953.21	

LEGEND: n; number of respondents, p**; statistical significance < 0.01, BH; body height, BW; body weight, BMI; body mass index, MM; muscle mass, BF; body fat, IPAQ; value of energy expenditure described in MET minutes per week, SITT; total week time spent sitting expressed in minutes

Discussion

This study has revealed several interesting factors. Considering the global trend of increasing body weight among young people (Wang et al., 2008; Ward et al., 2017), the adolescents in this study, according to validated and widely accepted body mass index values, with a result of 23.61 ± 4.99, belong to the group of normal-weight individuals (Weir, 2019). Such favorable results are likely due to the fact that the participants in this study are above-average physically active. The results on the IPAQ test indicate that the average physical activity value expressed in MET units per week is 4615.33 MET/min/per week. This is particularly significant when compared to other developed countries such as Australia, the United Arab Emirates, or Portugal, whose participants have significantly poorer values (Hasket et al., 2023; Alrahma et al., 2023; Pizarro et al., 2023). The reasons for such a good result in our study can be explained by the improving infrastructure solutions of educational institutions, where students have better conditions and opportunities for regular physical exercise. Additionally, cultural and social customs are not negligible, as Croatia is a sports-oriented nation with a tradition of achieving good results and success in various sports activities. Of course, we cannot overlook education and various public programs and campaigns aimed at animating and encouraging adolescents to engage in physical activity. In addition, we cannot ignore the fact that the respondents in this research are mostly adolescents from the city of Osijek and smaller surrounding towns that are geographically located and belong to the city. This created more favorable conditions for practicing and participating in various physical activities provided by the urban environment, such as the city of Osijek, which represents the cultural, economic, educational and sports center of Eastern Slavonia. Furthermore, correlation analysis has established that variables such as body fat percentage (BF) and total time spent sitting (SITT) potentially contribute to reduced physical activity. Although the correlations are small, for BF r = - 0.33 and SITT r = -0.34, they are still significant and should not be disregarded. It is indeed possible that the overall average time spent sitting in this study, 2465.77 ± 1144.88 minutes, contributes to reduced physical activity and potential increase in BF. Considering that the T-test analysis by gender revealed that female adolescents have significantly lower physical activity (IPAQ = 3075.40 ± 2494) compared to their male counterparts (IPAQ = 5855.82 ± 2627.58), it is likely that solutions should be sought in this factor to improve physical activity among female adolescents and thereby the overall picture of physical activity. This phenomenon is not an isolated case, and several studies have confirmed higher physical activity levels among males compared to females (Mendoza et al., 2020; Sluijs et al., 2021). Sociocultural factors, such as stereotypes and gender role expectations, may influence the level of physical activity, as women are more focused on family care while men engage in external activities, and sports is certainly one of them. Additionally, women may feel social pressure or body consciousness, which may discourage them from participating in physical activities, especially if they feel insecure or uncomfortable in public spaces such as gyms or sports fields. These factors are interconnected and complex, varying depending on culture, economic status, education, and other factors. It is important to promote understanding and support to encourage greater physical activity among all members of society, regardless of gender.

Conclusion

Based on the results, it can be concluded that the level of physical activity among adolescents is quite satisfactory. However, additional efforts and education of all stakeholders in society are needed in order to reach the level of physical activity of other parts of the Republic of Croatia, especially the coast and to reduce gender differences in physical activity and, consequently, sedentary lifestyles.

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REASONS FOR STUDENT ENGAGEMENT IN FITNESS PROGRAMS

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Abstract
Contemporary social concepts emphasize health and well-being, especially among young people. Fitness programs are popular among the student population, and the reasons for their participation are diverse and complex. An empirical (survey) study was conducted on a sample of 304 students from higher education institutions in the Unsko-Sanski Canton to explore the reasons for students' participation in fitness programs. Two dominant factors were identified: 1) health benefits of exercise and 2) the need for social interaction. Understanding the reasons for student participation in fitness programs enables the development of interventions and policies that promote healthy living among youth. Understanding the reasons for student participation in fitness programs can serve as a basis for developing interventions and policies that promote healthy living among the student population.

Keywords: *physical exercise, fitness programs, motivation*

Introduction
Regular physical activity, especially active exercise, represents significant factors in preserving and improving the psychophysical health of youth (Malčić & Marić-Jurišin, 2018.). In the study by Malčić & Marić-Jurišin (2018.), they suggest the existence of significant differences based on gender regarding the level of intense physical activities. Specifically, male students are more engaged in intense physical activity compared to female students. Additionally, there are differences in physical activities based on the type of faculty. Besides the various positive effects it has on the overall well-being of young individuals (improved physical and mental health, stress reduction, increased self-confidence, etc.), it is not uncommon for this part of the population to face challenges in maintaining motivation for regular physical exercise (Jenko-Miholić, S., Lorger, M., & Vuljanić, 2015.). Recognizing and understanding the factors (internal and external) that can influence the motivation of young people for regular physical exercise is of great importance for the development of quality programs, as well as potentially necessary interventions, that support a healthy lifestyle among youth (Bogdan & Babačić, 2015.). This, of course, is also consistent within the student population. In the research conducted by Gut, Schmid, Schmid, and Conzelmann (2019.), motives and goals were identified, and potential attitudes were developed. For adolescence and young adulthood, there are 26 items covering eight motives and goals: Contact, Competition/Performance, Distraction/Catharsis, Body/Appearance, Fitness, Health, Aesthetics, and Risk/Challenge, while the targeted factor of Activation/Pleasure did not appear.

Students represent a specific post-adolescent group that is under significant influence from various social factors (Diehl & Hilger, 2015.). This is a life stage where significant physical, social, psychological, and structural changes come into play, which can impact the dynamics of the motivational space directed towards regular physical activity (Sawyer et al., 2012.). In the broadest sense, the daily life of students is characterized by sedentary behavior, highlighting the importance of physical activity in this age group is particularly indicative. Future patterns of psychophysical health and healthy lifestyles tend to stabilize during this life stage. For example, obesity as a consequence of lack of physical activity in this age group can have negative health consequences in later life periods (Diehl, Fuchs, Rathmann & Hilger-Kolb, 2018.). In various studies attempting to identify reasons for participation in physical activities among students, as well as potential barriers to such engagement, the motivational space is most commonly treated in the light of intrinsic motivation (Wang & Biddle, 2003.). While the most prominent motivational dispositions focus on health, enjoyment, and socializing (Egli et al., 2011.). Reasons, as well as internal incentives of young people for participation in various fitness programs, are often conditioned by the very nature of the program content, as well as the structure of factors that predispose them to activities. The diversity of motivational aspects depends on several factors that must be taken into account when considering this issue (age-related, demographic, socioeconomic, gender, educational, and other characteristics) (Nešić & Rajić, 2015.). Additionally, the trend of continuous decline in physical activity has been noticeable lately, and life during the pandemic has further intensified this problem (Šabić, 2018.). Dominant are individuals who do not engage in sports and recreation in their free time, which corresponds to certain statistical indicators at the level of Bosnia and Herzegovina regarding the physical inactivity of the majority of the adult population, and it has been found that respondents do not recognize the significance of aerobic sports and recreational activities as one of the most effective activities for improving health and preserving quality of life (Šabić, Selimović, Skender, & Nešić, 2020.). It is important to note that multiple factors influence the successful manifestation of functional abilities, with the morphological characteristics of students being one of them. It is important that conditions for the appearance of students in physical activities are met (Skender, 2004; Skender, Šabić, Selimović, Kurtović, & Karalić, 2022.). According to the World Health Organization (WHO, 2016.), 27.5% of people over the age of 18 showed a prevalence of insufficient physical activity, with 23.4% being men and 31.7% women. Matković et al. (2010.) conducted a study on the level of physical activity among students of the School of Medicine at the University of Zagreb and found that approximately half of the students do not engage in sports or recreational activities.

Fitness clubs are now one of the very popular places for young people where there are resource conditions for regular physical exercise (Saayman & Van der Merwe, 2018.). They offer a wide range of modern programs and content, with appropriate infrastructure, that can meet the various needs and preferences of students for physical exercise (Gonçalves, Meireles & Carvalho, 2016.). Fitness clubs and similar organizations have witnessed a trend of increasing prevalence over the past two decades. It can be noted that this type of organization, based on individual initiative, or rather, represents a kind of private entrepreneurship in the field of recreational sports, is becoming an increasingly relevant area in the space of sports and recreational services. Therefore, the need to identify current trends in physical exercise/recreation among students represents a very important professional and scientific question, especially in periods when the dynamics of normal functioning of the social environment are disrupted (Šabić, Skender, Kurtović, & Nešić, 2021.). The diversity of the offer primarily relies on the marketing context and consistency towards a healthy lifestyle. Correlatively, a program structure of services provided to their clients has been created. According to available knowledge from current practice in organizations of this type, some of the offered programs of recreational content mainly involve the younger population. Fitness clubs mostly operate on the basis of spatial-content offer principle, and participation in selected programs is individual, with payment of participation fees for using any of the offered programs (Nešić, 2010.). The aim of the research was to detect the reasons why students participate in fitness programs available in their immediate living environment.

Methods

The research, conducted as a brief cross-sectional empirical study, aimed to detect the reasons that determine students' participation in fitness programs available in their immediate living environment. The research sample consisted of students from the Unsko-Sanski Canton (N = 304; M = 162/53.3% and F = 142/46.7%) who occasionally or regularly exercise in fitness organizations (clubs and centers) in their place of residence. The average age of the respondents was 23 years (min. = 18; max. = 30).

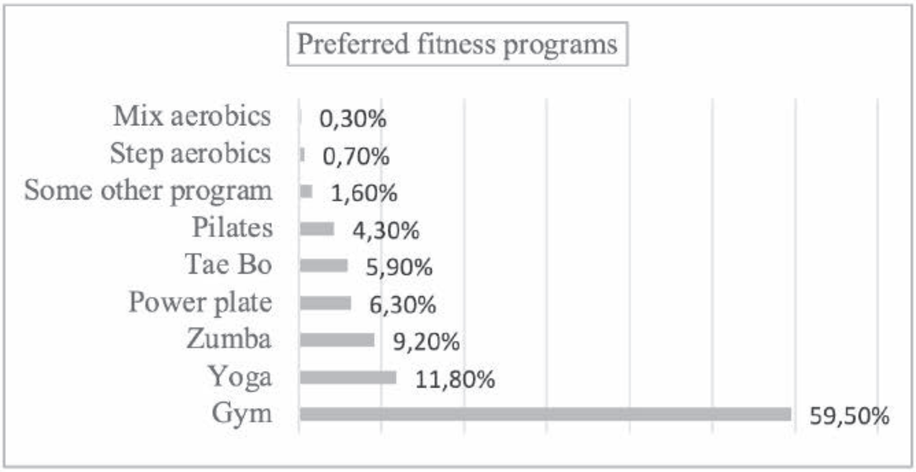
The research instrument was designed in the form of a questionnaire, which, with its item structure, covered individual indicators significant for identifying the subject of the study. Reasons for participation in fitness programs were detected through a five-point self-assessment scale (reasons for participation in fitness programs). The intensity range ranged from 1 to 5, where the score "one" indicated the lowest intensity of the item indicator assessment (least significance for participation), and the score "five" indicated the highest level (most intensive reason). The applied scale reflects a construct similar to instruments used in previous studies to assess the perception of motivation for participation in physical exercise/recreation (Nešić, Frtarić & Ilić, 2010; Nešić, Srdić & Fratrić, 2013; Nešić & Rajić, 2015). Furthermore, the scale has been validated in terms of its internal consistency within a specific sample, demonstrating an adequately acceptable value (Cronbach's Alpha = 0.704), consistent with the recommended theoretical value of 0.7 (DeVellis, 2003.). Other indicators significant for the research scope were created in the form of nominal scale statements. Statistical analysis of empirical data was performed using appropriate descriptive (frequency distribution, standard deviation, and chi-square test) and comparative (one-way analysis of variance - ANOVA) statistical procedures. Factor analysis was applied to determine the latent structure of the research space. All statistical inferences were conducted at a significance level of 0.05 (Sig. < 0.05).

Results

An exploratory survey was conducted on a sample of 304 students from the Unsko-sanski Canton (M = 162/53.3% and F = 142/46.7%), who occasionally or regularly participate in various fitness programs available in their place of residence. The survey aimed to identify the reasons for their participation in these programs. Analysis of empirical data indicates a trend where the predominant form of physical exercise within the work of fitness clubs and centers is preferred by most respondents to be gym activities (59.9%). As expected, the male student population is significantly more inclined towards gym workouts (47.7%) compared to females (12.2%). On the other hand, the popularity of yoga programs is more pronounced among the female population, as evidenced in this study (11.5%). All other indicated fitness programs are significantly less represented among the respondents as a whole. The detected differences also showed statistical significance (Sig. = 0.000) (Table 1). If conditionally establishing a hierarchy of fitness program popularity within the research entity, then the distribution would be as follows: 1) Gym workouts (59.9%), 2) Yoga (11.8%), 3) Zumba (9.2%), 4) Power plate (6.3%), 5) Tae Bo (5.9%), 6) Pilates (4.3%), 7) Step aerobics (0.7%), and 8) Mix aerobic (0.3%) (Graph 1).

Table 1. Fitness Activities Most Commonly Practiced

Fitness program	**Gender**		**Σ**
	Men	Women	
Gym	145 47,7%	37 12,2%	182 59,9%
Yoga	1 0,3%	35 11,5%	36 11,8%
Zumba	0 0,0%	28 9,2%	28 9,2%
Power plate	3 1,0%	16 5,3%	19 6,3%
Tae bo	9 3,0%	9 3,0%	18 5,9%
Pilates	0 0,0%	13 4,3%	13 4,3%
Some other program	3 1,0%	2 0,7%	5 1,6%
Step aerobic	1 0,3%	1 0,3%	2 0,7%
Mix aerobic	0 0,0%	1 0,3%	1 0,3%
Σ	162 53,3%	142 46,7%	304 100,0%



Graph 1. Fitness Program Preferences - Total Sample

In the context of these identified preferences for fitness programs, efforts were made to determine how respondents perceive the reasons for practicing these selected activities. From the provided eight reasons, which were used in several previous studies on exercise motivation among the student population (Nešić, Fratrić & Ilić, 2010.; Nešić, Srdić & Fratrić, 2013.; Pejić, Krpan & Nešić, 2012.), by calculating scalar averages for each of them, the distribution of their importance to the respondents was obtained. It is observed that the highest level of significance (scalar values greater than 4) is attributed to: health improvement and maintenance (4.42), physical appearance (4.20), fun and enjoyment (4.13). A slightly lower intensity (scalar values between 3 and 4) was recorded for: weight control (3.84) and relaxation (3.84), as well as socializing/belonging to a group (3.79) and self-competition (3.36). At the bottom of the perception of reasons is exercising as a lifestyle (2.85). Statistically significant differences were observed in the context of perceived importance of certain indicators when considering gender differentiation (items 2, 3, 4, and 8), where reasons indicating relaxation and lifestyle were more significant for men, while weight control and physical appearance were more dominant perceptions for women (Table 2).

Table 2. Reasons for Engaging in Fitness Programs

No	Reason	Sv	St. Dev.	M	W	*F*	*Sig.*
1	Improvement and maintenance of health	4,42	0,915	4,43	4,40	0,085	0,771
2	Relaxation	3,84	1,063	3,98	3,68	6,061	**0,014**
3	Weight control	3,84	1,119	3,72	3,98	4,222	**0,041**
4	Physical appearance	4,20	1,041	4,04	4,37	7,780	**0,006**
5	Enjoyment and fun	4,13	1,071	4,07	4,20	1,118	0,291
6	Socializing and group belonging	3,79	1,155	3,85	3,73	0,728	0,394
7	Self-competition	3,36	1,357	3,35	3,37	0,008	0,927
8	Fits own lifestyle	2,85	1,320	3,06	2,60	9,583	**0,002**

Sv = scalar values, St. Dev. = Stdard Deviation, M = men, W= women, F = F-value, Sig. = Significance

The scale assessing the reasons for participating in fitness programs was further subjected to a suitability check for factor analysis. The assessment of data suitability based on the correlation matrix showed coefficients with values of 0.3 and above. . According to the Kaiser-Meyer-Olkin criterion (Kaiser-Meyer-Olkin Measure of Sampling Adequacy), the recommended value of 0.6 (Kaiser, 1970., 1974.) was significantly exceeded in this case, well above the statistically recommended level (KMO = 0.750). Additionally, Bartlett's test of sphericity (Bartlett, 1954.) reached statistical significance (Sig. = 0.000), indicating the factorability of the correlation matrix. This allowed the empirical data to undergo principal component analysis (PCA). After Oblimin rotation, the presence of two components with eigenvalues exceeding one was discovered, explaining 30.54% and 17.14% of the variance. Based on the intercorrelations of observed variables, an initial correlation matrix was formed, defining the hierarchical structure of eight initial vectors in the observed space. Eigenvalues greater than one were observed for the first two vectors that entered further analysis and from which factors of latent structure were formed (explaining 47.68% of the shared variance) (Table 3).

Table 3. Factor Structure of Reasons for Participating in Fitness Programs

No	Reason	Communalities:	Faktor 1	% of varian.	Faktor 2	% of varian.	% cumulative
1	Enhancement and preservation of health	0,366	0,694				
2	Relaxation	0,355	0,653				
3	Weight control	0,412	0,618	30,543			
4	Physical appearance	0,413	0,615				47,687
5	Enjoyment and pleasure	0,506	0,431				
6	Socializing and belonging to a group	0,566			-0,843		
7	Competition with oneself	0,701			-0,717	17,144	
8	Fitting into personal lifestyle	0,496			-0,620		

Projections onto the first principal component, defined as Factor 1 and explaining the largest part of the total variability, are predominantly driven by indicators such as health enhancement and preservation, relaxation, weight control, physical appearance, and enjoyment/socializing. Consistent with the logical content and semantics of these five indicators, the first hierarchical factor in the analyzed latent space can be defined as the health benefits of exercise. This suggests that these five reasons fundamentally drive students to engage in fitness programs. The second factor saturates three indicators formulated in the questionnaire as socializing and belonging to a group, competition with oneself, and fitting into personal lifestyle. Based on the social message they contain, this factor can be defined as the need for social interaction. In this case as well, there is consistency with the observed general trends among the student population, where the need for social interaction predominates. Fitness clubs/centers represent one of the potent environments where social connectedness can be effectively realized among those young individuals oriented towards physical exercise.

Discussion

The results of the study could be viewed from a broader perspective of the societal existence of physical exercise among young people, especially in terms of contemporary trends among the current student population, where individual needs to follow trends propagated on social media are recognized. In contemporary spaces of virtual (IT) communication among young people, which emphasize physical attractiveness and morphological attributes of a beautiful body, the fitness industry places participation in exercise programs at the forefront, along with the inevitable rhetorical cliche of health care. Fitness as a fashion trend has deeply penetrated into the sphere of lifestyle among a large part of the younger population (hence also among students), so it is advisable to intensively discuss (and study) all its aspects (both positive and negative). Research and discussions regarding the reasons that inspire students to actively engage in exercise programs offered by fitness organizations undoubtedly shed light on consistent theoretical frameworks related to motivation. Some of the highly receptive theoretical perspectives that can be connected with the subject of this research provide a basis for understanding the motivation of students to exercise in fitness clubs. Primarily, they highlight key factors that can influence their individual decision to engage in physical exercise and their perseverance in its implementation. This primarily relates to the context of self-determination theory (Deci & Ryan, 2000.), which directs the focus of activities in fitness clubs and suggests that students will be motivated to exercise if they feel they have control over their activity (autonomy), feel competent in performing exercises (competence), and perceive connection with other exercisers or instructors (relatedness). Persistence in exercising is associated with motives focused on enjoyment, competence, and social acceptance, but not on external appearance (Ryan et al., 1997.). The latent structure of motivation for student participation in sports consists of six factors - engaging in sports with friends, popularity, fitness and health, social status, sports events, and relaxation through sports (Kondrič et al., 2013.). Encouraging interest in physical exercise through kinesiological activities should meet at least some of the specific subject's motives that would be sufficient to invest the effort required to overcome them, resulting in satisfaction and pleasure associated with a particular activity (Lorger, 2002.), as well as the level of aspiration for mastering it (Biddle et al., 1996.). Additionally, goal-setting theory (Latham & Locke, 2007.) suggests that students will be more motivated to exercise if they set specific and challenging goals, but which can be achievable and related to specific activities in the fitness club (such as improving physical fitness, reducing body weight, achieving a certain level of strength or endurance, etc.). Equally relevant is the theory of social connectedness (Henry, 2012.), which can consistently be directed towards the interpretation that fitness clubs provide opportunities for social interaction and connection with other students, as well as instructors or community members (group training or exercising with friends can enhance the sense of belonging and support, contributing to motivation for regular physical activity). Additionally, the expectancy-value theory (Fishbein & Ajzen, 2010.) can be added, which states that motivation for exercise depends on students' individual expectations of the success of achieving desired outcomes (e.g., improving physical fitness, appearance, etc.). Students will be more motivated to exercise in fitness clubs if they believe they will achieve improvements in some important aspects (physical appearance, health, or self-confidence), or if they consider those results worth the effort they invest.

Conclusion

In this sense, it is evident that the reasons guiding students towards exercising in fitness clubs can be very diverse and dependent on individual goals and preferences. This often relates to factors related to:

1. Health benefits: Exercising for health benefits, such as improving psycho-physical health, maintaining adequate body weight, reducing stress, improving mental health, etc.
2. Aesthetic goals: Improving one's appearance, increasing muscle mass, weight reduction, body shaping according to bodybuilding models, etc.
3. Social context: Fitness clubs as places for socializing and socialization, which can increase motivation for exercise.
4. Achievement: Setting specific goals, such as increasing the number of repetitions of a particular exercise or long-term goals such as achieving the desired physical form.
5. Rewards and recognition: Rewards or recognition for achievements in exercising can further motivate students, such as reward systems within fitness clubs or external recognition through certificates of achievement, etc.

Understanding these factors and adapting exercise programs and offerings of fitness clubs can help maintain a high level of motivation among students. The context of our research can thus be consistently compared with similar studies analyzing various aspects of motivation and factors influencing exercise within the student population. Especially in the context of the relationship between motivation, physical activity, and self-esteem of students who visit fitness centers (Wicker & Frick, 2015.), exercising in relation to life satisfaction (Maher et al., 2014.), different forms of physical activity through the context of motivation for exercise and the quality of life of students (Bassett-Gunter et al., 2017.), etc. These studies provide valuable information for the development of lifestyle support programs among the student population. Our study identified two main latent factors that encompass reasons for participating in fitness club exercise programs among students in our research entity. Firstly, health benefits were recognized as a significant motivational factor for students. The majority of respondents highlighted maintaining health and physical fitness as key reasons for regular exercise in fitness clubs. This indicates the need for education and promotion of the health benefits of exercise among the student population to raise awareness of the importance of regular physical activity. Secondly, social interaction also has a significant impact on students' motivation for physical activity. Most respondents emphasized social interaction and support as important factors motivating their involvement in activities in fitness clubs. This suggests that activities promoting group dynamics or teamwork can be effective in encouraging greater engagement of students in physical activities and exercise. In conclusion, understanding these motivational factors can help in developing programs to support a healthy lifestyle among students and improve their physical well-being. It also emphasizes the importance of adapting the offerings of fitness clubs to meet the needs and preferences of students and ensure their long-term engagement in physical activities.

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CURRENT TRENDS AND INNOVATIONS IN KINESIOLOGY RESEARCH: PROCEEDINGS

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CORRELATIONS BETWEEN KINEMATIC VARIABLES AND RESULTS IN ELITE MALE 100-METRE SPRINTERS

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Abstract
The aim of this study was to determine the correlations between kinematic indicators of sprint running with the results of the 100m sprint. This research was conducted on a sample of eight (8) athletes and by analysing their results in the 100m final race at the 2017 World Championships in London.

The results of the research showed that the crucial role in winning the gold medal was played by the maximum speed and the ability to maintain it until the end of the race. Maximum speed is determined by two parameters - step length and step frequency. The mentioned parameters of step length and step frequency were statistically negatively correlated with a high coefficient of correlation of -0.99.

The race interval between 50 and 70 metres is the interval in which the athletes achieved their highest velocities, and after which there was a decrease in the speed in the final part of the race.

Keywords: *sprint, step frequency, step length, flight time, ground contact time*

Introduction
Sprint speed is determined by step frequency and step length (Mann and Herman, 1985). Maximum speed can be improved by increasing step frequency or step length. As these two variables are interdependent, it is quite difficult to expect improvement, i.e. development of both variables simultaneously. An increase in step frequency shall thus result in a decrease of step length and vice-versa. There are several different factors which are responsible for a perfect sprinting performance, namely, maximum power, explosive strength, neuromuscular coordination and optimal technique level (Maćkała et al., 2015).

A proper sprinting technique requires a combination of high-level biomechanical variables of sprinting and their understanding, as well as favourable external and environmental factors (Monte et al., 2017).

A sprint race can be divided into several phases: the initial acceleration phase – referring to the start from the block and acceleration until reaching maximum speed; the maximum speed phase – referring to the segment of the race during which the sprinter maintains the achieved maximum speed; and the deceleration phase – referring to the part of the race in which muscle fatigue prevents the sprinter from running at maximum speed and when speed endurance thus becomes responsible for a successful completion of the race (Maćkała et al., 2015).

Previous research have demonstrated that sprinting performance is affected by multiple factors, such as starting technique, step length, step frequency, psychological factors, muscle structure, running biomechanics, anthropometry, as well as external and environmental factors. The start of the race and the acceleration at the beginning of the race are largely determined by muscle strength, i.e. by the ability to produce great force in a short amount of time. On the other hand, running at maximum speed is a result of step length and step frequency (Slawinski et al., 2017).

While step length is mostly defined by a sprinter's morphological characteristics, step frequency is largely determined by muscle structure, the level of neuromuscular coordination and specific sprint training. Due to the short duration of a sprint race, as well as numerous factors which can affect the final result, each new finding from researching elite-level sprinters can be valuable to researchers and coaches in producing model sprint trainings and to its individualization.
The aim of this study was to determine the correlations between kinematic indicators of sprint running with the final results of the 100m sprint race among elite male sprinters.

Methods
The subject sample consisted of eight (8) athletes, finalists in the 100m race at the 2017 World Athletics Championships in London, with the average age of 26.79±4.81 years, average body height of 183.25±8.45 cm, and average body mass of 78.25±9.10 kg.

The sample of variables included as follows: results in the 100m race (R), reaction time (RT), step frequency (SF), step length (SL), relative step length (RSL), flight time (FT), contact time (CT), step time (ST) and split time (ST) for each 10m race interval. The results and kinematic parameters were downloaded from the official Biomechanical report for the IAAF 100m men's race at the London 2017 World Championships (Bissas et al., 2018). For conducting the biomechanical analysis, a total of 23 high-speed cameras were used to record the final 100m men's race. The video files were then imported into the SIMI Motion (SIMI Motion, version 9.2.2, Simi Reality Motion Systems GmbH, Germany) and manually digitised by a single experienced operator in order to obtain the kinematic data. The Direct Linear Transformation (DLT) algorithm was used for reconstructing the three-dimensional (3D) coordinates from each individual camera's x and y image coordinates.

The descriptive parameters, Kolmogorov - Smirnov test for normality of distribution and Spearman correlation coefficient were calculated by using the Statistica programme package, version 13.5.0.17 (TIBCO Software Inc, Palo Alto, CA, USA). The level of statistical significance was set at $p<0.05$.

Results

The average result in the final 100m men's race was 10,04±0,12 s, while the winner ran 9,92 s. The fastest reaction time was 0.12 s, whereas the average reaction time was 0.16±0.03 s, which points to a high level of technical preparation of all the competitors. The average step frequency was 4.80±0.22 Hz, with the maximum frequency of 5.00 Hz, which also reaffirms that this was a top-level sample of respondents. The relative step length as a proportion of the athlete's height (body height = 1.00) was 1.21±0.03 m. Both left and right foot ground contact time in the segment of running at maximum speed was 0.09±0.01 s.

Table 1 shows key kinematic characteristics during the high velocity running phase (47.00 - 55.50 m). It should be noted that some athletes are likely to still be accelerating at this stage.

Table 1. Descriptive statistics

	M	Min	Max	St. Dev.
Result (s)	10.04	9.92	10.27	0.12
Reaction time (s)	0.16	0.12	0.22	0.03
Step frequency (Hz)	4.80	4.39	5.00	0.22
Step length (m)	2.20	2.08	2.44	0.12
Relative step length (m)	1.21	1.16	1.25	0.03
Flight time (s) L	0.11	0.10	0.14	0.01
Flight time (s) R	0.12	0.11	0.13	0.01
Contact time (s) L	0.09	0.08	0.10	0.01
Contact time (s) R	0.09	0.09	0.10	0.01
Step time (s) L	0.21	0.20	0.24	0.01
Step time (s) R	0.21	0.20	0.22	0.01

Legend: M – Mean, Min – Minimum value, Max – Maximum value, St. Dev. – Standard deviation, L – Left, R – Right

The duration of contact with the ground, as well as the duration of the flight phase, did not show any large differences among the athletes. The results of only one sprinter differ from the rest, as it can be noticed he demonstrated a somewhat longer duration of contact with the ground and a longer duration of the flight phase, however, with the longest step of 2.44 m. This was precisely the sprinter who achieved his maximum speed more on the basis of his step length, and less on the basis of his step frequency (Čoh et al., 2018).

Figure 1 demonstrates the average time results for each 10m interval, and it can be noticed that the sprinters took the least time to pass the T50-60 and T60-70 intervals. The average running speed achieved in the T50-60 interval was at 11.58 ms-1, while the fastest individual result was at 11.90 ms-1. This is in line with the results from other research of elite male sprinters, according to which the maximum sprinting speed is achieved and maintained in the T50-80 race interval (Graubner & Nixdorf, 2011; Kersting, 1999; Čoh et al., 2018; Healy et al., 2022).

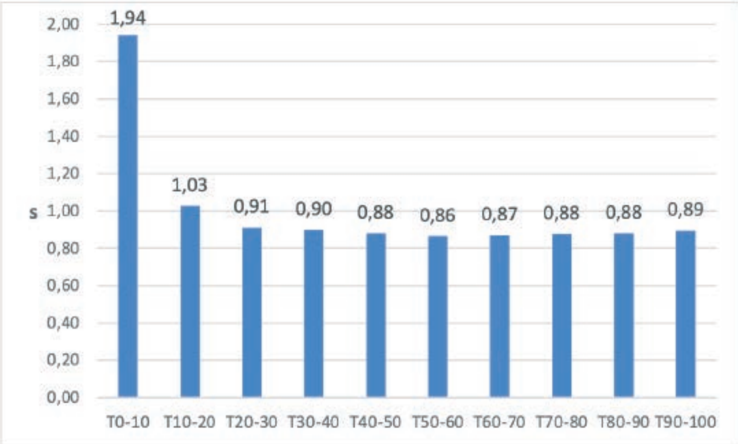

Figure 1. Average split time at each 10m interval

The correlations between the results of the 100m sprint and the observed kinematic variables were not statistically significant. Statistically significant positive and negative correlations were found in relations among variables 'step frequency' and 'step length' to other kinematic variables. Likewise, the highest number of statistically significant correlations were determined for the variables of step time left and step time right.

Table 2. Correlations between results and kinematic variables

Variable	R	RT	SF	SL	RSL	FTL	FTR	CTL	CTR	STL	STR
R	1.00										
RT	0.65	1.00									
SF	0.30	-0.05	1.00								
SL	-0.37	0.04	-0.99*	1.00							
RSL	-0.16	0.10	-0.73*	0.75*	1.00						
FTL	-0.25	0.12	-0.71*	0.74*	0.64	1.00					
FTR	0.10	0.18	-0.82*	0.77*	0.70	0.41	1.00				
CTL	-0.26	0.13	-0.75*	0.75*	0.24	0.33	0.45	1.00			
CTR	-0.57	-0.47	-0.40	0.41	0.32	-0.20	0.38	0.41	1.00		
STL	-0.31	0.15	-0.88*	0.90*	0.59	0.89*	0.52	0.72*	0.05	1.00	
STR	-0.17	-0.07	-0.79*	0.76*	0.67	0.23	0.92*	0.51	0.71*	0.41	1.00

Legend: R – Result, RT – Reaction time, SF – Step frequency, SL – Step length, RSL – Relative step length, FTL – Flight time left, FTR – Flight time right, CRL – Contact time left, CTR – Contact time right, STL – Step time left, STR – Step time right; *Marked correlations are significant at p<0.05

Statistically significant correlations were also determined between the kinematic variables and the average split times at each 10m interval. The results of the 100m sprint showed a statistically significant correlation with the T0-10 and T80-90 intervals. The variables of step frequency and step length showed a statistically significant correlation with the T60-70 and T70-80 intervals.

Table 3. Correlations between results, kinematic variables and split time at each 10m interval

Variable	T0-10	T10-20	T20-30	T30-40	T40-50	T50-60	T60-70	T70-80	T80-90	T90-100
R	0.87*	0.63	0.60	0.55	0.50	0.56	0.51	0.52	0.73*	0.35
RT	0.68	0.21	0.25	0.09	0.42	0.46	0.28	0.21	0.34	0.38
SF	-0.15	-0.12	0.28	0.28	-0.26	0.34	0.76*	0.76*	0.70	0.56
SL	0.09	0.02	-0.34	-0.35	0.22	-0.35	-0.75*	-0.76*	-0.74*	-0.52
RSL	0.14	-0.08	-0.00	-0.15	0.51	-0.11	-0.48	-0.64	-0.67	-0.30
FTL	0.19	-0.08	-0.18	-0.24	-0.00	-0.59	-0.67	-0.80*	-0.63	-0.02
FTR	0.45	0.52	0.26	0.25	0.61	-0.11	-0.63	-0.60	-0.46	-0.65
CTL	0.05	-0.02	-0.65	-0.59	0.00	-0.04	-0.36	-0.26	-0.30	-0.38
CTR	-0.53	-0.17	-0.31	-0.27	0.16	0.06	-0.31	-0.22	-0.51	-0.75*
STL	0.16	-0.07	-0.44	-0.46	-0.00	-0.45	-0.67	-0.71*	-0.61	-0.20
STR	0.11	0.33	0.07	0.08	0.53	-0.06	-0.61	-0.55	-0.56	-0.81*

Legend: T0-10 to T90-100 – Split time each 10m interval, R – Result, RT – Reaction time, SF – Step frequency, SL – Step length, RSL – Relative step length, FTL – Flight time left, FTR – Flight time right, CRL – Contact time left, CTR – Contact time right, STL – Step time left, STR – Step time right; *Marked correlations are significant at $p<0.05$

Discussion

Step frequency and step length showed a strong negative correlation (r=-0.99), which is also confirmed by findings of similar research (Bruggeman & Glad, 1990; Graubner & Nixdorf, 2011; Miyashiro et al., 2019). The step frequency variable is likewise in negative correlation with other variables that characterize step length, as well as with the overall duration of the running step phase, which includes the ground contact time and the flight time phase. On the other hand, upon running with a higher step frequency, the duration of ground contact time thus reduces. The maximum running speed, which is attained in the T60-70 race interval, showed a significant correlation with the final result in the race (Kersting, 1999).

According to the results presented in Table 3, a statistically significant correlation was determined between the result and the split times at the T0-10 and T80-90 intervals. In accordance with the aforementioned, the sprinters who ran faster than others during the intervals at the beginning and at the end of the race were more successful. Statistically significant correlations were found between the variables of step frequency and the T60-70 and T70-80 intervals in such a way that a higher step frequency was noticed among the sprinters who ran slower during the mentioned intervals. The sprinters with a longer step length achieved a higher running speed in the T60-70, T70-80 and T80-90 intervals.

Maximum speed is an important parameter which affects the final result, however, as the 100m race lasts approximately 10 seconds, it is understandable that maintaining the achieved maximum speed between the 50th to 70th metre is a much greater challenge than it was achieving it (Healy et al., 2022). The start of the race and the starting acceleration at the beginning are parts of the race that are dominated by athletes of lower body height, due to their lower centre of gravity, as well as their ability to achieve a higher step frequency. However, on the other hand, maintaining the maximum speed in the final stretch of the race is realized on account of step length and developing a great ground reaction force, which is a characteristic of the taller athletes with a higher centre of gravity. The athlete who shall be capable of achieving a higher average step length will have a chance to accomplish a top-level result or set a new world record. Elite male sprinters reach almost an identical maximum running speed in the T50-80 interval of the race, however, only the ones who manage not to lose too much speed in the T80-100 interval have a greater potential for winning. It is a known fact that stiffness in the lower extremities increases simultaneously with the fatigue at the end of a sprint race (Morin et al., 2006), as well as that stiffness of the Achilles tendon is greater in men than in women (Kubo et al., 2003; Fletcher et al., 2013). It was precisely the winner of the analysed 100m race who succeeded in running the final two intervals only 0.01 of a second slower than in the previous fastest interval, which can be explained for by a high level of speed endurance.

Over the last 20 years, the sprinters who have set records in the 100m discipline have been taller in comparison with their predecessors from the last century (Brechue, 2011). Thus, in addition to the selection of taller athletes, planning and programming the training process for male 100m sprinters, more attention could be directed towards improving maximum speed on account of step length, as step length and generating greater ground reaction force in the final part of the race make the crucial difference in the final outcome of the race.

Sprinters with a higher maximum speed shall generally produce greater speed during the acceleration phase of the race, as well as require more time to attain their maximum sprinting speed. Subsequently, a longer acceleration phase and a longer phase of running in maximum speed shall result in turn with a shorter deceleration phase, so that in that case the reduction of speed in the final part of the race due to fatigue is therefore limited (Volkov & Lapin, 1979; Slawinski et al., 2017). All combined, the aforementioned factors result with a faster result in the 100m sprint.

Conclusion

The sample of respondents in this study was represented by elite athletes whose sprinting technique is at a high level, as a result of which there is even less variability in kinematic indicators. Nevertheless, upon conducting an analysis, it is possible to logically explain the factors which most influenced the outcome of the race and the final ranking order of the athletes. According to the findings of this study, the ability of the sprinter to maintain the horizontal ground reaction force and the running speed during the intervals of maximum speed, as well as in the final part of the race, is more important than the ability to generate a great force in the first metres of the race.

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DIFFERENCES IN SITUATIONAL EVALUATION OF GOALKEEPER'S EFFICIENCY IN HANDBALL REGARD TO GENDER AND SHOOTING POSITIONS

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Abstract
The aim of the study was to determine situational efficiency of goalkeepers through the suitable created survey according to the criterion of the difficulty of the shots from different playing positions and from different situations in the game. The sample of entities consisted of 30 goalkeepers, aged 18-45, of which 15 are male and 15 are female. The sample of variables consisted of the 7 different shots from different position and distances in handball game. The differences between male and female goalkeepers evaluating were determined using the Mann-Whitney U-test, and between different player position using Kruskal Wallis test. The results showed statistically significant differences between 9m shots and all other shots, Significant difference can be noted between 9m and all other playing positions, and also between close shots (6m, 7m, wing shot) and situational shots (fast break, breakthrough, fast trow-off). Differences in defense assessment by goalkeeper gender was in the one variable: shots from 9m line (5.4 vs. 4.2; on a scale 1-10).

Keywords: *handball, goalkeeper, saves, evaluation, efficiency*

Introduction

The goalkeeper is the player who significantly determines the situational effectiveness and the success of their team in handball (Rogulj, 2000). Hergeirsson (2008) noted that in recent major tournaments like the European Championships and the Olympic Games, the average number of attacks per game remains consistent. However, there is a noticeable trend of decreasing efficiency among most teams, as evidenced by the reduction in goals scored per game. This decline in efficiency, particularly in goal scoring, is often attributed to organized defense and the performance of goalkeepers, who hold a unique and vital position on the team (Dumitru, 2010).

The goalkeeper serves as both the last line of defense and the first offensive player, making them one of the most influential factors in the game and playing a critical role in defensive efficiency and counterattacks (Czerwinski, 1997). Their technique, tactics, and isolation from other players make them a unique part of the team. With their good saves, they can contribute significantly to their team's success and achieving victory. Additionally, goalkeepers' performance is influenced by their perceptual skills and the quality of team defense (Justin et al., 2013). Goalkeeper efficiency emerges as a key variable in explaining team performance: teams with higher goalkeeper efficiency tend to achieve better rankings, with top teams generally exhibiting superior goalkeeper efficiency compared to others (Fuertes et al., 2010). A longitudinal study spanning eight Olympic Games (1982-2012) found no significant change in goalkeepers' effectiveness or standards over thirty years, despite variations in individual actions (Espina-Agulló, 2016).

Unlike field players, where the responsibility in attack is shared among all six players, in defense, the responsibility when the ball is heading towards the goal lies solely with the goalkeeper. Each goalkeeper (and their coach) must know themselves well, their work habits, and the players on the opposing team in order to tactically adjust their training sessions. Goalkeepers must exhibit exceptional reflexes and agility to respond to shots that come from various angles and speeds. Different types of goalkeepers suit different opposing teams. The most characteristic types of goalkeepers are: 1. Stationary goalkeeper, 2. Dynamic goalkeeper, 3. Speedy goalkeeper (Struzik, 2020). Therefore, each team has two or three different goalkeepers in their lineup that the coach uses depending on the opposing team and the result of the match. In addition to their adopted technique and tactics, goalkeepers can also differ in their anthropometrical and conditioning characteristics (Ghobadi et al., 2013).

In the past, goalkeepers were often slow and larger, while today there are more explosive. Success in this position requires a unique combination of technical skill, agility, mental resilience, and the ability to adapt to dynamic game situations. There are goalkeepers who are better suited to certain shots, for example, shots from the outside positions, while others are better at defending shots from the wing positions. Considering that handball has accelerated and changed with several new rules, goalkeepers have also changed, as have their training methods. Nowadays, it is almost impossible for a team not to have a goalkeeper coach, especially if it is a team playing at a professional level. Unlike other player positions, experience is also very important for goalkeepers in handball. According to the expert estimation of handball goalkeeper’s quality, better goalkeepers was older and more experienced (Kajtna et al., 2012). Goalkeepers are often said to get better as they get older; experience brings them many advantages, and we often see some goalkeepers at the professional level still making saves in their forties.

Although partially separated from the team, referring to the goalkeeper's area, goalkeepers are still part of the team, and cooperation between the team and the goalkeeper is particularly important. One of the most common forms of cooperation is in defense, where the goalkeeper and defensive players coordinate covering the corner during a jump block. In addition, cooperation is necessary during fast breaks, and fast throw-offs.

The goalkeeper's performance in a match is usually evaluated by the total number of saves or the percentage of saved shots. Experts suggest that a proficient goalkeeper should achieve an efficiency rate exceeding 35% and can significantly impact the final score of a match by up to 50% (Arvidsson et al., 2003).

However, do all saves carry the same weight? Can we say that saving a shot from 9 meters is equivalent in difficulty to saving a shot from an individual fast break? The aim of the present study was to establish differneces in the saves made by goalkeepers from different player positions and situations. This will be done based on the goalkeepers' defence difficulty self-assessment. Even further, differences between genders will be analysed.

Methods
Participants
The sample consisted of 15 male goalkeepers and 15 female goalkeepers from all over Croatia aged 17 to 52 in the 21/22 season. The sample is dominated by goalkeepers from the Paket24 Premier League and female goalkeepers from the First Croatian Women's League. The mean age of female participants was 21± 4.12 years, while the mean age of male goalkeepers was 28.9± 10.07 years. The average height of female goalkeepers is 174.1± 6.1 cm, with an average weight of 69.3± 7.5 kg. Male goalkeepers have an average height of 189.1± 7.33 cm and an average weight of 91.9 ± 10.15 kg. Male goalkeepers have a higher average of goalkeeping experience, with an average of 16.8 years, while female goalkeepers have an average of 10.3 years.

Sample of variables
Variables in this research were obtained through a suitable created survey, where goalkeepers assessed the difficulty of defense from each playing position or situation using a rating from 1 to 10 on a Likert scale, where a rating of 1 indicates very easy save and a rating of 10 indicates very difficult save:
- Difficulty of saving shots from outside positions 9m (O9m) – save against shots from the side or center-back player outside the 9-meter line.
- Difficulty of saving shots from the 6-meter line (O6m) - save against shots taken from the goalkeeper's field line by a pivot player or any other player involved in the line play.
- Difficulty of saving shots from the wing position (OKR) – save against shots taken from the left- and right-wing positions.
- Difficulty of saving penalty shots from 7m (O7m) – save against penalty shots taken from the 7-meter line.
- Difficulty of saving shots from fast breaks (OKN) – save against shots taken from individual, group, or collective fast breaks.
- Difficulty of saving shots after a 1:1 situation (OPR) - save against shots taken after a 1:1 situation, i.e., after a breakthrough by the opposing player.
- Difficulty of saving shots after a fast throw-off (OBC) – save against shots taken after a fast throw off where the defense is often not fully prepared, and attackers have an easier opportunity to score.

Data analyses
The data obtained were analyzed by standard statistical methods package MedCalc® Statistical Software version 22.018. The first step in data processing was to determine the basic statistical parameters and distribution of variables. All data were presented using arithmetic mean (AM), standard deviation (SD), minimal (MIN) and maximal (MAX) results, kurtosis (KURT) and skewness (SKEW). Normality of distribution was tested with the use of the Kolmogorov-Smirnov test. Statistically significant differences between shots from different situation position was calculated used Kruskal Wallisov test, and differences between male and female goalkeepers save evaluation was calculated used Mann Whitney U test ($p<.00$).

Results
The descriptive statistical data of some anthropometric variables for goalkeepers and the results of the median and range are presented in Table 1.

Table 1. Age of participants and anthropometric characteristics of participants

Variable	Median (interquartile range)	Range (min-max)
Age (years)	23 (20 – 28)	15 – 52
Height (cm)	183 (173 – 189)	165 – 201
Weight (kg)	77 (69 – 90)	54 – 110
BMI (kg/m^2)	24,54 (22,27 – 25,42)	18,25 – 31,46

Results of the Kruskal-Wallis test for determination differences between playing positions in position and transition phases of the game are shown in table 2. It is observed that saving shots from 9 meters had the smallest value from goalkeepers survey compared to all others variables. Significant difference can be noted between 9m and all other playing positions, and also between close shots (6m, 7m, wing shot) and situational shots (fast break, breakthrough, fast trow-off)

Table 2. Assessment of defense difficulty by shooting position

Variable	Median (interquartile range)	Range	*P**
9 m shot	5 (4 - 5,6)	1 - 7	
6 m shot	6 (5 - 7)	4 - 9	
Wing shot	6 (5 - 7)	2 - 10	
7 m penalty	7 (6 - 7,3)	4 - 8	**<0,001**
Fast break	7 (7 - 8)	3 - 9	
Breakthrough	8 (6,8 - 8,1)	2 - 9,7	
Fast throw-off	8 (6,5 - 8,1)	1 - 10	

*Kruskal Wallisov test (post hoc Conover)
† $p < 0,05$ level of significance: save 9 m vs. (all others); (6 m save, wing save, 7m penalty save) vs. (fast break save, breakthrough save, fast throw offf save)

By Mann Whitney U test was analysed differences in defense assessment by goalkeeper gender. We established statistically significant difference (p=0,029) in variable 9m shot, while in other variables there are no significance in gender evaluation (Table 3).

Table 3. Differences in defense assessment by goalkeeper gender

	Median (interquartile range)		95% CI		*P**
	Male	Female			
9 m shot	5 (5 – 6)	4 (3 – 5)	-1	-2 do 0	**0,029**
6 m shot	6,4 (6 – 7)	6 (4,6 – 6,8)	-0,6	-1,5 do 0,5	0,229
Wing shot	6,2 (5 – 7)	6 (5 – 7)	0	-1,4 do 1	0,657
7 m penalty	7 (6 – 7,5)	7 (6 – 7)	0	-1 do 1	0,874
Fast break	7,5 (7 – 8)	7 (7 – 8)	0	-1 do 1	0,835
Breakthrough	8 (6 – 8)	8 (7,5 – 8,8)	0,5	-0,5 do 1,5	0,491
Fast throw-off	7 (7 – 9)	8 (6,3 – 8)	0	-1 do 1	0,807

*Mann Whitney U test

Discussion

The aim of the present study was to establish differneces in the saves made by goalkeepers from different player positions and situations on the suitable crated survey of 30 male and female goalkeepers. There are different evaluation methods to analyse goalkeepers' save performance (Cvenić, 2019). Regarding the values of height and weight, the body mass index ranged from 18.25 kg/m2 to 31.46 kg/m2. Srhoj et al. (2002) found that some international-level handball goalkeepers had the average BH of 191.86 cm and the average BM of 91.79 kg In this study, the goalkeepers' players experience is 11 years (interquartile range from 9 to 16 years) ranging from a minimum of 5 to a maximum of 35 years (Table 1).

The 9m saves are usually the easiest for the goalkeepers because the shots are made from the longest distance, so the goalkeeper has more time to react, and the attackers have defence players in front of them who are trying to obstruct them more or less. The ball can be thrown from the position of the left, middle or right backcourt attackers. In this case synchronized action of goalkeeper and defence is very important because usually the goalkeeper covers one side and the players the other side of the goal (Cvenić, 2008). Comparing these results obtained in this study with the ones reported by Foretić et al. (2013) it can be concluded that the obtained results are not so similar. In our study 9m shots is most easy to save but if we look at the impact on the outcome of match itself then biggest importance for the match result are shot defences outside 9 metres and counter-attacks, while defending shots from the wing positions and from the 7-metre line have an average importance. Additionally, shots from 6 meters, wings, and penalty shots are significantly easier to save compared to fast break, breakthrough, and fast throw-off (Kruskal-Wallis test, $P < 0.001$). Attack finalization efficiency on unorganized, compared to the set opponents' defence, is significantly higher due to a lower defence influence and favourable physics conditions for attack finalization, particularly with relation to distance and a more convenient shooting angle (Rogulj et al., 2020). Hatzimanouil,et al. (2017) ascertained the highest goalkeeper effectiveness was found to be in the shots from the wing area and from the 9m shots. In contrast, the lowest effectiveness was found to be in fast break shots and in 7m shots.

Saving shots from 9 meters is significantly easier for female goalkeepers compared to male ones (Mann-Whitney U test, $P = 0.029$), while in other defense difficulty assessments, there is no significant difference based on the gender of the goalkeepers (Table 3). The reason may be that in men's handball, even from a distance of 9m, the speed of the shot can reach and more then 130 km/h, in avarage 102 km/h (Foretić et al., 2022) which becomes elusive even for the best goalkeepers. Shot speed in women's handball is still 20-30 km/h lower on average (Soto et al., 2020). In almost all variables, male goalkeepers placed more difficulty on saves than female goalkeepers, except for the fast throw-off.

Conclusion

The study examine various factors influencing the difficulty of saving different types of shots in handball, particularly focusing on the goalkeeper position. The demographic composition of the participant group, comprising 30 individuals, 15 male and 15 female goalkeepers, with a median age of 23 years. The participants exhibited a wide range of experience levels, spanning from 5 to 35 years, emphasizing a diverse skill set within the cohort. Self evaluating were made on a Likert scale 1-10 indicating the perceived difficulty of saving shots from different positions. The results showed statistically significant differences between 9m shots and all other shots, Significant difference can be noted between 9m and all other playing positions, and also between close shots (6m, 7m, wing shot) and situational shots (fast break, breakthrough, fast trow-off). The results showed statistically significant differences between the male and female goalkeepers self evaluation in the one variable: shots from 9m line (5.4 vs. 4.2)

Research limitations and practical suggestions

This sample was limited only to handball goalkeepers from Croatia, so it would be advisable to find a larger international sample. Likewise, in this sample, heterogenity of a sample based on experience (5-35 years), could possibly impacts different results and discussion about the difficulty of saves from different handball positions. As for the suggestions for handball coaches, in training for goalkeepers, different situations from the game that end with a shot at the goal should be practiced more, as opposed to undisturbed shots at the goal without any contact. In further research, in addition to saving from different shoting positions, the evaluation of other situational elements of the goalkeeper play should also be included, such as assisting, preventing counterattacks, scoring goals, etc.

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PASSING DIFFERENCES BETWEEN WINING AND LOSING TEAM IN NATIONAL HOCKEY LEAGUE (NHL)

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Abstract
Ice hockey is a highly popular winter Olympic sport that reqiures significant increase in the use of sport analytics. Elite ice hockey players need to have well-rounded physical and physiological capabilities including aerobic and anaerobic fitness, muscular strength, power, and endurance. These physiological qualities are expressed in ice hockey by combining dynamic skating movement patterns with skills such as shooting, passing of the puck, and evading defenders.

The sample was collected by analyzing 20 randomly selected matches from the NHL With use of notational analysis. 8533 phases of attack were extracted from the selected matches of the National Hockey League.

T-test shows that there is statistically significant difference between winning and losing teams (1,809 ± 1,66 and 2,012 ± 1,83, respectively) with T-value = - 5,3308 with 95% confidence p = 0,0000. The most differences make variables Giveaway and Attempt shot

Keywords: *Notational analysis, tactics, hockey, passes in finish actions*

Introduction

Ice hockey is a highly popular winter Olympic sport that needs significant increase in the use of sport analytics (Lignell et al., 2020; Parničan et al., 2021). The analysis of the characteristics of hockey players and teams through the use of statistics and other tools is necessary to gain a greater understanding of the effects of their performance. To contribute in such analytics, most major leagues collect and share increasing amounts of play-by-play data and other statistics done by Sportradar (NHL) or Wisehockey (Finnish, Sweden, Norwegian league, KHL) (Ovchinnikov & Miftakhov, 2020). This includes official and accurate scoring, face-offs, substitutions, hits, giveaways and more other statistics. Hockey has lagged behind other sports in advanced analytics due to technical challenges caused by the fast pace, small puck, white-colored ice, and other hardware challenges (Douglas & Kennedy, 2019). However, the new tracking system broadens the scope of potential metrics, analysis, and performance evaluations in hockey (Radke et al., 2021). Additionally, some websites specialize in making such data available to the public in user-friendly forms. However, these sites fail to capture the semantic information of the data, and cannot be used to support more complex data requirements. Various notational motion analysis methods have included video-based tracking, computer-based tracking, and the use of electronic transmitters (Doğramaci et al., 2011).

Ice hockey is characterized by athletes repeatedly performing high-intensity, short-duration efforts, while maintaining highly complex movements over the course of a 60-minute competition. For optimal performance, elite ice hockey players need to have well-rounded physical and physiological capabilities including aerobic and anaerobic fitness (Burr et al., 2008), muscular strength, power, and endurance. These physiological qualities are expressed in ice hockey by combining dynamic skating movement patterns with skills such as shooting, passing of the puck, and evading defenders (Douglas & Kennedy, 2019).

Ritchie et al. (2022) made model of the rink control for each team and the scoring probability of the offensive team. These models are then combined into novel metrics for quantifying where a pass should be made in such way that it would result in a high scoring opportunity or result in a high chance of maintaining possession. They use various metrics to evaluate passes made throughout the available power plays and compare them with the optimal options at that time. That can be used to identify players' risk-reward tendencies and can be used by coaches when selecting which players that are best suited for a power play given the circumstances of the game.

Our ontology is substantially larger than previous ice hockey ontologies (that cover only a small part of the domain) and provides a formal and explicit representation of the ice hockey, supports information retrieval, data reuse, and complex performance metrics. The aim of this paper is to find there are differences between winning and losing teams in National hockey league in passes made due to finish action. From this goal we set H0 hypothesis and assume that there is a statistically significant difference between the winning and losing teams in the number of passes in the final actions.

Methods

Entity

The attack phase is the basic entity of this investigation, defined by the acquisition of a puck and lasting until an action is taken or the puck is lost. The sample was collected by analyzing 20 randomly selected matches from the NHL played in the playoffs of the 2017/2018 season. The matches were chosen by random selection through an application on the website www.graphpad.com. We put one game out of analysis because end result was tie. With use of notational analysis 8533 phases of attack were extracted from the selected matches of the National Hockey League (NNHL=8533). For every attack number of passes made was analyzed. It were 17160 passes accounted and put to further analysis. Analysis is made by Statistica 12.0 (Tibsco).

Variables

The analyzed variables are: GOAL - goal scored, SHOT - shot into the goal frame, i.e. which was saved (touched) by the goalkeeper, ATTSH - shot attempt at the goal that the goalkeeper did not touch, including shots that hit the goal frame, GIV - give pack to the opponent, TAW – pucks taken away by a tactical variant of the opponent or an individual, SP – action during which the game was interrupted (forbidden shooting, shot puck outside the field fence, defense of the goalkeeper and other actions during which the game was interrupted, BLPL – action during which is blocked by a player or an intercepted pass attempt to a player with a good scoring opportunity.)

Data

Due to more results that deviate from the majority of the outliers, the Kolmogorov-Smirnov test (K-S test) for checking the normality of variables shows the non-normality of the function. Altman and Bland (1995) explained that variables with a frequency greater than hundred are considered normal (Ghasemi & Zahediasl, 2012) and thus the variable can be analyzed normally. Differences between the winning and losing teams were analyzed with the T-test for independent samples.

Results

Table 1. No. of passes in different types of attack

No. Pass	0	1	2	3	4	5	6	7	8	9	10	11+
ST_ATT	262	529	610	415	158	47	13	4	2	1	0	0
NEG_OUT	1145	1101	735	353	94	28	7	3	4	1	0	0
OZ_ATT	507	644	635	499	319	128	89	32	28	12	7	1
PP	27	54	81	111	94	67	37	38	31	16	13	11
N(NHL)	1941	2328	2061	1378	665	270	146	77	65	30	20	12
%	21,58	25,89	22,92	15,32	7,39	3,00	1,62	0,86	0,72	0,33	0,22	0,13
CUM %	21,58	47,47	70,39	85,71	93,11	96,11	97,73	98,59	99,31	99,64	99,87	100,00

Legend - ST_ATT – Straight attack, NEG_OUT – Negative outcome, OZ_ATT- Offensive Zone Attack, PP – Power Play, % - row percentage (passes made in attack), CUM% - cumulative percentage of passes in attacks

Results in Table 1. show number of passes during different types of attack. The most of attacks are done with up to 3 passes (85.71%). The most of Straight Attack actions contains up to 3 passes (88.98%). Offensive zone attack little less (78.77%) up to 3 passes, but the most attacks with negative outcome finish after the most 3 passes (96.05%). 60 % of power play attacks are done in 2-6 passes and the maximum number of passes are going up to 22.

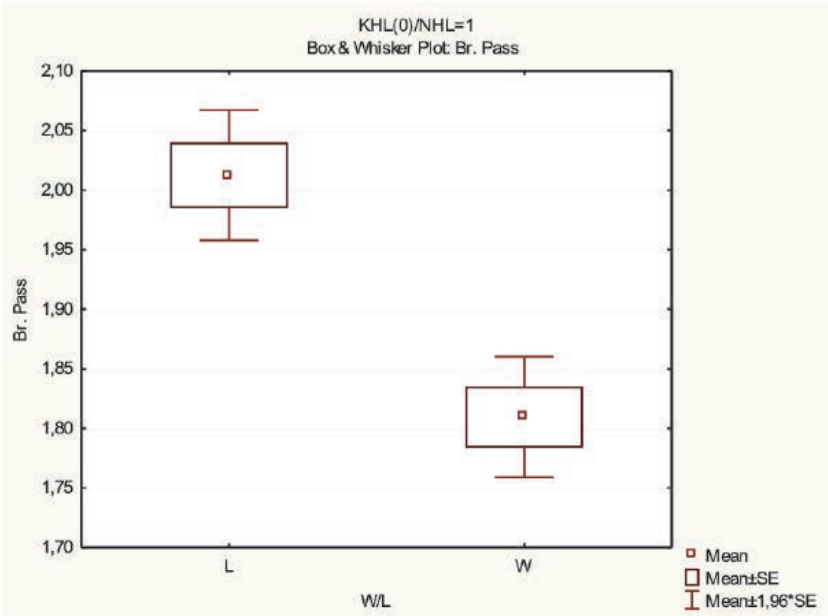

Figure 1. Box plot of T-test differences in passing between winning and loosing team

T-test shows that there is a statistically significant difference between winning and losing teams (1,809 ± 1,66 and 2,012 ± 1,83, respectively) with T-value = - 5,3308 with 95% confidence p = 0,0000. The fact that we didn't expect was that winning team had statistically less passes than losing team.

Table 2. T-test results of passing vatiables in finnish outcomes

	Mean L	Mean W	t-value	df	p	Valid N L	Valid N W	S.D. L	S.D. W	F-ratio Var.	p Var.
GIV	1,7498	1,5919	3,4028	4722	0,0007	2342	2382	1,6780	1,5070	1,2398	0,0000
SHOT	2,4822	2,3860	0,8007	1173	0,4234	618	557	2,1448	1,9536	1,2053	0,0244
TAW	1,8776	1,7205	1,6143	871	0,1068	433	440	1,4581	1,4179	1,0575	0,5595
BLOCK	1,8776	1,7205	1,6143	871	0,1068	433	440	1,4581	1,4179	1,0575	0,5595
ATTSH	2,7581	2,2995	2,3869	472	0,0174	277	197	2,1659	1,9051	1,2926	0,0552
SP	1,7401	1,5225	1,5341	447	0,1257	227	222	1,6505	1,3342	1,5304	0,0016
BLPL	2,6837	2,4730	0,7098	170	0,4788	98	74	1,8534	2,0220	1,1902	0,4206
GOAL	2,6750	1,9733	1,6383	113	0,1041	40	75	2,4114	2,0597	1,3706	0,2434

Legend - GIV – Giveaway, SP – Stoppage of play, TAW - Takeaway , BLOCK – Blocked shot , ATTSH – attempted shot, SHOT – Shot on net, BLPL – blocked player, GOAL – Score a goal, Mean W/L – mean values of passes in variables, S.D. – standard variation, p - confidence

Winning teams have fewer passes in every variable (segment of attack). In analysis of attack end actions there are only statistically significant differences between win and losing teams are in Giveaways and Attempt shots.

Discussion

The aim of this paper was to determine the differences between winning and losing teams in the number of passes that precede the final action in National Hockey League playoff games. Passing is passing a puck to a teammate, and it can be passed in several ways: directly, from the fence, along the fence (English rim), saucer pass, on the weaker side, in the air, etc. The pass must be strong, accurate, exact and purposeful. According to Table 1, up to 3 passes are used the most (85.71%), and so is the average number of passes in attacks that end with a shot on goal or an attempted shot. Power play attacks players probably contribute to such a high average, where in some attacks the number of passes goes up to 22, followed by a shot on goal.

The results of T-test show statistically significant differences between the winning and losing teams are in the only variable Giveaway and Attempted shot and they contain very important information. In the NHL, since the field is large (according to IIHF standards), attempted shots are a very important segment, because increasing the total number of shots on goal increases the possibility of scoring goals (Franjković et al., 2017).

The fewest passes were made in attacks with a lost puck, which is to be expected because a lot of possession changes happen immediately after a lost puck, and the high pressure (forecheck) prevents the opponent from making a large number of passes and developing the game forward. Also, very few passes were successfully completed before a puck was taken by an opponent in the Takeaway variable. In the variable Goal, winning teams have less passes in every variable especially before scoring a goal.

The values of the t-test on the differences of the vector of arithmetic means indicate that it can be concluded that in the end there is statistically significant difference between the winning and losing teams at the significance level of 0.05 therefore the H0 hypothesis can be accepted and concluded that there is a statistically significant difference between the winning and losing teams in the National Hockey League and only in two variables, namely Giveaways and the variable Attempted shots makes such difference when performing final actions.

Conclusion

In this paper we found significant differences between winning and losing teams in number of passes in end actions. Attempted shot and Giveaways make such a difference.

A completed pass is when the puck moves from one player, the passer, to another player on the same team, the receiver. There are different types of passing like forehand, backhand, board, saucer, drop, rim and overhead pass. Good pass must be hard, tape to tape, exact and expedient. As a paper shows there must be more shots and less passing when you need to finish actions. There is lot of space in progress at defending zone trying to make good breakout with good first pass, and with good pass/es try as quickly as you can enter offensive zone and try to score.

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DIFFERENCES IN COMPETITIVE PERFORMANCE INDICATORS BETWEEN WINNING MEN AND WINNING WOMEN 3X3 BASKETBALL TEAMS

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Abstract
The aim of this research is to identify differences in standard indicators of competitive performance between winning men and women teams in 3x3 basketball games. Data for this study was collected from 273 games across all FIBA 3x3 Women's Series and FIBA 3x3 World Tour tournaments in the competitive season of 2021. Within each game, records of winning teams were separated for further statistical analysis. The sample of variables in this study was composed of 11 standard competitive performance indicators in 3x3 basketball. All data were obtained from the official Women's Series and World Tour competition website. To determine differences between winning men and winning women 3x3 teams Mann-Whitney U test and Median test were utilized, all conducted at a significance level of $p<.05$. The results revealed a statistically significant distinction between successful teams in male and female competitions across 7 out of the 11 assessed variables - successful 1-point shot (S1PT), successful 2-point shot (S2PT), unsuccessful 1-point shot (U1PT), unsuccessful 2-point shot (U2PT), defensive rebound (DREB), turnover (TO), and team foul (TF). These results suggest that there are specific variations in the gameplay strategies of male and female 3x3 basketball teams.

Keywords: *3x3 basketball, competitive performance, gender*

Introduction

FIBA (International Basketball Federation) introduced a new sports discipline in 2010 known as 3x3 basketball, also referred to as 3x3 (FIBA 3X3 – Vision, n.d.). The 3x3 is played on a court slightly smaller than half the size of a standard basketball court, measuring 15 meters wide and 11 meters long, with a single hoop. Games run for 10 minutes of "live play" with a 12-second shot clock. Each team comprises three starting players and one substitute per team (FIBA 3X3 - Official 3x3 Basketball Rules, n.d.). On June 9, 2017, 3x3 was incorporated into the Olympic Games program, marking a significant milestone in its development, starting from the Tokyo 2021 Olympic Games (Olympics - 3x3 Basketball, n.d.). Key factors for enhancing athletes' performance include the feedback they receive through advancements in technology. Analyzing data from training sessions and competitions helps to identify areas for improvement in athletic performance (Liebermann et al., 2002). Ortega et al. (2021), analyzing games from the 2017 3x3 World Championship, concluded that the highest efficiency percentage was achieved in group-tactical situations involving all players on the court, particularly utilizing off ball screens. They also discovered that shooting accuracy from beyond the 6.75 m line and points scored from fast breaks after a defensive rebound were strong predictors of a team's success or failure. Drawing from data of 12 World Tour tournaments in the 2019 season, Andrianova et al. (2022) highlighted the performance indicators with the greatest impact on win percentage in a competitive season. Turnovers emerged as the most influential on winning, followed by the number of rebounds. The authors stressed the significance of shooting from distance (for 2 points) and the battle for rebounds. Harapin, Knjaz, and Milanović (2023) pinpointed differences in performance indicators in men's 3x3 basketball between winning and losing teams. The analysis included 152 games from men's elite tournaments (World Tour) in the 2021 season. Among eleven standard performance indicators, statistically significant differences were detected in variables such as successful 1-point shots, successful and unsuccessful 2-point shots, key assists, turnovers, successful and unsuccessful free throws, defensive rebounds and team fouls. In the study of competitive performance indicators in women's 3x3 basketball during the Tokyo 2021 Olympic tournament, Xu, Zhou, and Zhang (2022) noted that winning teams achieved a higher percentage of successful 1-point shots, more 1-point field goals, more successful free throws, defensive rebounds, and committed fewer fouls than losing teams in all matches. In closely contested games, winning teams also made more attempts and successful free throws, secured more defensive rebounds, and committed fewer fouls. Madarame (2023) delved into shot distribution and accuracy across two age groups (seniors and U18) and in male and female competitions. Men's teams were inclined to attempt more 2-point shots and fewer mid-range shots compared to women's teams. In general, male teams demonstrated higher efficiency. Ferioli et al. (2023) conducted a study aiming to quantify the technical-tactical demands of international 3x3 basketball games concerning outcome, gender, and competition phase. Based on the results of the 2019 European Championship in 3x3 basketball, the authors found that male players were more efficient in scoring, made more 2-point field goals, and generally scored more points, while female teams had more attempts for 1-point shots, more turnovers, and had more possessions.

The objective of this research is to identify differences in standard indicators of competitive performance between winning men and women teams in 3x3 basketball games. The hypothesis suggests that contributions to variables in the performance of male and female 3x3 winners will significantly differ.

Methods

Sample of entities

Data for this study was collected from 273 games across all FIBA 3x3 Women's Series and FIBA 3x3 World Tour tournaments in the competitive season of 2021. Within each game, records of winning teams were separated for further statistical analysis. All data were obtained from the official Women's Series and World Tour competition website (FIBA 3x3 Women's Series 2021, n.d.) (FIBA 3x3 World Tour 2021, n.d.).

The sample of variables

Within the study, researchers examined 11 standard variables related to situational performance indicators in 3x3 matches (Table 1).

Table 1. Situational performance indicators in 3x3 basketball matches based on the given date from FIBA 3x3 official website

Variables	Description
S1PT	Successful 1-point shot
U1PT	Unsuccessful 1-point shot
S2PT	Successful 2-point shot
U2PT	Unsuccessful 2-point shot
SFT	Successful Free Throw
UFT	Unsuccessful Free Throw
DREB	Defensive Rebound
OREB	Offensive Rebound
KAS	Key Assist
TO	Turnover
TF	Team Foul

Data processing methods

The Shapiro-Wilk test was used to check the normality of data distribution for all 11 variables studied, while the Levene's test was employed to determine the homogeneity of variables. Descriptive statistics yielded the following data – standard deviation (SD), mean, minimum, and maximum results (Min and Max). To determine differences between winning men and women 3x3 teams Mann-Whitney U test and Median test were utilized, all conducted at a significance level of $p<.05$. The data were analysed using the statistical software package Statistica for Windows, version 14.0.

Results

In the Table 2, the results of the Shapiro-Wilk test (W, p-value) are presented to determine the normality of distribution of the before mentioned variables. Based on the obtained results (if S-W $p>.05$, it indicates a normal distribution), it can be observed that the hypothesis of normal data distribution cannot be accepted for all of the variables. The Levene's test results indicate that in the case of S1PT, S2PT, SFT, DREB, OREB, KAS, and TO, the variances are homogeneous ($p>.05$), while in the variables U1PT, TF, and UFT, there is heterogeneity of variances ($p<.05$). For the variables U1PT, TF, and UFT, the Median test will be conducted, while for the variables S1PT, S2PT, SFT, DREB, OREB, KAS, and TO, the Mann-Whitney U test was applied.

Table 2. Number of entities (N), Shapiro-Wilk test and Leven's test results

	N	Shapiro-Wilk	Levene	df	p
S1PT	273	W=,98260, p=,002	3,03	271	0,08
U1PT	273	W=,96157, p=,000	14,54	271	**0,00**
S2PT	273	W=,96118, p=,000	0,21	271	0,65
U2PT	273	W=,96393, p=,000	7,86	271	**0,01**
SFT	273	W=,93028, p=,000	0,03	271	0,87
UFT	273	W=,86098, p=,000	3,98	271	**0,05**
DREB	273	W=,98218, p=,002	1,43	271	0,23
OREB	273	W=,95434, p=,000	0,05	271	0,82
KAS	273	W=,95345, p=,000	0,01	271	0,93
TO	273	W=,97635, p=,000	0,92	271	0,34
TF	273	W=,96549, p=,000	3,90	271	**0,05**

Table 3 displays the descriptive parameters and results of the Mann-Whitney U test and Median tests, illustrating the statistical disparities in performance indicators between winning teams in men (FIBA 3x3 World Tour) and women (FIBA 3x3 Women's Series) matches during the 2021 competitive season.

Table 3. Central (Mean) and descriptive (Min, Max, SD) parameters, as well as the results of the Mann-Whitney U test (U, Z, p) and Median test (Chi-Square, df, p), for differences between winning teams in FIBA 3x3 Women's Series and FIBA 3x3 World Tour competitions in the 2021 season.

	Variables	Mean	Min	Max	SD	U	Z	p
Mann-Whitney test	S1PT-m	9,34	2,00	17,00	2,95	7941,50	-1,94	**0,05**
	S1PT-w	9,97	1,00	17,00	2,65			
	S2PT-m	3,99	0,00	9,00	1,83	5381,00	5,89	**0,00**
	S2PT-w	2,59	0,00	7,00	1,81			
	SFT-m	2,74	0,00	9,00	1,93	9179,50	-0,02	0,98
	SFT-w	2,74	0,00	10,00	1,94			
	DREB-m	11,66	5,00	22,00	3,42	7285,50	-2,95	**0,00**
	DREB-w	12,76	5,00	21,00	3,18			
	OREB-m	5,25	0,00	14,00	2,64	8331,50	-1,33	0,18
	OREB-w	5,77	1,00	15,00	2,74			
	KAS-m	3,44	0,00	9,00	1,96	9147,00	-0,07	0,94
	KAS-w	3,45	0,00	9,00	1,91			
	TO-m	4,28	0,00	10,00	2,22	6397,50	-4,32	**0,00**
	TO-w	5,63	0,00	13,00	2,47			
Median test	Variables	Mean	Min	Max	SD	Chi-Square	df	p
	U1PT-m	5,83	0,00	14,00	2,76	32,29	1	**0,00**
	U1PT-w	9,35	2,00	20,00	3,73			
	U2PT-m	9,08	2,00	20,00	3,68	31,63	1	**0,00**
	U2PT-w	6,16	1,00	17,00	3,04			
	UFT-m	1,30	0,00	5,00	1,16	2,56	1	0,11
	UFT-w	1,07	0,00	4,00	1,03			
	TF-m	6,88	2,00	11,00	1,58	10,54	1	**0,00**
	TF-w	5,63	1,00	12,00	1,86			

The Mann-Whitney U test revealed a statistically significant difference between male winning teams compared to female winning teams in 4 out of 7 tested variables. This difference was observed in the variables S1PT, S2PT, DREB, and TO. On the other hand, using the Median test, statistically significant differences were found in 3 out of 4 variables, namely U1PT, U2PT, and TF. Variables where no statistically significant difference was found are SFT, OREB, KAS, and UFT (Table 3).

Discussion

The results revealed a statistically significant distinction between successful teams in men's and women's competitions across 7 out of the 11 assessed variables (S1PT, S2PT, DREB, TO, U1PT, U2PT, and TF) (Table 3). However, no statistically significant difference was observed in the variables SFT, OREB, KAS, and FTU. From this, it can be concluded that there are certain differences in the game structure of men and women winning teams in 3x3 basketball. In all variables related to scoring from the field (S1PT, S2PT, U1PT, and U2PT), a statistically significant difference was found, some in favor of male teams and some in favor of female winning teams. In the variables S1PT and U1PT, a significant relationship was found in favor of female teams, meaning that women score more 1-point field goals but also miss more. On the other hand, male winning teams achieved higher values in the variables S2PT and U2PT, meaning they scored more points from 2-point shots despite more misses. These results suggest that female winning teams rely more on a game that involves more scoring from within the 6.75 m line. One possible reason for this might be the difference in physical characteristics between men and women. In other words, it is harder for women to get into a favorable position for an open 2-point shot. Two-point shots require greater explosive strength (Pojskić et al., 2014) than one-point shots due to the need to overcome a greater distance. Female winning teams recorded more defensive rebounds, which can be interpreted as a consequence of more missed shots. The higher number of turnovers in women's 3x3 may be a result of the tendency to score more points from close range, which increases the number of risky passes. Male teams commit more personal fouls compared to female teams, which disrupt the opponents' attacks more frequently and tactically prevent them from scoring from close range.

A previous study, which focused on a very similar topic and aimed to determine the shot distribution and shooting accuracy from distance, mid-range, and close-range, while comparing gender and age (Madarame, 2022) found no statistically significant difference in the success rate of 2-point shots, but similar to this case, male players took more 2-point shots compared to female players. This study also confirms the findings of Ferioli et al. (2022), where the authors discovered that male players were more efficient in scoring, made more 2-point field goals, and generally scored more points, while women's teams had more attempts for 1-point shots, more turnovers, and more possessions.

Conclusion

From the results obtained, there was a statistically significant difference observed between winning male and female teams in 7 out of 11 tested variables (S1PT, S2PT, DREB, TO, U1PT, U2PT, and TF). However, no statistically significant difference was found in the variables SFT, OREB, KAS, and UFT. Male teams tend to take more 2-point shots, although they also have a higher rate of misses and commit more team fouls. Conversely, female teams score more 1-point shots but also have a higher rate of misses. In terms of defense, women achieve more defensive rebounds but also have more turnovers. These results suggest that there are specific variations in the gameplay strategies of male and female 3x3 basketball teams. Men generally strive more to create favorable situations for a 2-point shot, while women attack the depth of the court more and base their offense on scoring from close range. A higher number of team fouls suggests that men are more aggressive in defense, attempting to hinder offensive collaboration. Future research should continue to investigate competitive performance indicators to uncover the underlying reasons for these disparities.

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THE RELATIONSHIP OF SKILLS, REACTION AGILITY AND COGNITIVE ABILITIES IN FOOTBALL

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Abstract
Introduction: The purpose of this study was to investigate the relationship of physical, technical, and cognitive parameters in specialized football classes. One hundred football players (dec. age 11.17y to 14.8y) performed a test of ball dribbling, reactive agility, and a test of divided attention. Methods: Differences in terms of age were determined using the Kruskal-Wallis´ test and T-test. Spearman's correlation analysis was used to determine relationships between variables (slalom with the ball, reaction agility with the ball, response time, and decision efficiency). Results: Differences by age were found in the level of ball dribbling (p=0.006) and reaction agility with the ball (p=0.003), differences in the level of divided attention were not found. Relationship analysis confirmed a negative relationship between decision efficiency and response time (r=-0.978 to 0.881); special skill and reaction agility time (r = 0.721 to 0.452). Conclusions: It was found that reaction agility time with the ball was not predicted by cognitive abilities. In conclusion, the mutual conditionality of ball dribbling, reactive agility with the ball and divided attention was only selective and unique. These findings suggest that special skills and decision-making are likely to have different predictors.

Keywords: *football, cognitive abilities, divided attention, special skills, reactive agility*

Introduction
Achieving the best possible result in sports is connected with the acquisition of motor skills of players, which directly affect the performance of movement, i.e. speed, automation, accuracy and adaptability (Wei & Luo, 2010). Demanding sports require extraordinary physiological abilities combined with excellent abilities in motor control, perception and cognitive functions (Nimmerichter et al., 2016; Scharfen & Memmert, 2019). These refer to the ability to identify and obtain information about the game environment in order to integrate it with existing knowledge (Marteniuk, 1976). It is generally known that all gaming activities of the player are not isolated but are always connected with other factors. However, the relationship between them is discussed in the literature, respectively. share of individual factors. Some studies have found strong, positive relationships between physical activity and cognitive outcomes (Fedewa & Ahn, 2011; Paśko et al., 2021), while other studies report small, negative associations (Baláková, Boschek & Skalíková, 2015; Granacher & Borde (2017). In general, there are many studies that confirm that athletes are characterized by a better level of cognitive abilities than non-training people (Nakamoto & Mori, 2008; Ghuntla et al., 2012). Although the relationship between reaction agility and cognitive abilities has been proven (Yaktas, 2019), new tests of reactive agility that are designed according to the type of sports specialization are needed.

Huijgen et al. (2015) also demonstrated that cognitive abilities depend on the training level of young soccer players. However, it should be noted that previous research has focused mainly on the cognitive abilities of elite adult athletes (Mann et al., 2007; Voss et al., 2010), but there are far fewer studies on youth elite players - especially in the age range from 9 to 14 years. In addition, number of studies have been carried out at the level of brain and functional operations, so they should also be analyzed at the level of behavior. Current knowledge supports the thesis that the improvement of motor and cognitive skills is related not only to general movement activity, but also to specific skills related to the ball (Alesi et al., 2015). Acquiring skills associated exclusively with planned activities does not provide an optimal environment for their development, because young players are not confronted with the need to make a correct, fast and effective decision.

Activities with the ball are mostly associated with decision-making processes because they combine mental components and physical structures. Football stimulates not only simple technical elements during training, but also motor and cognitive growth, specifically attention skills. Focusing consciousness on certain objects allowing optimal information reception is a process of attention (Gregor, 2013). Already at the age of 9, soccer players show lower reaction times and more increased decision-making abilities than their sedentary peers (Chang et al., 2013). The exact decision was in the work of Baker, Cote & Abernethy (2003) identified as an important factor of successful performance in team sports. However, there is a hypothesis that the quality and accuracy of decisions can be influenced by various covariates, such as physical and sports age, expertise (Sierra-Diaz et al., 2017; Araújo et al., 2017), as well as acute factors such as fatigue (Russel et al., 2019).

Following on from the above, the aim of this study was to determine the relationship between soccer dribbling speed, reaction agility and cognitive abilities (divided attention) in the age group of 11-14-year-old young soccer players.

The object of the research were young players (n= 100) of the Nitra football academy aged 11-14 in three categories U11 (n= 20; x =148.1± 2.7 cm, 40.1 ± 2.2 kg), U12 (n= 37; x =151.5 ±3.7 cm, 45.4±3.9 kg) and U14 (n= 43, x =166.8 ±3.1 cm, 53.9±3.3 kg). For organizational reasons, the U13 category was absent. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki and approved by the institutional review board. Participants and their parents were informed about the risks of the study and provided written informed consent to participate.

Study Design
The test procedures were performed indoors under standard light and temperature conditions. For reasons of maximum concentration, the cognitive test was performed at the beginning of the training, while the tested person was alone in the room in the presence of the administrator. After its completion, a 20-minute warm-up was performed, which consisted of jogging (5 min.), dynamic stretching of the lower limbs (10 min.) and 5 minutes of progressive speed running with and without a change of direction (50-90% max). The warm-up was followed by skill and agility testing. The research data were obtained using precise measuring equipment - a Witty electronic timer (with an accuracy of 0.01s), light semaphores Witty SEM (Micrgate) and common aids (meters, meter).

Three tests were performed:
1. Test of cognitive abilities - Divided Attention. The proband was assigned a task based on a predefined level. When two shapes are displayed on traffic lights B and C, the user selects one of the two responses by bringing the palm of the hand to one of the two traffic lights, e.g. answer "Y" (if you see two different shapes), or answer "N" (if you see two identical shapes).

2. Modified Y-Test (Lockie et al., 2014)
a) Special skill – slalom (Fig. 1). The proband had to cross the slalom between 4 goals, 1m apart from the start to photocell no. 2 (5m from the start – section I.).
b) Reactive agility: After passing photocell no. 2, the shape of an arrow (right or left) was displayed on the traffic light. The tested person guided the ball according to the specified direction through photocell no. 3 (section II.), 3 m away from photocell no. 2. Evaluation: In the slalom, we evaluated the proband's time in section I and in section II., with an accuracy of 0.01s. The test of ball control and reaction agility took place without interruption.

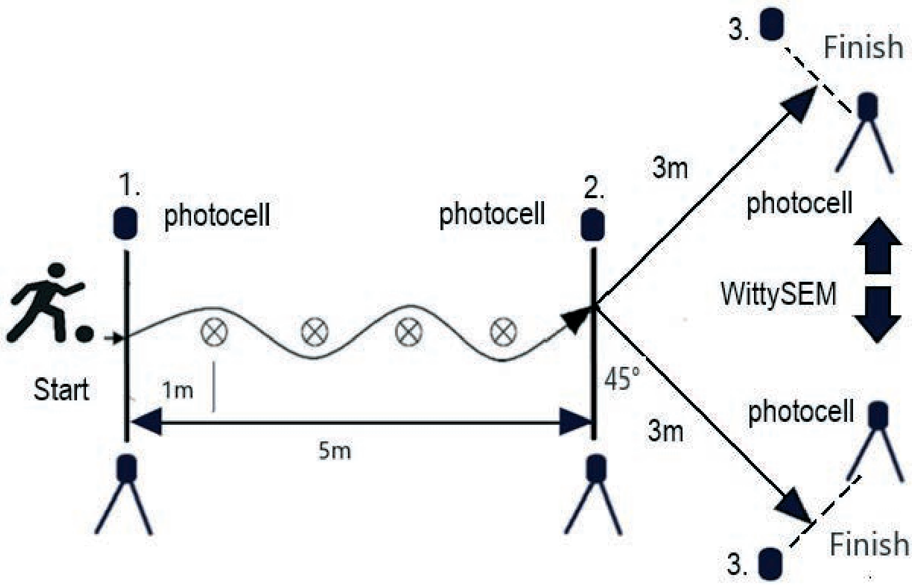

Figure 1 Modified Y agility test

Statistical Analysis

Analysis of data obtained from the study was analyzed using standard MS Office tools and statistical software SPSS version 16.0. Basic descriptive statistics were determined (means and standard deviations). A Shapiro-Wilk test was performed to verify that all data met the assumption of normality of data distribution. The agreement of the selection distribution functions of the compared sets was verified using one-factor analysis of variance - Kruskal-Wallis ANOVA test; the hypothesis of a difference in the means of two independent groups was verified by a two-sample t-test. An independent samples t-test was used to evaluate the difference in the means of two groups. In all cases, the significance level p = 0.05 was chosen. Spearman's correlation coefficient (rhó) was calculated to determine univariate associations between variables, while the age of the probands was not taken into account.

Results

In motor indicators, we found a gradual increase in performance (decrease in time) - ball control (5.20 - 4.08s) and reaction agility (2.71 - 2.39s). In cognitive indicators, there was a reduction in the reaction time of distracted attention (2.15 - 1.35s) and an increase in reaction efficiency with increasing age (61.95 - 66.97%). The significance of the differences between the three age categories (table 1) was found only in motor indicators: the level of skill – driving the ball (p = 0.007) and in reaction agility (p = 0.013), it was not demonstrated in the monitored cognitive indicators.

Table 1 Kruskal-Wallis ANOVA test (3 age categories)

Tests	Age category (U11 – U12 – U14)			
	χ^2	df	p	ε^2
Divided Attention / time (s)	0,459	2	0,795	0,0094
Divided Attention / efficiency (%)	1,131	2	0,568	0,0231
Special Skills/dribbling/s	9,907	2	**0,007**	0,2022
Reactive agility Y test/s	11,54	2	**0,013**	0,2356

In the partial analysis of the differences between the individual categories (tab. 2), the statistical significance of the differences was found only in the case of the comparison of the U12 and U14 categories: ball control (p = 0.006) and reaction agility (p = 0.003).

Table 2 Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	*Sig.*	df	*Sig. (2-tailed)*
Special Skills/dribbling/s	Equal var. assumed	3,506	0,036	427	0,006
	Equal var. not assum.				
Reactive agility Y test/s	Equal var. assumed	4,012	0,047	411	0,003
	Equal var. not assum.				

Correlation analysis (tab. 3) confirmed statistically significant relationships between cognitive factors. There was a strong dependence between effectiveness (DA/eff.) and reaction time in distracted attention (DA/time), (ρ = -0.881, p < 0.01), but with a negative polarity. We observed an equally strong dependence between reaction agility time (RA Y) and skill time (ρ =0.721, p < 0.01). Among the other indicators, we did not find a significant association.

Table 3 Correlation analysis of factors – Divided Attention, Dribbling and Reactive agility

		DA / time (s)	DA/ eff./%	SS/dr./s	RA Y/s
DA/ time (s)	Spear. ρ	—			
	df	—			
	p-value	—			
DA / eff. (%)	Spear. ρ	-0,881	—		
	df	40	—		
	p-value	**< .001**	—		
SS/dr./s	Spear. ρ	-0,198	0,165	—	
	df	40	40	—	
	p-value	0,208	0,298	—	
RA Y/s	Spear. ρ	-0,227	0,219	0,721	—
	df	40	40	40	—
	p-value	0,148	0,163	**< .001**	—

Notes: DA/ time (s) - Divided Attention / time (s); DA / eff. (%) - Divided Attention / efficiency (%); SS/dr./s - Special Skills/dribbling/s; RA Y/s - Reactive agility Y test/s

Discussion

Our findings contribute to a comprehensive understanding of the approach to the sports training of young football players. The results confirm the continuous growth of skills, agility and cognitive abilities in all categories of football players. From the point of view of age, we found significant differences in the level of agility and dribbling, but not in reaction speed and success in the divided attention test. Our findings are consistent with Valente Dos Santos et al., (2012), who claim that overall skill performance in dribbling improves with age and training, and is predicted by body height, respectively, stage of maturity and experience (Malina et al., 2007). Similarly, Frensen et al. (2017) state that agility shows continuous development up to the age of 15 to 17 years. Our results indicate that agility performance accelerates more dynamically than dribbling, which may be a consequence of the fact that abilities are natural, but skills learned. We also found that efficiency in the divided attention test is inversely proportional to reaction time and that it does not associate with reaction agility, not even dribbling. Attention, as a regulatory mental phenomenon, accompanies these processes (Vişan, Stoica & Dreve, 2022).

The probable cause is the absence of wider contextual information of the game. However, research confirms that cognitive training can change the size or number of brain regions involved and change the pathways used by the skill (Posner & Patoine, 2009). Although there are different views in sports science on the causes of differences in player performance, the authors (França et al., 2022) agree that the primary factors are the specificity and volume of preparation, individual limitations, psychological factors, technical and tactical skills, anthropometric and physiological factors, influence of relative age, or socio-cultural influences.

Conclusion

The identification of performance requirements in the specific activities of a player in a match is essential to create appropriate training programs to optimize the load. This study provides further evidence of the interdependence of cognitive, or physical factors in performing complex (sports) motor skills. The results of this study indicate that (a) both physical and cognitive performances continuously increase with age; b) the dynamics have a progressive tendency, especially in physical parameters; c) reaction time and effectiveness in distracted attention are mutually associated, but negatively; d) performance in reaction agility and ball handling are mutually dependent. Physical and mental development have different dynamics, their mutual associations are currently not fully explored. Many studies suggest that certain aspects of cognitive abilities, including attention (such as divided attention), reach their peak between the ages of 20 and 30. However, divided attention (DA), as one of several cognitive abilities, does not appear to be a moderator of reactive agility performance, in part because physical components of performance may be prioritized over attentional components. The environmental conditions during testing probably did not provide the subjects with enough contextual information in the form of spatial and temporal stressors of the match. Since the content of the reaction agility test was based only on the speed and speed of reaction to light, and the performance was not related to cognitive factors, further studies should be conducted in order to investigate which other factors condition the player's decision-making in the context of the game.

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STRUCTURAL ANALYSIS OF THE OPTIMAL AGE TO LEARN WATER POLO TACTICS ELEMENTS ACCORDING TO EXPERT OPINION

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Abstract
Aim of this research is to analyse the appropriate age for beginning of learning tactical elements in water polo according to water polo experts' coaches' opinion. Accordingly, 27 expert water polo coaches completed a novel questionnaire, specifically designed for this study. Test-retest reliability indicated satisfactory scores (r ranged from 0.85 to 1.00 with $p<0.05$ for all variables). By using tree-joining cluster analysis, a dendrogram was obtained that shows the process of hierarchical formation of groups of tactical elements of the water polo game and the level at which the element joined the group in relation to its proximity. Therefore, hierarchical cluster analysis was used in order to obtain relatively homogeneous groups of elements of the tactical game of water polo according to the requirements of the experts' point of view. Two groups were established: the first group can be defined as Tactical activities in the form of static defences and less frequent attacks with an equal number of players whilst the second group can be defined as Tactical activities in the form of dynamic defences and usual attacking activities. The current results provide a better insight into the opinions of experts on learning water polo tactics and offer essential guidelines for all stakeholders in the training process of young water polo players.

Key words: *water polo coaches, tactical elements, didactic principles*

Introduction
Tactics in water polo is a very important link on which the outcome of the match significantly depends. Tactics can be defined as planning how to use the available resources for the game (Hraste, 2021, p.79). The acquisition and development of tactical skills in young athletes is variable and non-linear, because they develop in the same way in all segments of anthropological status, and the need for continuous assessment during the training process through age is justified (Praça et al., 2017; de Castro Ribeiro et al., 2021). In water polo, coaches' views on the optimal age for learning a set of 39 water polo technical elements were identified and explained (Hraste et al., 2023). Didactic principles are general norms through which teaching-learning-assessment is carried out in practice, so that the functioning of goals/competencies becomes effective at the level of the educational dimension (Marius-Costel, 2010). Some of the basic didactic gradation rules are usually followed when arranging learning content, i.e. from easier to harder, from simpler to more complex and from known to unknown (Bjelica & Bilić, 2008). The aim of this research is to analyse the appropriate age for starting to learn tactical elements in water polo according to the opinion of water polo expert coaches.

Material & methods
Twenty-seven water polo experts from Croatia participated in this research. Given that there are around 140 licensed water polo coaches in Croatia, it can be said that the sample used in this research was ~20% of the available population. The sample of variables to estimate the optimal age to start learning all the tactical elements known in water polo consisted of 24 elements divided into several relatively homogeneous groups. Detailed explanation sand use value of each of the listed elements can be found in Hraste (2021, pp.79-93). All tactical water polo elements are known to water polo experts. According to the phases of the game tactics in water polo is divided into: (1) system of 'shallow' zone defence; (2) system of 'deep' zone defence; (3) system of 'M' zone defence; (4) press defence at 8 meters from the goal; (5) press defence on the defensive half of the pool; (6) press defence across the whole court; (7) system of the combined zone defence to one player; (8) system of the combined zone defence to two players; (9) system of the combined zone defence to three players; (10) system of the combined zone defence to four players; (11) individual counterattack, known as 1:0; (12) the group counterattack 2:1; (13) the group counterattack 3:2; (14) the group counterattack 4:3; (15) the group counterattack 5:4; (16) the collective counterattack 6:5; (17) man up 4-2; (18) man up 3-3; (19) active man down with shifting from one side to another; (20) semi active man down with block and occasional shifting; (21) passive and deep man down with blocks only; (22) system of positional offense with one centre forward; (23) system of positional offense with two centre forwards; (24) system of positional offense without a centre forward. A novel questionnaire was used to ascertain the best age tactical aspects of water polo should be learnt. Participants were asked to select one of seven options for all tactical aspects, with reference to the best time to start. The first selection available was 10 years of age, as this pertains to the first year of water polo training for youth players. Descriptive statistics, including mean (M), standard deviation (SD), median (MED), mode (MOD), minimum (MIN), and maximum (MAX), were calculated for each item. The test-retest method was applied to assess

reliability. Coefficients of correlation between test and retest were utilised as a measure of reliability. Furthermore, tree-joining hierarchical cluster analysis together with Ward's minimum variance method based on Manhattan distances was used and dendrogram (i.e. tree diagram representation displaying the course of hierarchical formation of groups) was presented. All statistical analysis was conducted using statistical software package "Statistica for Windows" ver.14.0.1. (Dell Inc, USA)

Results

After the initial validation of the instrument, consultation with four coaches took place, the final version of the questionnaire was then constructed. Test-retest reliability was high: 0.85-1.00 ($p<0.05$). Moreover, for all variables, the arithmetic mean, standard deviation, median, mode, minimum and maximum value were additionally calculated. Table 1 shows the basic descriptive indicators for the tactic variables. According to the results in Table 1, it can be seen that the knowledge and skills of press defence in the defensive half of the pool, individual counterattack and group counterattack 2:1 begin to be learned at the end of the second educational year of training (M-11.96; M-11.93 ; M-11.96). The other two defensive press tactics, known as press defence 8 meters in front of the goal and press defence across the entire playing field, are taught at the beginning of the first half of the third educational year of training (M-12.00; M -12.15). Group counterattack 3:2, group counterattack 4:3, man up 4-2, man up 3-3, active man down with shift, semi-active man down, attack with one centre forward and positional attack without centre forward are taught in the third year of training (M-12.30; M-12.81; M-12.89; M-12.44; M-12.44; M-12.44; M-12.37; M- 12.85). Table 1 defines in detail the shallow zone, deep zone, one-player combination zone, three-player combination zone, 5:4 group counterattack, 6:5 collective counterattack, passive player down and attack with two central attackers belong to the fourth training period (M- 13.63; M-13.96; M-13.67). Furthermore, according to the results, coaches teach M zone defence and combined zone defence for two and four players in the fifth year of water polo training (M-14.52; M-14.00; M-14.00).

Table 1. Results of descriptive statistics for all water polo tactical variables: Arithmetic mean ± standard deviation (M ± SD), Median (Med), modal value (Mod), Minimum value (Min), Maximum value (Max)

Tactical element	M±SD	Med	Mod	Min	Max
SHALZD	13.63±0.79	14.00	14.00	12.00	16.00
DEEPZD	13.74±0.81	14.00	14.00	12.00	16.00
ZONEM	14.52±0.89	15.00	15.00	13.00	16.00
PRES8M	12.00±0.78	12.00	12.00	11.00	14.00
PRESHC	11.96±0.90	12.00	12.00	11.00	15.00
PRESWC	12.15±1.13	12.00	12.00	10.00	15.00
COMZ1P	13.96±0.76	14.00	14.00	13.00	16.00
COMZ2P	14.00±0.83	14.00	14.00	13.00	16.00
COMZ3P	13.96±0.71	14.00	14.00	13.00	16.00
COMZ4P	14.00±0.96	14.00	14.00	12.00	16.00
IC1:0	11.93±0.73	12.00	12.00	10.00	13.00
GC2:1	11.96±0.71	12.00	12.00	10.00	13.00
GC3:2	12.30±0.72	12.00	12.00	11.00	14.00
GC4:3	12.81±0.68	13.00	13.00	11.00	14.00
GC5:4	13.04±0.76	13.00	13.00	12.00	15.00
CC6:5	13.63±0.79	14.00	14.00	12.00	15.00
MU4-2	12.89±1.01	13.00	13.00	11.00	15.00
MU3-3	12.44±1.01	12.00	12.00	11.00	15.00
AMDSHI	12.44±1.01	12.00	12.00	11.00	14.00
SAMDBS	12.44±0.75	14.00	13.00	12.00	16.00
PMDBLO	13.67±0.88	15.00	15.00	13.00	17.00
OF1CF	12.37±0.88	12.00	12.00	11.00	15.00
OF2CF	13.70±1.10	14.00	-	12.00	16.00
OF0CF	12.85±1.32	13.00	13.00	10.00	16.00

Legend: SHALZD - system of 'shallow' zone defence; DEEPZD - system of 'deep' zone defence; ZONEM - system of 'M' zone defence; PRES8M - press defence at 8 meters from the goal; PRESHC - press defence on the defensive half of the pool; PRESWC - press defence across the whole court; COMZ1P - system of the combined zone defence to one player; COMZ2P - system of the combined zone defence to two players; COMZ3P - system of the combined zone defence to three players; COMZ4P - system of the combined zone defence to four players; IC1:0 - individual counterattack, known as 1:0; GC2:1 - the group counterattack 2:1; GC3:2 - the group counterattack 3:2; GC4:3 - the group counterattack 4:3; GC5:4 - the group counterattack 5:4; CC6:5 - the collective counterattack 6:5; MU4-2 - man up 4-2; MU3-3 - man up 3-3; AMDSHI - active man down with shifting from one side to another; SAMDBS - semi active man down with block and occasional shifting; PMDBLO - passive and deep man down with blocks only; OF1CF - system of positional offense with one centre forward; OF2CF - system of positional offense with two centre forwards; OF0CF - system of positional offense without a center forward

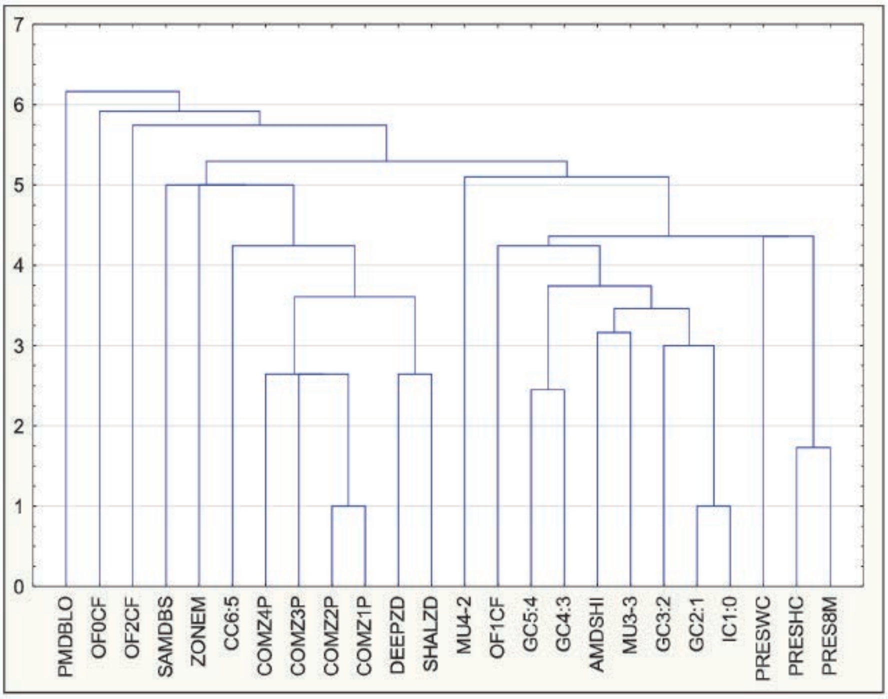

Figure 1: The tree diagram presentation of hierarchical grouping of water polo tactic elements

Two homogeneous groups were observed using hierarchical cluster analysis in the space of water polo tactical elements. A presentation via dendrogram of the hierarchical grouping of water polo game elements based on an expert assessment of the optimal age for learning water polo tactics is shown in Figure 1.

Discussion

The results of the present research confirmed that it is a reliable and valid questionnaire for determining the optimal beginning age for learning tactical skills in water polo. The results of the mean values indicate that the coaches probably think that it is too early to start acquiring tactical knowledge in water polo in the first year of training. In the second year of training, coaches start learning tactics in only three variables, while most of the simpler tactical solutions start to be learned in the third year of training. Most of the more complex tactical variations are only learned in the fourth and fifth year of training. Two groups were established using hierarchical cluster analysis. The first group can be defined as Tactical activities in the form of static defences and less frequent attacks with an equal number of players whilst the second group can be defined as Tactical activities in the form of dynamic defences and usual attacking activities. In the first group defined as tactical activities in the form of static defences and less frequent attacks with an equal number of players all static defences with the same number of players can be noted (system of 'shallow' zone defense; system of 'deep' zone defense; system of 'M' zone defense; system of the combined zone defense to one, two, three and four players), static defences with a numerical handicap (passive and deep man down with blocks only; man down with block and occasional shifting) and unusual offensive activities (system of positional offense with two center forwards; system of positional offense without a center forward; the collective counterattack 6:5). In the second group defined as tactical activities in the form of dynamic defences and usual attacking activities all dynamic defences with an equal number of players can be noted (press defines at 8 meters from the goal; press defines on the defensive half of the pool; press defines across the whole court), dynamic defences with a numerical handicap (active man down with shifting from one side to another), all dynamic group and individual counterattacks (individual counterattack, known as 1:0; the group counterattack 2:1; the group counterattack 3:2; the group counterattack 4:3; the group counterattack 5:4) and the usual collective attacks with an equal number of players and with a numerical advantage (system of positional offense with one centre forward, man up 4-2; man up 3-3). Results obtained shows two fundamental groups of variables pointing to the learning approaches in modern water polo. Interrelations of variables in first cluster, observed trough similar distance function are pointing to advanced water polo tactical systems. By insights into second cluster, necessity of early learning complex relations of basic tactical solutions in water polo can be noted. There is reasonable possibility that two essentially different identified clusters are due to the well know didactical principles of learning water polo. The results of this study indicate that the coaches logically believed that the tactical elements should be taught according to the didactic principles of simpler and easier to more complex and difficult (Marius-Costel, 2010; Bjelica & Bilić, 2008). By distributing tactical solutions according to complexity in four years, the possibility of injuries in young water polo players can be reduced, which is in line with the recommendations that it is very harmful to start specialization in sports early (Baker, 2003; Jayanthi et al., 2013). Apart from a higher injury rate, the risks of early sporting specialization also include increased psychological stress and giving up sport at a young age (Jayanthi et al., 2013). In general, only appropriate periodization and methodically correct training can lead to the desired effects in young water polo players and other athletes. There is a possibility that such a clearly defined tactical curriculum will provide additional motivation for young water polo players (Murillo et al., 2022). Following this research, the results could be incorporated into the training process and curricula for tactical training in water polo. Furthermore, refining these processes could help to reduce the risk of injury, increase player career longevity and promote optimal growth, development and performance.

Conclusion

It can be said that this study can most likely be applied to the curriculum of tactical skills training as it has been identified and explained according to certain criteria and didactic principles. Future research should aim to increase the number of coaches with different levels of coaching experience, playing experience and qualifications involved in this work to gain a deeper insight into the understanding and application of didactic principles in water polo.

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DIFFERENCES IN THE COMPETITIVE PERFORMANCE INDICATORS OF GRAND SLAM WINNER AT AUSTRALIAN OPEN AND WIMBLEDON IN 2021

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Abstract
The aim of this research study was to analyze the differences in the competitive performances of the winner of the Australian Open and Wimbledon Grand Slam tournaments in 2021. The data is based on his performance in the seven matches played in each of the Grand Slam tournaments. In a total of 14 matches, the data collected on his competitive performances is divided into 13 variables representing basic statistical indicators of competitive performances in tennis.

Statistically significant differences were obtained through the analysis of the performance variables between the two tournaments, with the most prominent differences observed in service performance. In particular, variables related to the performance of the first and second serves, as well as the "percentage of points won on the first serve," exhibited statistically significant differences between the Australian Open and Wimbledon tournaments.

These statistically significant differences are attributed to the difference in playing surfaces, with the Australian Open being held on a hard surface and Wimbledon on a grass surface. The ball bounces differently on these surfaces, affecting the angle and speed of the ball, which in turn impacts the player's service performance.

Keywords: *tennis, Grand Slam tournaments, winner, competitive performance indicators, surface*

Introduction

Tennis is a sport where players must collect, recognize, and analyze a large amount of information, subsequently reacting adeptly to various situations on the court. Serve tactics are crucial as the type of serve significantly influences the subsequent point. A serve must be assured, powerful, precise, and tactically placed.

The return of serve is another critical element of the game, dependent on the quality of the opponent's serve. When facing a well-served ball from the opponent, the primary objective is to return it at all costs. Conversely, if the serve is weak, the return can potentially determine the point's course. Forehand and backhand are the fundamental strokes performed from the baseline, with each top player exhibiting a distinctive style. The volley, characteristic of net play, is executed directly in mid-air. The smash, primarily used to win the point from an opponent's high return, differs from the serve in that players react to the opponent's shot rather than throwing the ball themselves. According to Milanović (2013), observing the parameters during sporting activities could be used to document and compare sport performances. In 2004, P. O. Donoghue analyzed 104780 points in 569 matches held at different Grand Slam tournaments in 2002/2003. He ascertained that the speed of the serve is affected by gender of the player and the type of surface played on. The serve is of greater importance for male tennis (Furlong 1995). It was proven that male tennis in general sees a statistically significantly higher percentage of unreturned serves than the female counterpart (Donoghue 2001). According to the classification, the serve is the most important for the matches.

Barbaros Tudor, Zečić and Matković (2014) investigated the differences in tennis play at Grand Slam tournaments in 2010 and 2011. The research included three out of four Grand Slam tournaments: Roland Garros, Wimbledon and the US Open. In all three tournaments the researchers found that in 2011, there was a reduction in speed in the first and second serve when compared to 2010.

Reid, Machar, Mcmurtrie, Darren, Crespo, Miguel (2010) published a study about the correlation of match statistics and the position of the top 100 players on the ATP Rankings list. The research showed that the two variables which had most influence over the position on the list were second serve return points won and second serve points won.

Born, Grambow, O'Shannessy and Vogt (2018) researched the serves of male tennis players at Wimbledon 2016, aiming to determine whether there was a significant difference in serve performance on break points compared to regular points. The authors concluded that while mental stress is present at various points in a match, break points are among the most critical situations for the server, as losing a service game at this juncture can lead to losing the entire set.

The goal of the present research is to ascertain the differences in the statistical determinants of the competitive performances of the winner at two Grand Slam tournaments: the Australian Open and Wimbledon.

H1.2: There are significant differences in the competitive performances of a top player and winner of the Australian Open and Wimbledon.

Research methods
For the purpose of this research, secondary data was used, specifically publicly available statistical indicators of the winner and his opponents in men's singles matches played at the Australian Open and Wimbledon in 2021. The data was obtained through the official match statistics from the websites of the two Grand Slam tournaments analyzed in 2021. "Hawk-Eye" technology was used to collect statistical data at both the Australian Open and Wimbledon.

The subject of this study is the winner of both Grand Slam tournaments in 2021. By analyzing his participation and success at the Australian Open and Wimbledon, and given that he played seven matches in each tournament, a sufficient amount of data was gathered to achieve the necessary statistical power for this study. Data on his competitive performances across the 14 matches were collected for the specified variables. The 14 matches constitute the number of entities, which is sufficient to achieve the necessary statistical power to conduct the research and draw valid conclusions.

For the purpose of this research, 13 variables were chosen in order to represent the basic statistical indicators of competitive performances in tennis. The variables are shown in Table 1.

Table 1. Sample of variables, competitive performance indicators in tennis

No.	Marker	Name	Description
1	NAS	Number of aces	Refers to the efficiency of the first serve.
2	NDF	Number of double faults	Refers to the efficiency of the second serve.
3	PSFS	Percentage of successful first serves	Indicates the efficacy of the first serve performance.
4	PFSPW	Percentage of first serve points won	Indicates the play efficacy after the first serve
5	PSSPW	Percentage of second serve points won	Indicates the play efficacy after the second serve.
6	POBPW	Percentage of break points won	Player's ability to overturn the point in case of a break point.
7	PONP	Percentage of net points	Indicates the efficacy of the player's net play.
8	NWS	Number of winning shots	The total number of winning shots.
9	NUE	Number of unforced errors	The total number of errors not affected by the opponent.
10	NPW	Number of points won	The total number of tennis match points won.
11	MAS	Maximum ace speed	The fastest ace expressed in km/h.
12	AFSS	Average first serve speed	The average speed of the first serve expressed in km/h.
13	ASSS	Average speed of the second serve	The average speed of the second serve expressed in km/h.

First, the central tendency and dispersion parameters of all variables were determined using elementary statistical procedures. To test the hypothesis regarding the differences in the competitive performances of the winner at the two Grand Slam tournaments, a t-test will be conducted to analyze the differences in mean values.

Results
In Table 2 and Table 3 are shown central and dispersion indicators of competitive performance of the 2021 Australian Open winner (Table 2) and of the 2021 Wimbledon winner (Table 3).

Table 2. Central and dispersion indicators of competitive performance of the 2021 Australian Open winner

Marker	MV	Min	Max	SD
NAS	14.71	3	26	8.10
NDF	3,29	1	5	1.70
PSFS	68.43	62	75	4,35
PFSPW	77.00	71	86	5.94
PSSPW	58.71	44	79	10,92
POBPW	52.86	27	86	20.42
PONP	72.00	58	89	9,83
NWS	41.14	20	56	12.63
NUE	30.43	11	56	18.55
NPW	121.00	87	157	31.31
MAS	203.86	201	206	1.95
AFSS	189.86	186	193	2.54
ASSS	158.71	153	168	5.35

Table 3. Central and dispersion indicators of competitive performance of the 2021 Wimbledon winner

Marker	MV	Min	Max	SD
NAS	9.71	4	25	7.02
NDF	3.00	1	6	2.08
PSFS	63.14	54	78	7.63
PFSPW	84.86	79	92	4.53
PSSPW	57.71	44	69	9.34
POBPW	38.71	29	50	7.23
PONP	75.86	60	85	8.13
NWS	31.57	23	47	7.91
NUE	21.00	6	30	8.21
NPW	110.14	91	145	17.84
MAS	200.00	198	201	1.00
AFSS	184.29	182	185	1.25
ASSS	150.29	142	154	4.54

MV - Mean value; Min - Minimum value; Max - Maximum value; SD - Standard deviation

At the Australian Open tournament, the player achieved the highest number of aces (26), while at Wimbledon, he achieved just one ace less (25). This underscores the great importance of the first serve on faster surfaces, provided the serve is efficient and consistent. Within the category of the first serve, a minimal range of only 7 km/h was observed. The average number of aces per match was 14.71. The maximum ace speed was 206 km/h, and the minimum was 201 km/h. At the Australian Open, the player won 77% of points on the first serve and 58.71% of points on the second serve, with an average first serve success rate of 68.43%. He managed to win an average of 52.86% of break points, and his net play had a success rate of 72%.

At Wimbledon, the player achieved a high maximum number of aces (25) and obtained the highest minimum percentage of points won on the first serve, further highlighting the importance of a strong and efficient initial shot on this type of surface. The average speed of the first serve had a range of 3 km/h. The player won 84.86% of points on his first serve on average, while this percentage dropped to 57.71% on the second serve. The average success rate of the first serve was 64.14%. At the net, the player was successful in 75.86% of cases. The average number of break points won was 38.71%. The player won an average of 110.14 points per match at Wimbledon. The average number of unforced errors was 21. The maximum ace speed was 201 km/h. The average first serve speed was 184.29 km/h, and the average second serve speed was 150.29 km/h. The player made, on average, three double faults per match at Wimbledon, with the highest number being six and the lowest being one. The player achieved 31.57 winning shots per match at Wimbledon.

Table 4. Differences in the competitive performances of the winner of Grand Slam tournaments: the Australian Open and Wimbledon in 2021.

Marker	MV (A.O.)	MV (W.)	SD (A.O.)	SD (W.)	t	p
NAS	14.71	9.71	8.10	7.02	1.23	0.24
NDF	3.29	3.00	1.70	2.08	0.28	0.78
PSFS	68.43	63.14	4.35	7.63	1.59	0.14
PFSPW	77.00	84.86	5.94	4.53	-2.78	0.02
PSSPW	58.71	57.71	10.92	9.34	0.18	0.86
POBPW	52.86	38.71	20.42	7.23	1.73	0.11
PONP	72.00	75.86	9.83	8.13	-0.80	0.44
NWS	41.14	31.57	12.63	7.91	1.70	0.12
NUE	30.43	21.00	18.55	8.21	1.23	0.24
NPW	121.00	110.14	31.31	17.84	0.80	0.44
MAS	203.86	200.00	1.95	1.00	4.65	0.00
AFSS	189.86	184.29	2.54	1.25	5.20	0.00
ASSS	158.71	150.29	5.35	4.54	3.18	0.01

MV - Mean value; SD - Standard deviation; t - t-test value; p - probability value

Table 4 presents the competitive performance data of the winner of the Australian Open and Wimbledon. Among the variables tested, statistically significant differences were identified in four competitive performance indicators of the professional tennis player. T-test values ranged from -2.78 to 5.2, demonstrating a significance level of 95% certainty. The variables showing significant differences primarily pertain to the serve, specifically the percentage of points won on the first serve, as well as three indicators related to the speed of the first and second serves.

The average speed of the first serve at the Australian Open is 189.86 km/h, while at Wimbledon, the average speed is 184.29 km/h. For the second serve, the average speed at the Australian Open is 158.71 km/h, compared to 150.29 km/h at Wimbledon. No significant differences were found in other variables related to points won during the first and second serves, break points, and net play.

Discussion

Through the analysis of these two tournaments, statistically significant differences in competitive performance were also observed in the following variables: "maximum first serve speed" (MFSS), "average first serve speed" (AFSS), and "average second serve speed" (ASSS). The average values of serve-related variables favored the Australian Open, with the exception of the "percentage of points won on the first serve" (PPWFS), which was statistically more significant at Wimbledon.

Other variables related to net play, the total number of winning shots, break points, and double faults did not show statistical significance. Based on the processed data, a professional performance model of a two-time Grand Slam winner can be created. The model values concerning the number of aces, winning shots, total points won, net points won, break points won, the number of unforced errors, and the maximum and average first and second serve speeds could be valuable for those aiming to achieve top results.

Although the fourteen matches analyzed provided the study with sufficient statistical power, a limitation of this study is that it included only two Grand Slam tournaments. Another limitation is the focus on the performance of a single respondent, though this was a condition of the study to observe only tournament winners. Future research could analyze the performance of two players if the sample included both tournament finalists and winners.

Conclusion

In this research study, which analyzed 13 competitive performance variables of the winner of two Grand Slam tournaments in 2021, the main hypothesis and the three auxiliary hypotheses have been confirmed. It can be concluded that there are significant differences in the competitive performances of the respondent concerning the different types of surfaces on which the tournaments are held.

Statistically significant differences were found between the Australian Open and Wimbledon in 2021, primarily in variables related to the success rate and efficiency of the first and second serves. Researchers recognize the importance of an efficient, fast, and indefensible serve. More importantly, the serve needs to be consistent, as it is the only shot not affected by the opponent.

In addition to the importance of the serve, this study also highlighted the differences in playing surfaces used at different tournaments. The respondent achieved the highest serve speeds on the hard courts.

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PRESSURE DISTRIBUTION DIFFERENCES ACROSS VARIOUS TURNS IN ALPINE SKIING – CASE-CONTROL STUDY

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Abstract
This study uses kinetic analysis to highlight the importance of force/pressure distribution during different alpine skiing manoeuvres by leveraging advanced technology to measure the force (in N) and the pressure (in N/cm^2) on different parts of the foot within the ski boot during turns. The research was conducted with a 25-year-old female ski instructor from the Faculty of Kinesiology in Zagreb. Using insoles embedded in ski boots, the study measured pressure forces during plow turns, basic turns, parallel turns, and short turns. Significant differences in pressure force were found between the left and right foot, as well as between the inner and outer ski during left and right turns. For instance, maximum force reached up to 1454 N on the medial side of the heel and under the first metatarsal heads, with force of up to 2127 N in some manoeuvres. These findings underscore the impact of precise force/pressure management on the execution and safety of different skiing techniques. The results have practical implications for improving skier performance and reducing injury risk.

Keywords: *kinetic analysis, pressure distribution, skiing technique, insoles, turns*

Introduction

Alpine skiing is a highly valued sport due to its attractiveness and widespread popularity as a recreational activity across various age groups. Skiers, regardless of their skill level, need to effectively control their direction and speed while navigating snowy slopes. This control requires selecting an appropriate slope steepness for their abilities. Beginners often push beyond their technical limits in pursuit of speed and adrenaline (Giraldi et al., 2010).

With the rapid advancement in technology and devices that enable precise measurement and definition of performance at specific moments, this study focuses on measuring plantar force and pressure through different phases of a turn in various skiing elements using a system that collects data via insoles in ski boots. The goal is to accurately depict and define when and where skiers need to exert force/pressure to optimize their turns, which is beneficial not only for competitive skiers but also for ski instructors and recreational skiers.

Previous research has explored various aspects of plantar force/pressure in skiing. Schaff, Senner, and Kaiser (1997) investigated pressure distribution in ski boots using two different systems, providing qualitative data on plantar pressure among professional ski racers. Lafontaine et al. (1998) used the PEDAR mobile system to study pressure in ski boots of ski instructors performing different types of turns, including short-radius, dynamic parallel, giant slalom, and basic parallel turns. Lamontagne (2001) analyzed foot pressure distribution and forces during slalom and giant slalom turns using the Pedar Mobile and Novel Electronics GmbH systems, focusing on different regions of the feet of professional ski instructors. Falda-Buscaiot et al. (2017) examined the impact of turn phases and slope gradients on ground reaction forces (GRF) across the entire foot during giant slalom turns, employing measurement insoles in ski boots to analyze pressure in various foot zones during each turn phase.

The international scientific consensus on medical plantar pressure measurement devices emphasizes the need for precise measurement protocols and clear definition of pressure zones (Giacomozzi et al., 2012). This study aims to build on this foundation by determining the distribution of load on the inside and outside ski during turns and the pressure force on the medial, lateral, and rear parts of the foot. This will be analyzed across different skiing elements—plow turn, basic turn, parallel turn, and short turns—while considering specific kinetic parameters during left and right turns. Further research in this area is essential as it could significantly contribute to minimizing injuries and enhancing performance in both professional and recreational alpine skiing.

Methods

This study was designed as a case-control study to explore and compare plantar force/pressure distribution during various phases of skiing turns. The focus was on analyzing force/pressure dynamics across different skiing elements to enhance understanding of skiing performance.

The participant in this study was a 25-year-old female ski instructor, with a height of 165 cm and a weight of 60 kg. She was selected based on specific inclusion criteria, which required her to be in good health with no history of foot or lower limb injuries. Additionally, her advanced skiing skills made her an ideal candidate for this research. Individuals with chronic foot or lower limb conditions or recent injuries were excluded from participation to ensure the accuracy of the results.

The research was conducted over four days in February 2020 at the Sappada ski resort in Italy. During this period, the participant performed a series of skiing turns—specifically, plow turn, basic turn, parallel turn, and short turns. Each type of turn was executed in controlled conditions to accurately measure force/pressure dynamics. In total, 40 turns were analyzed, with 20 turns performed to the right and 20 to the left.

To measure plantar force/pressure, a Novel PEDAR measurement system was used. This system employs insoles equipped with force/pressure sensors that record data in Newtons (N) and Newtons per square centimeter (N/cm^2) respectively. A detailed illustration of the Novel PEDAR system is provided in Figure 1. Before testing began, the system was meticulously calibrated to ensure the precision of the measurements.

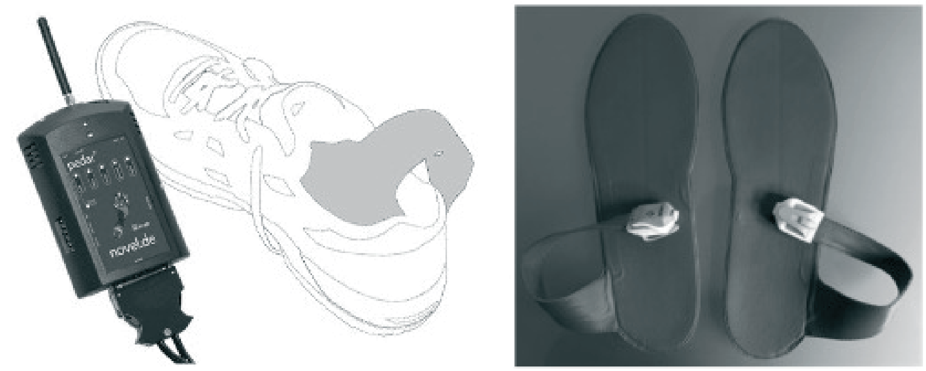

Figure 1. Novel PEDAR System. Retrieved from https://www.novel.de/products/pedar/

During the skiing tests, force/pressure data were collected continuously throughout the turns. The data measured included the total maximum pressure force on the outer foot (referred to as MAX_F), pressure force on the medial part of the foot (MED), pressure force on the lateral part of the foot (LAT), and pressure force on the heel (PETA). Specifically, medial pressure force encompassed the medial forefoot and midfoot, while lateral pressure force included the lateral forefoot and midfoot. Care was taken to ensure that these zones did not overlap.

Data collected during the field measurements were transmitted via Bluetooth and stored via a USB cable for subsequent analysis. The analysis involved calculating descriptive statistics using Statistica 13.3. To determine differences in ground pressure forces among the four skiing elements, Multivariate Analysis of Variance (MANOVA) was employed. The Tukey post-hoc test was used to identify significant differences between the elements for each force/pressure variable.
This comprehensive approach allows for a thorough analysis of plantar force/pressure distribution, providing valuable insights into skiing performance and areas for potential improvement.

Results

The analysis revealed statistically significant differences among the four skiing elements, showing variations in both left and right turns, and between the outside and inside legs relative to the turn axis. Table 2 presents the basic descriptive statistics for 16 observed variables across four skiing elements, along with the results of the univariate analysis of variance.

Table 2. basic descriptive statistical parameters and ANOVA for observed variables in plow, basic, parallel turns, and short turns.

Variables	plow AS±SD	basic AS±SD	parallel AS±SD	short turns AS±SD	F	p
MAX_F_D_v	581,36±45,75	680,26±45,94	764,43±76,93	927,17±155,94	12,46	0,00
MED_D_v	151,20±80,34	172,00±130,08	97,83±28,74	122,20±21,44	0,86*	0,48*
LAT_D_v	58,47±38,99	38,82±41,42	0,00±0,00	39,59±13,17	3,54	0,04
PETA_D_v	371,71±102,20	469,43±159,67	666,52±103,72	765,40±169,51	8,60	0,00
MAX_F_L_u	63,78±32,90	34,78±32,74	84,71±31,73	376,21±129,75	25,25	0,00
MED_L_u	5,91±6,44	0,00±0,00	0,00±0,00	0,52±1,15	3,87	0,03
LAT_L_u	49,90±21,58	2,92±4,33	0,00±0,00	9,42±14,01	15,85	0,00
PETA_L_u	7,97±13,02	29,86±24,64	84,71±31,74	366,27±118,07	34,99	0,00
MAX_F_L_v	517,06±78,29	731,42±54,82	742,12±103,96	937,62±94,75	20,57	0,00
MED_L_v	215,89±35,55	62,07±80,46	17,86±18,98	152,23±35,71	16,91	0,01
LAT_L_v	44,50±21,15	27,17±35,77	14,34±8,08	44,24±14,50	2,13*	0,14*
PETA_L_v	256,67±81,70	642,18±111,97	709,90±96,25	741,14±93,29	27,08	0,00
MAX_F_D_u	49,84±37,29	29,96±53,41	103,72±31,40	259,74±93,81	15,44	0,00
MED_D_u	0,00±0,00	0,00±0,00	0,00±0,00	10,00±22,36	1,00*	0,42*
LAT_D_u	18,91±6,45	3,00±6,71	0,00±0,00	22,48±13,80	9,13	0,00
PETA_D_u	30,94±31,65	26,96±54,87	103,72±31,39	222,46±112,09	9,51	0,00

Legend. AS±SD – Arithmetic Mean ± Standard Deviation; MAX_F_D_v – Maximum pressure force on the right foot during the left turn; PETA_D_v – Pressure force on the heel of the right foot during the left turn; MED_D_v – Pressure force on the medial part of the right foot during the left turn; LAT_D_v – Pressure force on the lateral part of the right foot during the left turn; MAX_F_L_u – Maximum pressure force on the left foot during the left turn; LAT_L_u – Pressure force on the lateral part of the left foot during the left turn; MED_L_u – Pressure force on the medial part of the left foot during the left turn; PETA_L_u – Pressure force on the heel of the left foot during the left turn; MAX_F_L_v – Maximum pressure force on the left foot during the right turn; LAT_L_v – Pressure force on the lateral part of the left foot during the right turn; MED_L_v – Pressure force on the medial part of the left foot during the right turn; PETA_L_v – Pressure force on the heel of the left foot during the right turn; MAX_F_D_u – Maximum pressure force on the right foot during the right turn; PETA_D_u – Pressure force on the heel of the right foot during the right turn; MED_D_u – Pressure force on the medial part of the right foot during the right turn; LAT_D_u – Pressure force on the lateral part of the right foot during the right turn

Table 3 displays the Tukey post-hoc test results for foot pressure variables in the chosen skiing elements for both left and right turns, showing statistically significant differences.

Table 3. Tukey Post-Hoc test for all observed variables in four skiing elements (plow, basic, parallel, short turns)

Variable	Element	1 PLOW TURNS	2 BASIC TURNS	3 PARALLEL TURNS	4 SHORT TURNS
MAX_F_D_v	1		0,363007	0,030415*	0,000290*
	2	0,363007		0,498296	0,003472*
	3	0,030415*	0,498296		0,059057
	4	0,000290*	0,003472*	0,059057	
MAX_F_L_v	1		0,005236*	0,003523*	0,000187*
	2	0,005236*		0,997124	0,007095*
	3	0,003523*	0,997124		0,010569*
	4	0,000187*	0,007095*	0,010569*	
MAX_F_D_u	1		0,950363	0,495079	0,000378*
	2	0,950363		0,240139	0,000251*
	3	0,495079	0,240139		0,003774*
	4	0,000378*	0,000251*	0,003774*	
MAX_F_L_u	1		0,914638	0,965040	0,000195*
	2	0,914638		0,685026	0,000188*
	3	0,965040	0,685026		0,000211*
	4	0,000195*	0,000188*	0,000211*	
LAT_D_u	1		0,036637*	0,011816*	0,903691
	2	0,036637*		0,939631	0,009505*
	3	0,011816*	0,939631		0,003062*
	4	0,903691	0,009505*	0,003062*	
LAT_L_u	1		0,000348*	0,000263*	0,000963*
	2	0,000348*		0,984364	0,858518
	3	0,000263*	0,984364		0,669895
	4	0,000963*	0,858518	0,669895	
LAT_D_v	1		0,715575	0,027654*	0,739081
	2	0,715575		0,194363	0,999976
	3	0,027654*	0,194363		0,181655
	4	0,739081	0,999976	0,181655	
MED_L_v	1		0,000796*	0,000214*	0,202045
	2	0,000796*		0,492027	0,042578*
	3	0,000214*	0,492027		0,002443*
	4	0,202045	0,042578*	0,002443*	
MED_L_u	1		0,050596	0,050596	0,080842
	2	0,050596		1,000000	0,994410
	3	0,050596	1,000000		0,994410
	4	0,080842	0,994410	0,994410	
PETA_L_v	1		0,000225*	0,000189*	0,000186*
	2	0,000225*		0,688416	0,394385
	3	0,000189*	0,688416		0,955025
	4	0,000186*	0,394385	0,955025	
PETA_D_v	1		0,678480	0,017311*	0,001826*
	2	0,678480		0,145943	0,016861*
	3	0,017311*	0,145943		0,670713
	4	0,001826*	0,016861*	0,670713	
PETA_D_u	1		0,999709	0,338121	0,001736*
	2	0,999709		0,295335	0,001461*
	3	0,338121	0,295335		0,052802
	4	0,001736*	0,001461*	0,052802	

Note. An asterisk (*) indicates statistical significance at $p < .05$.

Discussion

The results indicate that the four skiing elements differ significantly in the distribution of pressure forces on the ground across almost all variables. Time spent applying pressure on the heels is an important performance criterion observed across all skiing techniques from plow to parallel turns (Schaff Senner & Kaiser 1997). Maximum pressure force on the outside leg when skis are parallel to the fall line shows significant differences across all skiing technique elements. These differences can be attributed to varying skier speeds and the distinct techniques used for each type of turn. Absolute force measurements show higher forces on the outside leg compared to the inside leg during turns, with significant differences found only in short turns due to their higher turn frequency and more intense weight transfer to the outside ski. The greatest forces were observed during the shortest turns due to the faster bending of the skis, with average pressures being similar across all turn types but varying in rhythm and speed (Falda-Buscaiot et al. 2017).

There was a statistically significant difference in the medial part of the outside foot among all the skiing techniques, which aligns with the significant differences found in the maximum force generated on the outside ski during turns. The study by Falda-Buscaiot et al. (2017) found that pressures under the feet reached maximum forces of 522 to 1454 N on the medial side of the heel and under the first metatarsal heads, with the center of pressure (COP) shifting from the first metatarsal head to the medial side of the heel, reaching up to 2127 N. The greatest pressure during turns was observed on the inner part and heel of the outside foot (Lamontagne 2001). Higher pressure on the medial side of the outside foot is expected, as the outer ski is placed on the inner edge to avoid lateral sliding, leading to a significant statistical difference between the analysed elements. Similarly, the lateral sides of the inner and outer skis experience significantly lower pressure, with no substantial difference between the right and left foot. The overall maximum force on the outside foot is about twice the body weight, while the force on the inside foot is about 1.2 times the body weight (Lamontagne 2001). According to Lafontaine et al. (1998), maximum pressures under the skier's feet varied between 522 and 1454 N/cm2, with the highest pressures on the medial side of the heel and under the first metatarsal heads. During giant slalom turns, the COP moved from the first metatarsal head to the medial side of the arch and heel, with maximum forces reaching up to 2127 N (Lafontaine et al. 1998). In most ski turns, pressure on the rear of the foot is undesirable except during short turns and at the end of high-speed turns, where it can help increase speed. Excessive pressure on the rear of the foot generally reduces the quality of ski control. The highest forces were recorded in short-radius turns due to more intense edging (Lafontaine et al. 1998). The significant differences observed across all technique elements in variables describing rear-foot pressure are related to differences in the total forces generated on the inner and outer skis. This finding indicates that variations in rear-foot pressure are closely connected to how total forces are distributed between the inner and outer skis during different skiing techniques. The study's limitations include the participant's lack of extensive skiing experience and potential inaccuracies from using insoles in a rigid ski boot. Field variability and a small sample size also affect result precision. Additionally, the specifics of the field study on a ski slope, which varied across different sections, might have introduced deviations in the recorded data due to minor terrain changes. Furthermore, it is reasonable to assume that a larger sample size would have provided greater statistical power for comparing the results and drawing more robust conclusions.

Conclusion

This study highlights the significant impact of force/pressure distribution on skiing performance and safety. The findings suggest that managing force/pressure precisely across different parts of the foot can enhance the execution of skiing manoeuvres and potentially reduce the risk of injuries. Future research should focus on larger sample sizes and more diverse participant groups to validate these results further. The practical implications of this study are valuable for ski instructors, professional athletes, and recreational skiers aiming to optimize their technique and safety on the slopes.

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ASSOCIATION OF DEMOGRAPHIC, GEOGRAPHIC, AND ECONOMIC FACTORS OF COUNTRIES WITH THE NUMBER OF MEDALS WON IN TABLE TENNIS AT THE EUROPEAN CHAMPIONSHIPS

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Abstract
This study researched the association between the number of medals won in table tennis, at European Championships, over the past 30 years, with geographic (country size), demographic (population), and economic (GDP per capita) factors. It has shown that there are no statistically significant associations between the criterion and dependent variables. However, the only statistically significant correlation was observed between the size of the country and the population variables. Although countries with a larger population have a larger selection base for athletes, those with higher GDP per capita have the potential to provide greater financial resources for sports programs, equipment, infrastructure, coaches as well as training programs that can improve the development and success of table tennis athletes. Nevertheless, this analysis has not confirmed these hypotheses. It should be noted that other factors influence athletic achievement. Persistence, motivation, the composition of a competition and its organization system, as well as investment in quality coaching staff, can be key for the development of young talents and achieving record achievements, as well as the tradition and recognition of a sport in a particular country.

Keywords: *GDP per capita, population, country size, sport*

Introduction
The beauty of sport is the fact that it connects people of different countries as well as prevails over the differences between their languages, regardless of the country's size, population, and level of development. It provides an irreplaceable experience that helps overcome the social differences between athletes, but also their fans who highlight their national identity at major sports competitions. In addition, sports achievements at major international sports competitions such as the Olympics, World Championships, and Championships at the continent level alongside numerous other competitions depending on the individual sport contribute to the recognition of individual countries at the global level (Milanović, 2013). Sports and recreational activities play an important role in every society since involvement in various sports activities from an early age can successfully help promote the importance of physical exercise throughout life to preserve and improve one's health (WHO, 2018). This can indirectly lead to an increase in an individual's productivity, and thus affect the economy of the entire country. It is also an important factor for a particular country's economy, where the highest added values are identified in the tourism, fitness, media, and education sectors, including hotel and restaurant services. Moreover, there is also a noticeable link with other sectors such as construction and transport services (SPEA, 2012).

Table tennis is one of the sports and recreational activities that has gained popularity all over the world, especially in Asian countries. The sport was developed in England, during the 19th century, more as a game than a sport whose great advantage is that it can be played from early childhood to old age, both indoors and outdoors for professional as well as recreational purposes. The International Table Tennis Federation (ITTF) currently has 227 members, including National Table Tennis Federations or federations from around the world, of which 56 are members of the European Table Tennis Union (ETTU) (Wikipedia, ITTF).

Although table tennis does not require specific infrastructure or large investments in equipment, success in this sport is certainly influenced by many factors. In addition to investing in the largest possible base of successful athletes, coaching as well as other staff, it is necessary to provide financial resources for equipment, training sessions, and travel expenses, alongside organization and participation fees in tournaments and major international sports competitions. That is why, the following questions were raised: Which factors affect the performance of individual countries resulting in record achievements in table tennis? Do countries that have higher GDPs provide their athletes with better training conditions that enable them to achieve better results? Is the statement that countries with a larger population win more medals regarded as a fact? Is it as such accepted as an objective indicator of success in a particular sport due to a potentially larger base of promising athletes and the possibility of careful selection of those best in table tennis for example? Although Gotal (2017) found an association between population and total number of won medals in football, similar research did not find statistically significant correlations between the mentioned variables in water polo (Milanović & Babić, 2019), rowing

(Sinković et al., 2019.) and athletics (Dominković et al., 2021.) in which a statistically significant association was determined only between the size of the country and the population.

This research focuses on the analysis of the association of sports performance in table tennis measured by the total number of medals won at European championships in the last 30 years as a criterion variable with geographic, demographic, and economic measures as predictor variables.

Research methods

This research was conducted by entering the data collected into Microsoft Excel. All results are compiled from online sources as well as from the official website of the table tennis association. The included categories are Men's singles, Women's singles, Men's doubles, and Women's doubles. For this study, the medals won by 26 European countries over the last 30 years (1992-2022) were taken into account. The only medals that were included were gold, silver, and bronze medals won at the European Table Tennis Championships in Men's and Women's Singles, Men's and Women's Doubles (Wikipedia, Championships).

Bronze medals were awarded to the athletes who lost in the semi-finals. It is important to note that the list of medal winners also included three countries that no longer exist (as such) and that they were therefore excluded from further processing: Serbia and Montenegro, Czechoslovakia, and Yugoslavia.

The European Table Tennis Championships is an international table tennis competition for the national teams of the member associations of the European Table Tennis Union (ETTU). First held in 1958, the ETTU organized the European Championships every two years in even-numbered years until 2002, when they changed to odd-numbered years. Since 2007, the competition has been contested annually (Wikipedia, ETTU).

In addition to countries with medal winners also geographic, demographical, and economic indicators were used. The official data on the total size of the country (land and water area) expressed in sq km was regarded as the geographic indicator, the estimated population was used as the demographic indicator while the gross domestic product (GDP) per capita served as the economic indicator for the year 2021 (the World Factbook). GDP per capita is an indicator of the total market value of goods and services produced by a country's economy over some time (Britannica Money). The population density of a particular country was not taken into account.

The data were processed in the statistical package Jamovi (Version 2.3), Descriptive parameters of the form of the distribution (skewnis and kurtosis) indicate significant deviations of the analyzed variables from the normal distribution, which is further confirmed by the Shapiro–Wilks test for normality of the distribution. The value in the Shapiro-Wilks test should be greater than 0.5, however, in this case, its value is 0 which means that the distribution does not conform to the norm or Gaussian Curve. One cause of such distributions in variables is extreme results in individual variables. Due to the established distributions, the Spearman correlation coefficient was used for further analysis. In it, only a significant correlation between the population and the size of the country was determined, unlike all other variables. A statistical significance level of $p < 0.05$ was set.

Results and discussion

Insight into the tables of descriptive indicators shows that the obtained results significantly deviate from the normal distribution, which is primarily conditioned by extreme differences in all the above parameters. Namely, in the analyzed countries there are very large differences in size, population, and GDP, which makes it difficult to analyze them due to a lack of similarities. On the one hand, some countries are extremely small, while on the other hand, Russia stands out in its size. Similar differences are noticeable in GDP and population variables. An insight into the arithmetic means and medians, which should be similar in their numerical values, immediately shows us that here there are no similarities in any variables. Values and standard variations as well as the coefficient of variability are extremely high, while the largest deviations are noticeable between the minimum and maximum (visible in Table 1 and 2)

Table 1: Number of medals won by a particular country in the period between 1992 and 2022 in the men's and women's competition, total area of the country, population, and GDP per capita

	States	Medalists M 1992-2022	Medalists W 1992-2022	**Total M+W**	Area total sq km	Population	GDP per capita ($) 2021. year
1	Austria	11	24	**35**	83.879	8.940.860	54.100
2	Belarus	10	9	**19**	207.600	9.383.853	19.800
3	Belgium	3	2	**5**	30.528	11.913.633	51.700
4	Bulgaria	1	0	**1**	110.897	6.827.736	24.400
5	Croatia	11	8	**19**	56.594	4.169.239	31.600
6	Czech Republic	1	0	**1**	78.867	10.706.242	40.700
7	Denmark	2	4	**6**	43.094	5.935.619	58.000
8	France	7	13	**20**	643.801	68.521.974	45.000
9	Germany	42	53	**95**	357.022	84.220.184	53.200
10	Greece	3	5	**8**	131.957	10.497.595	29.500
11	Hungary	5	27	**32**	93.028	9.670.009	33.600
12	Italy	2	8	**10**	301.340	61.021.855	41.900
13	Lithuania	3	9	**12**	65.300	2.655.755	39.300
14	Luxembourg	3	6	**9**	2.586	660.924	115.700
15	Netherlands	9	13	**22**	41.543	17.463.930	56.600
16	Poland	5	14	**19**	312.685	37.991.766	34.900
17	Portugal	6	10	**16**	92.090	10.223.150	33.700
18	Romania	8	22	**30**	238.391	18.326.327	30.800
19	Russia	3	32	**35**	17.098.242	141.698.923	28.000
20	Serbia	1	2	**3**	77.474	6.693.375	19.800
21	Slovenia	2	2	**4**	20.273	2.099.790	40.000
22	Spain	0	7	**7**	505.370	47.222.613	37.900
23	Sweden	13	33	**46**	450.295	10.536.338	53.600
24	Turkey	2	1	**3**	783.562	83.593.483	31.500
25	United Kingdom	1	0	**1**	243.610	68.138.484	45.000
26	Ukraine	4	4	**8**	603.550	43.306.477	12.900
Czechoslovakia		1	0	1			
Serbia and Montenegro		1	8	9		No longer exist as states	
Yugoslavia		0	4	4			

Table 2: Descriptive parametars

	MIN	MAX	RANGE	MEAN	MEDIAN
Medalists M+W	1	95	94	17,92	11
Area	2,59	17098,24	17095,66	872,06	121,43
Population	660,92	141698,92	141038	30093,08	10621,29
GDP 2021.	12,9	115,7	102,8	40,89	38,6
	SD	**CV**	**SKEW**	**KURT**	**Shapiro-Wilk test**
Medalists M+W	19,99	111,51	2,23	5,83	p = 0
Area	3316,52	380,31	4,5	19,04	p = 0
Population	35136,99	116,76	1,47	1,59	p = 0
GDP 2021.	19,44	47,53	2	5,82	p = 0

From the results obtained, it can be concluded that there are no statistically significant associations between the number of medals won in table tennis at the European Championships with the size of the country, the number of inhabitants, or GDP per capita. A statistically significant correlation was found only between surface and population variables, which is also confirmed by research in some other sports: water polo (Milanović & Babić, 2019.), rowing (Sinković et al., 2019.) and athletics (Dominković et al., 2021.)

Table 3: Correlation between variables

	Medalists M+W	Area	Population	GDP 2021.
Medalists M+W	1			
Area	0,249	1		
Population	0,186	**0,806**	1	
GDP 2021.	0,173	-0,353	-0,063	1

From the above, it can be concluded, taking into account the countries that have won medals at the European Championships in the last 30 years, that the achievement of top results is not affected by these economic, demographic and geographical indicators.

Conclusion

The success of individual athletes in international sports competitions can certainly contribute to the popularization of a particular sport, but also to the affirmation of the country itself. Because sports performance is rewarded with medals and members of the same countries are often presented with awards, several questions arise. Such as why some countries are rewarded while others are not or even why some countries win more than others.

Exploring the relationship between the number of medals won at European Table Tennis Championships in the last 30 years (1992-2022) in male and female competition, in singles and doubles, with country size, population, and GDP per capita, it should be noted that statistically significant correlations have not been found between the variables except in the case of the size of a country and its population.

It is more likely that performance in a particular sport is influenced by other factors that should be further investigated. In some of the following research, it would be interesting to analyze whether the tradition and popularity of a particular sport, as well as the number of active competitors and the size of the selection base have an influence on the achievement, i.e. on the number of medals won in table tennis. The assumption is that such research would give more insight into investment in the sports sector, the quality of work as well as the achievement of athletes themselves alongside the ratio between the number of competitors and the number of medal winners in table tennis, but also the influence of tradition and popularity of the sport in a particular country.

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METRIC CHARACTERISTICS OF FLEXIBILITY TESTS IN ARTISTIC GYMNASTICS

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Abstract
Early selection is crucial for the development of young talents and their abilities in artistic gymnastics. One of the main abilities is flexibility and it is necessary to find specific tests that are reliable and valid. The aim of this research is to determine the metric characteristics of tests for evaluating flexibility in gymnasts. The research was conducted on a sample of 26 preschool children (age 5,42 ± 0,50 years) who practice artistic gymnastics recreationally twice a week. The tests that were used were the sit-and-reach, gymnastic bridge, middle split, and front split. While factor validity and reliability were determined using factor analysis and reliability/item analysis, respectively, homogeneity and sensitivity were assessed using the Kolmogorov-Smirnov test and correlation test. The results show a good sensitivity of the tests (K-S value >0,10), a high correlation that confirms the homogeneity of the tests (>0,89), reliability where Cronbach's alpha, standardized alpha, and average inter- item corr. are in all tests greater than 0,92. Factor analysis confirms the factorial validity of the tests. It is concluded that the used tests are reliable and valid in evaluating flexibility in preschoolers.

Keywords: *preschoolers, split, bridge, sit- and- reach, reliability.*

Introduction
Artistic gymnastics is specific for the very early involvement of children in sports (mostly at the age of 5) and the high intensity of training that is maintained through the children's growth (Armstrong & Sharp, 2013; Bradshaw & Hume, 2012). Due to earlier involvement in sports, talented gymnasts must be recognized earlier than in other sports (Virkki & Kalaja, 2019). For an athlete to succeed in artistic gymnastics, it is necessary to achieve a higher level of skill and physical fitness, such as: flexibility, power, speed, balance, and strength (Sleeper et al., 2012). A review of the literature leads to the conclusion that flexibility is the biggest discriminator of gymnastics from all other sports (Sands et al., 2016). The most used tests for evaluating flexibility in artistic gymnastics are split, which was used in 33% of studies; the bridge test and sit- and-reach test (Vernetta et al., 2022). There is a lack of research using split tests in preschoolers. The split test was used in the study of Šadura et al. (1991) on a sample of 39 gymnasts aged 6 and 7 years where some metric characteristics were measured, so the reliability measure for the front split is 0,98, while for the middle (side) split it is 0,93. The measure of representativeness is 0,78 for the front split and 0,72 for the middle split. In the systematic review of Salse - Batan et al. (2022) 16 studies were reviewed in which the reliability of physical tests in gymnastics was determined; and the results for split test are ICC= 0,998, while r2= 0,52. The bridge test was used in a study with 46 gymnasts of 9.9±1.3 years old and the ICC for the test is 0,89 ($p<0,01$) (Kritikou et al., 2017). For sit-and-reach test the metric characteristics according to Metikoš et al. (1989) is 0,99 for reliability; 0,77 for representativeness and 0,99 for homogeneity.

The research will be conducted on children aged 5 and 6, because according to the sensitive phases of the development of abilities, flexibility can be really affected in earlier age of childhood (Donti et al., 2022). In general, there are no recent studies with validated and reliable battery of test for evaluating flexibility in preschoolers. Given the early selection of children for elite gymnastics and their involvement in systematic training from a young age, it is crucial to conduct testing using valid and reliable measures, which forms the problem of this research. The aim of this paper is to determine some of the metric characteristics of tests for evaluating flexibility specific to artistic gymnastics so that coaches can include them in their plan and program as an auxiliary factor in determining the first selection from the recreational group.

Methods
Participants
Twenty- six preschool children participated in this study (age 5,42± 0,50 years) of which 20 are female (age 5,45± 0,51 years) and 6 are male (age 5,33± 0,51 years). All participants practice in the gymnastic club twice a week for an hour in the recreational gymnastics in Croatian academic gymnastics club Mladost The research was approved by the Faculty of Kinesiology University of Zagreb ethics committee (number 101/2023.) and the consent of the parents was signed.

Sample variables
The sample of variables consists of tests for evaluation of motor abilities (Table 1)

Table 1. Tests for evaluation of flexibility

Variable name	Abbreviation	Measuring unit	Motor abilities
Middle (side) split	MS	cm	Hip flexibility
Right front split	RFS	cm	Hip flexibility
Left front split	LFS	cm	Hip flexibility
Gymnastics bridge	GB	cm	Shoulder flexibility
Sit- and- reach test	SRT	cm	Hamstring and lower back flexibility

1. Middle (side) split (MS) and front split (DFS)
Description: Legs are in line with each other and extended in opposite directions of the torso (side split) or extending one leg forward and other leg to the rear of the torso (front split). The distance between the middle of the legs and the floor is measured with measurement tape. The results are expressed in centimeters (cm). The test is repeated three times in a row.

2. Gymnastics bridge (GB)
Description: The initial position is from lying on the back, the palms are placed next to ears and the knees are bent. The position of the bridge is reached by extending the elbows and hyperextension of the lumbar spine. The distance between the wrist and the heel was measured in the bridge position with the measurement tape. The results are expressed in centimeters (cm). The test is repeated three times in a row.

3. Sit and reach test (SRT)
Description: The initial position is in a seated position with spread legs. The arms go forward as much as the person can while the knees are straight. The position is held as long as the measurer measures the distance from the navel to the floor with the measurement tape. The results are expressed in centimeters (cm). The test is repeated three times in a row.

Testing procedures
All participants practice gymnastics twice a week for 60 minutes. During the training session of recreational program, one of the coaches individually tested one participant at a time in all the variables listed under Sample variables, and the other coach conducted the usual gymnastics training with the other participants. Each subject performed each test three times and all three measurements were recorded in the measurement table.

Data analysis
An online tool for creating spreadsheets (Microsoft Excel, 2023) was used for data entry, and the Statistica 14.0 program was used for data processing and analysis (Statsoft, Inc., Tulsa, OK, USA). Metric characteristics were calculated for all tests listed under Sample variables. Reliability was determined by the Reliability/Item test, and Cronbach, standardized alpha and average inter- item corr. were calculated. Sensitivity was determined by the Kolmogorov- Smirnov test for normality of distribution. Homogeneity was determined by the correlation test and factor validity by factor analysis.

Results
Table 2. Descriptive characteristics

N=26	AS	SD	Skew	Kurt	K-S	p
MS1	13,38	7,09	-0,62	-0,70	0,14	p<,15
MS2	12,65	6,38	-0,73	-0,22	0,14	p<,15
MS3	11,73	6,25	-0,69	-0,63	0,18	p<,05
RFS1	11,31	4,44	0,29	0,99	0,10	**p>,20***
RFS2	10,54	3,99	0,04	0,53	0,13	**p>,20***
RFS3	10,15	3,70	-0,50	0,15	0,11	**p>,20***
LFS1	11,42	3,43	-0,40	-0,67	0,11	**p>,20***
LFS2	10,73	3,61	0,03	-0,71	0,16	p<,05
LFS3	10,35	3,30	-0,15	-0,66	0,15	p<,10
GB1	60,04	13,44	1,02	1,66	0,13	**p>,20***
GB2	59,85	12,90	1,08	-0,65	0,10	**p>,20***
GB3	60,35	11,73	0,45	-0,65	0,13	p<,20
SRT1	8,77	5,60	0,46	-0,90	0,19	p<,01
SRT2	7,62	5,32	0,50	-0,45	0,14	p<,15
SRT3	7,31	5,22	0,38	-0,67	0,12	**p>,20***

Legend: 1- first measurement, 2- second measurement, 3- third measurement, AS- mean value, SD- standard deviation, Skew- coefficient of asymmetry, Kurt- coefficient of curvature, K-S- the value of the Kolmogorov- Smirnov test, p- significance value, *- statistically significant

Table 3. Correlation for MS- middle split

	MS1	MS2	MS3
MS1	1,00	**0,96***	**0,95***
MS2	**0,96***	1,00	**0,96***
MS3	**0,95***	**0,96***	1,00

Table 4. Correlation for RFS- right front split

	RFS1	RFS2	RFS3
RFS1	1,00	**0,91***	**0,89***
RFS2	**0,91***	1,00	**0,94***
RFS3	**0,89***	**0,94***	1,00

Table 5. Correlation for LFS- left front split

	LFS1	LFS2	LFS3
LFS1	1,00	**0,91***	**0,92***
LFS2	**0,91***	1,00	**0,95***
LFS3	**0,92***	**0,95***	1,00

Table 6. Correlation for GB- gymnastics bridge

	GB1	GB2	GB3
GB1	1,00	**0,95***	**0,89***
GB2	**0,95***	1,00	0,91*
GB3	**0,89***	**0,91***	1,00

Table 7. Correlation for SRT- sit and reach test

	SRT1	SRT2	SRT3
SRT1	1,00	**0,98***	**0,97***
SRT2	**0,98***	1,00	**0,99***
SRT3	**0,97***	**0,99***	1,00

Table 8. Reliability

	MS	**RFS**	**LFS**	**GB**	**SRT**
Cronbach's alpha	0,98	0,97	0,97	0,97	0,99
Standardized alpha	0,99	0,97	0,97	0,97	0,99
Average inter- item corr.	0,96	0,92	0,93	0,92	0,98

Table 9. Factor analysis

	Factor 1	Explained variance	Total proportion
MS1	-0,98	2,92	0,97
MS2	-0,99		
MS3	-0,99		
RFS1	-0,96	2,83	0,94
RFS2	-0,98		
RFS3	-0,97		
LFS1	-0,97	2,86	0,95
LFS2	-0,98		
LFS3	-0,98		
GB1	-0,97	2,83	0,94
GB2	-0,98		
GB3	-0,96		
SRT1	-0,99	2,96	0,99
SRT2	-1,00		
SRT3	-0,99		

Table 10. Eigenvalue and percentage of total explained variance of all tests

	Eigenvalue	% Total variance	Cummulative eigenvalue	Cummulative %
MS	2,92	97,23	2,92	97,23
RFS	2,83	94,28	2,82	94,28
LFS	2,86	95,17	2,86	95,17
GB	2,83	94,35	2,83	94,35
SRT	2,96	98,54	2,96	98,54

Discussion

Based on the obtained results (Table 2), sensitivity was determined in the test RFS in all three measurements (p>,20). In the LFS test, sensitivity was obtained in the first measurement (p>,20). There is possibility that the second and third measurements are not sensitive due to the fatigue of the gymnasts. As for the bridge test, the first and second measurement show the sensitivity of the test (p>,20), while in the SRT test only the third measurement has the sensitivity of the test with p>,20. The reason for this may be the practice, where the flexibility increased with each repetition (p value in SRT1<,01; in SRT2<,15, while in SRT3 the p value is >,20. Other tests (MS) do not show sufficient sensitivity. According to the correlation test (Table 3- Table 7), all tests show a strong correlation, which means that the tests are homogeneous (>0,89). Sensitivity can also be concluded based on the value of the Kolmogorov-Smirnov test (Table 2), where the results show normal curvature (0,10 ≥ 0,18) for all tests. High reliability is confirmed by the results of Cronbach's alpha, standardized alpha and inter- item corr. where in all tests they are more than 0,90 (Table 8). These results confirmed the results obtained by Šadura et al. (1991) and Salse- Batan et al. (2022) in which high reliability was established in both front split (0,98; Šadura et al., 1991) and middle split (0,93; Šadura et al., 1991). Based on factor analysis, one factor was obtained in all tests, and the explained variance (Table 9) and eigenvalue (Table 10) in MS is 2,92; in RFS and GB it is 2,83; in LFS 2,86 and the largest explained variance and eigenvalue is in SRT, and it is 2,96 (Table 9 and Table 10). Total proportion in MS is 0,97; in RFS and GB is 0,94; in LFS is 0,95 and it is the highest in SRT where it is 0,99 (Table 9). These results confirm the factor validity of the tests. Results of this research confirm the results of previous research (Šadura et al., 1991; Salse- Batan et al., 2022; Metikoš et al., 1989).

Conclusion

Due to early selection in artistic gymnastics, it is important to recognize young talents in time and direct them to first selection. Since flexibility is considered one of the important motor skills essential for success, it is important to find reliable and valid tests to be used in the coach's plan and program. This research determines the metric characteristics of flexibility tests: middle split, front split (right and left), gymnastics bridge and sit- and- reach test. The results show a high correlation and normal curvature which confirms the sensitivity, reliability, homogeneity, and factorial validity of the tests. Based on the results, it is recommended to use these tests to evaluate flexibility. For future research, it is recommended to carry out the procedure on a larger number of subjects and determine the impact of flexibility on the final success of the gymnasts.

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DIFFERENCES IN FLEXIBILITY OF LOWER EXTREMITIES BETWEEN ARTISTIC AND RHYTHMIC GYMNASTICS

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Abstract
Rhythmic and artistic gymnastics are akin sports, with flexibility in performing body difficulties as one of the main links between them. To determine the differences in active and passive flexibility, as well as the differences in flexibility between dominant and non-dominant side of the body, 7 tests of active and passive flexibility, constructed by the International Gymnastics Federation (FIG), were used. The sample of respondents consisted of 21 rhythmic and artistic gymnastics competitors (7 male artistic gymnasts, 7 female artistic gymnasts and 7 rhythmic gymnasts) of junior and senior category, A program. The Mann-Whitney U test for independent samples was used for differences in total flexibility between sports, while the Sign test for dependent samples was used for differences between the dominant and non-dominant side in each sport seperately. The results show that there is a statistically significant difference in active and passive flexibility between all three sports, while the biggest difference between the dominant and non-dominant side of the lower extremities was recorded in rhythmic gymnastics.

Keywords: *aesthetic sports, flexibility, asymmetry*

Introduction

Rhythmic gymnastics is a juncture of sport and art, created under the great influence of ballet and modern dance. Rhythmic gymnasts, as individuals or part of a group, perform their routines accompanied by music with one of the five apparatuses: rope, hoop, ball, clubs or ribbon (FIG, 2024). Flexibility, strength, endurance, coordination, agility, balance and rhythm are the abilities that are dominant for the performance of body and apparatus difficulties at a high level (Polat & Gunay, 2016; Batista, Rui & Avila-Carvalho, 2019). It should be emphasized that flexibility is the most important ability that stands out as a contributing factor to performance in rhythmic gymnastics (Di Cagno et al. 2009; Douda et al. 2008; Miletić et al. 2004; Rutkauskaitė & Skarbalius 2009, 2011; Batista et al., 2019). With roots in Ancient Greece, men's artistic gymnastics is a sport in which gymnasts in six different disciplines (floor exercise, pommel horse, still rings, vault, parallel bars and horizontal bar) combine speed, strength and flexibility while demonstrating various acrobatic elements and skills (FIG, 2024). Women's artistic gymnastics is one of the most popular women's sports, in which, with a thrilling combination of daring and grace and an emphasis on agility, art, flexibility and strength, gymnasts perform challenging elements in four disciplines (vault, uneven bars, beam and floor exercise) (FIG, 2024). Flexibility, according to Milanović (2013), can be defined as the ability to perform movements with a large amplitude, of which, the most common measure is the maximum amplitude of movement of body parts in individual joint systems. A higher level of flexibility enables a higher level of technical performance, which consequently leads to improved competitive results (Boligon et al., 2015). The selection of children into the sport of gymnastics starts at an early age (3-6 years). Childhood, between the ages of six and eleven, is a crucial time for the development of flexibility and is considered a "window of opportunity" (Lloyd and Oliver, 2012). One of the possible mechanisms for this assumption is increased flexibility and reduced muscle-tendon stiffness, which enables a greater range of motion to be achieved and thus can make flexibility training more effective (Kubo et al., 2001). It is also necessary to emphasize that the importance of flexibility is specific to each sport, so in sports such as gymnastics and dance, children must be able to perform technical elements with a very large range of motion from an early age (7-9 years) (Sands et al. , 2016). With the increasingly rapid development of sports, the need for a higher level of performance is also increasing and gymnasts, in order to adapt to the changes, go through a series of physiological adaptations (Kyselovičová et al., 2023). In theory, rhythmic gymnastics aims at bilateral performance of exercises, but in reality, in order for gymnasts to perform each element at a high level, training often consists of repetitive motor actions only with the dominant side, which eventually results in unilateral training (Teixeira & Paroli, 2000; Zaidi, 2011). Disbalance (eg during movement performance) and body asymmetries lead to an increase in the risk of injury. The appearance of asymmetries can be present between the agonist and antagonist muscles of the same side of the body/extremity or between the dominant and non-dominant side of the body/extremity (Keelley et al., 2011; Čeklić and Šarabon, 2021). International Gymnastics Federation, FIG (2021), developed a battery of tests to assess active and passive flexibility. The performance of the tests requires work on both lower extremities, which, in addition to overall flexibility, enables coaches to see the level of flexibility of the dominant and non-dominant lower extremities, thus indicating the presence of asymmetries, if they exist. It has been established that the symmetry of movements affects the improvement of technique, the reduction of physical load on the dominant side of the body and the prevention of injuries (Starosta, 2018; Aydin et al., 2023) and that the development of the skills of the non-dominant side protects health and contributes to the beauty of the composition, in terms of the variety of movements (Aydin et al., 2023). Despite the growing number of researches and constructed tests, a large number of coaches still do not use the available data in the detection of disbalances and the training of their athletes. This indicates the need for better education of professional staff, especially when it comes to the training process of a sensitive group such as children.

Main goal and hypotheses

The main purpose of this paper is to determine whether there is a statistically significant difference in the active and passive flexibility of men's and women's artistic gymnastics and rhythmic gymnastics competitors, as well as to check whether there are asymmetries in performance between the dominant and non-dominant side of the lower extremities. In this way, coaches will get an insight into the state of flexibility of their athletes and, depending on the test results, they will be able to further plan and correct the training process, if necessary. From this, the following hypotheses are established:

H_1: there is a statistically significant difference in active and passive flexibility between male and female artistic gymnasts and rhythmic gymnasts and

H_2: there is a statistically significant difference in active and passive flexibility between the dominant and non-dominant lower extremity of male artistic gymnasts, female artistic gymnasts and rhythmic gymnasts.

Sample of respondents

The sample of respondents consists of 21 gymnasts, where 7 respondents are men's artistic gymnasts (18 ± 5 years old), 7 women's artistic gymnasts (16 ± 4 years old) and 7 rhythmic gymnasts (16 ± 2.7 years old) of the competitive A program, junior and senior categories. The condition for participation in the research was the complete absence of illness, painful conditions or injuries that could affect the final result or whose condition could be worsened by participation. Before conducting the research, all respondents were informed about the protocol and the purpose of the research and declarations of voluntary participation in the research were signed. Also, in addition to the protocol itself, the possible risks of performing the tests were stated. For minor gymnasts, the declarations were signed by their parents, while adult gymnasts signed the declarations themselves. The research was approved by the Ethics Committee of the Faculty of Kinesiology, University of Zagreb.

Measurement protocol and tests

The research was conducted in "SC Lučko", "ZTD Hrvatski sokol" and Arena Zagreb, where gymnasts usually have their training sessions. Before the tests, the gymnasts warmed up for at least an hour so that they could give their best during the tests and reduce the possibility of injury to a minimum. For the purpose of research, 7 tests of active and passive flexibility, constructed by the International Gymnastics Federation (FIG), were performed. Tests are performed on both lower extremities in order to determine, in addition to overall flexibility, whether there are differences between the dominant and non-dominant side. Each test was recorded and photographed with the camera of the Samsung Galaxy S21+ mobile phone, with the help of which the performances were later given appropriate grades from 1 to 10 according to certain criteria. The scoring criterion is determined by degrees from 0° to 90°, where the starting point of each test is the leg raised at 90°, which actually stands for zero. A score of 1 indicates that the test was performed the worst, while a score of 10 indicates the maximum performance of the test. Each test is performed first on the non-dominant leg and then on the dominant leg, with the end position of each test held for a minimum of two seconds, so that the performance can be recorded on camera. Tests used to assess passive flexibility are front split with help of hand, side split with help of hand, back split with help of hand and forward-backward split between two blocks, while tests used to assess active flexibility are front split without help of hand, side split without help of hand and back split „penche“. The respondents performed two additional flexibility tests (trunk bend forwards and shoulder mobility test), but given that they do not indicate asymmetries between the dominant and non-dominant side of the lower extremities, they were not used in further analyses.

Data processing

Microsoft Excell 365 was used for better transparency and easier data processing, while Statistica 14.1.0 was used for further analysis. Before processing the data, to select the statistical procedure (parametric or non-parametric tests), the normality of the distribution was checked. For differences between the dominant and non-dominant side of the lower extremities, the Sign test for dependent samples was used, while the Mann-Whitney U test for independent samples, with a statistical error of $p < 0.05$, was used for the difference in total active and passive flexibility between male artistic gymnasts, female artistic gymnasts and rhythmic gymnasts.

Results

The results in Tables 2, 3 and 4 show that there is a statistically significant difference in active and passive flexibility between competitors in rhythmic, women's artistic and men's artistic gymnastics, which confirms the first H_1 hypothesis. Furthermore, in tables 5 and 6, the results show that there is also a statistically significant difference in active and passive flexibility between the dominant and non-dominant lower extremity in rhythmic and women's artistic gymnastics, while men's artistic gymnastics is the only group in which there are no differences in any test. Therefore, the second H_2 hypothesis, can be partially accepted.

Table 1. List and description of variables and marks

Variable	Description of variable	Mark
FSWH DOM	Front split with help of hand – dominant leg	1 – 10
FSWH NDOM	Front split with help of hand – non - dominant leg	1 – 10
FSWH SUM	Front split with help of hand (sum of marks for both legs)	1 – 10
FSWOH DOM	Front split without hand – dominant leg	1 – 10
FSWOH NDOM	Front split without hand – non - dominant leg	1 – 10
FSWOH SUM	Front split without hand (sum of marks for both legs)	1 – 10
SSWH DOM	Side split with help of hand – dominant leg	1 – 10
SSWH NDOM	Side split with help of hand – non - dominant leg	1 – 10
SSWH SUM	Side split with help of hand (sum of marks for both legs)	1 – 10
SSWOH DOM	Side split without hand – dominant leg	1 – 10
SSWOH NDOM	Side split without hand – non - dominant leg	1 – 10
SSWOH SUM	Side split without hand (sum of marks for both legs)	1 – 10
BSP DOM	Back split „penche" – dominant leg	1 – 10
BSP NDOM	Back split „penche" – non - dominant leg	1 – 10
BSP SUM	Back split „penche" (sum of marks for both legs)	1 – 10
BSWH DOM	Back split with help of hand – dominant leg	1 – 10
BSWH NDOM	Back split with help of hand – non - dominant leg	1 – 10
BSWH SUM	Back split with help of hand (sum of marks for both legs)	1 – 10
FBS DOM	Forward – backward split between two blocks – dominant leg	1 – 10
FBS NDOM	Forward – backward split between two blocks – non - dominant leg	1 – 10
FBS SUM	Forward – backward split (sum of marks for both legs)	1 – 10

Table 2. Difference of active and passive flexibility between rhythmic and women's artistic gymnastics

	Mann-Whitney U Test, with an error p <,05									
Variable	Rank Sum RG	Rank Sum ŽSG	U	Z	p-value	Z adjusted	p-value	Valid N RG	Valid N ŽSG	2*1sided exact p
SSWH SUM	73,00	32,00	4,00	2,55	0,01	2,60	0,00	7	7	0,00
SSWOH SUM	70,50	34,50	6,50	2,23	0,02	2,25	0,02	7	7	0,01
BSWH SUM	76,50	28,50	0,50	3,00	0,00	3,01	0,00	7	7	0,00
FBS SUM	69,50	35,50	7,50	2,10	0,03	2,11	0,03	7	7	0,02

Table 3. Difference of active and passive flexibility between rhythmic and men's artistic gymnastics

	Mann-Whitney U Test, with an error p <,05									
Variable	Rank Sum RG	Rank Sum MSG	U	Z	p-value	Z adjusted	p-value	Valid N RG	Valid N MSG	2*1sided exact p
FSWH SUM	76,00	29,00	1,00	2,93	0,00	2,96	0,00	7	7	0,00
FSWOH SUM	75,50	29,50	1,50	2,87	0,00	2,89	0,00	7	7	0,00
SSWH SUM	77,00	28,00	0,00	3,06	0,00	3,09	0,00	7	7	0,00
SSWOH SUM	76,50	28,50	0,50	3,00	0,00	3,02	0,00	7	7	0,00
BSP SUM	77,00	28,00	0,00	3,06	0,00	3,10	0,00	7	7	0,00
BSWH SUM	77,00	28,00	0,00	3,06	0,00	3,27	0,00	7	7	0,00
FBS SUM	77,00	28,00	0,00	3,06	0,00	3,27	0,00	7	7	0,00

Table 4. Difference of active and passive flexibility between men's and women's artistic gymnastics

	Mann-Whitney U Test, with an error p <,05									
Variable	Rank Sum ŽSG	Rank Sum MSG	U	Z	p-value	Z adjusted	p-value	Valid N ŽSG	Valid N MSG	2*1sided exact p
FSWH SUM	70,50	34,50	6,50	2,23	0,02	2,25	0,02	7	7	0,02
FSWOH SUM	74,00	31,00	3,00	2,68	0,01	2,70	0,01	7	7	0,00
SSWH SUM	72,50	32,50	4,50	2,49	0,01	2,49	0,01	7	7	0,01
SSWOH SUM	73,50	31,50	3,50	2,61	0,01	2,63	0,01	7	7	0,00
BSP SUM	76,00	29,00	1,00	2,93	0,00	2,96	0,00	7	7	0,00
BSWH SUM	77,00	28,00	0,00	3,06	0,00	3,29	0,00	7	7	0,00
FBS SUM	77,00	28,00	0,00	3,06	0,00	3,27	0,00	7	7	0,00

Table 5. Difference of active and passive flexibility between dominant and non-dominant lower extremity in rhythmic gymnastics

	Sign Test, with an error p <,05			
Pair of variables	No. of Non-ties	Percent v < V	Z	p-value
FSWH DOM & FSWH NDOM	6	0,00	2,04	0,04
FSWOH DOM & FSWOH NDOM	7	0,00	2,27	0,02
SSWH DOM & SSWH NDOM	7	0,00	2,27	0,02
SSWOH DOM & SSWOH NDOM	7	0,00	2,27	0,02
BSP DOM & BSP NDOM	6	0,00	2,04	0,04
BSWH DOM & BSWH NDOM	6	0,00	2,04	0,04
FBS DOM & FBS NDOM	7	0,00	2,27	0,02

Table 6. Difference of active and passive flexibility between dominant and non-dominant lower extremity in women's artistic gymnastics

Pair of variables	Sign Test, with an error p <,05			
	No. of Non-ties	Percent v < V	Z	p-value
FSWOH DOM & FSWOH NDOM	6	0,00	2,04	0,04
SSWH DOM & SSWH NDOM	6	0,00	2,04	0,04
SSWOH DOM & SSWOH NDOM	6	0,00	2,04	0,04
FBS DOM & FBS NDOM	7	0,00	2,27	0,02

Discussion and conclusion

As shown in the results, there is a statistically significant difference in the total active and passive flexibility of the lower extremities between the competitors of rhythmic, women's artistic and men's artistic gymnastics. While there is a statistically significant difference in all tests between rhythmic gymnastics and men's artistic gymnastics, as well as women's and men's artistic gymnastics, the difference between rhythmic and women's artistic gymnastics is somewhat smaller and mostly refers to tests of passive flexibility (side split with help of hand, back split with help of hand and forward-backward split between two blocks) and one test of active flexibility (side split without help of hand). Furthermore, when it comes to active and passive flexibility of the dominant and non-dominant lower extremity in each sport, the largest number of differences exist in rhythmic gymnastics (asymmetries in all tests), followed by women's artistic gymnastics (asymmetries in front split without help of hand, side split with help of hand, side split without help of hand and forward-backward split between two blocks), while in men's artistic gymnastics there are no differences between the dominant and non-dominant lower extremity. Since rhythmic gymnastics is a sport in which flexibility plays a very important role in the performance of the elements and the emphasis is on the maximum range of motion, which is why the elements are mostly practiced only on the dominant side, the test results are not that unexpected. Batista et al. (2019), obtain similar results in their research on active and passive flexibility and functional asymmetries, where the tested groups of rhythmic gymnasts show large differences between the dominant and non-dominant lower extremity (69% in passive and 71% in active flexibility). According to the results of Santos et al. (2015), the level of active and passive flexibility of gymnasts was higher for their dominant lower limb than for their non-dominant lower limb. Such results can be explained by the majority unilateral work, especially during the competitive period. This indicates the need for more frequent testing and monitoring of athlete's abilities, as well as the use of available tests in detection and correction of weaknesses, in order to prevent the occurrence of possible painful conditions and injuries in the future. Further testing is also proposed, which will include a larger number of gymnasts, and thus provide a better insight into the overall situation in each gymnastics discipline.

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THE RELATIONSHIP OF REACTIVE AND PLANNED AGILITY AND SELECTED MOTOR INDICATORS TO GAME PERFORMANCE OF FEMALE PLAYERS IN VOLLEYBALL

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Abstract
The main goal of our research was to determine the relationship of different types of agility and selected motor indicators to the game performance of female volleyball players. There were 10 players (average age 17.2 ± 2,27 y.; height 173.2 ± 9,8 cm), in the team of Volley Project UKF Nitra. Witty SEM system and photocells (Microgate) and Fitro Jumper (Fitronic) were used for testing. Then there were used T agility test, velocity (5m and 10m sprint) and explosive strength of the lower limbs (DJ, CMJ, Swing). Evaluation of game performance was realized by the sports analysis tool Data Volley 4 (Data Project). We found relationship between the indicator of game performance "Vote" with velocity 5m sprint ($r = -0.587$, $p = 0.074$) and the indicator of explosive strength of the lower limbs DJ ($r = 0.552$, $p = 0.098$). Another relationship at the 5% ($p<0.05$) level of statistical significance with opposite polarity between the "Defensive Agility" test and the game performance indicator "Vote" ($r = -0.685$, $p = 0.029$). Other statistically significant relationships are between indicators of the explosive strength of the lower limbs (DJ, CMJ, Swing) and the 10m sprint, and between DJ and CMJ with tests of reactive agility "Defensive Agility" and planned agility (T agility test). Based on the results of our research, we recommend trainers to focus on the development of agility and the improvement of speed and strength abilities in the training process.

Keywords: *volleyball, reactive and planned agility, game performance, motor abilities*

Introduction

Our opinion agrees with the statement of the author Wilson et al. (2020) that agility is difficult to define from a technical point of view. Some experts still traditionally refer to it as the physical activity of stopping, turning, and starting, without recognizing that the brain and the ever-changing, dynamic nature of the sport can influence agility performance to some extent. We tend to prefer the definitions by the authors Sheppard & Young (2006) or also the statement by Verstegen & Marcello (2001), who presented agility as a complex movement ability. The players can change their way of move, slow down or speed up the direction in response to a stimulus related with a role that can be represented by an opponent or anticipation of a pass from a teammate. Brown & Ferrigno (2005), who defined agility as the ability to accelerate, decelerate and stop, while the sportsman changes the position of the body quickly and explosively. Then he will start at the highest possible speed he can produce.

Horička et al. (2018) agreed that there are four important abilities to achieve the highest level of reactive and planned agility: speed abilities, coordination abilities, dynamic strength, and dynamic balance. According to Bompa (2000), the high level of agility of an athlete is determined by the speed of changing direction and the decision-making and cognitive processes of the individual.

Měkota & Cuberek (2007) claim that closed skills are characterized as stable and predictable in terms of their implementation. There is not important to predict any complicated situation for sportsman without a time limit or the demands of the environment. However, according to Horiička et al. (2018), this is difficult to apply in sports matches, because the game and its course changes and develops every moment. Paul et al. (2016) supports the idea of using open-ended skills in the training process, where individuals use both physical and cognitive stimuli.

Light & Evans (2017) state that it is not always possible to train for all scenarios involving agility that may occur during a match. The movements of players in invasive sports can be hectic and at this point, athletes are required to engage their creativity and ingenuity in adverse game conditions. It is an extremely important ability that encompasses the mental, technical, and physical aspects of an individual. Other factors affecting performance in sports are perceptual and decision-making skills (Paul et al., 2016). Sekulic et al. (2019) state that agility in games requires a multifaceted analysis that considers decision-making, perceptual abilities and physical fitness. The lack of agility testing has resulted in the athlete being forced to rely on simple reaction time paradigms during competition, which are characteristic of lower cognitive functions (Morral-Yepes et al. 2020).

Methods

Ten female volleyball players participated in this study. They were playing in the first women junior league in Slovakia. (n=10, mean decimal age: 17.2 ± 2.27 years, height: 173.2 ± 9.8 cm, body weight: 66.6 ± 31.4 kg). All players involved in the study had to complete at least 80% of the total number of training sessions.

Indicators of selected motor abilities such as: reactive agility test (RAT) was chosen Y-agility test (Horníková & Zemková, 2022), planned agility test (PAT) was chosen T-test (Paoule, 2000), Modified Shuttle run test with "offensive" movement on reactive stimuli (Sekulic, et al 2014) and Modified Shuttle run test "defensive" movement on reactive stimuli (Sekulic et al, 2014). All agility tests were realized using Witty Sem (Microgate Bolzano, Italy). Explosive strength of lower limbs was recorded by the Drop jump (Pedley, 2017), Counter movement jump (Heishman et al, 2013) and countermovement jump with arm swing (Heishman et al, 2013). Evaluation of game performance of players "Vote" was realized by using Datavolley 4 (Rajič, 2019). Anthropometric parameters such as body height and body weight were also included in this study.

The testing was carried out once during the competition period, when the members of the team completed a weekly microcycle of 5-8 training units lasting 90-120 minutes. The conditions in which the testing took place were standard, we carried out a thorough warm-up of 15 minutes.

The evaluation of the obtained data took place as follows: the normality of the sample distribution was realized by the Shapiro-Wilk test. Subsequently, we continued with the correlation analysis (Pearson). The correlation analysis was realized from the available data, which were prepared in MS Excel sheets. Subsequently, we evaluated the correlation matrix and marked the stronger correlation coefficients, and we were interested in the 1, 5 and 10% level of statistical significance (Boruvkova et al., 2014). An alternative significance level of 10% was used based on research in team sports, where higher level of significance than 1% and 5% were also used in research Peráček & Hrnčiarik (2012) or Paška et al. (2019, 2023). Later there were statistically evaluated the measured values using the SPSS program also tables and graphs processed in the Microsoft Excel program to record the obtained data in our research.

The study protocol was approved by the Ethics Committee of the Faculty of Education of the University of Nitra (registration number: UKF-2020/1355-1:191013) in accordance with the conclusions of the Declaration of Helsinki.

Results

Microgate's Witty SEM system and photocells were used for RA testing. There were used modified shuttle run tests, considering the offensive or defensive movement together reaction stimulus that occurs in volleyball (Table 1). The mean of the "offensive" test was 18.92s (Std. 1.02), while the "defensive" agility test had a Mean of 22.62s (Std. 1.37). In these two modifications, the player with the identification number H5 dominated, whose best time was 17.19s in the "offensive" and 21.09s in the "defensive" test. The weakest performance in the first test was H9 with a time of 20.71s and in the second test H6 with a time of 25.23s where she was 4.14s slower than the player with the fastest time. Mean Y Agility test 5x3m was 2.81s (Std. 0.14). The fastest tested in this test was the H8 with a time of 2.46s, and the slowest time was recorded in H9 with a time of 3.10s, where it was behind its teammate by 0.64s. We used the same equipment for the planned agility test. In the T Agility test, player H5 had the best time of 9.94s. Her teammate H3 was the slowest by 1.48s, whose performance was up to 11.42s. The mean of this test was 10.80s (Std. 0.46). The mean of the last test of maximum acceleration speed on a short running track was 1.86s (Std. 0.08). Volleyball player H8 dominated the sprint with the fastest total time of 1.74s. The tested H1 was evaluated in this test with the slowest time of 1.98s.

Table1 Motor indicators

	Shuttle run (offensive)	Shuttle run (defensive)	Y Agility test	T Agility test	5m sprint	10m sprint
Max.	20.71s	25.23s	3.10s	11.42s	1.13	1.98
Min.	17.19s	21.09s	2.46s	9.94s	0.62	1.74
Mean	18.92	22.62	2.81	10.80	0.96	1.86
Std.	1.02	1.37	0.20	0.46	0.18	0.08

In our research were realized three tests using a sensory pad and the Fitro Jump program by Fitronic in our research when testing the explosive power of the lower limbs of female volleyball players (Table 2). The mean measured during the DJ test was 30.36 cm (Std. 3.54). We recorded the highest jump in the DJ test with the tested H2 with a jump height of 35.5 cm. Player H1 reached the worst result in the first test, 24.7 cm. In the second test using counter movement jump (CMJ) test, the mean was 31.54 cm (Std. 4.03). The highest jump was recorded with H8 39.3 cm and the lowest was H6 25.5 cm. In the third test using the arms (Swing) the Mean was 36.89 cm (Std. 5.09). The highest numbers in this test were again the tested H8, which jumped 43.3 cm. H1 recorded the lowest jump of 29.4 cm, which is up to 13.9 cm less than her teammate. Among the standouts of this team were the tested H5 and H8, who dominated seven of the nine tests ("Offensive and Defensive" Agility, Y Agility test 5x3, T Agility test, 10m Run, CMJ and Swing).

Table 2 Explosive strength of lower limbs

	DJ	CMJ	CMJ with Arm Swing
Max.	35.5cm	39.3cm	43.3cm
Min.	24.7cm	25.5cm	29.4cm
Mean	30.36	31.54	36.89
Std.	3.54	4.03	5.09

Subsequently, we calculated the normality of the sample. There was found that most indicators meet the condition of normality (p 0.05). Next, we continued using correlation analysis and looked for mutual relationships between the selected variables, which are determined more closely by Perarson's correlation coefficient.

Table 3 Correlation analysis (planned and reactive agility)

		OA	DA	Y test	T test	5m sprint	10m sprint	DJ	CMJ	Swing	Vote
OA	Pearson Correlation	1	0.622*	.853***	.742**	0.035	0.427	-0.542	-0.499	-0.133	-0.276
	Sig. (2-tailed)		0.055	0.002	0.014	0.924	0.219	0.105	0.142	0.713	0.441
	N	10	10	10	10	10	10	10	10	10	10
DA	Pearson Correlation	0.622*	1	0.599*	.721**	0.104	0.508	-0.577*	-.691**	-0.281	-.685**
	Sig. (2-tailed)	0.055		0.067	0.019	0.776	0.134	0.081	0.027	0.432	0.029
	N	10	10	10	10	10	10	10	10	10	10
Y test	Pearson Correlation	.853***	0.599*	1	.804***	-0.012	0.383	-0.516	-0.478	-0.209	-0.256
	Sig. (2-tailed)	0.002	0.067		0.005	0.974	0.274	0.127	0.163	0.563	0.476
	N	10	10	10	10	10	10	10	10	10	10
T test	Pearson Correlation	.742**	.721**	.804***	1	-0.004	0.517	-0.615*	-0.579*	-0.444	-0.414
	Sig. (2-tailed)	0.014	0.019	0.005		0.991	0.126	0.058	0.080	0.199	0.235

p<0.01*** - level of significance
p<0.05** - level of significance
p<0.1* - level of significance

According to the statistics we found a statistically significant relationship with a strong negative dependence at the 10% level of significance (p = 0.081) in the Drop Jump test (r = -0.577). There were recorded statistical values at the 5% (p<0.05) level of significance in the T Agility test (r = 0.721, p = 0.019), Countermovement Jump (r = -.691, p = 0.027) and in the game performance indicator "Vote" (r = -.685, p = .029). At the 10% (p<0.10) level of statistical significance (p = 0.058), a relationship between the T Agility test and the explosive power of the lower limbs DJ (r = -0.615) was demonstrated with a moderately strong negative dependence. There was a strong negative correlation between planned agility and CMJ (r = -0.579) also at the 10% level of statistical significance (p = 0.080).

Subsequently, we found a weak dependence between acceleration (10m run) and indicators of explosive power of the lower limbs Drop Jump (r = -0.922, p = 0.000) and Countermovement Jump (r = -0.868, p = 0.001), which was demonstrated at 1% (p<0.01) level of statistical significance. A moderately strong relationship at the 5% level of statistical significance (p = 0.037) was noted between the Countermovement Jump with Arm Swing and the 10-meter sprint.

Furthermore, we found statistical significance at the 1% (p<0.01) and 5% (p<0.05) levels between Drop Jump and the remaining indicators of explosive power of the lower limbs. We noted a relationship at the 1% (p<0.01) level of statistical significance (p = 0.000) between DJ and the 10m Run (r = -0.922). There were found a statistically significant relationship between planned agility and DJ at the 10% (p<0.10) level of statistical significance with a moderately strong negative dependence (r = -0.615, p = 0.058). Furthermore, a strong negative dependence (p = 0.081) and a 10% level of statistical significance was also demonstrated with the "Defensive Agility" test with a reaction stimulus, the correlation coefficient of which was (r = -0.577). A very strong positive dependence at the 10% (p = 0.098) level of statistical significance was between the DJ test and the game performance indicator "Vote", the correlation coefficient of which was (r = 0.552).

Discussion

Taye and Wondirad (2017) discussed the connection between planned agility (T Agility test) and explosive power of the lower limbs in female volleyball players in their article. The Pearson correlation coefficient at the 5% level of statistical significance (p<0.05) was used in the analysis of the obtained data. Their results show that there is no statistically significant relationship between the planned agility and the vertical jump performance of female players. Similarly, Pauole and the team (2000) in their work present low to moderate dependencies between T Agility and the indicator of explosive power of the lower limbs in women. On the contrary, we noted in our research significant statistical relationships with medium to strong dependence between the planned agility (T Agility test) and the indicators of the explosive power of the lower limbs Drop Jump (r= -0.615, p = 0.058) and Countermovement Jump (r = -0.579, p = 0.080) at the 10% level of statistical significance.

The aim of the study by Sahin (2014) was to find out how acceleration, agility and explosive power of the lower limbs are interrelated in female volleyball players. Total number of players was 12 (age x = 20.30 ± 4.244; height x = 1.74 ± 0.057m). The T Agility test, acceleration and vertical jump test were applied in the research. The test of explosive power of the lower limbs showed significant negative relationships at the 1% level of statistical significance (p<0.01) with both acceleration (r = -0.799) and agility (r = -0.777). Overall, this study demonstrated that the explosive power of the lower limbs of female volleyball players significantly affects their acceleration and planned agility. In our work, we also noted significant relationships at the 1% and 5% (p<0.05) levels of statistical significance with a weak to moderately strong dependence between the acceleration at 10m and the DJ tests (r = -0.922, p = 0.000), CMJ (r = -0.868, p =0.001) and Swing (r = -0.662, p = 0.037). A weak relationship was shown between "Defensive Agility" and CMJ (r = -0.691, p = 0.027) at the 5% level of statistical significance. With the same reactive agility test and DJ (r = -0.577, p = 0.081), we noted a strong dependence at the 10% level of statistical significance.

McFarland et al. (2016) studies focused on how the counter-movement jump (CMJ) and squat jump (SJ) relate to CODS, acceleration, and maximal speed. A total of 36 (20 men and 16 women) athletes completed tests measuring their explosive power of the lower limbs (CMJ. SJ), CODS (T Agility test, for agility) and acceleration at 10 and 30m. We were interested in the results of the female team, which showed moderate to strong dependencies between the 30m sprint, pro agility, and the T Agility test with the indicator of the explosive power of the lower limbs CMJ (r = -0.502 to -0.751) and SJ (r = -0.502 to -0.681). The results of the authors' work coincide with our findings, as in our research we noted statistically significant relationships at the 5% and 10% level of significance between the T Agility test (r = -0.579, p = 0.080), acceleration to 10m (r = -0.868. p =0.001) and CMJ.

Studies by Vencúrik et al. (2021) noted significant statistical relationships between reactive agility (Y Agility test) with lower extremity explosive strength tests and with 20m acceleration in female basketball players. Our findings differ from the authors' claims, because in the research we observed a statistically significant relationship neither between acceleration and the Y Agility reaction test, nor with indicators of the explosive power of the lower limbs. We also mention the work by Paška et al. (2023), who found a statistically significant relationship between planned agility and acceleration in the 5 and 10 m Run test. Even in this case, our results do not agree with the findings of the authors, as we did not observe statistically significant relationships between these variables in our research. The last research mentioned in the paper is the research by Đolo et al. (2022) who found non-significant statistical relationships between reactive and running agility. Here again, our results do not agree with the authors' findings, since in our measurement we found weak to moderately strong dependencies and statistically significant relationships at the 1% (p<0.01) and 5% (p<0.05) levels of statistical significance between the planned agility (T Agility test) and all applied reaction agility tests "Offensive Agility" (r = 0.742, p = 0.014), "Defensive Agility" (r = 0.721, p = 0.019) and Y Agility test (r = 0.804, p = 0.005).

Conclusion

There were reached several very interesting relationships with different dependence in our research. As the first is the relationship of planned agility (T test) and explosive strength of lower limbs (CMJ and DJ). Then we can follow with other relationship between velocity (10m sprint) and explosive strength of lower limbs (DJ. CMJ and Swing). Important relationships were also confirmed between reactive agility (defensive agility) and explosive strength of lower limbs (DJ and CMJ). Finally, we can confirm that game performance of players (Vote) was also in relationship with velocity, acceleration (5m sprint), and with explosive strength of lower limbs (DJ). We think that there can be also other important determinants which can also reach a different relationship with the planned or reactive agility. This paper should open the possibility how to look on this phenomenon. We also think that there will be new research in this field in next few years.

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DEVELOPMENT CURVE OF THE BEST RESULTS OF FEMALE PARA SWIMMERS IN THE 200 INDIVIDUAL MEDLEY IN THE SM8 CLASS

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Abstract
The aim of this study is to analyse the trend and determine the development curve of the eight and three best results and the best result in the world among female para-swimmers in the SM8 class in the 200 m individual medley. According to the statistically determined results, there is no statistical significance in any of the data sets. We can conclude that the results of the world's best female para-swimmers in the 200 m individual medley of the SM8 class show a small tendency for their constant progress which are significantly influenced by events at the global level and changes in the rules for para-swimming.

Keywords: *para-swimming, results, trend, 200m individual medley, SM8 class*

Introduction

Para-swimming can be described as a special kind of sport. The body moves through a medium that is up to 780 times denser than air (Siljeg et al., 2016). When moving through the water, there are resistances such as turbulence, waves, additional friction that can affect the speed of movement, and para-swimmers experience additional resistances due to asymmetries and different diagnoses of para-swimmers (Payton et al., 2020).

To ensure the integrity of fair competition, para-swimming has a classification system in place to ensure that victory is determined by sporting factors that are crucial to the success of non-disabled athletes. Para swimmers compete in special classes with the prefixes S (freestyle, backstroke, and butterfly) and SB (breaststroke), while SM is a combination of these two classes for performance in the individual medley events. Ten classes for S and nine classes for SB are for physical disabilities (S1-S10, SB1-SB9 from the most severe to the mildest impairment), then three classes for people with visual impairments (S11-S13 and SB11-SB13 from the most severe to the mildest impairment) and one class for people with intellectual disabilities (S14 and SB14) (WPS, 2024).

All swimming and para-swimming competitions are demanding, whether it's the 50m freestyle, backstroke, breaststroke, butterfly, 800m or 1,500m freestyle. Each event is difficult in its own way and has its own challenges, but the individual medley is certainly unique and special in its own way. All four types of swimming strokes are unique and usually require a special group of people to perform them well. However, swimmers and para-swimmers must be adequate in all four types of swimming strokes. It has been shown (Del Castillo et al., 2022) that the most important predictor variable for 200m individual medallist status was having scored more than 900 FINA points in at least one 100m event. In the same study, we see that the sprint distance events in each stroke individually for both genders have a strong correlation with the final performance in the 200 m individual medley events. Start and turn performance is found to be a differentiator in the event, and breaststroke technique may offer the greatest potential for future development of times in the individual medley race times (Born et al., 2022). To achieve a medal position in the 200 m individual medley race, men and women must achieve specific lap times in butterfly, breaststroke, and backstroke in long-course competitions (González-Ravé et al., 2023). The best para-swimmer in this event is the US Paralympic swimmer Jessica Long, who has been competing for more than 15 years and has set numerous world records and finished in the top 3 at every competition. According to a study that examined the development curve of the 8 best results of a pair of S9 para swimmers in the 50, 100 and 400 m freestyle events, it was found that with the introduction of a new classification system, there was a significant improvement in the trend of results for the 50 m and 100 m freestyle disciplines (Dragic, 2022).

The aim of this study is to analyse the trend and determine the development curve of the eight and three best results and the best result in the world among female para-swimmers in the SM8 class in the 200 m individual medley.

Methods

Participants

Women's 200m individual medley swimming results in seconds from the official websites of World Para Swimming (WPS, 2024) and the International Paralympic Committee (IPC, 2024).

Variables

The first dataset consists of the official women's 200m individual medley para-swimming results of the SM8 class from the Paralympic Games for the 20-year period from 2000 to 2021 (POI-00-20-8, RK-00-20-3). The second data list is the official women's para-swimming results in the 200m individual medley in the SM8 class at the Para Swimming World Championships for the 10-year period from 2013 to 2023 (WC-13-23-8, WC-13-23-3). The third data list is the best female results in Para swimming competitions over 200 m individual medley in the SM8 class from the official World Para Swimming Rankings for the 14-year period from 2009 to 2023 (RK-09-23-8, RK-09-23-3), starting from the first day of January to the last day of December of the same year. All data sets consist of the 8 and 3 best results and the best result (best time) from each type of competition or Para Swimming ranking list.

Data Analysis

The data were processed with the software package for statistical data processing, Statistics 14.01.25. The models of the second-degree polynomial regression function are presented in tables and graphs. All results available at the time of data collection were obtained for the Para Swimming World Championships and World Para Swimming Ranking. The study is not an animal or human intervention, and no ethical approval is required.

Results and discussion

POI-00-20-8	**Multiple R**	**R²**	**b**		**p**
			b0	436925,9	0,124021
Polinom			b1	-433,9	0,124528
Year	0,87824824	0,77131997	b2	0,1	0,124937
POI-00-20-3					
			b0	362471,9	0,078026
Polinom			b1	-359,4	0,078629
Year	0,95995581	0,92151516	b2	0,1	0,079155
WC-13-23-8					
			b0	-519352	0,793161
Polinom			b1	515	0,793022
Year	0,18075815	0,03267351	b2	0	0,792951
WC-13-23-3					
			b0	-831858	0,684796
Polinom			b1	824	0,684843
Year	0,27785113	0,07720125	b2	0	0,684949
RK-09-23-8					
			b0	294170,0	0,380564
Polinom			b1	-291,6	0,380936
Year	0,26031472	0,06776376	b2	0,1	0,381036
RK-09-23-3					
			b0	382859,9	0,131141
Polinom			b1	-379,8	0,131122
Year	0,464595	0,21584851	b2	0,1	0,130953

Table 1. The results of the second-degree polynomial regression function

According to the statistically determined results, there is no statistical significance in any of the data sets. If we look at the data obtained for the best 3-time results of the SM8 class in the 200m individual medley at the Paralympic Games from 2000 to 2021 (RK-00-20-3), we can see that the results are close to statistical significance, indicating a positive trend that the times of the event are faster in each final of the Paralympic Games from 2000 to 2023.

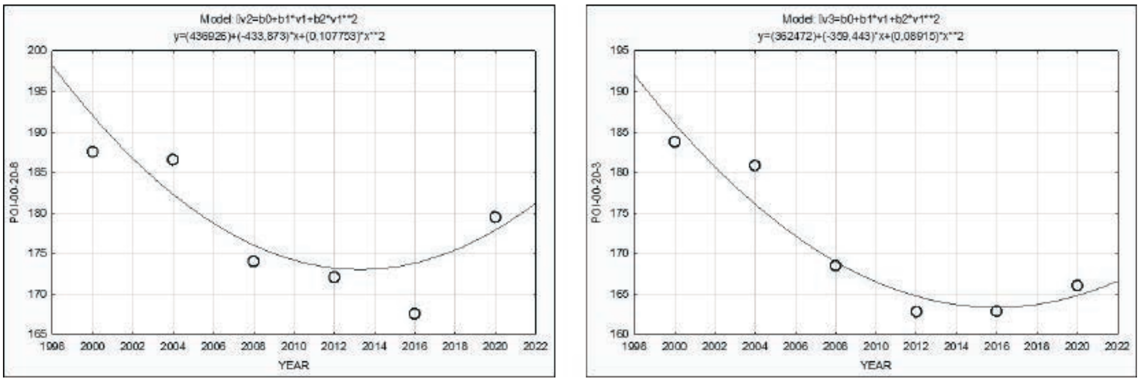

Figure 1. Diagrams of the regression function of the second-degree polynomial for the best 8 and best 3 results of the SM8 class over 200 m individual medley at the Paralympic Games 2000 to 2021 (POI-00-20-8 and POI-00-20-3).

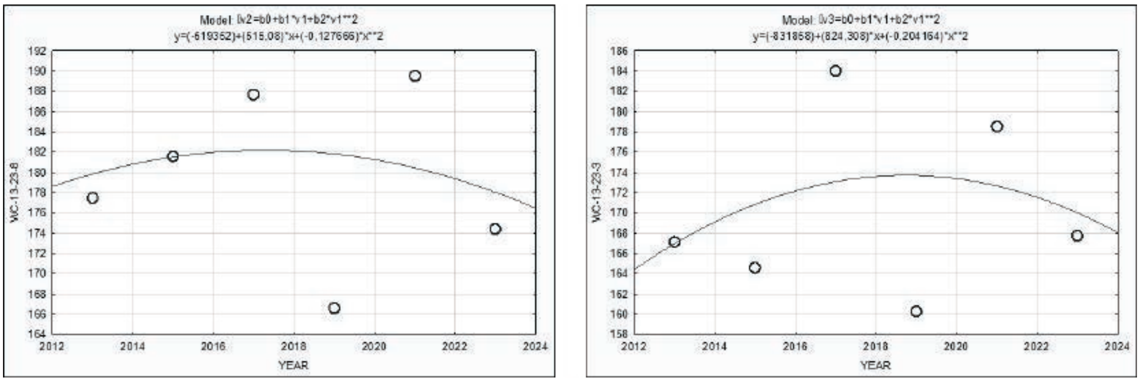

Figure 2. Diagrams of the regression function of the second-degree polynomial for the best 8 and best 3 results of the SM8 class over 200 m individual medley at the World Championships 2013 to 2023 (WC-13-23-8 and WC-13-23-3).

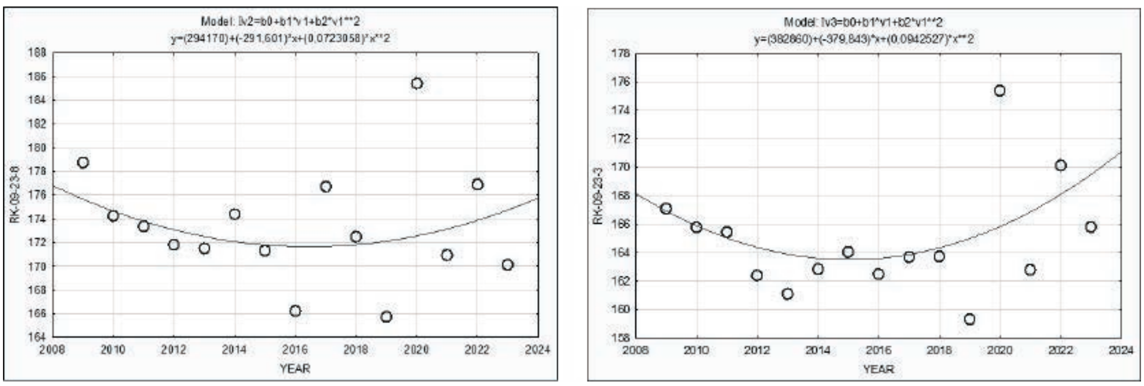

Figure 3. Diagrams of the regression function of the second-degree polynomial for the best 8 and best 3 results of the 200 m individual medley in the SM8 class from the World Para Swimming Ranking Lists for the years 2009 to 2023 (RK-09-23-8 and RK-09-23-3).

If we look at the results of the Paralympic Games (Figure 1), which took place from 2000 to 2021, we can see a positive trend of progress in the results of the 200 individual medley SM8 class until 2009, when FINA (the governing body of aquatic sports worldwide, known as World Aquatics from January 2023) restricted the use of high-tech bodysuits. After this year, we can see that the trend of progress in results over the 20 years is slowing down. Looking at the results achieved during the 10-year period of the World Championships from 2013 to 2023 (Figure 2) shows a trend where the results are getting weaker. We can see a slightly different situation and trend when we look at the results of the rankings in the period from 2009 to 2023 (Figure 3), where we can see a positive trend in the results until 2017, when the results start to have a negative trend until today.

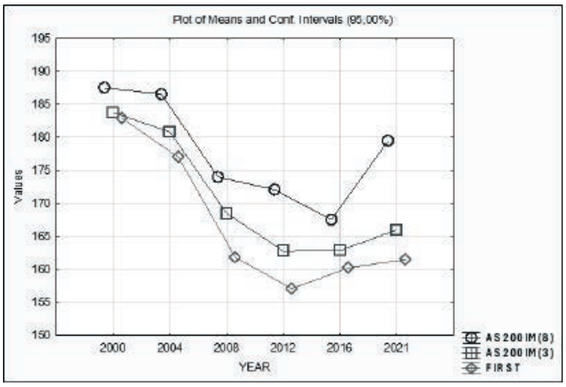

Figure 4. Plot of mean values and coefficient intervals for the Paralympic Games from 2000 to 2021 in the 200 m individual medley of the SM8 class.

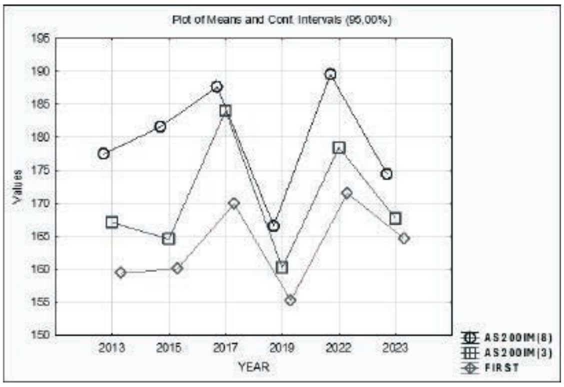

Figure 5. Plot of mean values and coefficient intervals for the World Para-Swimming Championships from 2013 to 2023 in the 200 m individual medley in the SM8 class.

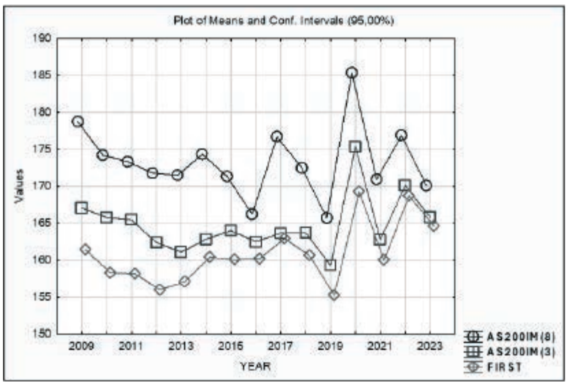

Figure 6. Plot of mean values and coefficient intervals for World Para Swimming rankings from 2009 to 2023 in the 200 m individual medley in the SM8 class.

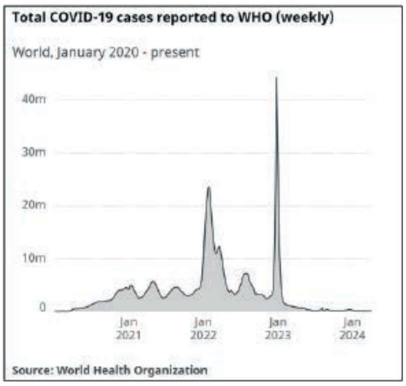

Figure 7. Total number of COVID-19 cases reported to the WHO (weekly). Source: World Health Organisation.

If we look at the mean plot of results achieved for the 20-year period of the Paralympic Games (Figure 4), we can see a positive trend in results, with para-swimmers getting faster every 4 years of a Paralympic cycle. The first place at the Paralympic Games has a positive trend until the competition in Rio 2016. The arithmetic mean of the first 3 places shows a stagnation in the further development of the results in this year. The arithmetic mean of the first 8 places (finalists) still shows a positive trend in the results. All results show a negative trend for the last Paralympic Games in Tokyo 2020, which were postponed to 2021 due to the COVID-19 pandemic (Figure 7), which started on 31 December 2019 (WHO, 2020). Training sessions were initially restricted in accordance with the regulations of the individual countries and the World Health Organisation. The unprecedented year of Olympic Games and qualifying in Tokyo does not appear to have affected the performance of all Olympic swimmers, suggesting that stakeholder support and athletes' coping skills could ensure the continuation of performance (Demarie et al., 2022). After observing the results achieved, we cannot say the same for the performances of the Paralympic swimmers, especially the 8 finalists of the Paralympic Games in Tokyo.

Plot of the mean values of the results achieved for the 10-year period of the World Championships (Figure 5) shows a slight stagnation and a slightly negative trend in the results until 2017, when a strong negative trend in the results occurs. This is due to the 7.1 magnitude earthquake in Mexico on 19 September 2017, shortly before the World Championship scheduled to take place in Mexico City from 30 September to 6 October (NASA, 2017). More than 12,000 facilities were damaged (Tena-Colunga et al., 2021) and the Para Swimming World Championship was postponed until December 2017, which significantly affected the periodization of training and results of the said championship (IPC, 2017). Many para-swimmers did not compete because they feared further earthquakes, and the safety of the athletes was jeopardised. At the Para Swimming World Championship, which took place in 2019, a positive trend in the results can be seen. These results can be attributed to the changes to the classification rules that came into effect on 1 January 2018 (WPS, 2018). The postponed Para Swimming World Championship in 2022 show a high negative trend in results due to the restrictions still in place related to the COVID-19 pandemic. In 2023, we can see the return of the positive trend in results, which can additionally be attributed to the fact that we are approaching the Paralympic year and the upcoming Paralympic Games in Paris 2024.

When looking at the plot of the mean values for the results achieved for the World Para Swimming rankings from the 14-year period (Figure 5), we can see a small positive trend up to the Paralympic year 2012. After that we have a small negative trend for the first and the best three results, but a strong positive trend in the best eight results. In 2017, there is a slightly negative trend for the first and top three results, but a high negative trend for the top eight results, which can be explained by an extended periodisation due to the consequences of the earthquake in Mexico and the postponed World Para Swimming Championship that year. All results have a high negative trend in 2020 due to the COVID-19 pandemic and a positive trend in the Paralympic year 2021. 2022 has a high negative trend, which can be explained by the combination of the events of the two previous years related to increased stress doses due to the pandemic, training restrictions and the postponement of various events, including the Paralympic Games.

Conclusion

Despite the fluctuations in the results, we can conclude that the results of the world's best female para-swimmers in the 200m individual medley in the SM8 class show a small tendency for their constant development, which is significantly influenced by events at the global level and changes in the rules of para-swimming. The presented trend of the development of the results can be used to collect the data necessary for a more detailed and precise planning and programming of training sessions, which would serve as a guide for para-swimming coaches and sports experts of different profiles for further work.

Further analysis is needed for the results obtained before 2013 for the World Para Swimming Championships and before 2009 for the World Para Swimming Rankings. Unfortunately, the above data was not available on the official World Para Swimming website at the time.

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TOPOLOGICAL STRUCTURE DIFFERENCE BETWEEN ISOMETRIC STRENGTH AND RATE OF FORCE DEVELOPMENT IN ELITE YOUTH FEMALE TEAM HANDBALL PLAYERS

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Abstract
This study aimed to investigate differences in the topological structure of muscle groups with different contractile characteristics (isometric strength and rate of force development) among youth elite female handball players. Thirty-two players from the Serbian Youth National Team (age: 16.8 ± 0.9 yrs., BH: 173.5 ± 5.9 cm, BM: 70.6 ± 7.6 kg, and BMI: 23.41 ± 1.89 kg/m2) underwent assessment with five individual tests: isometric right hand grip (iHG_R), isometric left hand grip (iHG_L), isometric dead lift (iDL), isometric standing leg extension (iLE) and isometric bilateral ankle extension (iAE). For each subject, maximal isometric force (Fmax) and maximal rate of force development (RFDmax) were derived from the isometric strength tests and analyzed. Relative values were calculated to depict the topological structure of the tested muscle groups in relation to the general body strength and explosiveness. Statistical analysis revealed significant differences among all pairs (five pairs) of variables. In four pairs of variables (corresponding to four muscle groups), RFDmax demonstrated a higher topological influence compared to Fmax in overall body strength (iHG_L, iHG_R, iLE, and iDL). Conversely, one pair of variables showed the opposite effect.

Keywords: *isometric strength, team handball, female, youth athletes.*

Introduction

Sport training is a long-term, planned and structured process, essential for achieving optimal athletic performance over a career, particularly in sports like team handball (Manchado et al., 2013). This process spans various developmental stages, progressing from novice levels to elite, high-performance standards (Karcher & Buchheit, 2014). Team handball is a very demanding body-contact sport characterized by its intense physical demands and highly developed motor skills such as speed, strength, power and endurance (Saeterbakken et al., 2011). Numerous studies highlight the significance of strength and power in enhancing team handball performance (Bayios et al., 2001; Marques & González-Badillo, 2006). Therefore, permanent assessment of anthropometric and physical profiles is crucial for gathering objective data that informs structured talent identification and development training programs (Moss, 2015). Optimal intermuscular coordinated muscles with high levels of strength and power is a critical determinant of performance excellence in both male and female team handball players While studies predominantly focus on male players due to their higher levels of maximal strength, muscle power, and throwing velocity (Marques et al., 2007; Van den Tillaar & Ettema, 2007), there exists a notable gap in comprehensive research specific to female handball players, particularly at the youth level. Although there are differences between male and female handball players, the results of studies on male's players mostly have been used for training in female's team handball. This study aims to investigate the differences in the topological structure of various muscle groups' contractile characteristics (maximal isometric force and maximal rate of force development) in youth elite female team handball players.

Methods

This research falls under the category of applied research utilizing laboratory testing to collect data. Prior to conducting the tests, participants were informed about the purpose and goals of the study, and voluntary consent was obtained. Approval for the study was also granted by the National Handball Federation and the Ethics Commission of the Faculty of Sports and Physical Education (FSPE), University of Belgrade (Approval Number: 484-2). The study adhered to the principles outlined in the Helsinki Declaration and guidelines for biomedical research involving human subjects (Christie, 2000).

Subject Sample

The study sample of subject comprised 32 female players from the Serbian Youth National Team, selected during a preparatory training camp. The participants' characteristics were as follows: age 16.8 ± 0.9 years, body height 173.5 ± 5.9 cm, body mass 70.6 ± 7.6 kg, and body mass index 23.41 ± 1.89 kg/m^2.

Testing Procedures and Variables

All measurements were conducted using a standardized protocol for isometric assessments, consistent with previously described methods (Zarić et al., 2018; Majstorovic et al., 2020). The testing battery included five individual tests: isometric right-hand grip (iHG_R), isometric left-hand grip (iHG_L), isometric dead lift (iDL), isometric standing leg extension (iLE) and isometric bilateral ankle extension (iAE). Two variables were analyzed from each isometric strength test: maximal isometric force (Fmax), measured in Newton (N), and maximal isometric rate of force development (RFDmax) results expressed as Newton per second (N/s). This provided maximal force and maximal RFD potentials for all three body segments (arms, trunk and legs) of each subject. Measurements were performed using a densiometric force transducer (Hottinger, Type S9, Darmstadt, Germany; tensile/compressive sensitivity 2 mV/n), and data were collected and processed using specialized software (Isometrics Lite, ver. 3.1.1). The force–time signal was sampled at 500 Hz and low-pass filtered (10 Hz), by using a fourth-order (zero-phase lag) Butterworth filter. The onset of the contraction was determined as the point in time where the first derivative of force–time curve exceeded 3% of its maximum value above baseline. Before testing, protocols were explained into the detail to all subjects. Testing sessions began with a 5-minute general warm-up, followed by a 5-minute specific warm-up. Subjects underwent two submaximal familiarization attempts prior to each test and performed three trials with a 2-minute rest period between trials and a 10-minute rest period between tests. The best result from the trials was selected for further analysis.

Data Analysis

Criterion variables were calculated by summing the Fmax and RFDmax values across all tested muscle groups for each subject. Relative contributions of each muscle group to the total strength and explosiveness were then determined. This analytical approach provided insights into the topological structure of the tested muscle groups relative to the overall measures of strength and explosiveness.

Statistics

Descriptive statistics including Mean, Standard Deviation (SD), and 95% Confidence Interval for the Mean (95% CI) with Lower and Upper Bounds (Low_Upp B) were calculated to summarize the data. The normality of the distribution was assessed using the Kolmogorov-Smirnov non-parametric test (KSZ). To investigate differences in the topological structure between maximal isometric force (Fmax) and maximal rate of force development (RFDmax), analyses of variance (ANOVA) and Student's t-tests for paired samples were employed. All statistical analyses were conducted using IBM SPSS Statistics version 25 (IBM Corp., 2017), with a significance level set at p<0.05.

Results

The basic descriptive statistics for the tested muscle groups and characteristics are presented in Table 1. All variables demonstrated a normal distribution, validating the appropriateness of the results for interpretation.

Table 1. Basic Descriptive Statistics of Tested Muscle Groups and Characteristics

	Isometric Strength (F_{max}%)			Rate of force development (RFD_{max}%)		
	MEAN±SD	95% CIM Low_Upp B	KSZ test	MEAN±SD	95% CIM Low_Upp B	KSZ test
HG_L	5.19±0.67	4.95-5.44	0.111, p=0.200	5.93±1.15	5.52-6.34	0.094, p=0.200
HG_R	5.53±0.61	5.31-5.75	0.107, p=0.200	6.47±0.72	6.21-6.73	0.245, p=0.084
HG_{SUM}%	10.72±1.07	10.34-11.11	0.093, p=0.200	12.41±1.65	11.81-13.00	0.088, p=0.200
DL	15.98±1.78	15.34-16.62	0.090, p=0.200	20.45±4.21	18.93-21.97	0.081, p=0.200
LE	15.41±1.32	14.93-15.88	0.133, p=0.162	20.09±3.87	18.69-21.14	0.108, p=0.200
AE	57.88±3.12	56.76-59.01	0.116, p=0.200	47.27±4.97	45.27-48.85	0.093, p=0.200
ANOVA F_{max}% vs RFD_{max}% - F = 143.50, p = 0.000, Observed Power = 0.985						

HG_L - left handgrip maximal force or RFD percent; HG_R - right handgrip maximal force or RFD percent; HG_SUM% - sum of hand grip maximal force or RFD percent; DL - dead lift maximal force or RFD percent; LE - leg extension maximal force or RFD percent; AE - ankle extensors maximal force or RFD percent.

Figure 1 depicts a radar chart illustrating the comparative results of the analyzed variables, highlighting the statistical differences between observed pairs. All five pairs of variables showed statistically significant differences. Notably, in four pairs of variables (iHG_L, iHG_R, iLE, and iDL), there was a higher topological influence of maximal rate of force development (RFD_{max}) compared to maximal isometric force (F_{max}). Conversely, in one pair (iAE), a higher topological influence of F_{max} compared to RFD_{max} was observed.

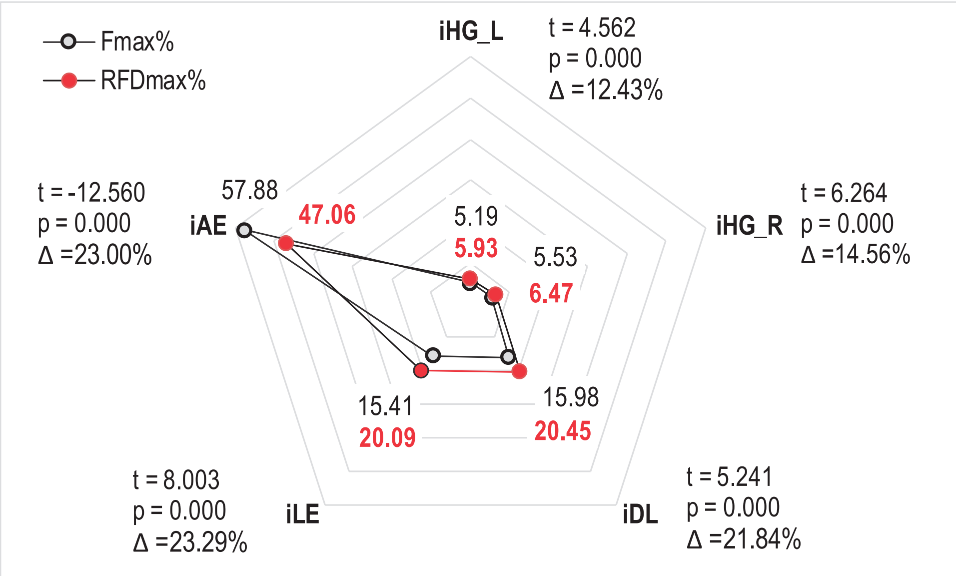

Figure 1. Radar Chart comparative results of the analyzed variables with the values of statistical differences of observed pairs of variables.

Discussion

The results of the ANOVA indicated a statistically significant difference in the topological structure of the measured muscle groups ($F = 143.50$, $p = 0.000$, Table 1). This suggests that muscle's ability to achieve maximum isometric strength in relation to the muscle's ability to exhibit maximum isometric explosiveness in the same muscle groups is not proportional, i.e. it is not topologically distributed in the same way. Across five observed muscle groups, a statistically significant difference were found between pairs of variables, with the largest relative difference observed in the leg extensors (iLE) ($t = 8.003$, $p = 0.000$, 23.29%, Figure 1).

Moreover, it is noteworthy that in four muscle groups (iHG_L, iHG_R, iDL and iLE), there was a higher topological representation of maximum explosiveness (RFDmax%) compared to maximum strength (Fmax%), whereas the opposite proportion was observed only in the ankle joint flexors (iAE, Figure 1).

Based on these results, it can be concluded that among youth female team handball players, the ability to exhibit maximum explosiveness in the finger flexors of both hands, back extensors, and knee extensors appears to be a more dominant muscle contractile characteristic compared to maximum force production, except for ankle joint flexors.

Previous research (Hermassi et al., 2019) has highlighted the significant relationship between maximum strength and specific physical performance in young team handball players. Specifically, maximal strength training programs targeting lower limb muscles have been associated with improvements in throwing speed and jumping performance. However, it has also been established that in addition to maximum isometric strength, maximum explosiveness, particularly represented by RFD, may serve as a better predictor of jumping performance than maximum force alone (Ćopić et sl., 2014). Therefore, to enhance the jumping performance and various explosive movements in different sports, and especially in youth female team handball players, coaches should target training interventions to improve sport-specific muscle strength, balancing both the force and explosiveness across different muscle groups. It is evident that there is a lack of sufficient scientific data regarding the topological structure of Fmax and RFDmax, not only in team handball but across team sports in general. Hence, these results should be considered as specific and valuable research findings rather than generalized phenomena.

Conclusion

This study has confirmed statistically significant differences in the topological structure of various contractile characteristics—specifically isometric strength and rate of force development (RFD)—across different muscle groups in young elite female team handball players. Additionally, when testing, it is necessary to monitor both measured contractile characteristics (isometric strength and rate of force development). It is evident that both variables, although measured within the same muscle groups, they have different topological structure and most likely differently influnce overall team handball performance. A notable limitation of this study is absence of comparable research findings for comparative analysis. Future studies should aim to replicate these investigations among senior-level female players and extend them to include male team handball players and athletes from other team sports. Such endeavors are essential for developing a comprehensive model of topological structure in elite team handball players.

In practical terms, this study underscores the importance of monitoring both isometric strength and rate of force development (explosiveness) during assessments and training regimes. By understanding the distinct characteristics of muscle groups related to these variables, coaches and sports scientists can tailor training programs more effectively to enhance specific aspects of performance crucial to team handball.

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COMPARISON OF POINTS WON IN A SET IN TOP-LEVEL WOMEN'S BEACH VOLLEYBALL WITH REGARD TO THE RESULT OUTCOME

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Abstract
The main goal of this study is to analyse point-scoring actions in top-level women's beach volleyball regarding the result outcome. At the 2019 FIVB Beach Volleyball World Championships in Hamburg, a total of 8,585 single point-scoring actions in rallies were analysed. According to the official beach volleyball rules, actions that can result in winning points during rallies include spikes, blocks, serves, and errors by the opponent team, which also represent the research variables. Considering the number of points required to win a set, statistical analyses were performed separately for 21-point sets and 15-point sets. Basic statistical parameters were calculated for all the variables, while the Mann-Whitney test was used to determine the differences between won and lost sets, and the effect size was also calculated. Upon comparing won and lost 21-point sets, a statistically significant difference was determined in all the observed variables, whereas in 15-point sets a statistically significant difference was found only in the spike and block variables. In addition, the calculated magnitude of the effect size for all variables is medium, except for the variable spike in 21-point sets, where it is high. This research offers valuable insights for coaches and players, serving as an educational tool to set goals and adjust training processes. It highlights the distribution of points needed to win a set, which can inform strategies for both training sessions and matches.

Keywords: *notational analysis, Mann-Whitney test, female volleyball players, performance*

Introduction
Identically as in indoor volleyball, in beach volleyball points are directly won only in terminal actions, while continuous actions prevent the opponent team from winning points, as well as put one's own team in a better position for winning a point (Medeiros et al., 2017). Terminal actions are actions which allow a team to directly win a point, such as serve, spike and block. In addition to these three actions, opponent errors are also an important part of the game and can thus be divided into forced and unforced errors. Forced errors are errors caused because of opponent pressure, while unforced errors are completely controlled by players and thus made without any opponent pressure. In addition to the errors, there are also penalties from referees that can ensure winning a point for the opponent (Singh et al., 2020).

In addition, according to Hughes & Franks (2004), data obtained through notational analysis at competitions provide insight for coaches, athletes and analysists into team or player performance, which can improve their performance and thus allow for gaining competitive advantage. Beach volleyball matches generate many performance indicators, and it is therefore necessary to select the data that shall be useful in further analysis (Marcelino et al., 2011). Likewise, the aim of performance analysis includes identifying potentially important aspects of the game form this large amount of data, as well as revealing team strengths and weaknesses, as well as for individual players (Hömberg & Papagergiou, 1994). Beach volleyball matches are almost never played under the same conditions, and therefore weather conditions, the time of day when the matches are played, and the number of matches played in one day hinder performance comparisons between trainings and matches. For this reason, it is difficult to determine precise statistical standards, however, they are helpful in the process of accurately assessing team performance (Coleman, 2002).

Previous research aimed at determining winning norms (standards), but also at comparing point-scoring actions in a set, have been primarily conducted on a sample of matches, i.e. sets, played in indoor men's volleyball (Zhang, 2000; Marelić et al., 2005; Đurković et al., 2021), while the performed analyses did not include the deciding (tie-break) sets.

In accordance, the aim of this research is to compare point-scoring actions in a set of top-level women's beach volleyball regarding the result outcome, i.e. to winning or losing a set. In addition to analysing 21-point sets (first two sets), an analysis of 15-point sets (deciding sets) shall simultaneously also be performed.

Methods

Sample

For this research, all matches played at the 2019 FIVB Women's Beach Volleyball World Championships in Hamburg were analysed. A total of 48 female teams from 28 countries, divided into twelve groups of four, participated in the competition. The entities included in this research were sets from all matches played at the 2019 FIVB Women's Beach Volleyball World Championships in Hamburg. A total of 247 sets were played as part of 108 matches. Since each individual set is separately analysed both for team A and team B, the total number of sets must be multiplied with the number of teams (2), so that the overall number of observed entities amounts to 494. One match was forfeited due to an injury of a volleyball player, and thus the final number of entities is corrected to 490.

Data collection

During the official duration of the competition, an officially trained person for this purpose registered the number and quality of the performance of actions during all matches using the Click&Scout Rel 1.01.77 (Data Project S.r.l., Salerno, Italy) application, after which a digital match report was generated and uploaded at the official FIVB website. The mentioned official match reports were then downloaded and stored on a personal computer, and thus used as a base for collecting the required data about the point-scoring actions in a set.
Short description of actions that score points in a set:

- A serve point is scored when the ball lands directly in the opponent's court or is played by one or more players in a way that makes it impossible to return the ball over the net.
- A spike point is scored when the ball lands directly in the opponent's court or is played by one or more players in such a way that it cannot be returned over the net.
- A block point is scored when an opponent's blocked spike falls directly into the opponent's court or is touched by one or more players in unplayable manner.
- Opponent errors are categorized into forced and unforced errors. Forced errors occur under opponent pressure and result from aggressive play, not the player's fault. Unforced errors happen without opponent pressure and are due to poor technical execution or referee penalties.

The collected data was then entered into Microsoft Excel files, where they were edited for further analyses.

Variables

The independent variables that were studied in this research are serve point (SR_P), spike point (SP_P), block point (BL_P), and opponent errors (OP_E). All independent variables were described individually for 21-point sets and for 15-point sets. The dependent variable in this research was the outcome of the set, i.e. won or lost sets (WS_LS).

Statistical analyses

All statistical analyses were performed by using the application Statistica 14.0 (TIBCO Software Inc.). The reliability of the measurements was determined by means of the test-retest method according to the Spearman correlation coefficient (rs), whose values ranging between 0,87 and 1,00 points to a high reliability in the measurement process. Descriptive indicators were calculated for all variables. As the Shapiro-Wilk test established that the data deviate from normal distribution, the significance of the difference between the groups of won and lost 21-point sets and 15-point sets was determined in all the measured variables by using the non-parametric Mann-Whitney test. The level of statistical difference used in the analysis of differences in this research was $p<0.05$. Furthermore, r ($r = Z / \sqrt{N}$) was calculated as an indicator of the effect size, and which according to Cohen (1988) is interpreted as small (r=.1), medium (r=.3) and large (r=.5).

Results

Table 1 shows the results of basic indicators of descriptive statistics for points won in 21-point sets and 15-point sets, separately for won and lost sets.

Table 1. Descriptive indicators for won and lost sets

		Won sets				Lost sets			
Variables	n	Mean±SD	%tot	Mdn	R_{tot}	Mean±SD	%tot	Mdn	R_{tot}
SR_P21	214	2.00±1.47	9	2	6	1.01±1.08	7	1	5
SP_P21		12.67±2.45	60	13	12	9.04±3.28	61	9	16
BL_P21		1.23±1.12	6	1	6	0.66±1.02	4	0	5
OP_E21		5.34±2.00	25	5	10	4.11±1.88	28	4	9
SR_P15	31	1.00±1.03	6	1	4	0.61±0.92	5	0	4
SP_P15		9.58±2.45	61	9	9	7.94±2.06	64	8	8
BL_P15		1.29±0.97	8	1	4	0.68±0.79	6	1	3
OP_E15		3.74±2.00	24	4	7	3.10±1.78	25	3	7

n – number of entities; Mean – mean value; SD – standard deviation; %tot – percentage of total frequencies; Mdn – median value; Rtot – total range

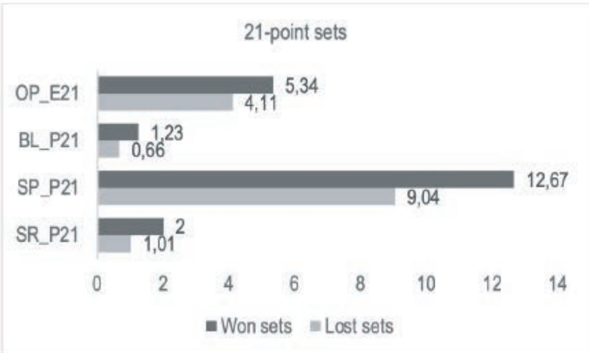

Figure 1. Graphical diagram of mean values for variables in 21-point sets

Upon observing the mean values in 21-point sets, it can be seen that in all the variables between the won and lost sets, higher results were accomplished to the advantage of won sets, while in both groups the highest number of points was won by spike, and then as a result of opponent error, while the lowest number of points was accomplished with serves and blocks (Diagram 1).

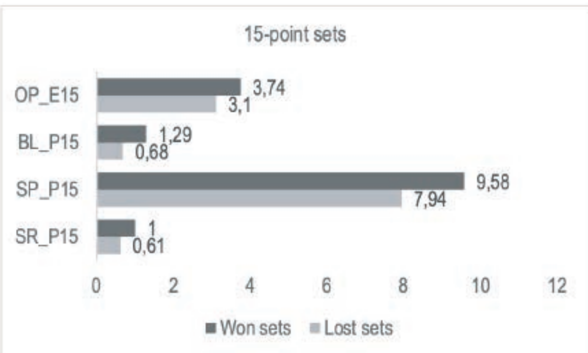

Figure 2. Graphical diagram of mean values for variables in 15-point sets

Similarly, upon observing the mean values in 15-point sets, it can be seen that in all the variables between the won and lost sets, higher results were accomplished to the advantage of won sets, while in both groups the highest number of points was won by spike, and then as a result of opponent error, however, the lowest number of points was first accomplished with blocks, and then finally with serves (Diagram 2).

Table 2 shows the results of the Mann-Whitney test for points between the groups of won and lost sets, as well as the effect size.

Table 2. Results of the Mann-Whitney U test between the groups of won and lost sets

Variables	U	Z	p	Effect size r
SR_P21	13787.5	7.34	0.000	0.35
SP_P21	8775.5	11.08	0.000	0.54
BL_P21	15350.5	6.29	0.000	0.30
OP_E21	15005.0	6.24	0.000	0.30
SR_P15	368.0	1.71	0.088	0.22
SP_P15	297.5	2.60	0.009	0.33
BL_P15	302.5	2.64	0.008	0.34
OP_E15	397.0	1.18	0.237	0.15

U – values of the Mann-Whitney U test; Z – z value; p – level of statistical significance of a test; r – effect size

By comparing won and lost 21-point sets, statistically significant differences were confirmed in all variables:
in variable SR_P21, values for won sets are higher (Mdn = 2) than for lost sets (Mdn = 1), U = 13787.5, $p < .001$, with a medium effect of r =.35

- in variable SP_P21, values for won sets are higher (Mdn = 13) than for lost sets (Mdn = 9), U = 8775.5, $p < .001$, with a high effect of r =.54
- in variable BL_P21, values for won sets are higher (Mdn = 1) than for lost sets (Mdn = 0), U = 15350.5, $p < .001$, with a medium effect of r =.30
- in variable OP_E21, values for won sets are higher (Mdn = 5) than for lost sets (Mdn = 4), U = 15005.5, $p < .001$, with a medium effect of r =.30

On the other hand, the comparison of won and lost 15-point sets confirmed statistically significant differences in only two variables:

- in variable SP_P15, the values for won sets are higher (Mdn = 9) than for lost sets (Mdn = 8), U = 297.5, $p < .01$, with a medium effect of r =.33
- in variable BL_P15, the values for won and lost sets are identical (Mdn = 1) than for lost sets (Mdn=0), U = 302.5000, p < .01, with a medium effect of r =.34

Discussion

According to the results, it can be noticed that the teams who won sets had higher values in all the observed actions that result in winning points in beach volleyball, which ultimately affected the result outcome of the set. In view of the different duration between the first two and the third set, 21-point sets and 15-point sets were analysed separately.

21-point sets

The results of descriptive statistics for sets going up to 21 points indicate that the teams that won the sets demonstrated higher median values in all the variables as follows - the most in attack points (13,9), then in opponent errors (5,4), serve points (2,1), and block points (1,0). Among all the observed elements in volleyball, the highest number of points in sets is won by spike. According to the research conducted by Inkinen et al. (2014), 60.3% of points in indoor volleyball are won by attack and counterattack, which is very similar to the research conducted by Häyrinen & Tampouratzis (2012), in which the percentage of points won by attack in beach volleyball is 61%. According to the results of actual research, teams that won 21-point sets accomplish as much as 60% points by attack. In this research, the variable SM_P21 covers smashing in all match phases. Koch & Tilp (2009a) studied different types of spikes in particular complexes (C1, C2, C3) of the game. As much as 55% of the spikes from the reception (C1) led to direct points. A similar percentage is also found regarding C3 (52%), while in counterattack (C2) the percentage is even higher (65%).

Next to spike, the highest number of points in top-level women's beach volleyball is won because of opponent errors, while the least number of points is won by serve and block. The presented results are in line with the percentages determined by

Häyrinen & Tampouratzis (2012), where the percentage of points won by opponent errors is 24%, by serve 9%, and by block 5%.

In present research, spike points in 21-point sets are a variable which made the greatest contribution to the outcome of the set result. The highest percentage of points in won sets was achieved by spiking, and the largest difference between won and lost sets is precisely in the median values for the variable SM_P21 (4). Set winners won 4 points more than the defeated team by smashing, which points to the fact that spiking is a skill which has a great influence on the outcome of the set. Giatsis et al. (2023) concluded that spike points were the most important factor in top-level female beach volleyball. In their research, as well as in present one, according to the mean values set winners won a significantly higher number of points in attacks (12.8, 9.6). Such results are entirely in accordance with the results obtained in present research where the mean number of points won by spike in 21-point sets was 12.7 for set winners and 9.6 for teams who lost sets.

Serve is the only phase of the game where the players have complete control over the ball and during which player can fully impact its performance. Although the difference in serve points between the winners and losers in this research is only one point, the serve can be correlated with winning. At the highest level of competition such as the World championships, there is great homogeneity among the players and many sets played with minimum score difference. In a set where both teams alternately win points on their own reception, a point won by an ace point or by an opponent error in reception has a great effect on the further course of the set, as well as of the entire match. In research by Giatsis et al. (2023), set winners, in sets which ended with less than a 5-point difference, won a statistically significantly higher number of points at serve. Likewise, Kumar et al. (2021) confirmed that a "break point" phase (also including points won by serve) is one of the factors which is positively correlated with winning. Such results point to the importance of serve trainings, as an element with a high influence on winning a set, aimed at increasing efficiency and reducing unforced errors.

Points won by block and opponent errors have also been defined as actions with a positive correlation with winning. Furthermore, in present research, according to median values set winners won one point more by block per set (1,0), as well as made less errors than the teams who lost (3,4). Considering the large number of points won by spike, consequently the number of block points is smaller. Identically as with serve points, the block can also have a great effect on the outcome of the set, in sets that end with a minimum score difference. The block represents the first line of defence and thus provides a possibility to win direct points.

15-point sets

In 15-point sets, according to median values teams who won sets accomplished a higher number of points by spike (9,8) and an equal number of points by block (1,1). Set winners also won more points in median values in the serve variables (1,0) and opponent errors (4,3), however, a statistically significant difference was not determined.

Block was also one of the most important factors in 15-point sets in the research conducted by Giatsis et al. (2023). Aside from block points, spike was highlighted as the most important factor that affects winning in 15-point sets, which were likewise the two elements that proved to be relevant factors for winning in this research as well. According to mean values, winners of 15-point sets won 9.3 spike points and 1.3 block points, which is consistent with the results in this research. It can be concluded that more experienced teams who win deciding sets have a better "reading" of the game and offer more solutions in attack, which in turn results with their higher results in block and spike points.

As most previous research did not differentiate the distribution of points between 21-point sets and 15-point sets, the results obtained for 15-point sets can be compared with research conducted by Häyrinen & Tampouratzis (2012). They studied the difference between teams who won and lost in different set phases. Set phases between point 8 and 11, as well as between point 12 and 18 can be compared with 15-point sets. Set winners in both mentioned set phases won a significantly higher number of points by spike in the attack and counterattack phases.

Considering that in this research there was no statistically significant difference in the variables of serve and opponent error, it can be said that teams make fewer mistakes in 15-point sets, i.e. in deciding sets as they play more safely due to the shorter duration of the set. For the same reason, it is possible that teams are less aggressive during serve, which in turn results with less errors. In case teams are serving less aggressively, it is probable that serve reception is thus more successful, and then consequently also attack realization.

Conclusion

Given that there is a small number of research with the topic of performance analysis of top-level women's beach volleyball, the scientific contribution of this study is in the fact that it is the first research in women's beach volleyball which analyses only terminal actions and opponent errors. Likewise, the contribution of the study is reflected in the performance analysis which was separately conducted for 21-point sets and for 15-point sets, which was not the case in previous research. This study provides insight into the playing model of top-level female teams and can serve as a model that should be adopted with the aim of winning. In practical terms, the results of this research can provide new findings for coaches and players, as an educational tool, that can be used for setting goals for the players and the entire team during trainings, as well as in matches, and thus also for adjusting the training process. In addition, this research provides insight into the distribution of points won in a set which are needed for winning.

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CHARACTERISTICS OF THE MATCH PERFORMANCE OF TENNIS PLAYERS UNDER 14 YEARS OLD

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Abstract
With the advancement of technology increasingly used on tennis courts, it has become possible to track various parameters of sports performance. The aim of this study is to explore the characteristics of male and female tennis players at the Tennis Europe super category tournament for under 14s - Les Petit As, and to determine if there are differences in the characteristics of technical-tactical performance between male and female players using the SwingVision mobile application. A total of 27 parameters were analyzed, which, depending on the aspect of the game they refer to, can be divided into 6 groups: time characteristics of the game, duration of points, success rate of specific shots, shot placement execution, player position on the court during shots and prevalence of specific shots. The results show a high percentage of shots played in the central part of the court and behind the service line. Additionally, male players play more aggressively than female players with a higher percentage of points won in rallies of up to 5 exchanges, also they play more forehand shots to the opponent's backhand and have a higher percentage of successful serves. The results of the study should be taken into account when planning and programming training processes specific to the observed age group and gender of the players.

Keywords: *technical-tactical performance, SwingVision, competition requirements*

Introduction
The characteristics of tennis game are the dynamics and complexity of various factors influencing success in the game. Highly developed physical abilities, technical-tactical knowledge and skills, as well as cognitive traits, enable tennis players to exploit their potential and competence at the highest levels of competition (Kovacs, 2007). In recent years, the level of quality and competitiveness of young tennis players has been increasing, leading to rising demands (Filipčić et al., 2021). Training volume has increased, with successful young players averaging 22.7 hours of training per week, focusing 15.1 hours on technical and tactical development and 7.6 hours on improving physical abilities (Fett et al., 2017). Additionally, they participate in approximately 15-25 tournaments annually, equating to around 50-120 official matches per year (Fleming et al., 2022). Performance analysis has become an integral part of the training process for elite athletes, where systematic monitoring of training and competitive loads is crucial for successful planning and programming (Janák et al., 2018). While extensive research has focused on performance indicators of senior tennis players at ATP and WTA tournaments using expensive technology, this is not often the case in younger age categories, where determining performance parameters often relies on coaches' intuition and subjective observation. Previous studies have investigated the progression of motor skills (Smajić et al., 2015) and technical performance attributes (Muhamed et al., 2016) among young tennis players. However, there has been limited research dedicated to analysing their competitive performance (Filipčić et al., 2011). By reviewing previous research, it has been noted that there is insufficient information on the model values of the game in younger age categories, specifically for tennis players under 14 years old. Tournaments of this rank and age category are not attractive to the broader sports public, they receive little media coverage, and as such, systems that would collect model values of top tennis players of this age during play are not used. Most of the data obtained is collected by coaches during tournaments, which overall represents a small amount of data from tennis players under 14 years old. The aim of this study is to explore the characteristics of the most successful male and female tennis players at the Tennis Europe super category tournament for under 14s - Les Petit As, and to determine if there are differences in the characteristics of technical-tactical performance between male and female players using the SwingVision mobile application. According to research (Bilić et al., 2023), the SwingVision mobile application enables automatic processing of recorded matches and displays statistical data on player characteristics and performance success, with good results in the metric characteristics of validity.

Methods
For the purposes of this research, parameters of technical-tactical performance in matches of the main draw of the Les Petits As tournament under 14 years old, held from January 19 to January 29, 2023, were analyzed. Match recordings were obtained from the official tournament website and analyzed using the SwingVision mobile application.

Sample
The sample consists of matches from the men's and women's main draw of the tournament. A total of 30 matches (15 from the men's and 15 from the women's draw) from the round of 16, quarterfinals, semi-finals, and finals were analyzed.

Variables

The sample of variables used in this study consists of 27 parameters of technical-tactical performance obtained through the SwingVision mobile application. The variables are divided into 6 groups based on the aspect of the game they refer to: time characteristics of the game, duration of points, success rate of specific shots, shot placement execution, player's position on the court during shots and prevalence of specific shots (Table 1.).

Instruments

The SwingVision application was developed in 2014 (SwingVision Inc, Saratoga, United States), it tracks the movement of players and the ball in real-time and works only on iOS mobile systems. The phone is placed on the net surrounding the court according to instructions within the application. It records the number, type of shots, duration of points, success rate of specific shots, shot placement execution and player's movement on the court. Recordings of matches played were uploaded to the application on an iPhone 14 mobile device.

Statistical Analysis

Data processing and statistical analysis were performed using the Statistica v14.0.0 software. Descriptive parameters (mean and standard deviation, minimum and maximum values) were calculated for all variables. Differences between male and female groups were determined using multivariate analysis of variance (MANOVA), while the post-hoc Whole model-R method was used to determine differences in individual variables.

			boys		girls	
	Variables	n	AS±SD	min-max	AS±SD	min-max
1.	Match time	30	101.87±25.92	60.00-152.00	102.60±36.24	54.00-170.00
2.	Active match time	30	45.53±13.28	20.00-70.00	45.90±18.06	25.00-84.00
3.	Points under 5 shots (%)	30	67.07±4.04*	60.00-74.00	62.00±7.49*	51.00-79.00
4.	Points 5-8 shots (%)	30	19.87±2.60*	17.00-25.00	18.47±2.70*	14.00-23.00
5.	Points above 5 shots (%)	30	11.67±2.82*	8.00-19.00	18.27±6.42*	4.00-28.00
6.	Forehand (%)	30	81.73±3.53	74.00-90.00	82.80±5.05	70.00-90.00
7.	Backhand (%)	30	80.13±4.07	72.00-88.00	80.50±14.52	52.00-90.00
8.	First serve (%)	30	62.93±12.19*	43.00-88.00	56.93±10.56*	40.00-78.00
9.	Second serve (%)	30	87.10±9.69*	59.00-100.00	81.63±10.56*	61.00-100.00
10.	Shots behind service line (%)	30	68.53±5.69*	55.00-78.00	75.60±5.03*	64.00-84.00
11.	Shots in front of service line (%)	30	30.50±5.66*	21.00-44.00	23.47±4.95*	15.00-35.00
12.	Shots directed on forehand side (%)	30	22.67±5.15	13.00-32.00	25.70±8.66	11.00-48.00
13.	Shots directed on backhand side (%)	30	33.50±5.99	21.00-42.00	30.93±6.98	17.00-42.00
14.	Shots directed in middle of court (%)	30	42.27±5.95	31.00-58.00	41.83±7.12	31.00-59.00
15.	Serve on deuce side –t (%)	30	44.83±14.44	12.00-76.00	39.97±16.66	12.00-79.00
16.	Serve on deuce side -middle (%)	30	31.43±11.45	8.00-61.00	35.57±14.16	6.00-64.00
17.	Serve on deuce side -wide (%)	30	22.37±11.07	5.00-44.00	23.17±12.10	2.00-40.00
18.	Serve on ad side -t (%)	30	25.83±10.52	7.00-47.00	24.93±12.05	8.0052.00
19.	Serve on ad side -middle (%)	30	37.63±10.21*	14.00-57.00	45.80±12.75*	6.00-52.00
20.	Serve od ad side -wide (%)	30	35.33±15.82	7.00-70.00	28.08±12.60	6.00-52.00
21.	Shots played behind baseline (%)	30	74.53±6.36*	62.00-88.00	77.87±6.96*	61.00-89.00
22.	Shots played in service box (%)	30	5.87±2.71*	1.00-12.00	2.87±2.10*	0.00-10.00
23.	Shots played between service line and baseline (%)	30	18.30±5.15	7.00-27.00	16.57±5.79	8.00-31.00
24.	Total shots number	30	510.60±170.81	191.00-826.00	556.74±242.00	292.00-1133.00
25.	Forehand shots (%)	30	38.50±4.17*	31.70-47.10	35.90±3.68*	29.40-44.90
26.	Backhand shots (%)	30	37.24±4.70*	26.30-46.00	38.00±5.41*	26.40-52.70
27.	Serve shots (%)	30	22.03±3.12*	15.21-28.30	18.65±4.55*	11.90-30.00

Table 1. Descriptive parameters (n=sample, AS=arithmetic mean, SD=standard deviation, min=minimum and max=maximum values) of observed variables and statistically significant differences between boys and girls
*statistical significant $p<0,05$

Discussion

The obtained results show that the total match duration (M: 101.87±25.92, F: 102.60±36.2) and active playing time (45.53±13.28, 45.90±18.06) do not significantly differ between male and female players. The average match time in this study aligns with previous research (Kovacs, 2007). In the observed matches, an average of 45% of the total game time was spent on active play, while previous research recorded values between 30 and 35% (Martínez-Gallego et al., 2013; Stare et al., 2015), but with older participants. With increasing chronological age, players tend to play at a faster pace, resulting in shorter points and consequently shorter active playing time. In addition to the duration of exercises and rest periods, the intensity of training is defined by the number of strokes. In the observed matches, both male and female players played over 500 shots (M: 510.60±170.81, F: 556.74±242.00). There are significant variations in this variable depending on the number of points played and the playing style of both players. The majority of points were played with exchanges lasting fewer than 5 shots (M: 67.07±4.04%, F: 62.00±7.49%). Previous research has shown that points of this duration are directly linked to a positive match outcome (Fitzpatrick et al., 2019). The fewest points were played with exchanges lasting longer than 8 shots (M: 11.67±2.82%, F: 18.27±6.42%). It is worth noting that female players had almost the same number of points of this duration as points lasting 5-8 shots. When comparing the duration of points between male and female players, it is evident that male players played significantly more points of short duration, while female players played a greater number of points with exchanges lasting above 8 shots. This suggests that male players, even at this age, are capable of creating dominance in points through aggressive play with the first few shots, which allows them to make more winners. Supporting this, male players executed a significantly higher percentage of shots from within the court (M:18.30±5.15, F: 16.57±5.79), while female players executed a higher percentage of shots from behind the baseline (M: 74.53±6.36, F: 77.87±6.96), Furthermore, male players approached the net significantly more often in an attempt to finish points with shots played from the net (M:5.87±2.71, F: 2.87±2.10). Similar findings have been reported in other studies (Filipčić et al., 2021; Stare et al., 2015). The percentage of forehand and backhand shots landed in court analyzed in both male and female players exceeds 80%. Moreover, the majority of these shots were played into the area behind the service line. A high percentage of deep shots reduces the opponent's chance of playing an offensive shot and winning the point. Comparing male and female players, male players directed more shots into the service box, while female players played more shots from behind the service line, i.e., deeper shots. Additionally, it is typical for players in the observed sample to execute the majority of shots into the safe central zone of the court (M: 42.27±5.95, F: 41.83±7.12). This reduces the risk of missing shots wide and limits the opponent's ability to open the court. It is noteworthy that male players tend to target the opponent's backhand more often, as it is usually the weaker shot. This trend is also present in female players, but the percentage of shots aimed at the backhand and forehand sides are more balanced compared to male players. Similarly, female players executed a higher percentage of shots with the backhand compared to the forehand (F: 35.90±3.68/ 38.00±5.41), while the opposite was observed in male players (M: 38.50±4.17/37.24±4.70). These findings are consistent with those reported for professional male and female players (Stare et al., 2015). Furthermore, boys recorded a statistically significantly higher percentage of successful first serve (M: 62.93±12.19, F: 56.93±10.56) and second serve (M: 87.10±9.69, F: 81.63±10.56) compared to girls. Given the dominance of points played within 5 shots, a quality first serve is of great importance. Many studies highlight the importance of the return and serve as the most crucial shots in tennis (Hizan et al., 2011; Krause et al., 2019). A high percentage of successful serves, coupled with a certain level of speed and accuracy, increases the chances of winning points. As players under 14 years old are still in a phase of growth and development, they may not derive as much advantage from their serves in the game, resulting in fewer points won directly from serves (Hizan et al., 2011; Johnson & McHugh, 2006). Consistent with previous research (Krause et al., 2019), male players recorded a higher percentage of successful first and second serves than female players. Besides technical execution, the reason for this difference may also lie in the greater muscle mass and height of boys at this age, which represents a significant advantage for successful serve performance. The practical implications that this research can offer tennis coaches are diverse. Primarily, by using the SwingVision app during their players' matches, coaches would obtain results for game parameters that they could compare with the results of the best players in the world under 14 years old. Secondly, based on the results of this research, coaches have received information about which technical and tactical components are more important than others and, accordingly, can focus more on training those aspects. The most important practical advice for coaches is to concentrate more on enhancing serves and returns, as results indicate that points involve fewer and fewer shots. Additionally, it is crucial to train more to play inside the baseline and at the net to develop an aggressive style of play. By using exercises that will improve the mentioned technical and tactical parameters, coaches can design more effective training sessions to achieve optimal results.

Conclusion

By examining the technical-tactical characteristics of play at the highest level of competition under 14 years old, standards of play that players must be prepared to meet to be competent at this level have been established. These values serve as guidelines for programming the volume and content of the training process. Knowledge of competitive performance characteristics at this level will enable coaches to develop a specific individual plan and program, directing the development of their players toward achieving the best possible results. Based on the obtained results, it is clear that the training plan and program for players under 14 years old should not be based on the demands of professional tennis, but rather strictly individualized and adapted to the characteristics of the player's age and gender.

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AGILITY, SPEED AND COORDINATION DIFFERENCES BETWEEN NATIONAL AND INTERNATIONAL HANDBALL REFEREES

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Abstract
The main aim of this paper is to determine differences in certain motor tests between national and international referees. Partial aim was to determine levels of motor abilities and to rank referees according to z-values in motor abilities which have an influence on quality of refereeing in handball. The study investigated a sample of 32 top-level handball referees in Croatia divided into national and international referees. The results showed significant differences in all variables (between $p<0.01$ and 0.02) between national and international referees. Calculated z-values for certain motor abilities that are important for success in match officiating revealed that international referees are ranked higher than national referees. Statistical power is moderate, but it could be concluded that national and international referees in this study have statistically significant differences in all variables assessing motor abilities space (agility, speed and coordination). Although other variables have an influence on quality of refereeing, it can be concluded when referees reach interval of z-values, they will also have their quality of refereeing at the level which is needed to officiate matches at the highest levels of competitions with success.

Keywords: *model values; motor abilities; team handball*

Introduction
Handball is a sport dominated by speed, explosive power (strength), endurance, agility (changes in direction and movement), and the ability to repeat short bursts of maximal effort throughout the match, along with other high-intensity actions (Ghobadi, 2013; Corvino et al., 2014). The ability to consistently perform these skills at the highest level throughout the match is crucial for both the quality of play (Massuca, 2013) and the final outcome.

In team sports, referees play a key role in ensuring fair and safe play. Their decisions about rules and disciplinary measures affect the nature and frequency of player misconduct (Mallo, 2012; Rebelo, 2015). Referees are exposed to a variety of psychological influences during a match, and their ability to control them and maintain a harmonious relationship with the players is essential to prevent conflict (Valdevit et al., 2011). The dominant and authoritative attitude of the referee, along with knowledge of the rules, prevents inappropriate behaviour and aggressive play (Philips, 1985). Loss of authority and confusion in decision-making leads to the opposite effect. In team contact sports, referees are faced with making complex decisions quickly (Plessner, 2005).

Referees must be in front of all players to make a correct decision regarding their actions on the court. Recent rule changes in handball have significantly reduced the transition time between defence and offense, making the game more dynamic and demanding (Povoas et al., 2014) for both players and referees. Interpreting the rules of passive play has led top teams to focus on counterattack tactics and accelerating offensive play. Another direct consequence of the rule changes is the shortening of the attack preparation phase, leading to a more dynamic and faster game with richer and more sophisticated tactics (Bilge, 2012). Consequently, the rule for a quick restart after a goal has also contributed to increased physical demands on players (Kruger, 2013) and referees.

Modern handball requires players to be faster, more dynamic, and versatile in defence and attack (Taborsky, 2008). This makes it difficult for referees to follow the game compared to the previous, slower handball with less actions (Belcic et al, 2022). Clegg and Thompson (1985) investigated referees in various sports and concluded that handball is a difficult and stressful sport to referee due to its complexity, technical demands, and speed of play. The physical demands of referees during a match are related to the rank of the competition (Bartha et al., 2009). Referees must be in good physical condition to cope with these demands (Caballero et al., 2015). The group of authors (Belcic et al., 2018) came to the conclusion that the correlation of motor abilities and the quality of refereeing is significant, especially this refers to the frontal agility test with 180 degrees turn. The movement of the test reflects the movements of the referees during the handball match, especially during counter attacks, and the authors is to use this test in official handball referees' tests and diagnostic procedures during official referee seminars.

With these assumptions the main aim of this paper is to determine differences in certain motor tests between national and international referees. Partial aim was to determine levels of motor abilities of top-level handball referees in Croatia, and to rank referees according to z-values in motor abilities which have an influence on quality of refereeing in handball.

Methods

Sample of respondents

The sample consisted of 32 handball referees who officiated at the highest level of handball competition in Croatia. All handball referees in the sample had an average age of 34.29±6.20 years, a height of 184.46±5.79 centimetres, and a body mass of 91.73±10.57 kilogrammes. The calculated morphological characteristics of the participants: percentage of body fat 19.20±3.94% and BMI 26.91±2.47 kg/m^2. Referees were divided into two categories: international referees (EHF and IHF) and national referees who only officiate in the national championship in Croatia. During the test, one referee suffered an injury, and he was excluded from the total number of referees evaluated.

Variables Sample

A study carried out in the Diagnostic Centre of the Faculty of Kinesiology, University of Zagreb investigated the essential motor skills of handball referees. The researchers have chosen five standardized tests with established reliability, validity, homogeneity, and sensitivity to evaluate these movement patterns. These tests assessed various aspects of a referee's movement on the court such as the following.

- Lateral agility: Evaluated using a sidestep test.
- Agility and coordination: Measured through two tests - a frontal agility test involving a 180-degree turn in a specific pattern (9-3-6-3-9) and an "eights with bending" test.
- Explosive power (sprint type): Assessed with a 20-meter sprint, recording split times at 5 and 10 meters.

Protocol

All the referees came for testing on their day off training and the match. Before testing referees signed voluntary agreement that they are familiar with all the risks (biggest risk is possible injury) and all the procedure of testing and they agree to participate in this research.

Before motor abilities testing, referees conducted standard warm-up protocol to raise their body temperature and increase blood flow which will consequently result in better supply of oxygen and nutrients to muscles, specially making them more elastic and help them achieve best results, and to prevent injury risk to minimum. After supervised warm-up protocol lead by professional, they conducted five motor abilities tests which represent referee movements during official matches.

Data Analysis

Data processing was performed with the statistical package STATISTICA (ver. 14.0.). Basic statistical parameters were calculated for each variable used in this research (arithmetic mean, standard deviation maximum and minimum value). Skewness and kurtosis values were calculated for all the motor abilities tests. The normality of the distribution was tested with the Kolmogorov-Smirnov test. The z-values were calculated according to four best results from each motor abilities test. T-test for independent samples was used to test differences between national and international referees. The sample size was calculated with the use of G*Power (v3.1.9.7) software. The total sample size of 32 respondents was divided into two groups (20 national and 12 international referees), with effect size of 0.8 and α error of 0.05 calculated 0.69 statistical power.

Results

Basic descriptive parameters of handball referees are presented in Table 1, z-values in Table 2 and results of t-test for independent samples are presented in Table 3.

Table 1. Descriptive statistical parameters of motor abilities tests

N = 31	Mean	MIN	MAX	SD	SKEW	KURT	MAX D	*p-value K-S test*
SST	8,78	7,53	11,14	0,74	1,04	2,31	0,10	0,10
93639	8,91	7,49	11,33	0,84	1,20	1,78	0,14	0,13
EWB	19,16	16,73	23,59	1,56	0,95	1,23	0,09	0,08
T-TEST	9,28	7,71	11,87	0,80	1,14	3,19	0,16	0,10
5m SPRINT	1,61	1,31	1,86	0,16	-0,21	-0,96	0,09	0,16
10m SPRINT	2,42	1,98	2,81	0,22	-0,15	-0,36	0,08	0,20
20m SPRINT	3,87	3,40	4,79	0,29	1,23	2,82	0,20	0,09

Legend: SST – sidestep test; 93639 – frontal agility test with a 180º turn; EWB – eights with bending; T-TEST – agility t-test; 5m SPRINT – sprint on 5m (20m sprint with split time); 10m SPRINT - sprint on 10m (20m sprint with split time); 20m SPRINT – sprint on 20m

Table 2. Z-values results of all top 4 referees according to results of motor abilities tests

N = 31	SST	93639	EWB	T-TEST	5m SPRINT	10m SPRINT	20m SPRINT
Referee 3	1,50	-0,93	-0,70	-0,95	-0,79	1,77	1,51
Referee 4	0,21	0,56	1,42	1,14	1,65	-0,38	-1,07
Referee 19	-0,88	1,20	0,65	0,73	1,03	1,00	0,39
Referee 21	1,38	-0,74	0,09	0,24	0,10	0,72	1,21

Legend – the same as in Table 1.

Table 3. T-test for independent variables (national and international referees)

Variables	National $\bar{x}$ + SD	International $\bar{x}$ + SD	t-value	*p*	F-ratio	p variances
SST (s)	9.02±0.79	8.41±0.44	2,47	*0,02	2,11	0,26
9-3-6-3-9 (s)	9.28±0.90	8.82±0.52	2,84	*0,01	4,20	0,03
5m sprint (s)	1.65±0.13	1.50±0.16	2,80	*0,01	1,65	0,37
10m sprint (s)	2.49±0.18	2.27±0.23	2,72	*0,01	1,68	0,35
20m sprint (s)	3.96±0.30	3.66±0.15	2,92	*0,01	4,18	0,03
EWB (s)	19.87±1.51	18.32±1.00	2,98	*0,01	2,52	0,16
Agility T-test (s)	9.51±0.87	8.72±0.51	2,89	*0,01	2,29	0,21

Legend – the same as in Table 1.

Discussion

The main aim of this paper is to determine differences in certain motor tests (agility, speed and coordination) between national and international referees. Partial aim was to determine levels of motor abilities of top-level handball referees in Croatia, and to rank referees according to z-values in motor abilities which have an influence on quality of refereeing in handball. With this procedure referees can see in which area of motor abilities they have deficits. With diagnosis of deficits referees can accordingly plan their training to raise level of motor abilities to the level which allows them to raise their quality of refereeing. Better motor abilities help referees to be closer to the action on the court and consequently make correct decision (Mallo et al., 2012; Mazaheri et al., 2016). To make correct decisions, also a distance from the place of action has a great influence, especially in younger and less experienced referees. Especially because refereeing experience has an influence on the quality of refereeing (Belcic, 2022), meaning that more experienced referees can compensate for their lower level of motor and functional abilities with experience. The standardized form (z-scores) of the results interpreted motor space and they are presented in table form with the results along with an example of the highest-ranked referee (Figure 1). Regardless of previous research findings, future research should consider other abilities that influence refereeing, such as cognitive abilities and conative dimensions of referees. The limitation of this study is the sample of subjects, which was limited to one country. Referees' sample is 100% of all referees which officiate in the highest rank of competition in Croatia, and although statistical power is not high, but moderate (0.69) it could be considered as one of the limitations of this study. However, it should be noted that the sample of respondents are elite referees, as the vast majority of them officiate the most important international matches in the most demanding and prestigious handball competitions. For future research, authors recommend to consider referees from different ranks of competition such as referees from first, second, and third rank, and with this sample conclusions might be different as all referees in this sample are already selected in process which allows them to officiate in highest rank of competition in Croatia.

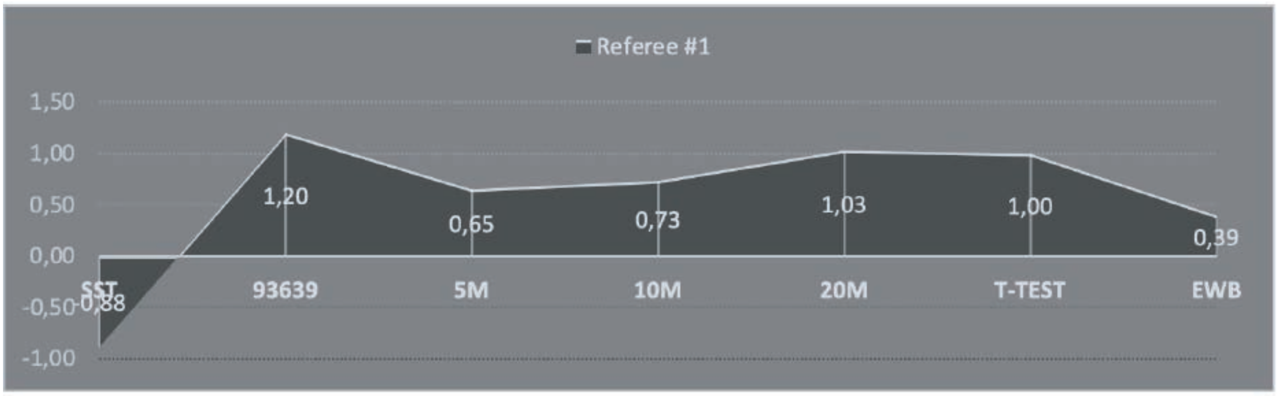

Figure 1. Overview of z-values in motor ability tests (the best ranked referee overview)

Conclusions

Although statistical power is moderate it could be concluded that national and international referees in this study have statistically significant differences in all variables assessing motor abilities space (agility, speed and coordination). Previous studies confirmed connection of better motor abilities with success in quality of refereeing, and this study confirmed that international referees achieved better results than national referees which just confirms their higher status. The study's findings demonstrate that z-scores in relevant motor abilities are crucial for successful match officiating. Referees with strong motor abilities can translate and use those abilities during the match which will directly influence and improve their performance on the court, and consequently raise the quality of the refereeing. By achieving a specific range of z-scores, referees can ensure their officiating quality will most probably meet the demands of high-level competition.

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EVALUATION OF BASKETBALL SET OFFENSE BASED ON DURATION AND MAJOR TACTICAL ELEMENTS

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Abstract
The study analyzed the influence of duration and quantity of major tactical elements on 1337 set offense outcome taken from Euroleague playoff games of the 2021/22 season. Using Spearman's rank correlation and logistic regression analysis, the variables used in the study formed a principal component defined as Tactical offensive duration. Contrary to expectation, this component did not show to be an indicator sensitive enough to differentiate successful from unsuccessful set offenses ($p<.05$), proving that both outcomes contain practically the same frequency of passes ($x = 3,3$), major tactical elements ($x = 4,6$), as well as equal time of realization ($x = 16$ s). The authors suggest slight enhancement of measuring instrument. The findings help coaches to shift focus towards the nature of tactical tasks in elite basketball and the quality of individual and group performance independently from the offensive duration in order to optimize their strategies for future competition.

Keywords: *basketball, set offense, duration, tactical elements*

Introduction

The set offense is the most common form of offense in basketball (Tavares & Gomes, 2003; Škegro, et.al., 2011). It is characterized by controlled positioning of the players, predetermined tactical plays or patterns and collaborated ball movement to generate effective scoring opportunities. Thus, the execution of this form of offense has a paramount impact on the final outcome of the game. The set offense is also the longest in duration. The length of the offensive possessions and the tactical components can vary depending on the team and the game situation. The ability to effectively execute various pre-planned plays and setups, along with quick adoption to spontaneous game circumstances is important for success in basketball.

Although maintaining the ball possession affects the pace of the game, and more importantly, the time frame of an offensive play allows for pre-planned tactical execution to create uncontested shots, there is no clear evidence in previous studies that the length of an organized set offense can affect its efficiency. Rather, there are conflicting reports on efficiency according to offensive duration. When evaluating offensive success in the playoffs in top Spanish basketball, Gomes et al. (2017) found that the winning teams had longer ball possessions and made more passes against different defenses than the losing teams. On the other hand, Bazanov et.al. (2006), Matulaitis & Bietkis (2021) showed that the scoring rate in offense decreases with increasing duration of ball possession.

Given the complexity of basketball, the one-dimensional analysis of basketball efficiency based only on length contains vast deficiencies and holds limited to no practical value. It is important to include numerous other factors, as the complexity of basketball comprises the combination of physical demands, tactical strategies, skill requirements, decision-making pressure, team dynamics and rule compliance, making it a multifaceted and demanding sport. The aim of this study was to investigate whether the duration of an offense in combination with the quantity of major tactical components can influence the offensive success. The tactical components observed include various individual and group maneuvers as well as passing as a complementary tactical element.

Methods

Sample of data: The entity sample consists of 1,337 set offences obtained from the analysis of 15 randomly selected Euroleague playoff games from the 2021/22 season. On average, 89 offenses per game were analyzed, i.e. approximately 45 offenses per team per game. Sample of variables: The outcome of set offense is a binary dependent variable that represents the result of the attack and is defined by the values 1 (successful) and 0 (unsuccessful). An offense is considered successful if at least one point is scored during the offensive phase, while a loss of ball possession is considered an unsuccessful offense. The independent variables in this research are Duration, Tactics and Passes. Duration is a variable that represents the total length of a set offense in seconds. Passes represent the total number of ball passes, while Tactics represent the overall number of major individual and group tactical elements made by the offensive team. The tactical elements that have been evaluated are: Screen, Stagger, Cross Screen, Kick Out Pass, Cut, Pick & Roll, Pick & Pop, Dribble Hand Off, Isolation, Post-Up Play, Post-Up Seal, 2pt Shot, 3pt Shot. The 13 major elements selected were adopted from Zukolo et.al., 2019. and Selmanović et.al., 2019. and modified according to the aim of the study.

Research methodology: Operational definition of set offense was established by several requirements: five-on-five player formation in the last third area of the basketball court; initial control of the defense; possession of the ball for at least 8 seconds; start of the offense from the backcourt. Data was collected using the video analysis system HUDL InStat (https://www.hudl.com/en_gb/), which contains the notation tools for the variables used.

Data processing: Frequencies were calculated for the categorical variable Outcome and the distribution graphically displayed in a pie chart. The descriptive statistics for the independent variables Duration, Passes and Tactics were calculated separately and in total and included basic statistical parameters: arithmetic mean (AM), median (ME), standard deviation (SD), minimum (MIN) and maximum (MAX) value, and the normality of the distribution was tested using Skewness (SKEW), Kurtosis (KURT) and the Shapiro-Wilk test (S-W). The correlation between the dependent variables was assessed by Spearman's rank correlation coefficients. The probability prediction for the binary variable Outcome was calculated by logistic regression analysis with reduced dimensionality. The dependent variables were reduced into a new variable TOD (Tactical Offense Duration) using the principal components method. As part of the regression analysis, the multiple correlation coefficient, the coefficient of determination, the significance level of the obtained coefficients as well as the beta weight and its significance level were calculated. All determined coefficients were tested at the significance level of p=0.05. The data was processed using Microsoft Excel (version 2017) and TIBCO Statistica (version 13.5).

Results

The research findings are presented under the aspect of offensive outcome. Figure 1 displays the overall distribution of the binary variable Outcome. It shows that the majority of positional offenses ended unsuccessfully (n=790), while 41% of them ended by scoring at least one point (n=547).

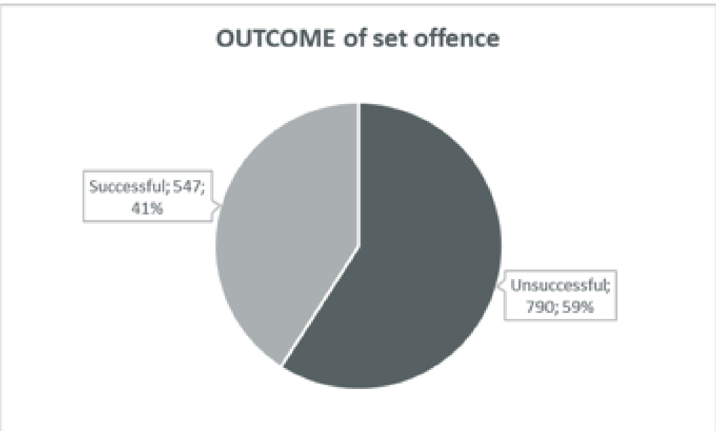

Figure 1. Outcome of set offense

Table 1. Descriptive parameters of independent variables according to outcome of the offense

OUTCOME	N	PREDICTOR	AM	ME	MIN	MAX	SD	SKEW	KURT	S-W p
1	547	DURATION	16,14	16	9	24	4,05	0,00	-1,06	0,00 *
		PASSES	3,28	3	0	10	1,57	0,54	0,26	0,00 *
		TACTICS	4,55	4	2	11	1,67	0,71	0,49	0,00 *
0	790	DURATION	15,64	16	8	23	3,79	0,11	-0,87	0,00 *
		PASSES	3,29	3	0	9	1,50	0,46	0,12	0,00 *
		TACTICS	4,63	4	2	11	1,62	0,67	0,47	0,00 *
0+1	1337	DURATION	15,93	16	8	24	3,95	0,05	-0,99	0,00 *
		PASSES	3,28	3	0	10	1,54	0,51	0,21	0,00 *
		TACTICS	4,58	4	2	11	1,65	0,69	0,47	0,00 *

OUTCOME - dependent categorical variable (0 = unsuccessful set offense, 1 = successful set offense, 0+1 = total variable), N - number of set offenses, PREDICTOR - independent variables in the study (DURATION = duration of the offense in seconds, PASSES = number of passes during offense, TACTICS - number of observed individual and group tactical elements performed during offense), AM = arithmetic mean, SD = standard deviation, ME = median, MIN = minimum score, MAX = maximum score, SKEW = measure of asymmetry, KURT = measure of curvature, S-W p = significance level according to the Shapiro-Wilk test of normality of the distribution, * = statistically significant deviation from the normal distribution

Table 1 shows the basic statistical parameters of the observed independent variables separately and in total. It is noticeable that the values of the successful and unsuccessful outcomes are very similar and are in proportion to the relative values of the overall outcomes. In all three cases, the variables deviate statistically significantly from the normal distribution, with significance level $p=0.00$.

The correlation between the independent variables was calculated using Spearmen's rank correlation and the results are shown in Table 2. There is a medium correlation between the variables ($0,50 < r < 0,61$), which is an indicator that a larger part of the common variance belongs to the same dimension. The variables were reduced using the principal components method, resulting in a linear combination of independent variables called TOD (Tactical offensive duration). All three manifest variables are strongly correlated with the first principal component and share 70.45% of the common variance.

Table 2. Correlation of independent variables

n=1337	DURATION	PASSES	TACTICS	TOD
DURATION	1,00	0,50 *	0,56 *	-0,81
PASSES		1,00	0,61 *	-0,84
TACTICS			1,00	-0,86
Lambda				2,11
%				70,45

DURATION - duration of offense in seconds, PASSES - number of passes during offense, TACTICS - number of observed individual and group tactical elements performed during offense, TOD - tactical offensive duration of offense (first principal component of independent variables), * = $p<0.05$

Table 3. Regression analysis

n=1337	Multiple R	R^2	p	b*	p
TOD	0,01	0,00	0,65	0,00	0,65

TOD - tactical offensive duration (first principal component of independent variables), Multiple R - correlation coefficient, R2 - determination coefficient, p - significance level of the specified coefficient in the previous column, b*- standardized regression coefficient

A logistic regression analysis with reduced dimensionality was used to examine the predictive capabilities of the TOD variable. In this case, the Outcome represents the criterion variable, while the TOD represents a set of predictor variables. The results presented in Table 3 clearly show that the predictive model is equal to zero (R2=0,00). Although the correlation coefficient (MR = 0.01) is not statistically significant (p = 0.65), based on the fact that 1337 entities and one predictor were used in the study, it is calculated that a minimum correlation coefficient of R = 0.05 would be required for statistical significance in this predictive model. Since this study did not achieve even this minimal correlation coefficient, it can be concluded with great confidence that there is no relationship between these two phenomena.

Discussion

Considering that the set offense provides a structured framework for teams to generate scoring opportunities through strategic decision-making process and coordinated player and ball movement, the goal was to investigate whether the duration of offense and its associated tactical components play a key role in offensive success.

Initially, the descriptive parameters confirmed certain theories from previous studies. The efficiency rate of set offenses generally tends to end unsuccessfully – through a missed shot and/or loss of possession (59%). Similar results were found by Bazanov et al. (2006) and Milanović et al. (2014). The duration of this type of offense is on average 16 seconds (+ 3.95 standard deviation), which corresponds with the findings of Tavares & Gomes, 2003; Škegro et.al., 2013. Special attention was oriented towards the quantity of main tactical actions used during an offense. The variable involved 13 major tactical elements: off ball screen, stagger, cross screen, kick out pass, cut, pick & roll, pick & pop, dribble hand off, isolation, post-up play, post-up seal and two modes of offensive finishes - 2pt shot, 3pt shot. The results show that elite teams use 4.6 tactical elements per possession. Considering the importance of ball distribution in realization of an attack, the research was supplemented by the evaluation of passing frequency. On average, 3.3 passes are played per each possession, which is consistent with the author's previous research (Selmanović et.al., 2021).

There are many studies that deal with the efficiency rate of offensive duration, tactical elements and the analysis of passes in basketball. Guided by the notion that increased spatial dynamics through a high motion speed of movement and/or a high frequency of concatenated cooperative maneuvers increases the probability of game success in professional basketball (Christmann et.al., 2018), the aim of this study was to investigate their mutual relationship in accordance to the offensive success. All three variables shared a significant common variance, which was defined as Tactical offensive duration (TOD). Contrary to expectations, the combination of all three observed variables cannot discriminate successful and unsuccessful offenses. The results obtained indicate that the measurement instrument should be enhanced with supplementary components.

It is important to highlight that results of this study do not contradict the theory that the length of offense, ball distribution and tactical elements have no general influence on the outcome of the set offense. Indeed, they are pivotal for success in basketball, however the study emphasizes that the focus is to combine the quality of performance with the quantity of tactical actions. Therefore, additional attention should be oriented more towards the assessment of implemented type of tactical tasks, their purposefulness, coordinated player and team movements. Further research should include a more detailed evaluation of anticipated player movements that directly and indirectly affect the execution of attacks (spacing, targeted opening towards and away from the ball, side clearance, etc.), along with an examination of significance of a particular tactical task, player skills and decision-making, and finally, the level of aggression and quality of performance in defense. Such comprehensive approach requires qualitative research of the subject. By combining quantitative and qualitative analysis of this topic, coaches and teams would gain more accurate insights into the success and efficiency of set offense and make informed decisions to optimize their game strategies.

Conclusion

The complexity of basketball contains abundance of manifested and latent dimensions that contribute to team success. The nature of set offense offers longer possessions, allowing patience and precision to utilize various synergistic tactical actions with the goal to enhance a team's ability to exploit defensive weaknesses and create optimal scoring opportunities.

This study analyzed the influence of the duration and number of major tactical elements on set offense outcome. The mutual correlation of the variables used in the study formed a principal component, defined as Tactical offensive duration. However, this component did not prove to be an indicator sensitive enough to predict successful from unsuccessful set offenses, suggesting that both outcomes involve practically the same frequency of passes, tactical elements and time of their implementation. The findings suggest that the future focus in offence outcome research should be on the nature of execution of tactical elements and the quality of individual and group performance independently from the offensive duration.

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QUANTIFICATION OF THE DEVELOPMENT TREND OF RESULTS DURING THE CAREER OF CROATIAN SPRINTERS IN THE 50M FREESTYLE CONCERNING THE BEST EUROPEAN SWIMMERS: INITIAL AGE-PERFORMANCE MODEL

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Abstract
The aim of this research is to compare the legality of Age-Trend changes in the development of results during the career of top European (EU) and Croatian (CRO) sprinter swimmers in the 50m crawl technique. The obtained results show an insight into the characteristics and diversity of the applied technology of training work in both systems. The paper used the results of current age and annual peak performance in a 50-meter pool for a sample of 24 male and 21 female swimmers (EU = 16 male and 15 female swimmers; CRO = 9 male and 7 female swimmers). Two variables were used for the analysis: 1) current age, and 2) the best result in the 50m crawl swum in a given calendar year. A career performance trajectory was calculated using the polynomial equation for each swimmer. The results showed that there is an evident quantitative difference between Croatians and European swimmers, which is dominantly related to the following: European crawl male sprinters and female sprinters during their careers reach their career peak at a later age (about 2 and 4 years later for men and women, respectively). The reached peak result is better for men by 0.74 sec. (3.26%), and for women by 1.81 sec. (6.73%). In addition, the career of European swimmers lasts on average 5 to 6 years longer. The results point to the conclusion that crawl-sprint swimming among women in Croatia is at a lower level of development and is systemically more endangered compared to men.

Keywords: *sprinters, swimming, freestyle, performance, model.*

Introduction
Sports training is a long-term, planned and programmed process that has its laws. The process is multidimensional and a large number of factors influence the final result in a sports career (González-Ravé et al., 2021). It is structured in stages, from the beginning of starting to play sports and the phase of primary selection. Depending on chronological and biological age, adaptive abilities, psychological-cognitive characteristics, as well as anthropological-morphological and physical-motor abilities, an individual advances at different speeds toward the stage of career peak results (Allen et al., 2014). From the methodological aspect of the organization of the training process, knowledge of relevant information about the development trend of swimmers is necessary for the process of planning and programming training (Allen et al., 2014; Dopsaj et al., 2023). The identification of an individual's potential in terms of the optimal age for achieving top competitive results as a function of gender, competitive level, distance or swimming technique is a current and important area of research in swimming science (González-Ravé et al., 2021; Gorzi et al., 2022). The aim of this research is to compare the legality of Age-Trend changes in the development of results during the career of top European (EU) and Croatian (CRO) sprinter swimmers using the crawl technique to define a trend model of changes in the state of competitive performance potential. The Age-Trend of changes in the best Croatian male and female sprinters using the crawl technique at 50m in a 50m swimming pool, and comparing it with the trend of changes in the best European male and female swimmers, will give an insight into the characteristics and diversity of the applied training technology in both systems. The obtained results can help sports scientists and researchers in swimming, but also coaches and sports workers in the management of Croatian swimming to perfect the technology of training work in Croatian swimming.

Methods
This research belongs to the category of fundamental research. Data collection was carried out using the method of secondary analysis.

Subject Sample
The results of the current age and annual peak performance of the total sample of 24 male and 21 female swimmers were used in the paper. A sub-sample of the best European sprinters in crawl technique at 50m in a 50-meter pool was represented by the results of 16 male and 15 female swimmers from 9 EU countries. The sample of the best Croatian

sprinters in the crawl technique is made up of the results of 9 male and 7 female swimmers, the best sprinters in the previous decade. All results were collected from the open database Swimrankings (https://www.swimrankings.net/), while the swimmers were selected following previously defined criteria (Dopsaj et al., 2023).

Variables

Two original variables were used for the analysis: 1). current age expressed in years for a given season; 2). the best result in the 50m crawl swum in a given calendar year expressed in seconds. Based on the given variables, the following two dependencies were defined for each respondent: a) Annual Best 50m free Results (ABR), time in sec. vs Age relation; b) Annual trend of change in 50m free results expressed in an annual percentage change (gain or results regression) vs Age relation. Based on each relationship equation, nominal (numerical) values were defined for each subject, which were analyzed in the following statistical procedure.

Statistics

Descriptive statistics were used to determine the basic descriptive measures (Mean, SD, and cV%). The definition of the dependence of used swimming variables vs age, the method of mathematical modeling was used by the polynomial function equation. Differences between explored variables concerning EU and CRO subsample and gender were determined by using ANOVA and T-test for the independent sample. All statistical analyses were performed using the IBM SPSS 25 (IBM Corp., 2017) and Microsoft Excel (Microsoft Corp., 2018).

Results

Pictures 1 and 2 shows the results of the defined relations for the 50m crawl ABR vs Age for explored subsamples (EU vs CRO) considering gender as a career performance trajectory model.

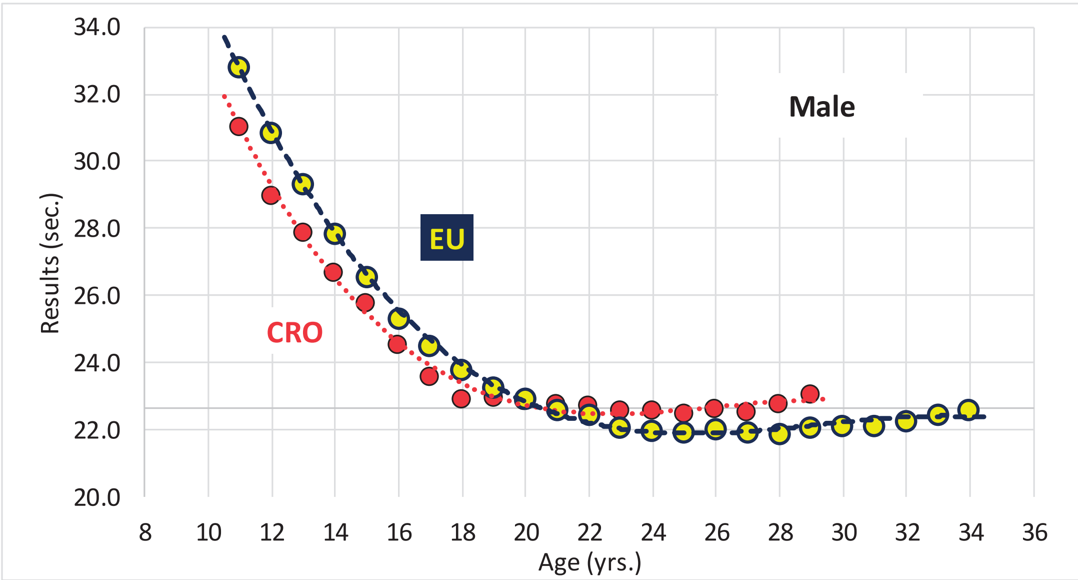

Figure 1. Defined relations for the 50m crawl ABR vs Age as a career performance trajectory model for males (CRO vs EU).

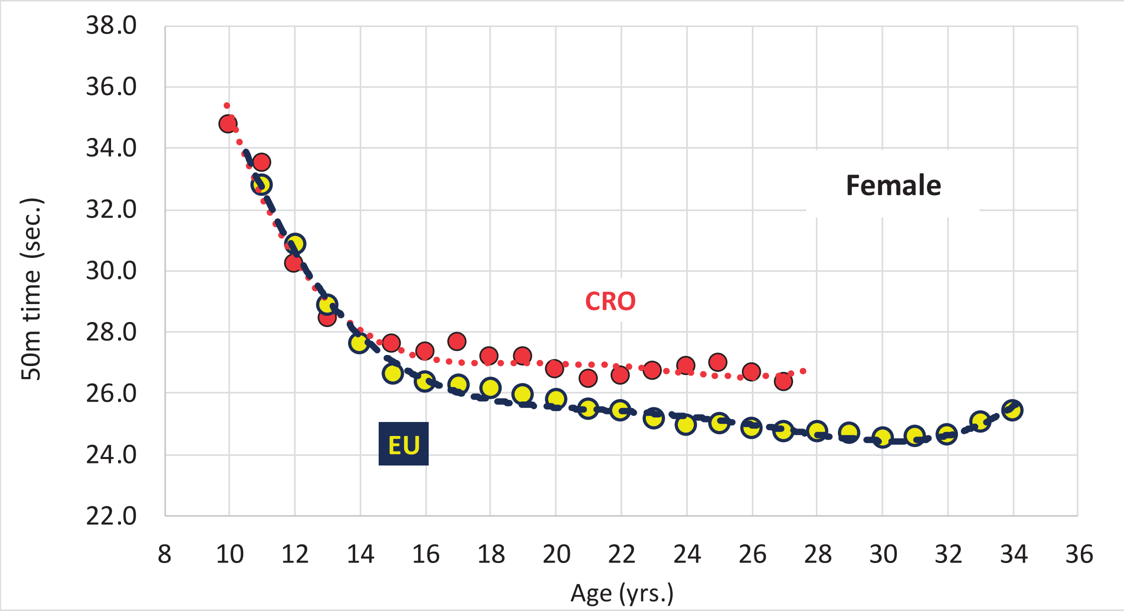

Figure 2. Defined relations for the 50m crawl ABR vs Age as a career performance trajectory model for females (CRO vs EU).

Table 1 presents the synthesized numerical descriptive data for the first defined model (trend of change in results as a function of years) with a presentation of the differences between the examined subsamples (EU vs CRO) considering gender as a career performance trajectory model.

Table 2 shows the synthesized numerical descriptive data for the model of the annual increase in the results of the subsample with the determined difference expressed in absolute (sec.) and relative (%) values of the same.

Table 1. Synthesized numerical descriptive data for the first defined model showing the differences between the best EU and CRO sprinters of both sexes (Absolutely and Relatively).

	Male Results (sec.)		Male Differences		Female Results (sec.)		Female Differences	
Age (yrs.)	EU	CRO	Abs (sec.)	Rel (%)	EU	CRO	Abs (sec.)	Rel (%)
12	30.88	29.25	1.64	5.60	30.64	30.41	0.23	0.75
13	29.26	27.76	1.51	5.42	29.07	29.01	0.06	0.21
14	27.85	26.50	1.35	5.08	27.90	28.08	**-0.18**	-0.64
15	26.61	25.45	1.17	4.59	27.05	27.51	-0.45	-1.65
16	25.56	24.59	0.97	3.95	26.46	27.19	-0.73	-2.69
17	24.66	23.90	0.76	3.19	26.07	27.05	-0.98	-3.62
18	23.92	23.37	0.55	2.34	25.82	27.01	-1.19	-4.39
19	23.31	22.98	0.33	1.44	25.68	27.02	-1.34	-4.95
20	22.83	22.71	0.12	0.53	25.60	27.03	-1.43	-5.29
21	22.46	22.55	**-0.08**	-0.37	25.54	27.01	-1.47	-5.44
22	22.20	22.47	-0.27	-1.21	25.50	26.97	-1.47	-5.45
23	22.02	**22.46**	-0.44	-1.96	25.44	26.89	-1.45	-5.38
24	21.92	22.50	-0.58	-2.59	25.37	26.80	-1.43	-5.34
25	**21.88**	22.57	-0.70	-3.08	25.27	26.72	-1.46	-5.45
26	21.89	22.67	-0.77	-3.41	25.15	**26.71**	-1.56	-5.85
27	21.95	22.76	-0.81	-3.57	25.01	26.82	-1.81	-6.73
28	22.03	22.83	-0.80	-3.52	24.89			
29	22.12	22.87	-0.74	-3.26	24.79			
30	22.22				**24.76**			
31	22.31				24.82			
32	22.37				25.03			
34	22.39				26.10			

Table 2. Synthesized numerical descriptive data for the model of annual differences of WoAq score results showing the differences between the best EU and CRO sprinters (Abs. and Rel.).

MALE - Annual WoAq score change					FEMALE - Annual WoAq score change				
Age	EU	CRO	Annual diff.	%	Age	EU	CRO	Annual diff.	%
11-12	50	44	**-6**	-12.0	11-12	89	115	26	29.0
12-13	60	63	4	6.0	**12-13**	89	86	**-3**	-3.6
13-14	65	71	6	9.9	**13-14**	75	42	**-33**	-44.5
14-15	66	70	5	7.2	**14-15**	57	9	**-47**	-83.5
15-16	63	64	0	0.7	**15-16**	39	-4	**-42**	-109.6
16-17	59	54	**-5**	-8.1	**16-17**	24	-1	**-25**	-103.2
17-18	53	43	**-10**	-18.5	**17-18**	15	9	**-6**	-38.0
18-19	45	32	**-13**	-29.8	18-19	11	18	7	65.6
19-20	37	22	**-15**	-41.3	19-20	10	19	9	82.1
20-21	29	14	**-15**	-52.2	**20-21**	12	11	**-2**	-13.7
21-22	21	8	**-13**	-61.3	**21-22**	15	-3	**-19**	-122.8
22-23	13	5	**-9**	-66.0	**22-23**	18	-16	**-34**	-191.7
23-24	6	3	**-4**	-58.7	**23-24**	19	-20	**-39**	-204.3
24-25	0	1	1	-1170.2	**24-25**	19	-10	**-29**	-152.9
25-26	-6	0	5	-93.0	**25-26**	17	9	**-8**	-48.7
26-27	-11	-4	6	-58.1	26-27	14			
27-28	-15	-13	2	-13.5	27-28	11			
28-29	-19	-28	**-9**	50.0	28-29	8			
29-30	-23				29-30	5			
30-31	-27				30-31	3			
31-32	-32				31-32	0			
32-33	-38				32-33	-8			
33-34	-46				**33-34**	-27			

Discussion

The ANOVA results showed that the results achieved at 50m during career differ statistically significantly between EU and CRO male and female swimmers at the general level $F=9.739$, $p = 0.000$. However, it was determined that the cause of the general difference found was only the sample of women, between whom a statistically significant difference was determined at the level of $t = 2.595$, $p = 0.007$, while in men this difference was not established ($t = 0.227$, $p = 0.410$).

The results of the defined model for men (Table 1, Picture 1) showed that the best EU swimmers reach a career peak at the age of 25 with a personal best result in the 50m crawl of 21.88 sec (875 points). CRO swimmers reach their career peak at the age of 23, with a personal best result of 22.46 sec (812 points). By quantitative comparison of the model, it is observed that the critical period of separation of progress trends between EU and CRO swimmers is at the chronological age of 21 years. By that age, CRO sprinters have better indicators of the development of results. From the age of 21, EU sprinters start to improve their results compared to CRO. The trend among EU swimmers continues until the age of 29, when the career of CRO sprinters ends (Table 1). The results of the defined model for women (Table 1, Picture 2) show that the best EU swimmers reach their career peak at the age of 30, with a personal best result in the 50m crawl of 24.76 sec. (899 points). CRO swimmers reach their career peak at the age of 26, at the level of the best result of 26.71 sec (710 points). Comparing the results development model, it is observed that the critical period of separation of progress trends, between EU and CRO female swimmers, is at the age of 14 years. Until that age, CRO sprinters have better indicators of the development of the result performance. From the mentioned age, EU sprinters start to improve their results better than CRO, until the age of 27, when the career of CRO sprinters ends (Table 2). At the moment of the end of the career, the difference between EU and CRO sprinters is at the level of -0.74 sec, i.e. -3.26%, for swimmers, i.e. -1.81 sec, -6.73% for female swimmers (Table 1). About the defined quantitative parameters of the model of the annual increase in results (Table 2), it can be concluded that the highest increase in results for sprinters from the EU is in the period between the ages of 14 and 15 (66 points). For sprinters from CRO, it was stated one year earlier in the period of the 13th and 14th year (71 points) (Table 2). It is interesting to point out that for the period from the age of 12-13 until the age of 15-16 (4 years), a greater, i.e. more intense annual increase in the results of CRO sprinters compared to the EU was determined. However, from the period of 16-17 years until the period of 24-24 years, EU sprinters have from 4 to 15 points higher annual increase in results. The biggest difference in the increase in results was determined in the period of 19-20 and 20-21 years of age and amounts to 15 points per season. The development process of the results in terms of the utilization of the maximum biological potential of organism adaptation in both analyzed samples of swimmers occurs in the chronological age period of 24-26 years of age, after which the period of exploitation of the achieved competitive performance begins. Unfortunately, in Croatia, the sports career of crawling sprinters lasts on average until the age of 28-29, while the best European sprinters last until the age of 33-34. So, in Europe top sprinters "last" on average 5 years longer.

Nominally, the largest increase in results (Table 2) for swimmers from the EU is in the period from 11 to 13 years (89 points per season), while for swimmers from CRO it is a year earlier, i.e. in the period from 11 to 12 years (115 points). The results show that there are two periods of stagnation of results in CRO female sprinters, namely in the period from 15 to 17, as well as from 21 to 25 years of age, while the progress of results in EU female sprinters is linear (although decreasing) until the period of 31 to 32 years. Unfortunately, the sports career of Croatian female sprinters ends on average between the ages of 25 and 26, while that of female swimmers from the EU only ends at around 33-34 years of age. The biggest difference in the increase in results, as a measure of the quality of the realized training technology, between CRO and EU sprinters, was determined for the periods from 14 to 15 years, and 23 to 24 years, where the difference is 47 and 39 points per season in favor of EU swimmers, respectively (Table 2).

The results of the range of characteristic periods of a swimming career /Carrier Windows Span Frame (CWSF)/concerning men showed that CRO swimmers can achieve a level of results of 99.5% of the personal best (PB), as an extremely high level of results in terms of the career peak of personal achievement (22.58 sec.) to swim during a period of 4.5 years at the age of 21.4 to 25.9 years of age. The given range for the best EU swimmers lasts 4.9 years, and at the age of 24.3 to 29.2 years, with a result of 22.02 sec. On the other hand, a high level of results, i.e. 95% of the PB, CRO swimmers can achieve in a period of 16.1 years of their career (from 17.6 to 33.7 yrs.), while for EU swimmers this period lasts longer 16.8 years (from 19.9 to 36.7 yrs), and at the result level of 22.45 sec.

Conclusion

The results showed that the career course of the development of results as a function of age among the best sprinters in the 50m crawl from the EU and CRO is different. The difference refers to the following observed phenomena: during their careers, European male and female sprinters reach their career peak at a later age (around 2 and 4 years for men and women, respectively), where the reached peak performance is better for men by 0.74 sec. (3.26%), and for women by 1.81 sec. (6.73%), and the career of EU swimmers lasts on average about 5 to 6 years longer. It is important to note that greater differences between EU and CRO sprinters in the crawl were found in female swimmers, compared to male swimmers. In other words, women's Croatian swimming in the crawl sprint is at a lower level of development and systemically more vulnerable compared to men's swimming.

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COMPETITION PERFORMANCE OF THE CROATIAN WRESTLING TEAM AT MAJOR COMPETITIONS

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Abstract
Monitoring of competitive performance in wrestling over the years has evolved, and the results of analyses are publicly available immediately after the competition. Analyses of major wrestling competitions provide wrestlers and coaches with feedback on competitive efficiency and allow for better technical-tactical preparation of wrestlers. To improve the competitive efficiency of Croatian wrestlers in major wrestling competitions, an analysis was conducted to determine the structure of offensive and defensive activities.

The analysis of the differences in won and lost points by Croatian Greco-Roman wrestlers in the major wrestling competitions in the Olympic cycle 2020-2024 shows that they significantly won points using passivity (22,0%) and gut wrench techniques (38,6%), while they lose the most points using techniques such as take down (12,4%), hip turning throw (5,9%), forward bending throw (7,6%), and lifts (22,4%). The results of this study indicate a deficit in the defensive phase in the parterre position and very weak offensive efficiency compared to the modal characteristics of medalists in major wrestling competitions.

Further analysis of tactical preparations, biomechanical and conditioning readiness analysis for each wrestler, analysis of implemented training programs (number of days, sparring partners, training duration), and timing of Croatian wrestlers' form is necessary. The limitation of refers to use of different names of variables as well as use different set of variables in other studies, because of that it is necessary to standardize and precisely describe variables to be appropriate, understandable and applicate to next researches.

Keywords: *seniors, Greco-Roman, Olympic cycle, standing position, parterre position*

Introduction

The monitoring of competitive efficiency in wrestling at the level of world championships started by Harlod Tünnemann, analysing videotapes of all matches and calculating a points-per-minute Index of Performance (points scored minus points allowed for each minute) for the 2003 World Championships which presented at the FILA Coaches and Referees Clinic (Tünnemann, 2004). Longitudinal monitoring of competitive performance and providing feedback to wrestlers and coaches about their performances in competitions is very important to improve competitive performance. The monitoring of competitive efficiency of Croatian wrestlers was conducted on a sample of juniors (Slacanac et al., 2017), while an analysis of the situational efficiency of the Croatian senior wrestling team was conducted at the European Championship in 2022 (Slačanac, 2022). There were not established differences between Croatian wrestlers and their opponents at the European championship 2022, but it is confirmed that they achieved 20% more points in standing position. In addition, they loss more point with other points which indicate on weak tactical preparation.

Over the past twenty years, members of the Croatian senior Greco-Roman wrestling team have won 11 medals (one silver and ten bronze medals) at European and world championships (UWW, 2024b). During the last Olympic cycle (2020-2024), Croatian wrestlers in the senior age group have won two bronze medals at the European Championships (in 2021 and 2023) and achieved five fifth-place finishes (four at the European Championships and one at the Olympic Games). To increase offensive and defensive efficiency, and consequently, improve performance (Slačanac, 2024) and increase the number of medals won at major wrestling competitions (UWW, 2024b), as well as to receive feedback on efficiency, it is necessary to conduct a detailed analysis of competitive performance at the major wrestling competitions in the previous Olympic cycle (2020-2024). Therefore, the aim of this study is to define the structure of offensive and defensive actions and determine the offensive and defensive efficiency of Croatian senior wrestlers at major wrestling competitions.

Methods

The sample of participants consists of 15 Croatian Greco-Roman wrestlers who competed in the major senior wrestling competitions (European Championships, World Championships, Olympic Games, and World Cup) in the previous Olympic cycle (2020-2024) in weight categories 60, 63, 67, 72, 77, 82, 87, 97 and 130 kg. Four wrestlers won bronze medals at European Championships and European Games, four wrestlers won silver medals at the U23 World Championships, while two wrestlers participated in the 2021 Olympic Games in Tokyo. Consequently, it can be said that this is a sample of elite wrestlers. For this study, the number of appearances of each Greco-Roman wrestlers (N=47) was observed, along with the number of points won and lost by each wrestler in each competition. The video analysis of matches was conducted manually by an independent expert team from the United World Wrestling (UWW), and the data is available on the Performance Data Analysis Report platform (UWW, 2024a).

The UWW technical and scientific committee standardized variables with exact name of the wrestling techniques (Roklicer at al., 2019). A set of 16 was variables applied, 10 of them (take down, hip turning throw, forward bending throw, suplex throw, counter, passivity, step out, caution, challenge and negative wrestling) refers to standing position and 6 of them (gut wrench, lifts, turn over, counter, challenge, caution) refers to parterre position.

The data was organized in the Microsoft Excel 365 software package, while data processing was conducted using the IBM SPSS version 25 software package. Normality of distribution was tested using the Shapiro-Wilk test, and since the data significantly deviated from normal distribution in all variables, non-parametric statistics were applied. The basic statistical parameters are presented in the study, and to determine differences in the number of points won and lost, the Kruskal-Wallis test was used at a significance level of p=0,05.

Results

It is evident that during the Olympic cycle 2020-2024, there were between 2 to 8 wrestlers participating in the major wrestling competitions, with an average of 3,2 matches per tournament (Table 1). They scored average 25,9 points and lost 37,0 points per tournament. Observing the number of won points at the European Championships compared to other competitions, it is noticeable that subjects won more points than World Championships, World Cup and Olympic games together.

Table 1. Descriptive statistic parameters

Competition	N	Won bouts	Lost bouts	W_pts	L_pts
European Championship 2020	5	3	6	34	48
European Championship 2021	5	6	7	14	38
European Championship 2022	5	5	7	43	40
European Championship 2023	8	7	9	50	80
European Championship 2024	6	4	7	58	60
Olympic Games 2021	2	3	3	19	23
Individual World Cup 2020	2	0	2	0	14
World Championship 2021	4	2	4	14	18
World Championship 2022	5	1	5	18	24
World Championship 2023	5	1	5	9	25
AVERAGE	**4,7**	**3,2**	**5,5**	**25,9**	**37,0**
STANDARD DEVIATION	**1,8**	**2,3**	**2,1**	**19,2**	**20,8**
SUM	**47**	**32**	**55**	**259**	**370**

By analysing the differences (Table 2), statistically significant differences were found between won and lost points in five variables. Statistically significant differences were observed in variables related to the standing position, specifically in the variables of take down (p=0,025), hip turning throw (p=0,029), forward bending throw (p=0,040), and challenge standing (p=0,015), as well as the variable lifts (p=0,001) related to the parterre position.

Table 2. Differences analysis of won and loss points (Kruskal-Wallis test results)

Variable	ST PA	won pts	loss pts	Test statistics	Df	Asymptomatic sig (2-sided test)
TAKE DOWN	ST	16 (6,2%/25,8%)	46 (12,4%/74,2%)	5,004	1	0,025
HIP TURNING THROW	ST	4 (1,5%/15,4%)	22 (5,9%/84,6%)	4,754	1	0,029
FORWARD BENDING THROW	ST	4 (1,5%/12,5%)	28 (7,6%/87,5%)	4,202	1	0,040
SUPLEX THROW	ST	24 (9,3%/85,7%)	4 (1,1%/14,3%)	2,845	1	0,092
COUNTER STANDING	ST	0 (0,0%/0,0%)	6 (1,6%/100,0%)	3,066	1	0,080
PASSIVITY	ST	57 (22,0%/47,9%)	62 (16,8%/52,1%)	0,419	1	0,517
STEP OUT	ST	13 (5,0%/38,2%)	21 (5,7%/61,8%)	1,520	1	0,218
CAUTION STANDING	ST	7 (2,7%/63,6%)	4 (1,1%/36,4%)	0,009	1	0,925
CHALLENGE STANDING	ST	1 (0,4%/11,1%)	8 (2,2%/88,9%)	5,957	1	0,015
NEGATIVE WRESTLING	ST	0 (0,0%/0,0%)	2 (0,5%/100,0%)	1,000	1	0,317
GUT WRENCH	PA	100 (38,6%/65,8%)	52 (14,1%/34,2%)	1,265	1	0,261
LIFTS	PA	18 (6,9%/17,8%)	83 (22,4%/82,2%)	11,195	1	0,001
TURN OVER	PA	0 (0,0%/0,0%)	6 (1,6%/100,0%)	3,066	1	0,080
COUNTER PARTERRE	PA	7 (2,7%/38,9%)	11 (3,0%/61,1%)	0,163	1	0,686
CHALLENGE PARTERRE	PA	6 (2,3%/46,2%)	7 (1,9%/53,8%)	0,088	1	0,766
CAUTION PARTERRE	PA	2 (0,8%/20,0%)	8 (2,2%/80,0%)	1,883	1	0,170
STANDING POSITION		126 (48,6%/38,3%)	203 (54,9%/61,7%)			
PARTERRE POSITION		133 (51,4%/44,3%)	167 (45,1%/55,7%)			
SUM		**259 (100,0%/41,2%)**	**370 (100,0%/58,8%)**			

LEGEND: ST – standing position; PA – parterre position; won pts – won points; loss pts loss points

Almost an equal number of points were scored in the standing position (126 points; 48.6%) and parterre position (133 points; 51,4%), while a slightly higher number of points were lost (203 points; 54,9%) in the standing position compared to the parterre position (167 points; 45,1%). The most points were scored using the gut wrench technique (100 points; 38,6%) and passivity (57 points; 22,0%), while the most points were lost by lifts technique (83 points; 22,4%), passivity (62 points; 16,8%), gut wrench (52 points; 14,1%), and take down (46 points; 12,4%).

Discussion

The technical and tactical activity of top five placements in the World Championships in Greco-Roman wrestling characterized using almost as many standing as par-terre techniques (Gonzalez, 2014). Croatian wrestlers significantly score fewer points in the standing position compared to values (48,6% VS 68,62%-71,37%) from other competitions (Roklicer et al., 2019; Dokmanac & Slačanac, 2018) and lose significantly more points in the standing position. This indicates a weak attacking efficiency in the standing position compared to Olympic Games medalists who score significantly more points than other wrestlers (non-medalists) using techniques such as forward bending throw and take down (Slačanac et al., 2021a). The statistically significant differences in variables related to lost points in the standing position (take down, turning hip throw, and forward bending throw) indicate insufficient awareness of the opponent and pronounced tactical preparation of the opponent using "shackles", "manoeuvring", and "unbalancing". In terms of tactical preparation and success (Baić et al., 2001), the importance of individual technical-tactical elements for success and statistically significant correlation of the beginnings of technical-tactical elements with the total number of scored points has been established (Starčević, 2023). According to Slačanac et al. (2021b), to increase competitive efficiency at the national championship, attention needs to be paid in training to different wrestling methods such as fighting in the zone, fighting against faster and stronger opponents, and fights with different technical-tactical tasks. In the tactical preparation of wrestlers, attention should be paid to the tactical preparation of "shackles", through which opponents have scored a significant number of points. Even though the challenge standing variable accounts for only 2,2% of lost points, its statistical significance indicates the importance of the coach's recognition of the situation and the wrestler's proper execution because every call for video review can result in a negative point, which can be crucial in a tied score.

In the parterre position, the highest number of points is scored by gut wrench and passivity, indicating tactical manoeuvring by scoring the first point using passivity in the standing position and then following up with a gut wrench attack in the parterre position, which is in line with international wrestling rules (UWW, 2023) and the fact that in 99% of cases, the continuation of the match after passivity is in a parterre position (Dokmanac & Slačanac, 2018). In terms of offense, Croatian wrestlers demonstrate low offensive efficiency (a small number of points scored with lifts), while medalists in major wrestling competitions are characterized by scoring a lot of points in the standing position (UWW, 2024a). Therefore, it is necessary to make corrections and modifications of the plans and programs of national selections, and to pay more attention to teaching and using lifting techniques in younger age groups. This would enable to gain a scoring advantage and increase chances of winning and achieving better placements in competitions.

One of the significant differences between opponents and Croatian wrestlers (the reason they lose points) lies in the execution of the take down technique in the standing position and the continuous execution of lifting techniques (max 4 points for one action) and several connected actions (3-5 attacks) by gut wrench and lifts in the par terre position, thereby gaining a significant advantage compared to (1-2 attack) gut wrench (max 2 points for one action). Statistically significant differences are highlighted in the lifts techniques, which is the result of quality tactical preparation, technical execution, and the number of repetitions and adequate strength conditional preparation of the opponent. The large number of lost points in the parterre position is a result of insufficient defensive activity (moving on the mat) in the parterre position and insufficient focus during the defensive phase.

The limitation of this research refers to variables. Some authors use different names of variables as well as use different set of variables so because of that it is difficult to compare results. According to this, UWW Technical and scientific committee had to standardize variables with exact name of the wrestling techniques (Roklicer at al., 2019). For this reason, in this research we used this standardized variables to be up to date and have to possibilities to compare results of with other research. Thus above mentioned, it is necessary to standardize and precisely describe variables to be appropriate, understandable and applicate in the future.

Conclusion

Croatian wrestlers score the most points using passivity and gut wrench techniques, while they lose the most points using techniques such as take down, hip turning throw, forward bending throw, and lifts. The results of this study indicate a deficit in the defensive phase in the parterre position and weak offensive efficiency compared to the modal characteristics of medal winners in major wrestling competitions. Therefore, it is crucial to increase offensive efficiency through greater aggression, imposing rhythm, and tempo of fighting, increase of number attempts (attacks), both in standing and parterre positions. Further analysis of tactical preparations, biomechanics, and analysis of physical conditioning for each wrestler, analysis of conducted training programs (number of days, sparring partners, duration of training), as well as timing of Croatian wrestlers' form, is necessary.

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REACTIVE AGILITY OF U19 FEMALE BASKETBALL PLAYERS AND ITS RELATIONSHIP WITH SPEED AND POWER

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Abstract
This study aimed to find a relationship between the reactive agility of U19 female basketball players and speed and power characteristics. This study involved twelve U19 female basketball players from the first division who participated in various tests aimed at evaluating different aspects of their physical performance. These tests included assessments of power through the squat jump, countermovement jump, and drop jump, linear speed through 5, 10, and 20-meter sprints, change of direction speed through the 505 test, and reactive agility through the Y-shaped test. The correlation coefficient showed a large association ($r = 0.64$, $p = 0.02$) between the Y-shaped test and the 20 m linear sprint. The Association of the Y-shaped test with other power and speed tests was small or moderate. These findings suggest that basketball coaches working with young female players can leverage the enhancement of reactive agility to concurrently develop linear speed.

Keywords: *Y-shaped test, vertical jumps, reactive agility, change of direction speed*

Introduction
In the context of basketball gameplay, the effective resolution of game scenarios hinges upon physical conditioning and coordination skills. Consequently, basketball imposes substantial physiological demands on its participants' cardiovascular and neuromuscular systems. This assertion finds support in numerous studies employing methodologies like heart rate monitoring and time-motion analysis (Ben Abdelkrim et al., 2007; Matthew & Delextrat, 2009; Reina et al., 2020; Scanlan et al., 2012; Svilar et al., 2019; Vencúrik et al., 2015). Across these analyses, the frequency of physical activities performed (such as walking, running, sprinting, jumping, etc.) varied notably, ranging from 21.2 to 56.9 movements per minute. According to Stojanović et al. (2018), alterations in movement activity arise approximately every 1 to 3 seconds, necessitating rapid responses to diverse environmental stimuli (e.g., teammate movements, opponent movements, ball movements, etc.). Effective management of game scenarios presupposes elevated levels of speed and power and proficiency in agility and cognitive processes, the latter encompassing decision-making abilities, constituting integral components of agility. As Sheppard and Young (2006) posited, agility is construed as an autonomous motor skill characterized by swift whole-body movements entailing alterations in speed or direction in reaction to specific stimuli. Accordingly, agility assessments hold pivotal significance in delineating player profiles. Traditional evaluations such as the T-test, the Illinois agility test, or the 505 test have conventionally been employed to gauge agility in basketball contexts (Ben Abdelkrim et al., 2007; Delextrat & Cohen, 2009).

Nevertheless, these conventional tests primarily focus on assessing the velocity of directional changes among basketball players, yet they neglect the cognitive aspects integral to agility performance (Scanlan et al., 2014). Recently, there has been a surge in studies wherein researchers endeavor to formulate agility testing protocols. A noteworthy advancement in these protocols involves the inclusion of cognitive elements, particularly decision-making processes (Lockie et al., 2014; Matlák et al., 2016; Sekulic et al., 2017). These assessments, termed reactive agility tests, incorporate perceptual and decision-making dimensions and are characterized by an open-skill framework. Notably, according to Scanlan et al. (2014), cognitive metrics exert a substantial influence on performance in reactive agility tests, whereas the impact of factors such as speed, change of direction speed, strength, and power remains ambiguous in some studies (Horníková & Zemková, 2022; Paul et al., 2016). This study elucidates the speed and power components associated with reactive agility performance among U19 female basketball players.

Material and methods
Participants
Twelve U19 female basketball players participated in this study (mean age 17.1 ± 0.9 years, mean body height 173.9 ± 9.3 cm, mean body weight 66.1 ± 8.2 kg). Players played in the 1st U19 division of the Czech basketball competition. They completed 4 training sessions per week and played 2 games every second week. Players participated voluntarily and signed (or their legal representatives) informed consent before the study. The study was conducted in accordance with the Declaration of Helsinki and was approved by the Research Ethics Committee of Masaryk University (EKV-2021-114).

Procedures
The participants underwent a series of assessments to evaluate their power, linear speed, change of direction speed, and reactive agility. Prior to the commencement of the testing regimen, the players engaged in a collective warm-up session lasting 15 minutes, supervised by the coach. Following a brief intermission, the players proceeded with the field tests in the following sequence: squat jump (SJ), countermovement jump (CMJ), drop jump (DJ), Y-shaped test (Y test), a 20-meter linear sprint with split times recorded at 5- and 10-meter intervals and the 505 test.

The SJ, CMJ and DJ assessments were conducted utilizing Kistler dual portable force plates, type 9260AA6 (Kistler Group, Winterthur, Switzerland). Participants were instructed to maintain their hands on their hips throughout the movement and execute a jump to attain maximum height. Each participant completed three attempts with a rest interval of 1 minute between trials. For the CMJ and SJ assessment, the jump height (in centimeters) from the best attempt was utilized for statistical analyses. In SJ, participants were instructed to flex their knees approximately at 90°, hold this position for 2–3 seconds, and then jump. In the DJ assessment, participants performed jumps from a 40-centimeter-high box, and the jump height (in centimeters) from the best attempt was employed for statistical analyses.

As described by Lockie et al. (2014), the Y test assessment utilized a timing-light system Speedlight (Swift Performance, Wacol, Australia). Participants initiated the test, positioned 30 centimeters behind the starting line, and sprinted maximally through the first two gates placed at the starting line and 5 meters. Upon passing the second (trigger) gate, participants visually identified the flashing gate and executed a 45° cut to sprint through it.

For the 20-meter sprint assessment, gates were positioned at 0 meters, 5 meters, 10 meters, and 20 meters. Participants initiated the sprint from a position 30 centimeters behind the starting line. In the 505 test, participants sprinted a distance of 15 meters, executed a 180° change of direction, and sprinted 5 meters back (Nimphius et al., 2018). A single gate from the Speedlight system was placed 10 meters from the starting line. In all sprint test, each participant completed three trials with a rest interval of 3 minutes between trials, and the fastest trial was selected for analysis.

Statistical analysis
Data are presented as mean ± standard deviation. Shapiro-Wilk's test checked the normality of distribution. In most cases, the data were normally distributed, but in one case, the normality was violated; therefore, Pearson's product-moment correlation was used for normally distributed data and the Spearman's rank correlation coefficient determined the relationship between variables for data where the normality was violated. The magnitude of the correlation coefficient was interpreted as trivial (0–0.1), small (0.11–0.3), moderate (0.31–0.5), large (0.51–0.7), very large (0.71–0.9), and almost perfect (0.91–1.0) (Hopkins, 2000). The proportion of the variance was defined by the coefficient of determination (r2). The level of statistical significance was set at $p \leq 0.05$. All tests were performed using the statistical software IBM SPSS 28 (IBM Corporation, Armonk, NY, USA).

Results
Descriptive statistics of performances in selected tests are presented in Table 1. A small correlation was found between the Y test and the 5 m sprint and between the Y test and CMJ. The 10 m sprint, 505 test, SJ, and DJ produced a moderate correlation with the Y test. The correlation between the Y test and the 20 m sprint was large. The relationship of Y test with selected tests is shown in Table 2.

Table 1 Descriptive statistics of speed and power tests

	Y test [s]	5 m [s]	10 m [s]	20 m [s]	505 test [s]	SJ [cm]	CMJ [cm]	DJ [cm]
Mean	3.09	1.2	2.06	3.6	2.61	23.37	25.2	24.01
SD	0.21	0.05	0.07	0.14	0.09	2.88	3.4	3.79

Table 2 Correlation between Y test and speed and power tests

	Correlation coefficient	p value	Coefficient of determination	Magnitude descriptor
5 m	0.24	0.46	0.06	small
10 m	0.47	0.12	0.22	moderate
20 m	0.64	0.02	0.41	large
505 test	0.46	0.14	0.21	moderate
SJ	-0.39	0.21	0.15	moderate
CMJ	-0.25	0.43	0.06	small
DJ	-0.44	0.15	0.19	moderate

Discussion

The study revealed a large correlation between reactive agility and the 20 m linear sprint test (r = 0.64). These findings align with similar observations reported by Scanlan et al. (2014), where correlations demonstrated an augmentation with increasing sprint distances. Conversely, these outcomes stand in contrast to those of other investigations wherein a lack of significant correlation was observed between reactive agility and linear sprint at the 10-meter distance (Sheppard et al., 2006; Young et al., 2015). Horníková and Zemková (2022) reported a large correlation between reactive agility and 20 m sprint but also found a very large correlation between reactive agility and 10 m sprint. These inconsistencies suggest that the choice of specific reactive agility tests or the nature of the team sport in question may influence the relationship between linear sprinting and reactive agility. Basketball coaches overseeing female players may benefit from incorporating reactive agility exercises into training regimens to enhance linear speed.

The jump heights observed in SJ, CMJ, and DJ tests exhibited moderate or small correlations with reactive agility, with coefficients of -0.39, -0.25, and -0.44, respectively. These correlations are in line with those reported in studies by Matlák et al. (2016), Northeast et al. (2019), and Young et al. (2015). These findings could highlight the nature of reactive agility and emphasize the significance of cognitive elements, including perception and decision-making processes.

In this investigation, a moderate correlation (r = 0.46) was identified between reactive agility and the change of direction speed test (505 test), consistent with prior research findings (Henry et al., 2011). This suggests that athletes' performance in a reactive agility assessment is partly impacted by their ability to change direction. While both tests involve altering direction, they differ in the change angle (approximately 45° in the Y test and 180° in the 505 test). However, presented results indicate that the performance in reactive agility tests can be affected by factors beyond sprint and power (Scanlan et al., 2014). Future studies could be appropriate to investigate other force and power characteristics from vertical jumps concerning reactive agility.

Conclusion

According to the findings of this study, there is a large association between the Y test of reactive agility and 20 m linear sprint in youth women's basketball. The association of reactive agility with performance in other speed and power tests is small or moderate. Consequently, if coaches focus on enhancing the speed capabilities of female basketball players, as mentioned, they will indirectly enhance their reactive agility as well. However, further research with a larger sample size and inclusion of additional performance variables is warranted to draw more universally applicable conclusions.

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DIFFERENCES IN HEART RATE PARAMETERS OF COMPETITIVE PERFORMANCES IN BOXING AND KICKBOXING

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Abstract
Physiological activity load is one of the main criteria for efficient training programming. The problem of the study is reflected in the fact that, although boxing and kickboxing belong to the group of polystructural sports in which the result is achieved by similar technical-tactical means, there are still certain differences in the physiological load of the competitive performance itself. The aim of this study is to determine differences in heart rate indicators (average and maximum heart rate during the three rounds) between competitive performances in two striking combat sports: boxing and kickboxing. The sample of subjects in this study consists of 20 athletes who practice the striking combat sports boxing and kickboxing. For the purposes of the study, the subjects fought each other according to boxing rules and K-1 discipline rules in kickboxing in a simulated competitive environment. The results have shown that the heart rate in both sports continuously increases during all three rounds, and the oscillations in the heart rate are more pronounced in kickboxing than in boxing, but only statistically significant difference was found in variable mean heart rate during the third round of boxing and kickboxing bout - HR AVG 3 B/KB (p 0,041). The results indicate that in a boxing fight there is a continuous increase in heart rate, while in a kickboxing fight the heart rate in the third round decreases significantly. From these results, it can be concluded that kickboxers drop in the rhythm of the fight in the third round. This may suggest that kickboxers fail to maintain a high rhythm of the fight in the third round probably due to the different structural characteristics of kickboxing sport and the bout itself.

Keywords: *Combat sports, Physiological parameters, Specific training load*

Introduction

In today's era of advancement in sports science, monitoring the load on athletes during training processes and competitions plays an increasingly important and significant role. Athletes engaged in individual sports are more susceptible to the risk of overtraining than athletes in team sports (Kenttä, 2001). Unfortunately, there are only a small number of scientific papers regarding physiological demands of combat sports which emphasize the need for new, well-designed studies (de Lira et al., 2013). Findings about the very specific demands of combat will allow the adaptation of training loads and methods. It appears that in combat sports conducting specific training, that matches the actual combat situation in terms of fight intensity (percentage of maximum heart rate), is extremely necessary for quick recovery between rounds and consecutive matches (Slimani et al., 2018), and will ultimately enable better performance during the rounds themselves. Although boxing and kickboxing have different structural characteristics, it is common practice for the athletes to compete in both sports, without properly adjusting their training habits. In part this happens due to the mistaken impression that these are very similar activities. The problem in setting the parameters of the training process is that training operators should simulate a high load, but that it does not happen that due to excessive volume of work the athlete is brought into a state of overtraining, which can significantly degrade or diminish his ability to perform specific technical-tactical tasks. The aim of this study is to determine differences in heart rate indicators between competitive performances in two striking combat sports: boxing and kickboxing.

Methods

The sample of subjects in this study consists of 20 athletes (18 male and 2 female) who practice the striking combat sports boxing and kickboxingThe youngest among them was 17 years old, and the oldest was 31 years old. The female subjects weighed 50 and 52 kilograms, respectively, while the men's lightest weighed 62 kilograms and the heaviest 107 kilograms. During the research, all competitors fought each other within their weights and did not lose weight before the experiment. All 20 athletes are active competitors, and they have gained their combat experiences in both of these sports. All of them have also achieved significant sports results in boxing and kickboxing and have won medals at national, European, and World championships. During the testing process of bout simulations in boxing and kickboxing they were in a very high degree of competitive form. For the first time, this research addresses the problem in such a way that the same insight into the physiological indicators of activity is obtained on the same subjects who will participate in boxing and kickboxing fights. It must be emphasized that the relevance and value of the data obtained also results from the fact that the selected group of respondents is a representative sample of top athletes in both boxing and kickboxing.

The sample variables in this study were: HR AVG 1 B – mean heart rate during the first round of boxing bout; HR AVG 2 B – mean heart rate during the second round of boxing bout; HR AVG 3 B – mean heart rate during the third round of boxing bout; HR MAX 1 B – maximal heart rate during the first round of boxing bout; HR MAX 2 B – maximal heart rate during the second round of boxing bout; HR MAX 3 B – maximal heart rate during the third round of boxing bout; HR AVG 1 KB – mean heart rate during the first round of kickboxing bout; HR AVG 2 KB – mean heart rate during the second round of kickboxing bout; HR AVG 3 KB – mean heart rate during the third round of kickboxing bout; HR MAX 1 KB – maximal heart rate during the first round of kickboxing bout; HR MAX 2 KB – maximal heart rate during the second round of kickboxing bout; HR MAX 3 KB – maximal heart rate during the third round of kickboxing bout.

For the purposes of the study, the subjects were divided into pairs by body weight criteria and fought each other according to boxing rules and K-1 discipline rules in kickboxing in a simulated competitive environment in a ring of official competitive dimensions, with referees inside the ring and coaches who, as in competition, gave suggestions to their fighters and encouraged them to fight. In the first measurement, the subjects conducted boxing bouts lasting three rounds of three minutes each with one minute of rest between rounds, and in the second measurement, they conducted bouts in the K-1 discipline of kickboxing also lasting three rounds of three minutes each with one minute of rest between rounds. During the break between the first and second measurements (3 days), the athletes regenerated well and did not have strenuous training sessions so that fatigue would not affect the level of monitored indicators and the rhythm of the fight. During the research, subjects wore Polar heart rate monitors placed around the chest under their shirts, additionally secured with adhesive tape. They did not injure the subjects because hits to the body in both sports are only allowed on the front side of the torso, and the monitors were placed on their backs.

Data was processed using the Statistica for Windows (Data Analysis Software System), version 7.1, using descriptive statistics, K-S test for normality of distribution and Student's t-test for independent samples.

Results and discussion

Table 1: Descriptive statistics of heart rate indicators in boxing

VAR	AS	MIN	MAX	SD	K-S
HR AVG 1 B (o/min)	181,31	170	190	5,43	0,204
HR AVG 2 B (o/min)	183,83	172	193	4,90	0,120
HR AVG 3 B (o/min)	186,52	175	194	5,18	0,109
HR MAX 1 B (o/min)	186,43	175	197	4,93	0,160
HR MAX 2 B (o/min)	189,27	183	199	4,12	0,128
HR MAX 3 B (o/min)	192,24	185	201	4,55	0,150

Legend: AS – arithmetic mean; MIN – minimal value; MAX – maximal value; SD – standard deviation; K-S – k-s values; HR AVG 1 B – mean heart rate during the first round of boxing bout; HR AVG 2 B – mean heart rate during the second round of boxing bout; HR AVG 3 B – mean heart rate during the third round of boxing bout; HR MAX 1 B – maximal heart rate during the first round of boxing bout; HR MAX 2 B – maximal heart rate during the second round of boxing bout; HR MAX 3 B – maximal heart rate during the third round of boxing bout

Table 2: Descriptive statistics of heart rate indicators in kickboxing

VAR	AS	MIN	MAX	SD	K-S
HR AVG 1 KB (o/min)	180,35	160	189	6,520	0,167
HR AVG 2 KB (o/min)	181,68	164	191	5,746	0,200
HR AVG 3 KB (o/min)	184,47	177	193	4,165	0,199
HR MAX 1 KB (o/min)	186,47	173	194	4,932	0,132
HR MAX 2 KB (o/min)	189,93	179	200	4,512	0,150
HR MAX 3 KB (o/min)	191,40	183	201	4,504	0,150

Legend: AS – arithmetic mean; MIN – minimal value; MAX – maximal value; SD – standard deviation; K-S – k-s values; HR AVG 1 KB – mean heart rate during the first round of kickboxing bout; HR AVG 2 KB – mean heart rate during the second round of kickboxing bout; HR AVG 3 KB – mean heart rate during the third round of kickboxing bout; HR MAX 1 KB – maximal heart rate during the first round of kickboxing bout; HR MAX 2 KB – maximal heart rate during the second round of kickboxing bout; HR MAX 3 KB – maximal heart rate during the third round of kickboxing bout;

Table 3: Differences in heart rate between boxing and kickboxing bouts

	AS	SD	N	T	Df	P
HR AVG 1 B	181,31	5,435				
HR AVG 1 KB	180,35	6,520	20	0,66	19	0,516
HR AVG 2 B	183,83	4,901				
HR AVG 2 KB	181,68	5,746	20	1,77	19	0,091
HR AVG 3 B	186,52	5,182				
HR AVG 3 KB	184,46	4,165	20	2,18	19	0,041
HR MAX 1 B	186,43	4,930				
HR MAX 1 KB	186,47	4,932	20	-0,02	19	0,980
HR MAX 2 B	189,27	4,127				
HR MAX 2 KB	189,93	4,512	20	-0,91	19	0,372
HR MAX 3 B	192,23	4,548				
HR MAX 3 KB	191,40	4,504	20	1,25	19	0,223

Legend: AS – arithmetic mean; SD – standard deviation; T – t values; HR AVG 1 B – mean heart rate during the first round of boxing bout; HR AVG 1 KB – mean heart rate during the first round of kickboxing bout; HR AVG 2 B – mean heart rate during the second round of boxing bout; HR AVG 2 KB – mean heart rate during the second round of kickboxing bout; HR AVG 3 B – mean heart rate during the third round of boxing bout; HR AVG 3 KB – mean heart rate during the third round of kickboxing bout; HR MAX 1 B – maximal heart rate during the first round of boxing bout; HR MAX 1 KB – maximal heart rate during the first round of kickboxing bout; HR MAX 2 B – maximal heart rate during the second round of boxing bout; HR MAX 2 KB – maximal heart rate during the second round of kickboxing bout; HR MAX 3 B – maximal heart rate during the third round of boxing bout; HR MAX 3 KB – maximal heart rate during the third round of kickboxing bout;

The results show that the average heart rates during the rounds progressively increase both in boxing and kickboxing bouts. Although numerical differences were found in favor of boxing bouts, and these differences increased with each new round, a statistically significant difference was only obtained in the variable of average heart rate in the third round (HR AVG 3 B/KB; p 0,041), again with higher values during the boxing bouts. Although one cannot conclude that the cardiorespiratory responses to these fights are different, the obtained results indicate a slightly higher intensity of fighting in boxing bouts, where higher heart rates are consistently manifested compared to kickboxing bouts. One could expect that the results would be higher in kickboxing where structurally more complex techniques are used but numerical higher values go in favor of boxing.

Due to the use of simpler techniques, boxers can maintain continuous movement and constantly (without much rest) use technical elements of hand strikes, blocks, dodges, and clinches, with a higher frequency of execution in the round itself. That way of fighting continuously raises the level of heart rate, and the short breaks (rests) that boxers take within the round do not significantly affect the reduction of heart rate.

The technical elements in kickboxing also include leg kicks, which are exceptionally complex elements, and when incorporated into technical-tactical systems in which they are combined with punches, movements, and dodges, a significant physiological load occurs which requires a longer rest after a series of attacks than is the case in boxing. The results of minimum and maximum heart rates support this explanation as well. According to the results visible in Tables 1 and 2, the range between the minimum and maximum values of mean heart rates in kickboxing bouts are numerically higher than in boxing bouts, which could mean that due to the use of complex technical-tactical systems in kickboxing, fighters must take longer breaks while boxers do not, so they manage to maintain a high fighting pace.

Also, kicks in kickboxing require moving a larger part of the body, and muscles must produce a greater force that acts on the opponent's hitting surface, thereby causing greater muscle loads. Such a combination, in which fighters in kickboxing spend significantly more energy performing strikes and at the same time experience greater muscle loads when receiving strikes, consequently leads to a situation in which the pace of the bout decreases in the third round, which does not seem to be the case in boxing bouts. For this reason, a statistically significant difference in average heart rate in the third round in favor of the boxing bout has appeared (HR AVG 3 B/KB; p 0,041).

These results contribute to the understanding of the character of the bout, which in turn makes it easier to create a training program. Although the results suggested that fighting in both sports have similar cardiorespiratory response, the results indicate that boxers will have to endure a continuously higher pace of fighting and will not have many opportunities for rest within the round. For this reason, it is very important to pay attention to the development of such capacities so that even minimal rests in the bout will be sufficient to reduce heart rate and more effectively remove metabolites produced by anaerobic glycolysis. On the other hand, it seems that it will be very important to ensure a very high tolerance to lactates in both sports, as well as for the tolerance to other byproducts and effects of anaerobic glycolysis.

Conclusion

Previous research has addressed this issue in a way that they diagnosed physiological indicators in these sports activities on independent samples of subjects. This research, for the first time, addresses the problem in a way that the same insight into physiological indicators of activity is obtained on the same subjects who will participate in both boxing and kickboxing bouts.

From the results of this research one can conclude that:

- Both boxing and kickboxing bouts indicate a high level of cardiorespiratory response.
- Heart rate indicators in both sports are very similar.
- Statistically significant differences in heart rate are visible in the last (third) round of the fight. So it seems that kickboxers drop in the rhythm of the fight in the third round probably due to the different structural characteristics of kickboxing sport and the bout itself.

A small sample as well as a comparison of boxing and only one discipline of kickboxing are the limitations of this research that could be paid attention to in the next one.

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THE EVOLVING LANDSCAPE OF HIGH-PERFORMANCE COACHING: A SYNTHESIS OF RESEARCH ON GENERAL AND CONTEXT-SPECIFIC ISSUES

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Abstract
The article critically evaluates high-performance coaching, underscoring its capacity to cultivate accountability and self-awareness for peak individual performance. It discusses obstacles including identity shifts, and work-life equilibrium, which disproportionately impact marginalized sectors, championing the need for additional scholarly investigation in this field.

Keywords: *High-performance coaching, Gender discrimination, The disabled, Career challenges*

Introduction
High-performance coaching represents a scientific approach to management that prioritizes a human-centric and sustainable perspective. It is adept at adapting to diverse contexts and environmental shifts, and it excels in aggregating knowledge and fostering innovation. Compared to traditional team models, high-performance coaching is characterized by its efficiency and reliability, generating greater amounts of value(Mo,2018). High-performance coaching is a multifaceted role that extends far beyond the mere instruction of skills and drills. Coaches are tasked with managing and leading various human elements that are crucial for enabling peak performance.

Nonetheless, the high-performance coaching,whether conceptualized as a technical strategy or embodied by an individual—a coach of high performace—one invariably encounters a spectrum of challenges. The adage "The higher one climbs, the colder it gets" rings true in the realm of greater complexity and elevated performance, which demand a commensurate sacrifice. Regarding the special cases of vulnerable groups in the field high-performance coaching, such as people with disabilities, It has been suggested that sport provides a context that can challenge and influence the social and cultural perceptions of disability and disabled people (Howe & Silva, 2016). Besides, the relatively weaker female group,the gender and sports coaching literature evidences that all groups of women are more likely to experience discrimination in the coaching workplace than men across most sports, performance domains, and at all points on the coaching pathway (Burton & LaVoi, 2016; Carter-Francique & Olushola, 2016; Kenttä, Bentzen, Dieffenbach, & Olusoga, 2020).In a broader view of this field, most professionals confront a spectrum of career hurdles, including transitioning roles, burnout, crises, reclaiming wellness, and maintaining work-life balance.

Given this position, this article provides an overview of the current limited knowledge of high-performance coaching and demonstrates the need for further research in this space.

The Underprivileged in High-Performance Coaching – Women in high-performance coaching
Australian case：Numbers are up, but top talent is scarce
The participation and media coverage of women in sports has seen a gradual uptrend globally over recent years. However, this increased involvement has not been reflected in a significant boost in the number of women assuming coaching roles, especially at the high-performance level.Take Australia as an example, where women account for a mere 15% of high-performance coaching positions(Damien et al.,2023).

In a qualitative Australian study, it uniquely emphasizes facilitating women's entry into high-performance coaching rather than just focusing on barriers, suggesting a positive approach for future studies.

Women encounter both overt and subtle gender discrimination in high-performance coaching
For instance, a study conducted by Donna and Popi in 2018, grounded in constructionism and critical feminism, revealed gender-based differentiation in coaching practices among 10 international male elite rowing coaches through semi-structured interviews and thematic analysis. Findings indicated that coaches' behaviors subtly discriminate against female athletes in training intensity, opportunities, encouragement, and expectations, potentially hindering their athletic development and competitiveness.

Disabled individuals in high-performance coaching
In sport, the disabled body is, as Edwards and Imrie (2003: 240) argued, a 'site of contestation' where impairment and its effects (physical and intellectual) can 'function as distinctive signs and as signs of distinction, positive or negative' (Bourdieu, 1989: 20). These distinctions can be shaped by the structures of the field, and thus the use of the work of Bourdieu can highlight the cultural resources and frameworks drawn upon in practice and the meanings attributed to disability across coaching in disability sport.

Thus, coaching research requires the application of sociology to reveal and challenge dominant values and ideologies that influence disability sport and, by extension, the way disability can be understood and reconstructed in society.

The Unique Challenges Encountered by the High-Performance Coaching
Identities & Transition
While developments in the mainstream literature have contributed to an increased sociological understanding of 'precarious work' and 'insecure workers' (Kalleberg, 2009, p. 1) in neo-liberal societies, there remains a paucity of such inquiry within sporting contexts.

In an study(Christopher et al.,2020),it delves into how top male athletes from English and Welsh football and rugby union teams forge their coaching identities following their athletic careers, grappling with the challenge of differentiating their playing philosophies from coaching ones, highlighting an imperative for educational programs that help coaches delineate between their roles as players and mentors.As you can see, the study underscores the significant investment and introspection required for high performance coaches to redefine themselves professionally and establish a clear identity that encapsulates both their athletic background and coaching aspirations.

Work-Family Balance
In a field where time is a precious commodity and the rhythm of work is often at odds with conventional hours, the challenge for coaches in the high-performance coaching is profound.

In our common logic,the difficulty of work-family balance can lead to just negative consequence,however,in a study examines how high-performance sport coaches combine their professional and family lives,the results of the participants who involved in the preparation of the French teams for the Olympic Games in Rio (2016), Pyeongchang (2018) and/or Tokyo (2020) showed different answers,for some coaches,they can't have both, for others, family life is a protection for their work.More interstingly,all the coaches interviewed have one thing in common: They do not consider stopping their careers. It is even the opposite, as a coach puts it: ''If I were asked to stop today, it would be terrible'' (Christine).Which gives us a insight to look at the question at another angle.

Future Directions
The Vulnerable Minority
As women's representation in pivotal coaching roles is still alarmingly low. Closing this gap necessitates a targeted push for best practices that advance gender equity in coaching, guaranteeing a clear pathway from grassroots to high-performance levels for women.It is also important to recognise that "one" woman in a highly visibly, powerful role is not enough,more attention should be put to engage more women in higher position in the field of high-performance coaching .

For disabled people ,coaches are guided to hone in on the capabilities of athletes, aiming to push and refine their talents, yet the distinction between disability and sport can sometimes be exploited for symbolic gain.It's essential to explore how societal norms and cultural values shape coaching methodologies. Moreover, the creation and assessment of coaching strategies that are inclusive and centered on the diverse requirements of athletes with disabilities should be a priority.

The General Majority
Given the multifaceted challenges faced by high-performance coaching, it should investigate power dynamics and symbolic violence influencing coaching, especially in the development of professional identity and the overlap between playing and coaching ideologies. Research should also tackle the work-family balance, examining how coaches navigate their professional and personal spheres amidst demanding schedules and travel.

Given the predominance of qualitative interview-based studies, there's a need for more cross-cultural and cross-racial research. Future studies should aim to diversify by including data from a broader range of sports.

Conclusion

This article shines a light on the complex hurdles within high-performance coaching.The finding stresses the importance of organizational initiatives to bolster women's coaching careers and expose the nuanced biases they and disabled coaches often face. Additionally, the demanding aspects of high-performance coaching can result in burnout and challenges to balancing work and family. The coaching sector must enact substantial reforms to tackle these concerns and foster a fairer, more sustainable coaching culture.

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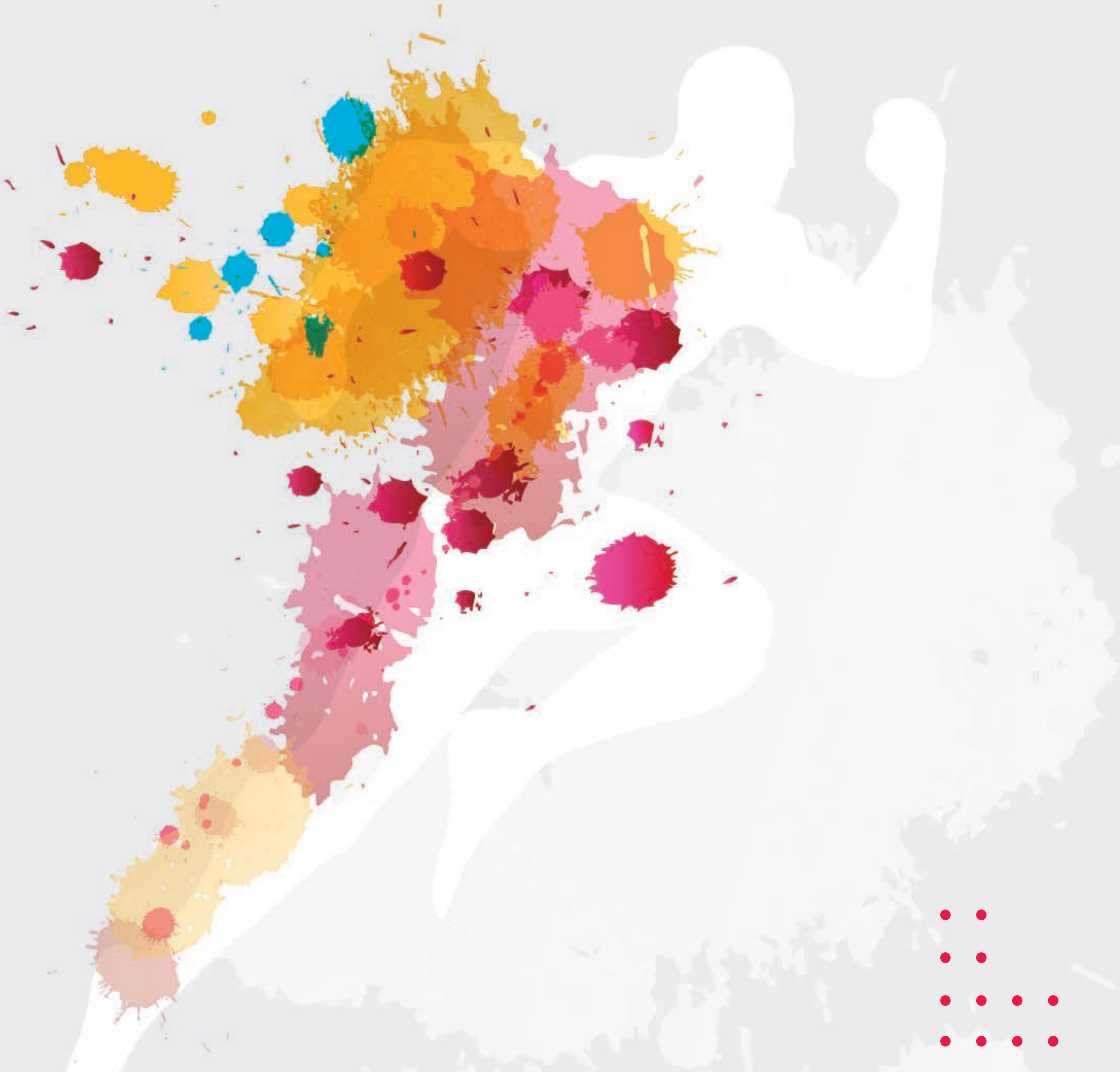

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