Sveučilište u Zagrebu

MACQUARIE University
SYDNEY·AUSTRALIA

FACULTY OF KINESIOLOGY

FACULTY OF ARTS

Petra Jurić

THE IMPACT OF SCHOOL-BASED PHYSICAL ACTIVITY PROGRAMS ON OBESITY PREVENTION

DOCTORAL THESIS

Zagreb, 2023

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Supervisors:

Associate Professor Maroje Sorić, PhD

Associate Professor Dean Dudley, PhD

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DOKTORSKI RAD

Mentori:
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Zagreb, 2023

THIS DOCTORAL DISSERTATION FOLLOWS A SCANDANVIAIAN MODEL

IT WAS WRITTEN AS PART OF AN INTERNATIONAL COTUTELLE AGREEMENT BETWEEN

UNIVERSITY OF ZAGREB
FACULTY OF KINESIOLOGY

AND

MACQUARIE UNIVERSITY
FACULTY OF ARTS

Declarations

I declare that this dissertation is my own work and that, to the best of my knowledge or belief, it does not contain any unattributed material previously published or written by any other person, apart from the published papers in Chapters 3, 4 and 5.

I also declare that this dissertation is a part of a Cotutelle agreement between Macquarie University, Faculty of Arts and University of Zagreb, Faculty of Kinesiology. Therefore, this dissertation has been simultaneously submitted to both institutions. The Cotutelle model represents a doctoral study where a student is enrolled at both universities. A single doctoral dissertation is prepared and submitted for independent examination by both universities. Each university makes its own decision about the award of the degree, including a grade or mark if that is the practice.

For this doctorate, a Scandinavian model was used, which includes three different studies with related research questions and aims. The Scandinavian model represents a doctoral dissertation composed of published scientific articles written as part of the doctoral research, exclusively published after the enrolment into the doctoral program.

Throughout the dissertation, I adhered to the NLM style of referencing. Chapters 1, 2 and 6 (which do not include scientific articles) have common list of references at the end of the document. Chapter 3, 4 and 5 (scientific articles) have their own list of references, each at the end of an article itself.

The first study is a systematic review and meta-analyses; thus, ethics approval was not necessary. For the second study, the protocol, measurement procedures and data management of the SLOfit surveillance system were approved by the National Medical Ethics Committee of the Republic of Slovenia (No. 52/03/14) and is in accordance with the Helsinki Declaration. The Healthy Lifestyle program did not require ethics approval nor registration with a trial registry since it was not an experiment and was independently evaluated by the SLOfit system. The third study was performed according to the Declaration of Helsinki and the procedures were approved by the Ethics Committee of the Faculty of Kinesiology, University of Zagreb (No. 38./2021.). The intervention is registered at the Australian New Zealand Clinical Trials Registry (ANZCTR) [ACTRN12622000209796].

Acknowledgements

This doctoral dissertation:

1. is a part of a Horizon 2020 Project *Science and Technology in Childhood Obesity Policy 'STOP'* and was funded by the Croatian Science Foundation Grant Number DOK-2018-09-8532.
2. is supported by an Australian Government and International Macquarie Research Excellence Scholarship Program (iMQRES).

First and foremost, I would particularly like to thank my supervisor, Maroje Sorić who provided me with an opportunity to do scientific research. With his knowledge, progressiveness, patience, and kindness, I feel grateful that he was the one who set my first scientific steps. Second, I am thankful to Dean Dudley, who supervised my work at Macquarie University. With his outside the box approach, I learned to expand my thinking in various interconnected scientific fields. Third, I would like to thank Peter Petocz who helped me with tips and tricks used in science and broadened my perspective about different scientific possibilities.

I would also like to mention my co-authors who participated in creating this dissertation by investing their time and effort. I would like to especially thank Josip Karuc who was my colleague from the very beginning of my work on the project. I would also like to thank all other co-authors: Hrvoje Podnar, Marc Saez, Maria A. Barceló, Ivan Radman, Gregor Starc, Gregor Jurak, Saša Đurić, Žan Luca Potočnik, and Shawnda A. Morrison. Their contribution has been invaluable for this dissertation. Furthermore, I would like to thank my colleague Antonio Martinko who was by my side at the office and supported me every day.

I want to thank my mother who was my biggest support along the way.

Lastly, my personal motto is: “Everything you've ever wanted is sitting on the other side of fear”.

Professional Editorial Assistance

Robert Trevethan was paid to edit the front matter, Chapters 1, 2, and 6, and small parts of the appendices in this dissertation.

Dr Trevethan's input was limited primarily to formatting, grammar, style, and English "idiom", and no alterations were made to the substantive content or conceptual organisation of this dissertation. Any advice that Dr Trevethan provided about matters of structure and content was provided by means of exemplars.

Abstract

This dissertation identified the most effective programs in the school environment aimed at combatting childhood obesity, provided evidence for the effectiveness of a long-lasting program at the population level, and offered evidence for a time-efficient intervention within physical education (PE) as a tool to improve fitness among students. It includes three distinct studies with related research questions and aims.

Study 1 involved a systematic search of the literature performed to compare the effects of interventions that targeted reduction of sedentary behaviours or increase of physical activity (PA) or physical fitness on primary prevention of obesity in 6- to 12-year-old children. The search identified 146 reports that provided relevant data for meta-analysis. Point estimates in % body fat were higher for fitness interventions compared with PA interventions (standardised mean difference = −0.11%; 95%CI = −0.26 to 0.04, and −0.04%; 95%CI = −0.15 to 0.06). Including sedentary behaviour in a PA- or fitness-oriented intervention was not accompanied by an increase in intervention effectiveness as evidenced by the point estimates being slightly smaller compared with those for PA- or fitness-only interventions. Overall, the effects tended to be larger in girls than in boys, especially for PA + sedentary behaviour interventions. There was some evidence of inequality in that the effects on body mass index (BMI) were seen when interventions were delivered in the general population (standardised mean difference = −0.05, 95%CI = −0.07 to −0.02), but not in groups of disadvantaged children (standardised mean difference = −0.01, 95%CI = −0.29 to 0.19).

Study 2 involved an examination of the effectiveness of a population-based, real-world, long-duration, PA intervention for children aged 6–14 in Slovenia, called *Healthy Lifestyle*. The intervention provided two or three additional lessons of PE per week. Although the focus was the improvement of physical fitness, it examined the intervention's effectiveness from the perspective of body mass index (BMI) units decreased and obesity cases reversed. The study studied over 34,000 participants from the *Healthy Lifestyle* project/cohort and compared their results with a matched sample of nonparticipants from the same schools. It employed generalised estimating equations to assess the effects of different durations of exposure to the program on BMI (from 1 to 5 consecutive years of participation) in children who enrolled with normal weight, overweight, or obesity at the start of the program. The intervention group had a significantly greater reduction in BMI than did the control group across all participation

durations and irrespective of baseline weight status. The largest effect was observed in girls with obesity at baseline, whose BMI was 1.4 kg/m^2 lower after 3 years of intervention compared with controls. The reversal of obesity was more pronounced in girls for whom statistically significant differences were observed between the control and intervention group after 2 years ($\chi^2(1,1112) = 5.776$, $p = 0.016$), 3 years ($\chi^2(1, 669) = 9.570$, $p = 0.002$), 4 years ($\chi^2(1, 343) = 5.107$, $p = 0.024$), and 5 years of participation ($\chi^2(1, 192) = 4.551$, $p = 0.033$). In boys, obesity reversal-rate differences between intervention and control groups attained statistical significance only after 3 years ($\chi^2(1, 766) = 6.435$, $p = 0.011$) and 5 years ($\chi^2(1, 198) = 4.863$, $p = 0.027$) of participation. Also, the number needed to treat (NNT) decreased steadily with the duration of the program in both sexes, with generally lower numbers for girls. The lowest NNTs were seen for 5 years of participation in the program (NNT = 17 and 12 for girls and boys, respectively). The proportion of obesity cases stratified by intervention participation and sex across all five years was 5-7%. Notably, a reduction in intervention effectiveness was evident in the year the program was hindered by a lack of funding. Intervention was effective with the largest BMI reduction in children presenting initially with obesity, and smallest in normal-weight children, indicating that the PA intervention(s) were able to benefit the children needing it most.

Study 3 determined the efficacy of a high-intensity interval training (HIIT) intervention lasting 12 weeks on the health-related fitness and adiposity of 10- to 15-year-old students implemented during PE. The focus of this study was to compare two approaches for increasing fitness level among adolescents, one approach focusing on regular PE sessions in accordance with the curriculum and the other on regular PE classes augmented by HIIT. A cluster randomised control trial (RCT) (pretest/posttest) was conducted. The total number of students across both groups was 207. I used general linear models to compare fitness and adiposity changes in both groups based on the Eurofit fitness test battery. A significant effect of the HIIT intervention was present for the 20-meter shuttle-run test scores ($p = 0.001$). The effect of the intervention compared with the control was estimated as an additional 181.2 metres, 95% CI (70.4 to 292.0). An additional intention-to-treat (ITT) analysis showed that the effect of the HIIT intervention on the 20-meter shuttle-run test remained statistically significant ($p < 0.011$), although the magnitude of the estimated effect was reduced from 181.2 meters; SE = 55.4 to 119.6 meters; SE = 46.4. The effect on the 20-meter shuttle run test scores occurred with a relatively low dose of HIIT in PE lessons undertaken twice a week. Whilst it appears HIIT had the opposite of the expected effect on body fat percentiles, the effect on body composition was

inconsistent. The effect of the regular PE classes compared to HIIT intervention is estimated as 2.76 percentiles, 95% CI (0.3, 5.1), with lower values among controls. However, this was also no longer evident following the ITT analysis (from p=0.03 to p=0.086). The intervention is registered with the Australian New Zealand Clinical Trials Registry (ANZCTR) [ACTRN12622000209796].

The overall and final conclusion resulting from this dissertation is that school-based PA programs represent a powerful tool for obesity management and cardiorespiratory fitness (CRF) enhancement. Tailoring interventions toward increasing fitness among children and adolescents should be a priority because these interventions have a twofold benefit: 1) they are effective in preventing and treating obesity, and 2) if implemented using an HIIT approach, they can effectively increase CRF in a relatively short period of time. A scaled-up, long-lasting approach should be the goal of any intervention because this approach was shown to be effective not only for preventing obesity but also for reversing obesity among children and adolescents. The longer the intervention lasts, the more effective it becomes, especially for individuals who need the intervention the most, that is, those who suffer from obesity.

EXTENDED ABSTRACT IN CROATIAN LANGUAGE (PRODUŽENI SAŽETAK NA HRVATSKOM JEZIKU)

Glavni cilj ove doktorske disertacije bio je ispitati učinke različitih školskih programa povezanih s tjelesnom aktivnošću na prevenciju pretilosti i poboljšanje fitnesa. U ovoj disertaciji identificirani su najučinkovitiji programi u školskom okruženju usmjereni na prevenciju pretilosti u dječjoj dobi (studija 1), pruženi dokazi o učinkovitosti dugotrajnog programa tjelesne aktivnosti na populacijskoj razini (studija 2) i ponuđeni dokazi za vremenski učinkovitu intervenciju visoko intenzivnog intervalnog treninga unutar nastave tjelesne i zdravstvene kulture, kao alata za poboljšanje fitnesa učenika i učenica (studija 3). Ova disertacija imala je trostruku svrhu: 1) izvršiti sustavni pregled i meta-analizu kako bi se usporedili učinci školskih intervencija usmjerenih ka sjedilačkom ponašanju, tjelesnoj aktivnosti ili fitnesu na prevenciju dječje pretilosti; 2) ispitati učinke populacijske, dugotrajne, fitnes orijentirane intervencije tjelesne aktivnosti kod učenika slovenskih osnovnih škola na prevenciju pretilosti; 3) utvrditi djelotvornost tromjesečne intervencije temeljene na intervalnom treningu visokog intenziteta uklopljenog u satove tjelesne i zdravstvene kulture na zdravstveni fitnes učenika. Rezultati ovog istraživanja pomoći će u optimizaciji i davanju prioriteta školskim programima tjelesne aktivnosti u prevenciji dječje pretilosti.

Metode Studija 1

Ova studija uključivala je sustavni pregled i meta-analizu studija koje izvještavaju o učincima školskih politika povezanih s tjelesnom aktivnošću na ishode povezane s pretilošću. Pretražili su se MEDLINE, The Cochrane Central Register of Controlled Trials (CENTRAL), Scopus, LILACS, OpenGrey, Open Access Thesis and Dissertations, Clinical Trials i WHO International Clinical Trials Registry. Recenzirane studije objavljene od 1.1.1994. uzete su u obzir. Istraživačko pitanje dizajnirano je pomoću PICOT okvira, koristeći MeSH pojmove u Medline plus pretrazi ključnih riječi. Kriteriji uključivanja bili su: (1) randomizirani ili nerandomizirani kontrolirani pokus, studija sa kontrolom prije i poslije ili prirodni pokus; (2) kontrolna grupa; (3) ispitanici od 6 do 12 godina (srednja vrijednost godina na početku studije = 5.5 do 12.49); (4) intervencije bilo kojeg trajanja usmjerene na: a) povećanje tjelesne aktivnosti i/ili tjelesnog fitnesa; b) smanjenje sjedilačkog ponašanja; (5) provedene primarno u školskom okruženju; (6) nastavak praćenja u trajanju od minimalno 12 tjedana od početka intervencije; (7) mjereni ishodi povezani sa pretilošću. Ekstrahirale su se sljedeće informacije: autori, godina, period studije, broj klastera i ispitanika, demografske karakteristike, detalji o

tipu intervencije i sadržaju, trajanje intervencije i perioda praćenja, i štetni ishodi. Ishodi povezani sa pretilošću zasebno su se ekstrahirali. Korišteni su Cochrane "Rizik od pristranosti" alat za procjenu za randomizirane studije i modificirana Newcastle-Ottawa skala za nerandomizirane studije. Studije koje su uključivale sljedeće ishode uključene su u ovaj sustavni pregled: indeks tjelesne mase, indeks tjelesne mase z-vrijednosti i % tjelesne masti, opseg struka, te učestalost i zastupljenost pretilosti. Meta-analiza provedena je pomoću modela slučajnih učinaka koji uzima u obzir heterogenost unutar i između studija. Pristranost publikacija procijenila se uz pomoć Egger testa na asimetriju. Intervencije koji su utjecale na tjelesnu aktivnost, tjelesni fitnes ili sjedilački oblik ponašanja kategorizirane su. Zatim su intervencije razvrstane na one koji koriste jednu komponentu ili više komponenti (tj. tjelesna aktivnost + sjedilačko ponašanje ili tjelesni fitnes + sjedilačko ponašanje). Analize su stratificirane po jednokomponentnim i višekomponentnim intervencijama kao i po spolu. Za analizu osjetljivosti, analize su stratificirane, odvojeno za jednokomponentne i višekomponentne intervencije, prema dizajnu studije, riziku pristranosti, razdoblju studije, i prosječnoj dob sudionika.

Rezultati Studija 1

Pretragom je identificirao 146 studija koje su pružile relevantne podatke za meta-analizu. Procjene bodova u % tjelesne masti bile su veće za fitness intervencije u usporedbi s intervencijama usmjerenih na tjelesnu aktivnost (standardizirana srednja razlika = −0,11%; 95% CI = −0,26 do 0,04, odnosno −0,04%; 95%CI = −0,15 do 0,06). Uključivanje sjedilačkog ponašanja u intervenciju orijentiranu na tjelesnu aktivnost ili fitnes nije bilo popraćeno povećanjem učinkovitosti intervencije, jer su bodovne procjene bile nešto manje u usporedbi s onima za intervencije usmjerene samo na tjelesnu aktivnost ili fitnes. Sveukupno, učinci su obično bili veći kod djevojčica nego kod dječaka, posebno za intervencije usmjerena na tjelesnu aktivnost + sjedilačko ponašanje. Bilo je nekih dokaza za nejednakost, budući da su učinci na indeks tjelesne mase vidljivi kada su intervencije provedene u općoj populaciji (standardizirana srednja razlika = −0,05, 95% CI = −0,07 do −0,02), ali ne i u skupinama djece u nepovoljnom položaju (standardizirana srednja razlika = −0,01, 95% CI = −0,29 do 0,19).

Zaključak Studija 1

Školske intervencije tjelesne aktivnosti učinkovita su strategija u primarnoj prevenciji pretilosti kod djece od 6 do 12 godina starosti, ali usmjerenost na smanjenje sjedilačkog ponašanje uz povećanje tjelesne aktivnosti ili fitnesa ne doprinosi povećanju učinkovitosti intervencije.

Metode Studija 2

Nacionalna intervencija „Healthy Lifestyle“ provođena je u Sloveniji od 2011 do 2018. Intervencijom je osigurana svakodnevna nastava tjelesna aktivnost za djecu od 6 do 14 godina. Intervencija je bila organizirana u obliku izbornog predmeta na temelju dobrovoljnog sudjelovanja i bila je dostupna svoj djeci. Prvi krug uključivanja započeo je sa 78 škola u školskoj godini 2010/11., 32 u 2011/12., 19 u 2012/13., 17 u 2013/14., 16 u 2014/15., 33 u 2015/16., 8 u 2016/17. i 13 u 2017/18., Ukupno je bilo uključeno 216 škola (između 18000 i 35000 učenika) tijekom zadnje godine provedbe. Kako bi se uočile moguće promjene u zastupljenosti pretilosti, potreban je bio podatak o zastupljenosti prije početka programa. Uključeni su oni učenici koji su sudjelovali najmanje jednu godinu u intervenciji. Štoviše, u analizu su bila uključena samo ona djeca koja su upisana u pojedinu školu već godinu dana prije prvog uključivanja škole u intervenciju. Oko 30000 bilo je uključeno u intervencijsku skupinu, a oko 35000 djece činilo je kontrolnu skupinu. Kvazi-eksperimentalni nacrt koristio se na temelju usporedbe intervencijske i kontrolne skupine s brojem uzastopnih godina sudjelovanja ili nesudjelovanja u intervenciji. Hi-kvadrat test koristio se za provjeru početnih razlika u broju dječaka i djevojčica u intervencijskoj i kontrolnoj skupini, a t-test za nezavisne uzorke za provjeru osnovnih razlika u dobi, triceps kožnom naboru, visini i početnoj prevalenciji pretilosti u pojedinoj školi ispitane na temelju podataka dobivenih putem SLOfit sustava praćenja između intervencijske i kontrolne skupine. Jednadžba generalizirane procjene koristila se za analizu mogućeg učinka intervencije na zastupljenost pretilosti u intervencijskoj i kontrolnoj skupini. Statistička značajnost bit će postavljena na α = 0,05.

Rezultati Studija 2

Intervencijska skupina imala je značajno veće smanjenje trenda porasta indeksa tjelesne mase od kontrolne skupine tijekom svih pet mogućih trajanja sudjelovanja i bez obzira na početni status tjelesne mase. Najveći učinak primijećen je kod djevojčica s pretilošću na početku intervencije, čiji je indeks tjelesne mase bio 1,4 kg/m2 niži nakon 3 godine intervencije u usporedbi s kontrolama. Preokret pretilosti prema normalnoj tjelesnoj masi bio je izraženiji kod djevojčica za koje su primijećene statistički značajne razlike između kontrolne i intervencijske skupine nakon 2 godine (χ2(1,1112)=5,776, p=0,016), 3 godine (χ2(1,669)= 9,570, p=0,002), 4 godine (χ2(1, 343)=5,107, p=0,024) i 5 godina sudjelovanja (χ2(1, 192)=4,551, p=0,033). Kod dječaka, razlike u stopi preokreta pretilosti između intervencijske i kontrolne skupine dosegnule su prag statističke značajnosti tek nakon 3 godine (χ2(1, 766)=6,435, p=0,011) i 5

godina (χ2(1,198)=4,863, p= 0,027) sudjelovanja. Potreban broj uključene djece da bi se preokrenuo jedan slučaj pretilosti također se ravnomjerno smanjivao s trajanjem programa u oba spola, s općenito nižim brojevima za djevojčice. Najniži brojevi zabilježeni su za 5 godina sudjelovanja u programu (17 odnosno 12 za djevojčice i dječake). Također, smanjenje učinkovitosti intervencije bilo je vidljivo u godini kada je program bio ometen nedostatkom financijskih sredstava.

Zaključak Studija 2

Utvrđeno je da je intervencija tjelesne aktivnosti na populacijskoj razini provedena u stvarnim uvjetima usmjerena na djecu i adolescente u dobi od 6 do 14 godina učinkovita u smanjenju stope pretilosti. Štoviše, ta su smanjenja bila najveća kod djece koja su u početku imala pretilost, a najmanja kod djece normalne tjelesne mase, što znači da je intervencija najviše koristila onoj djeci kojoj je bila i najpotrebnija.

Metode Studija 3

Ova intervencija provedena je u jednoj osnovnoj školi u Zagrebu tijekom drugog polugodišta školske godine 2021/2022. Intervencija je pružila dva podražaja visoko intenzivnog intervalnog treninga tjedno uklopljena u nastavu tjelesne i zdravstvene kulture djeci od 10 do 15 godina starosti. Intervencijska skupina započinjala je svaki nastavni sat sa 10 minuta visoko intenzivnog programa. Petra Jurić, mag. cin. provodila je intervenciju te je bila potpuno uključena u proces provedbe. Studenti Kineziološkog fakulteta, Sveučilišta u Zagrebu trenirani za postupke mjerenja, provodili su ista s punom transparentnošću, zaslijepljeni od grupne raspodijele. Efekti intervencije procijenili su se prije početka intervencije, te nakon tri mjeseca provedbe. Vezano uz prijenos instrumenata, isti su se kalibrirali prije svakog novog ciklusa uporabe, dok je prijenos biti izveden uz mjere opreza s ciljem minimiziranja mogućnosti oštećenja. Netaknuti razredi nasumično su se podijeliti u intervencijsku ili kontrolnu skupinu. Izvješće o zdravstvenom statusu dostavio je roditelj, a utvrđen je od strane liječnika. Glavni cilj intervencije bio je poboljšanje zdravstvenog fitnesa kao primarnog ishoda, te pretilost kao sekundarnog ishoda. Proveo se klaster randomizirani kontrolirani pokus. Intervencijska skupina provodila je visoko intenzivan intervalan trening na početku nastave, a kontrolna uobičajenu nastavu propisanu planom i programom. Eurofit baterija testova koristila se za procjenu učinaka intervencije. Opći linearni modeli korišteni su za usporedbu konačnih vrijednosti fitnessa i adipoznosti između intervencijske i kontrolne skupine, prilagođenih za početne rezultate

testova, početnu dob, početne vrijednosti percentila postotka tjelesne masti i spola pomoću MinitabTM statističkog softvera.

Rezultati Studija 3

Značajan učinak intervencije bio je prisutan za rezultate 20-meter shuttle run testa (p=0,001; d=0,31). Učinak intervencije u usporedbi s kontrolom procijenjen je kao dodatnih 181,2 metra, 95% CI (70,4 do 292,0). Dodatna analiza namjere liječenja (eng. intention-to-treat) pokazala je da je učinak intervencije na 20-meter shuttle run testu ostao statistički značajan (p<0,011), iako je veličina procijenjenog učinka smanjena sa 181,2 metra; SE=55,4 na 119,6 metara; SE=46,4. Iako se čini da je intervencija imala suprotan učinak od očekivanog na vrijednosti percentila postotka tjelesne masti, ovaj anomalični statistički događaj više nije bio vidljiv nakon analize namjere liječenja.

Zaključak Studija 3

Utvrđeno je da je tromjesečna intervencija visoko intenzivnog intervalnog treninga koja se provodila na redovnoj nastavi tjelesne i zdravstvene kulture učinkovita za poboljšanje kardiorespiratornog fitnesa procijenjenog putem rezultata testa trčanja. Taj se učinak dogodio s relativno niskom dozom visoko intenzivnog intervalng treninga. Učinkovitost intervencije na kardiorespiratorni fitness održana je čak i nakon korištenja analize namjere liječenja, čineći naše zaključke još jačima s najvišom razinom kliničkih dokaza.

Ključne riječi: indeks tjelesne mase, tjelesna masnoća, prekomjerna težina, pretilost, vrijeme ispred ekrana, djeca, adolescenti, tjelovježba, prirodni eksperiment, kardiorespiratorni, intervencija, škola.

Outline

This dissertation contains six chapters. **Chapter 1** comprises a general introduction to the scientific problem, research questions and aims, as well as a list of research studies. **Chapter 2** contains a description of basic concepts and definitions (i.e., obesity, physical activity, and fitness). **Chapter 3** contains the first publication. **Chapter 4** contains the second publication. **Chapter 5** contains the third publication. **Chapter 6** contains a general conclusion that integrates all three studies and identifies strengths and limitations as well as perspectives for future research. Following this, in appendices, supporting information for the studies is provided.

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Glossary of terms

%BF	Percentage of body fat
BMI	Body mass index
CRF	Cardiorespiratory fitness
HIIT	High-intensity interval training
ITT	Intention-to-treat
MVPA	Moderate to vigorous physical activity
NCDs	Noncommunicable diseases
NNT	Number needed to treat
PA	Physical activity
PE	Physical education
PROSPERO	Prospective Register of Systematic Reviews
RCT	Randomised controlled trial
SMD	Standardised mean difference

Chapter 1
Introduction

1.1 Introduction

The prevalence of childhood overweight and obesity has increased globally since the 2000s, particularly in economically advanced countries (1). Over the last 40 years, childhood obesity increased worldwide, with a dramatic eightfold rise in 5- to 19-year-old individuals compared with children under the age of 5 (2). Moreover, this global prevalence developed at a startling rate, from 0.7% to 5.6% in boys and 0.9% to 7.8% in girls between 1975 and 2016 (3). The present global obesity pandemic has laid the groundwork for increases in numerous noncommunicable diseases (NCDs) (4), which are no longer exclusively observed in adults but are becoming more frequent in younger populations as well. Decreased levels of physical activity in children, often accompanied by increased screen time, when paired with excess caloric intake, cause significant energy imbalance, contributing to the accumulation of adipose tissue (5). Additionally, the presence of an individual adipose condition increases a propensity toward behaviours that contribute to subsequent fat-mass accumulation (6). Although there is no straightforward proof of a causal relationship between reduced physical activity and adiposity (7), a recent study showed that replacing 1 hour of sitting tasks with moderate to vigorous forms of movement increases the estimated drop in body mass index (BMI) by more than seven times (8). Given the rise in number of children with obesity from 11 million in the 1970s to 124 million in 2016 (9), together with direct and indirect costs to the health care system (10), the need to implement convenient and controlled approaches on a global scale in order to prevent, and ultimately stop, this pandemic become obvious.

From childhood to adolescence, PA declines with age, then increases with age during young adulthood (ages 20-30), stabilizes during middle age (ages 31-59) and declines with age at the end of middle life and the beginning of older adulthood, corresponding to PA levels at the end of adolescence (11). However, the majority of adolescents do not have favourable amounts of PA per week, with the same trend continuing into adulthood (12), despite an increase in PA after adolescence. This highlights the need for more longitudinal trails with a strict focus on increasing PA among children and adolescents and changing behaviour from inactivity towards activity. Schools are considered excellent places to implement lifestyle interventions aimed at preventing and controlling obesity. Today, schooling is obligatory in most countries which makes schools perfect places for a reduction of many health problems and for preventing further health complications. Children and adolescents spend much

of their time in the school environment during weekdays (13, 14), excluding holidays, so a large number of young people can be reached simultaneously. Also, schools represent a convenient setting with powerful influences from teachers and peers (15). Compellingly, interventions are more effective in childhood than later in life due (in part) to a higher sensitivity to external influences (16). The sedentary character of most academic activities needs to be balanced with more comprehensive opportunities for physical movement that could encourage an increase in energy expenditure and introduce the benefits of physical activity (PA), not only on health but also on academic performance (17). It has been repeatedly shown that the greatest effects of school interventions on body weight are exhibited when movement is involved (18, 19, 20). Moreover, interventions lasting a longer period usually result in better and larger effects in comparison with shorter interventions (21). Hence, the World Health Organization (WHO) recommends programs lasting at least 1 year that involve many forms of movement, an optimal caloric intake, and parental involvement (17). Therefore, a school-based program that includes PA as a health component positively affecting well-being can serve as an important contributing feature in childhood obesity management, especially when led by experienced physical education (PE) professionals (18).

To be able to implement interventions in the school environment, it is necessary to address common gaps between school policies and actual implementation. Also, it is important to overcome deficiencies in school curricula, especially in countries where there is a greater focus on competitive rather than health-oriented activities (19). There is also an existing gap where specific characteristics of successfully implemented PA interventions are not specified. None of the previous studies compared interventions with a different type of energy expenditure component targeted nor documented and analysed specific elements of PA programs (18, 19, 20, 25, 26, 27, 28, 29). Also, several studies were restricted to certain research designs (26, 29), to high-income countries (19) or to a single obesity-related outcome (27, 28). This prevented a precise organisation of interventions for priority groups of children and an adaptation of interventions according to the needs of specific groups of children and adolescents. Furthermore, there is a lack of studies that provide a comprehensive overview of the majority of the population, which makes it impossible to generalize the findings, and although there are longitudinal data (30, 11), solid evidence of the sustainability of the effects over a long period of the intervention is lacking. Further, not only do we not know about the specific characteristics of interventions important to obesity prevention and cardiorespiratory fitness (CRF), but there is also a shortage of information about how to maximize the programs we do have for public health benefit. Although the beneficial health effects of initiating PA intervention programs during childhood are well documented, most of this evidence comes from short-term efficacy trials conducted in well-controlled settings, usually without implementation on a large scale, or scalable, population-based approaches

(31). Recognising this limitation, researchers are calling for PA interventions to be scaled up (32) and include children from diverse strata of society (33–35). The current lack of successfully implemented school-based PA interventions in real-world settings impedes the fight against the childhood obesity pandemic (36, 31). Even if a PA intervention is scaled up and includes a large number of children, it can be susceptible to poor implementation if the staff who are providing the field-implemented PA are not trained for specific conditions associated with such an intervention (37). Interventions can also be affected by external factors such as discontinuous funding or poor political decisions (38, 39). One of the most frequently identified obstacles affecting the sustainability of the intervention is lack of future financial support as an external factor and limited time, facilities, equipment and internal funding as internal factors. In order to facilitate the sustainability of the intervention in schools, care should be taken to manage these factors (40, 41). Typically, the effects of PA interventions remain at 75% or less of the effects reported in pre-scale-up efficacy trials (42), where lack of implementation models could potentially explain this decrease in efficacy (43). With known barriers to implementation and scale-up like time, cost, lack of resources and infrastructure, identifying time efficient strategies that impact fitness (e.g., high intensity interval training) is important.

Regardless of adiposity, low fitness levels can lead to a higher risk for cardiovascular diseases and diabetes, not only in children with excess weight but also in normal-weight individuals (44). Widespread lack of PA is associated with declining physical fitness among children and adolescents (45), with trends most likely continuing into adulthood (46). Several studies have demonstrated declining CRF (47–49), flexibility (50), and strength among children and youth (51). Nevertheless, poor physical fitness is a strong predictor of many NCDs in many countries (52-55). CRF, muscular fitness, and speed are all inversely correlated with overall adiposity in children (56), with abdominal adiposity also being a strong inverse correlate among adolescents (57). Because most NCDs start developing during youth (58), the need for implementation of more-effective solutions to enhance physical fitness tailored according to the needs of children and adolescents becomes evident.

Given that projected obesity-related morbidity incidence rates and all-cause mortality are very high, in addition to the anticipated costs for health care and economic losses (9), it is important to implement convenient and controlled approaches on a global scale and to monitor their effectiveness in order to slow down and ultimately reverse obesity pandemic. It has been established that the obesity pandemic is a consequence of reduced PA, often a result of increased sedentary time (59) and changed dietary habits (60). Strong evidence supports favourable outcomes of obesity prevention programs that include PA aimed at reducing BMI, especially in children aged 6 to 12 (20). Therefore, this dissertation was aimed at encompassing PA, physical fitness, and adiposity as equally important and intercorrelated

components of health during childhood and adolescence (61). Thus, this research focused on examining the specific determinants that lead to a successful implementation of an intervention that can prevent and control obesity by addressing PA and improving physical fitness among school-age children. Furthermore, the substantive evidence shows that school interventions are effective in managing all three factors but not all have been considered together. This research aimed to explore the school-based intervention literature using PA, adiposity and fitness as interrelated outcomes. The primary purpose of this program of research was to more clearly elucidate the characteristics of effective school-based obesity prevention/control, physical activity and fitness interventions and their impact on obesity over time. Secondarily, the research also explored the impact of a time efficient strategy (e.g., high intensity interval training) as a tool to improve fitness among children and adolescents, given the well-known barriers to implementation like time, cost, lack of resources and infrastructure.

This dissertation is based on a Scandinavian model. It includes three distinct studies with related research questions and aims. In all three studies, the effectiveness of various school-based interventions, including those that were fitness oriented, was analysed. In two studies, two specific interventions set throughout the school system were evaluated. One of these was a large-scale intervention in primary school focusing on the effectiveness of scaling up extra PE classes. In the other, a smaller intervention, also in primary school, the feasibility and effectiveness of a novel, more time-efficient strategy for improving health-related fitness was examined. This dissertation was done during the Covid 19 pandemic when the situation was aggravated, so this research was even more urgent and relevant.

1.2 Research aims and questions

The first two studies are a part of the Horizon 2020 Project *Science and Technology in Childhood Obesity Policy (STOP)* conducted at the University of Zagreb. The third study was conducted separately at Macquarie University.

The aims of all three studies are listed below:

1. To compare the effects of school-based interventions that target sedentary behaviours, physical activity, or physical fitness on primary prevention of obesity in 6- to 12-year-old children.

2. To examine the effects of a population-based, scaled-up, long-lasting, fitness-oriented physical activity intervention set across Slovenian elementary schools on obesity prevention in 6- to 14-year-old students.

3. To analyse the efficacy of a 12-week high-intensity interval training intervention embedded in physical education classes on health-related fitness and adiposity of 10- to 15-year-old students.

The questions of all three studies are listed below:

1. What types of school-based physical activity interventions represent the most effective solution for the primary prevention of obesity in 6- to 12-year-old children?

2. Is a population-based, scaled-up, long-lasting fitness-oriented physical activity intervention set across elementary schools effective for obesity prevention in 6- to 14-year-old students?

3. Is a 12-week high-intensity interval training intervention incorporated into physical education classes effective for improving health-related fitness and adiposity of 10- to 15-year-old students?

1.3 List of research studies

In order to answer the above questions, this dissertation includes three studies that have been published or accepted for publication or in the process of review:

1. Podnar H, **Jurić P**, Karuc J, Saez M, Barceló MA, Radman I, Starc G, Jurak G, Đurić S, Potočnik ŽL, Sorić M. Comparative effectiveness of school-based interventions targeting physical activity, physical fitness or sedentary behaviour on obesity prevention in 6- to 12-year-old children: A systematic review and meta-analysis

   Published in *Obesity Reviews*.

2. **Jurić P**, Jurak G, Morrison SA, Starc G, Sorić M. Effectiveness of a population-scaled, school-based physical activity intervention for the prevention of childhood obesity. Obesity (Silver Spring). 2023 Mar;31(3):811-822. doi: 10.1002/oby.23695. PMID: 36811242.

   Published in *Obesity*.

3. **Jurić P**, Dudley DA, Petocz P. Does incorporating high intensity interval training in physical education classes improve fitness outcomes of students? A cluster randomized controlled trial. Prev Med Rep. 2023 Feb 4;32:102127. doi: 10.1016/j.pmedr.2023.102127. PMID: 36816767; PMCID: PMC9932703.

   Published in *Preventive Medicine Reports*.

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Chapter 2
Basic Concepts and Definitions

2.1 The definition of adiposity and obesity

Adiposity refers to the degree of body fat accumulation and is usually associated with an excess of that fat (62). Therefore, in this dissertation, adiposity is the word most commonly used in relation to excess fat tissue. Other words used for adiposity (e.g., excess body fat) are overweight and obesity. These words are also used in this dissertation. However, obesity is defined by an additional feature: as well as excess adipose tissue, it refers to an increased risk of adverse health outcomes (63).

2.2 Obesity and its detrimental impact on human health

Obesity became one of the major public health concerns during the last century. Since the end of the 19th century, more than 57,000 obesity-related articles have been published (64). This is not surprising because both overall adiposity and abdominal adiposity are independently related to the risk of death. A J-shaped relationship between BMI and risk of death indicates that people with lower and higher BMI values have a higher risk of death compared with those who have optimal values (65). Interestingly, individuals with lower BMI values accompanied by abdominal adiposity tend to have an even higher risk of death compared with those who have higher BMI values (65). This is especially relevant because general medical practice still uses body weight and BMI as primary measures of adiposity among the general population but neglects visceral body fat, which is proven to increase cardiometabolic risk irrespective of BMI (66). Even if an individual has excess weight but low levels of visceral adiposity, a better cardiovascular risk profile is present, and this can be described as metabolically healthy obesity (67). Further, visceral adiposity is a powerful health biomarker and is associated with insulin resistance, inflammation, and endothelial dysfunction which indicate the first step toward atherosclerosis and cardiovascular diseases (68).

Obesity is, and will most likely remain, a global public health problem over the next decades. Even two decades ago, this pandemic affected 300 million people globally (69) across both developed and undeveloped countries (70). One decade ago, obesity affected more than 600 million people and had been associated with 45 comorbidities (71). When considering adiposity during the lifespan, estimated trends indicate that most of today's children will suffer from obesity when they reach 35 years of age. This is especially true for children who have current obesity because their chance of not having obesity in adulthood drops as they get older (72).

With obesity, a simultaneous worldwide increase in the prevalence of type II diabetes has occurred (73), with 90% of this metabolic dysfunction attributed to excess body weight (74). Further, together with obesity, the incidence of colon cancer has developed significantly, with insulin being the link between those comorbidities (75). Obesity has also been associated with the incidence and progression of osteoarthritis (76), obstructive sleep apnea (77), and, together with insulin resistance, to progression of nonalcoholic fatty liver disease causing many liver complications, especially among people in developed countries (78).

Although the link between obesity and cardiovascular diseases is proven, most of the evidence is based on single-timepoint estimates, where optimal levels of CRF largely reduce the negative effects of obesity on cardiovascular health (64). From there, different cardiovascular outcomes are present regardless of BMI. Therefore, CRF is the first line of defense against cardiovascular impairments. This emphasises that enhancing fitness should be a priority and that not all obesity cases should be treated equally because the relationship between obesity and different diseases is a complex phenomenon.

Furthermore, based on a meta-analysis including longitudinal studies, obesity increases the risk of depression (79). With obesity, systemic inflammation is usually present (80), which has been linked with depression (81). Obesity is also associated with cognitive impairment and dementia through endothelial dysfunction and disruption of the blood-brain barrier (82).

2.3 Obesity during childhood and adolescence

The prevalence of overweight and obesity has become especially marked among children and adolescents, presenting one of the largest and most serious contemporary public-health concerns (3). Obesity that transitions from childhood to adulthood leads to a large number of physical morbidities with serious health consequences (83). Moreover, since 1980, the global prevalence of childhood obesity has increased by 47% (63). This takes a huge toll on children's health, leading to a higher risk of developing several comorbidities including elevated blood pressure, atherosclerosis, elevated levels of triglycerides and low-density lipoproteins accompanied by low levels of high-density lipoproteins, metabolic syndrome, type II diabetes, cardiac impairments, and obstructive sleep apnea (84).

The Avon Longitudinal Study of Parents and Children, a prospective cohort study including 5235 children, indicated that in girls a 1 SD greater BMI at age 9–12 was associated with cardiovascular risk factors at age 15–16, with higher odds for high systolic blood pressure, high concentration of low-density lipoproteins and triglycerides, low concentration of high-density lipoproteins, and high concentration of insulin (85). The study reported the same for boys for systolic blood pressure, low-density lipoproteins, triglycerides, high-density lipoproteins, and insulin (85). Interestingly, children

who transitioned from excess weight at age 9–12 to normal weight at age 15–16 still had a higher risk of adverse health outcomes compared with children who consistently had normal weight (70). Additionally, advanced pubertal development and polycystic ovarian disease have been linked to childhood overweight and obesity (86), where excessive pubertal insulin resistance may contribute to earlier maturation in children with obesity (87). Furthermore, adiposity during childhood has been linked to poorer academic performance and memory (88) as well as to depression, lower emotional well-being, behavioural problems, lower self-esteem, and poorer perceived quality of life (89).

There has been extensive research on genetics as a cause of obesity. However, genetics contributes to less than 5% of all childhood obesity cases (90). Therefore, childhood obesity is largely influenced by external variables such as parental approach and lifestyle habits (91). An increase in sugar intake, together with consumption of excessive quantities of food, plays a pivotal role in childhood obesity development (91).

2.4 The economic burden of obesity

Widely available and extensive evidence links obesity to almost every major health problem. These problems start developing early in childhood, progress through youth, and results in symptomatic complications during adulthood. Apart from an increased risk of mortality, obesity puts a considerable financial toll on the healthcare system. For example, diabetes linked to obesity represents a significant economic cost. For example, in the U.S. the burden of prediabetes and diabetes reached 218 billion dollars in 2007 (92). This economic loss was present and is still present across different continents. For instance, in Europe this burden was 29 billion Euros in 1999 (93). Based on data up to 2009, between 0.7% and 2.8% of a nation's healthcare costs were related to obesity, with 30% higher medical costs among people with obesity compared with those without obesity (94). The latest data from 2019 indicate that obesity costs between 0.8% and 2.4% of gross domestic product across eight countries, with this burden being present irrespective of the country's economic development (95).

2.5 Measures of obesity

The most commonly used metric to assess the level of adiposity is BMI (62). In children and adolescents, the International Obesity Task Force uses age- and sex-specific BMI cut-off points to classify children with normal weight, overweight, or obesity (96). Children with BMI equal to or exceeding the 95th percentile are defined as suffering from obesity. Those with BMI between the 85th and 95th percentiles are defined as overweight. Although most studies use BMI cut-off points, this is not the best outcome measure for assessing a change in adiposity levels among children and adolescents. The percent over BMI method (BMI50) and the healthy fitness zone continuum (BMI85) are more suitable for assessing change in adiposity among youth because these measures avoid the

pattern of positive mean BMI% change in children with lower initial BMI scores, and negative mean BMI% change in those with higher initial BMI scores (97). BMI percentiles are not the most useful marker for tracking change over time because BMI percentiles charts are positively skewed with a much wider distribution above the 50th percentile than below it, especially at the upper centiles representing obesity (98). Further, a ceiling effect occurring at the high end of the BMI percentile distribution masks the real change when children gain or lose significant amounts of weight but remain at the same percentile level (97).

The most appropriate methods for assessing adiposity focus on body composition. There are several examples. Air displacement plethysmography is considered a valid method for assessing the body composition of children (99). Dual-energy X-ray absorptiometry, or DXA, which estimates the percentage of soft tissue for the whole body using an X-ray system, is also considered a reliable approach (100). A commonly used and easily available instrument is the Tanita BC-418 segmental body composition analyser. It is based on bioelectrical impedance where the person stands barefoot with weight evenly distributed between both feet on the analyser and holds a pair of hand grips, one in each hand. Each measurement takes approximately 30 seconds with a correction for light indoor clothing (101). However, the most easily accessible method for evaluating adiposity involves skinfold thickness measurements through subcutaneous body fat assessment (100), a method that has been shown to be better for assessing adiposity than BMI (102).

2.6 Concepts and definitions of physical activity

The WHO defines PA as any bodily movement produced by skeletal muscles that requires energy expenditure. PA can be performed in domains that include leisure time, transport, and work. The total volume of PA is defined by intensity, duration, and frequency. Intensity refers to the effort to perform a specific movement, duration relates to time/minutes spent in an activity, and frequency is defined by the number of physical movements performed per day. The WHO provides general PA guidelines for different populations, including children, adolescents, adults, older adults, pregnant and postpartum women, and people living with chronic conditions or disabilities (103). Further, a newer definition of physical activity has also been proposed with more focus on interdisciplinarity of physical activity in the academic and policy domain. This broader definition is “people moving, acting and performing within culturally specific spaces and contexts, and influenced by a unique array of interests, emotions, ideas, instructions and relationships” (104). Despite widely present evidence supporting the beneficial effects of PA for the prevention of many NCDs, the existing lack of PA irrespective of socio-economic conditions is evidenced by 1.4 billion adults not meeting minimal PA levels for maintaining optimal health with an increase in prevalence since 2001 (105).

The initial epidemiological research about the health benefits of PA was published in the 1950s (106), and since then the research field has expanded progressively, with more publications, researchers, international expert groups, and research centres producing knowledge and creating new policies tailored to the needs of different populations. Moreover, publications of world significance related to this topic include the 2012 (31, 107, 108, 109, 36) and 2016 Lancet series on PA (110, 32), displaying the highest quality of evidence encompassing different PA concepts globally. Currently, PA promotion has become one of the leading interests of many health-oriented organisations. Further, with partnerships between institutions, comes the possibility of an even more penetrating effect of PA into society, with schools being one of the examples (108). However, despite the fact that PA interventions are increasingly present in school systems, such interventions are not always successful in reducing children's BMI or body fat, which highlights the deceptiveness in this regard (111).

At the UN high-level meeting on NCDs held in September 2011, PA was considered an important element of NCDs in the global health context, but it still received less attention compared with other hazardous behaviours (112). Despite that, the surveillance of PA in adolescents and adults has progressed over the past decades, with lack of PA being more prevalent in women compared with men and in older adults compared with younger adults (31). The International Physical Activity Questionnaire (113) and the Global Physical Activity Questionnaire (114) enabled worldwide PA data collection. However, uninterrupted PA surveillance at the national level is lacking, resulting in a paucity of trend data (36).

Although progress in PA research has been made, specific recommendations for addressing the global pandemic of physical inactivity are yet to be developed. Based on widely available evidence, lack of PA is widespread, with an emerging need for more specific and well-designed approaches to slow down and ultimately reverse this costly pandemic. Comprehensive monitoring of different PA programs and interventions across all subgroups is necessary to tailor policies even more efficiently, and collaborations between different institutions and funding bodies over a longer period are essential for approaching this public health issue.

2.7 Physical activity during childhood and adolescence

Physical activity is vital for optimum human body functioning, whereas lack of PA causes maladaptation in the human condition, which may lead to poorer quality of life outcomes (115). Prolonged lack of PA is associated with impaired glucose metabolism and cardiometabolic disorders, which lead to increases in mortality worldwide (116). Three in four adolescents aged 11–17 around the world do not currently meet the global PA recommendations for maintaining optimal health (117), putting them at risk for coronary heart disease, metabolic impairments, some types of cancer, and

premature death (118). Despite widely available evidence in favour of PA, lack of PA among children and adolescents is still extensive and contributes to adverse health outcomes (119; 31).

The WHO shows that children and adolescents aged 5–17 should accumulate at least 60 minutes of moderate to vigorous PA (MVPA) per day, with strength-related exercises implemented at least three times per week (103). Based on data from over 100 countries, 80% of adolescents aged 13–15 (31), and 78% of boys and 84% of girls aged 11–17 (110), do not meet the recommended MPVA guidelines. It is important to emphasise that age and sex represent the main link with PA during youth, with boys and younger children usually more active compared with girls and older children (120). Children tend to be more active if they come from highly educated families with a higher socioeconomic status compared with less-educated families that are mostly associated with lower socioeconomic conditions (121). Encompassing available evidence pointing to a worldwide lack of PA during childhood and adolescence calls for precise solutions, especially since the level of PA among youth (ages 9 to 18) significantly predicts the level of PA later in life (122).

2.8 Concepts and definitions of physical fitness

Although PA and physical fitness are related, they are not exchangeable. Fitness refers to aerobic capacity, endurance, strength, or flexibility usually achieved by performing PA or exercise. Thus, physical fitness is an attribute (123). Physical fitness, usually accompanied with PA, contributes to psychological and physiological well-being, prevents adverse behavioural and metabolic outcomes, and acts as a protective element from many chronic illnesses (124). With an optimal physical fitness level, the human body is able to fight many stressors present in everyday life, serving as a beneficial stress-resistance agent (125, 126, 127, 128, 129).

In contrast, low physical fitness, mostly paired with physical inactivity and visceral adiposity, has been linked to elevated levels of inflammatory markers and unfavourable health consequences (130, 131, 132). Epidemiological studies providing consistent evidence since the last century indicate that optimal fitness levels correlate with lower cardiovascular and total mortality (133). However, although fitness and adiposity are closely connected, optimising adiposity levels is not associated with a lower risk of mortality, further emphasising the importance of physical fitness and putting fitness first when targeting chronic impairments (123).

2.9 Physical fitness during childhood and adolescence

Although there is no doubt that PA is beneficial for health among children and adolescents, many researchers have argued that physical fitness is an even more powerful marker of health (134, 135). Lifestyle changes accompanied with increased screen time and poor dietary choices contribute to lower

levels of physical fitness (136, 137). The lack of PA associated with declining physical fitness among youth (45, 47) most often continues into adulthood (46). The evidence supports the fact that most cardiovascular impairments start developing early in life (58). It has been extensively documented that CRF (45, 47, 48, 49), flexibility (50), repetitive strength, and running speed generally worsen among youth (138).

Apart from CRF, muscular fitness has begun to receive more attention for the prevention of various diseases (139, 140). Results from the AVENA (Alimentación y Valoración del Estado Nutricional de los Adolescentes) study indicate that muscular fitness is inversely correlated with cardiovascular risk in adolescent girls (141). A systematic review focusing on the international evolution of fitness, encompassing over 1.7 million children and adolescents from 14 countries, showed that, regardless of where the evidence came from, most studies indicate a persistent downward trend in strength, endurance, and flexibility among youth, especially in the last 25 years. However, agility, speed, balance, and coordination do not follow the same trend, and variations between different countries and studies are present (51). Additionally, frequency of daily moderate to vigorous PA decreases from 11 to 15 years (30). This is supported by another study which showed that from childhood to adolescence, PA declines with age. The same study also showed that PA increases with age during young adulthood (ages 20-30), stabilizes during middle age (ages 31-59) and declines with age at the end of middle life and the beginning of older adulthood, corresponding to PA levels at the end of adolescence (11). Both studies show longitudinal trends of PA in adolescents and adults, which emphasises the importance of interventions targeting children and adolescents.

Low CRF has been linked to metabolic syndrome among adolescents because enhancing fitness early in life is crucial for healthy metabolic functioning (142). Additionally, optimal fitness levels attenuate metabolic syndrome scores even among youth with obesity (143). The improvement of physical fitness among adolescents may indirectly reduce low-grade inflammation independent of body fat (144). This is especially important given the fact that increased body inflammation affects many health irregularities, including atherosclerosis (145). Further, results from the HELENA study indicate that, irrespective of PA levels, adolescents with lower fitness levels usually have lower whole-body bone mineral content when compared with those who have better fitness (146). This is especially true for muscular fitness, where grip strength is regarded as an independent predictor of bone mass during adolescence. An increase in muscle mass achieved with developing physical fitness during adolescence acts as a stimulus for an increase in bone mass (147). However, if physical fitness testing is conducted, it should follow the several psychological implications and practices. Testing should promote enjoyment and regular PA and be an integrated part of a PE curriculum. Also, working in

informal environment with a partner is helpful. Children should actively plan their fitness development based on testing. Testing should be tailored to task-oriented (skill mastery) and ego-oriented students (challenges) where feedbacks from PE teachers are considered desirable (148). All those implications are important to consider because fitness tests have been criticised in the school system for the stigma they place on the least fit children. This explains why many school-based interventions prioritise physical interventions that promote physical literacy over physical fitness.

In summary, development of CRF and muscular fitness should be the priority when implementing PA interventions during childhood and adolescence, especially given that fitness is superior (but still linked) to PA and adiposity for the prevention of many health complications.

Chapter 3

Publication 1

Comparative effectiveness of school-based interventions targeting physical activity, physical fitness or sedentary behaviour on obesity prevention in 6- to 12-year-old children: A systematic review and meta-analysis.

Podnar H, **Jurić P**, Karuc J, Saez M, Barceló MA, Radman I, Starc G, Jurak G, Đurić S, Potočnik ŽL, Sorić M. Comparative effectiveness of school-based interventions targeting physical activity, physical fitness or sedentary behaviour on obesity prevention in 6- to 12-year-old children: A systematic review and meta-analysis. Obes Rev. 2021 Feb;22(2):e13160. doi: 10.1111/obr.13160. PMID: 33462934.

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Contribution

Petra Jurić extracted study characteristics, the details on the intervention content from the main papers, the intervention protocols and the related web resources (Appendix A3). Petra Jurić extracted obesity-related study outcomes from each study included in this systematic review and meta-analysis, revised the manuscript for important intellectual content and created visualisations of the data for the review process. All others contributions made by co-authors are mentioned throughout the entire text.

Abstract

A systematic search of the literature was performed to compare the effects of interventions that targeted sedentary behaviours or physical activity (PA) or physical fitness, on primary prevention of obesity in 6-12-year-old children. The search identified 146 reports that provided relevant data for meta-analysis. Point estimates in % body fat were higher for fitness interventions compared to PA interventions (Standardised mean difference = -0.11%; 95% CI = -0.26 to 0.04, and -0.04; 95% CI = -0.15 to 0.06, respectively). Including sedentary behaviour to a PA-oriented or fitness-oriented intervention was not accompanied by an increase in intervention effectiveness, as the point estimates were slightly smaller compared to PA-only or fitness-only interventions. Overall, the effects tended to be larger in girls than boys, especially for PA + sedentary behaviour interventions. There was some evidence for inequality, as the effects on BMI were seen when interventions were delivered in the general population (Standardised mean difference = -0.05, 95% CI = -0.07 to -0.02), but not in groups of disadvantaged children (Standardised mean difference = -0.01, 95% CI= -0.29 to 0.19). In conclusion, school-based PA interventions appear to be an effective strategy in the primary prevention of childhood obesity among 6-12-year-old children but targeting sedentary behaviour in addition to PA or fitness does not increase the effectiveness of the intervention.

Keywords: overweight, screen time, youth, BMI, body fat

Running title: Comparative effectiveness of obesity prevention interventions

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Conflicts of interest: MS reports grant from European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 774548. PJ and JK report grants by the Croatian Science Foundation (grant No. DOK-2018-09-8532 and DOK-2018-01-2328, respectively)

Acknowledgements: This study is a part of the Science and Technology for childhood Obesity Policy (STOP) that has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 774548. PJ's and JK's work is funded by the Croatian Science Foundation (grant No. DOK-2018-09-8532 and DOK-2018-01-2328, respectively). The authors would like to thank Marijana Briški Gudelj and Rebbeca S Jones for their dedicated help in designing, adapting and conducting the search of the literature.

Glossary of terms

NCDs - Non-communicable diseases

PA - Physical activity

BMI - Body mass index

PROSPERO - Prospective Register of Systematic Reviews

PICOT - Population, intervention, comparison, and outcome

%BF - Percentage of body fat

RCT - Randomised controlled trial

SMD - Standardised mean difference

3.1 Introduction

Non-communicable diseases (NCDs) remain the leading cause of death in most parts of the world, and large part of this mortality is ascribed to insufficient physical activity (PA) and obesity (1). Specifically, physical inactivity is the fourth, and obesity has been ranked as the fifth leading risk for global mortality (1). At the same time, the prevalence of overweight and obesity is rising worldwide among all age groups, with the epidemic being especially marked among children and adolescents (2). In this age group obesity has increased dramatically during the last few decades of the 20th century, especially in the most developed countries (2). Interestingly, it seems that this increase has been much larger in 5-19-year-old children as compared to younger children (3).

Obesity in children has been linked to both short (4) and long-term adverse health outcomes (5). Furthermore, childhood obesity frequently persists in adulthood, which is accompanied by many well-known detrimental effects on health (6). PA, alongside unhealthy dietary habits, is proposed as one of the major contributors to childhood obesity (7). In addition, PA in childhood has been linked to many other favourable health outcomes as well as to improved academic performance (8). While there remains little doubt that PA is beneficial for health, many posit that physical fitness is an even more powerful maker of health (9, 10). On the other hand, sedentary time has also been associated to several adverse health outcomes, although evidence for a specific link with obesity is weak (11). Currently there is only little or no evidence that a relationship between sedentary time and adiposity in children and adolescents is causal (12). Indeed, a recent study that collated data from 14 accelerometer investigations in children and used iso-temporal substitution to model the effects of reduced sedentary time on health estimated that replacing one hour of persistent sedentary time with non-sedentary pursuits would lead to only a mild reduction of body mass index (BMI) (13). On the other hand, the same study found that replacing one hour of sedentary time by moderate-to-vigorous PA increases the estimated decrease in BMI by more than 7 times (13). Hence, PA interventions might exhibit larger effects on obesity-related outcomes than interventions aimed at reducing sedentary behaviours. However, this remains to be confirmed in clinical trials.

Obesity, PA and sedentary pursuits are complex phenomena that require population-based solutions. For children, schools are frequently identified as an ideal setting for introducing lifestyle change and the prevention of weight gain. In most countries school is obligatory, at least by mid-adolescence, hence all children can be reached, which makes schools a perfect setting to reduce health inequalities. In addition, children spend a significant portion of the day in school. Because academic activities are mostly sedentary, ample opportunities for PA should be provided in order to increase energy expenditure and introduce the well-known benefits of PA on health and academic performance.

Indeed, several previous systematic reviews that examined the effects of obesity prevention interventions have shown that school-based interventions are most effective when a PA component is included (14-16). However, the characteristics of successful PA intervention are less understood.

This study aimed to bridge this gap by assessing what types of PA interventions in schools are the most effective in improving obesity-related outcomes. To this end, it compared the effects of three groups of interventions: 1) interventions that aimed to reduce sedentary behaviour; 2) interventions that intended to increase PA and 3) interventions that were designed to improve physical fitness. It identified several systematic reviews published in the last 10 years that assessed the effectiveness of PA interventions on obesity prevention (14-21). However, none of these studies attempted to document and analyse specific elements of PA programmes. Moreover, several of these analyses might have missed large studies as they were restricted to randomised designs (18-21). Others were restricted to high-income countries (15) or to a single obesity-related outcome only (19, 20). Thus, in order to cover a complete spectrum of PA interventions it included all school-based interventions that targeted energy expenditure, regardless of the type or duration of the intervention. The wide range of included interventions will serve to identify features that enhance the effectiveness of these programmes in primary prevention of obesity, with special focus on the type of energy expenditure component targeted.

3.2 Methods

The protocol for this review was registered with Prospective Register of Systematic Reviews (PROSPERO 2019 CRD42019129295), and the methods are briefly described in the following sections.

3.2.1 Literature search and data extraction

The study involved searching MEDLINE, The Cochrane Central Register of Controlled Trials (CENTRAL), Scopus, LILACS, OpenGrey, Open Access Thesis and Dissertations, Clinical Trials and the WHO International Clinical Trials Registry for peer-reviewed studies published in the last 25 years (between 1/1/1994 and 15/4/2019). The research question was designed by following the Population, Intervention, Comparison, and Outcome (PICOT) framework, used MeSH terms in Medline plus keyword searches structured around four constructs (population – children; intervention – PA, fitness and sedentary behaviour; setting – school; outcome – adiposity) and adapted this strategy to individual databases (see Supporting Information – List S1 for Medline search strategy). The search was not limited to any specific geographical region. However, it included only studies written in European languages. The search strategy was validated by conducting sensitivity analysis in MEDLINE with a test set of 10 key papers selected as exemplary papers answering the research question. Adjustments

to the search strategy finished when all 10 key papers were identified by the search. All database search results were extracted and imported into the web-based reference manager: Rayyan. After removing duplicates, results were screened initially by abstract and title. The first 500 results were screened independently by two reviewers (HP, JK). Given that >95% agreement between reviewers in included studies was recorded, each of the two reviewers screened half of the remaining results. Ambiguities on study eligibility were resolved through discussion with a third reviewer (MSo). In addition to this, the study group checked reference lists of key systematic reviews in the same area for eligible studies (14, 16-18, 20, 22). Lastly, the study searched reference lists of all included reports.

Inclusion criteria were: 1) randomised or non-randomised control trial, controlled before-after study or natural experiment; 2) control group; 3) participants aged 6 to 12 years (mean age at the start of the study = 5.5 to 12.49). Namely, as school-going youth are typically divided in two age groups: children (6-12 years) and adolescents (13-18 years). Considering that the same strategies would probably not work for both children and adolescents, and due to large heterogeneity in high-school curricula that precludes one-size-fits-all policies, it was decided to limit this review to children aged 6 to 12 years; 4) interventions of any duration that have aimed to either: a) increase PA and/or physical fitness; b) reduce sedentary behaviour; 5) intervention was performed primarily in school-setting; 6) follow-up of at least 12 weeks from the start of the intervention; 7) any obesity related outcome was measured (e.g. BMI, BMI z-score, BMI percentile, prevalence or incidence of overweight or obesity, % body fat (%BF), skinfold thicknesses, waist circumference, waist circumference percentile, waist-to-height ratio. Studies were excluded if: 1) no obesity related outcome was reported or the data came from self-report; 2) they included exclusively children with overweight or obesity or only special populations (e.g., children with a specific illness, blind, physically disabled etc.); 3) full text was not available (i.e., only conference abstract).

After study selection, an extraction template was created (MSo) and study characteristics were extracted by two reviewers working independently (ŽLP and PJ). Papers reporting on the results of the same study were collated so each study is the unit of analysis rather than each paper. Values at the longest available follow-up were taken for quantitative analyses.

The details on the intervention content were extracted from the main papers, the intervention protocols and the related web resources. Two reviewers independently extracted half of data (ŽLP and PJ), and about 10% of the extracted data were double checked by the third reviewer (MSo). Extracted items included: Authors, year, period of the study, number of clusters and participants, demographic characteristics, details on intervention type and content, duration of intervention and follow-up and adverse outcomes.

Obesity-related study outcomes were extracted by two reviewers (JK and PJ), working independently on half of data, and entered in a pre-designed excel template. The third reviewer (MSo) verified 10% of the extracted results, and any discrepancies were resolved through discussion.

3.2.2 Risk of bias assessment

A single reviewer (MSo) assessed the risk of bias of all studies that met the inclusion criteria using Cochrane "Risk of bias" assessment tool for randomised studies (23), and modified Newcastle-Ottawa scale for non-randomised study designs (24).

For individual randomised controlled trials (RCT) the assessment contained the following domains: 1) random sequence generation, 2) allocation sequence concealment, 3) blinding of outcome assessment, 4) incomplete outcome data, 5), selective outcome reporting, 6) other bias (in this domain the study assessed bias arising from: a) contamination, b) low fidelity). The study excluded blinding of participants and study personnel domain since this is generally not possible for PA interventions. For cluster-randomised trials, the study included several more domains specific to this design: 1) recruitment bias (when participants are approached after the clusters have already been randomised), 2) baseline imbalance (often present when small number of clusters are being randomised), 3) loss of clusters (when whole clusters are lost from the trial, either immediately after randomisation or during follow-up), and inappropriate data analysis (when clustering of observations is not taken into account in data analysis). It judged the risk of bias in each domain as having low, high, or unclear risk. Studies judged as having low risk of bias in at least 5 domains for individual RCTs and 8 domains for cluster-RCTs were classified as having an overall low risk of bias.

For non-randomised study design risk of bias assessment was performed using modified Newcastle-Ottawa scale for cohort studies. This scale originally includes 8 domains, but one domain (i.e., demonstration that the outcome of interest was not present at start of the study) was deemed not to be applicable for studies included in this review, hence it was omitted. The domains assessed included: 1) representativeness of the intervention cohort (were participants representative for the community?), 2) selection of the non-intervention cohort (were controls drawn from the same community as the participants of the intervention?), 3) ascertainment of intervention (was the intervention implemented according to the plan?), 4) comparability of cohorts on the basis of the design or analysis (were analyses adjusted for age, gender and other important features, such as clustering, baseline values for the outcome of interest etc.), 5) assessment of outcome (was the outcome measured with an objective method), 6) was follow-up long enough for outcomes to occur (follow-up longer than 6 months from the start of the intervention), 7) adequacy of follow up of cohort (subjects lost to follow up unlikely to introduce bias due to low or balanced attrition). According to the standard scoring protocol (24), the

study team awarded one star for domains 1, 2, 3, 5, 6, 7 and a maximum of 2 stars for comparability of cohorts domain. Studies that totalled at least 6 stars were classified as having an overall low risk of bias.

3.2.3 Data Analysis

In this study, mean differences were calculated as:

Mean difference = Differences in the intervention group - Differences in the control group,

where the mean differences in the intervention and control groups denote the differences between values at follow up and baseline in each of the groups. The units of measurement were kg/m^2, units of the standardized normal and % for BMI, BMI z-score and %BF, respectively. Next, when comparing 5 groups of interventions in both the main analyses and subgroup analysis (described in the next section), the raw differences were standardised using the standard deviations of the differences (apart from the BMI z score, since it is already standardised).

The study team computed the uncertainty parameter (I^2) representing the percent of total variance in the observed results explained by heterogeneity and assessed heterogeneity using the Q test (25). The meta-analysis used a random-effects model which considers both within and between study heterogeneity (26). Finally, publication bias was assessed for both overall results and main subgroup analyses with Egger's test for asymmetry (27). The level of significance (alpha) was set at 5%.

3.2.4 Subgroup analyses

To compare the effects of interventions targeting different elements of energy expenditure, interventions were categorised into those affecting PA, physical fitness or sedentary behaviour. This was done by examining the content of the interventions (e.g., the intensity and volume of introduced PA, and the aims explicitly stated by the authors). Then, interventions were classified into those aiming to change only one element of energy expenditure (i.e., decreasing sedentary behaviour or increasing PA/fitness) and those targeting two elements of energy expenditure (i.e., PA plus sedentary behaviour or physical fitness plus sedentary behaviour). Hence, 5 groups of interventions were created in total (1. sedentary behaviour; 2. PA; 3. fitness; 4. PA+sedentary behaviour; 5. Fitness + sedentary behaviour). Within each of these subgroups , the study examined how the characteristics of the content (e.g., duration and intensity of PA introduced, diet component) and the intervention (e.g., duration, follow-up period, parent involvement) modify the effectiveness of the programme.

Next, all analyses were stratified by gender (both genders, i.e., studies that did not distinguish gender; boys; girls). Lastly, as a very limited number of studies that directly compared the effects in

children of varying social-economic status (SES) were available. In order to examine the equality aspect of interventions studied, the effects that were compared found in studies that focused on economically deprived children with interventions that included general population of children.

3.2.5 Sensitivity analyses

For sensitivity analysis, the analyses were stratified separately for PA, fitness, and PA+sedentary and fitness + sedentary behaviour interventions, by study design (RCT vs. other designs), risk of bias (low risk of bias versus moderate and high risk of bias), study period (<2009 vs >= 2009) and mean age of participants (6-9 years vs. 10 -12 years).

3.3 Results

The search strategy retrieved 18 239 studies from 8 databases. After removing duplicates, 17 014 records were screened by title and abstract. In the next step, 1 091 were selected for screening of the full-text paper and 242 were found to conform to the inclusion criteria. Searching the reference list of 7 systematic reviews led to the addition of 11 papers, and additional search of references of included studies yielded 4 more reports. All in all, the search retrieved 257 papers. A large majority of the papers were in English (246 or 97%), while other languages included Spanish (8 papers), German (2 papers) and Dutch (1 paper). Several of the included papers reported on outcomes of the same intervention study at different time points or in different subpopulations. Hence, results were extracted from 200 individual intervention studies (see Supporting Information – List S2 for list of included and excluded studies), and 146 of these provided data suitable for meta-analysis and were finally included in this review (Figure 1). After excluding studies that did not provide standard errors, those that did not provide results at baseline (or pre-intervention) and those that did not provide information related to control group, the analysis combined, by meta-analysis, studies that assessed following outcomes: BMI (102 studies, 171 analyses), BMI z score (56 studies, 119 analyses) and %BF (46 studies, 91 analyses). On the other hand, obesity prevalence/incidence and waist circumference were found to be unsuitable for meta-analyses due to large heterogeneity in reporting and other outcome measures were not included frequently enough to deserve meta-analysis.

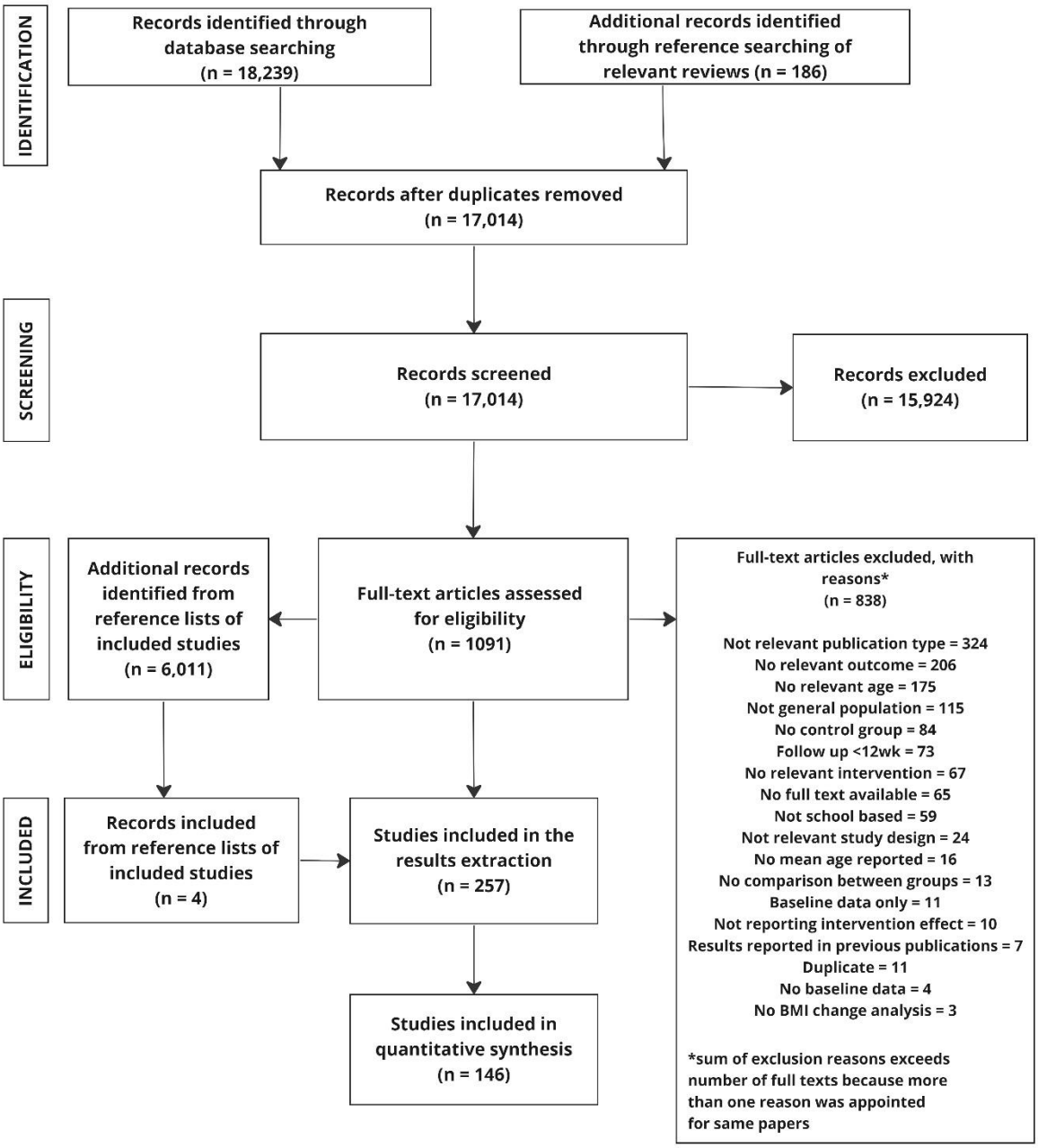

Figure 1: PRISMA flow chart showing the study selection process (from Moher et al., 2009)

3.3.1 Characteristics of the included studies

An overview of the characteristics of the included studies is given in Table 1 and the details on individual studies are presented in Supporting Information - Table S1.

Table 1. Characteristics of the included studies

Study Characteristics		N	%
Location			
	Europe	64	44
	North America	44	31
	South America	9	6
	Asia	16	11
	Oceania	9	6
	Africa	2	2
Study design			
	RCT	91	62
	Quasi-experimental	55	38
Study period			
	before 2009	71	49
	2009-2019	48	33
	Not specified	27	18
Age of Participants			
	6-9 yrs	74	51
	10-12 yrs	66	45
	Both age groups	6	4
Characteristics of Participants			
	General population	116	79
	Low SES	26	18
	Specific ethnic group	4	3
Aims of intervention[a]			
	Sedentary time	2	2
	PA	55	38
	Physical fitness	47	32
	Combined	43	30
Diet component			
	Yes	95	65
	No	51	35
Duration of intervention			
	<6 months	38	26
	6-12 months	62	42
	>12 months	46	32
Follow-up[b]			
	only post-intervention	99	68
	< 1 year	24	16
	>= 1 year	23	16
Parent involvement			
	Yes	81	55
	No	64	45
Additional setting			
	Yes	13	10
	No	133	90
Risk of bias			
	Low	36	25
	Moderate	71	48
	High	39	27

Legend: Quasi-experimental design includes non-randomised controlled trials, controlled before-after studies and natural experiments; RCT=randomised controlled trial; PA=physical activity; [a]one study had two experimental groups: one that included PA and the other exposed to a combined intervention that additionally included sedentary behaviour component; [b]follow-up period is given in months after the end of the intervention.

The largest part of the studies was performed in Europe (44%), although studies from Central and Eastern Europe were scarce. A slightly lower share of studies was situated in North America (31%), mostly in the United States (34 studies). On the other hand, only two studies were performed in Africa (both in South Africa). In addition, only one study was performed in multiple countries (i.e., in eight European countries). Randomised controlled design was applied in over 60% of the included studies, with over 90% of these studies being cluster RCTs, a type of experimental study in which groups of subjects and not individual subjects are randomised (e.g., randomisation is performed by class or by school). A similar number of studies included younger and older children, and about 20% of the studies were focused on vulnerable groups of children. Finally, only a small part of school-based interventions extended to the community and home settings (13/146 studies), and just over half of the school-only interventions attempted to involve parents and guardians (81/146 studies).

Majority of interventions included in this review were designed to affect only one component of energy expenditure (104/146 studies or 71%), with about half of these targeting PA and the other half aiming to improve physical fitness. On the other hand, only 2 interventions that focused exclusively on sedentary behaviour were included, one that restricted screen time and the other that introduced standing desks in the classrooms. Next, among 43 interventions that targeted multiple movement behaviours, only 6 aimed at reducing sedentary behaviour and improving fitness, while the other 37 strived to increase PA while reducing sedentary behaviour. Comparison of characteristics of interventions that included only PA or fitness vs. interventions that also addressed sedentary behaviour is given in Table 2.

Table 2. Characteristics of the studies stratified by movement behaviours targeted by the intervention

Study Characteristics		SB/PA/Fitness (N=104)	PA+SB/Fitness+SB (N=43)
Study design		N (%)	N (%)
	RCT	59 (57)	33 (77)
	Quasi-experimental	45 (43)	10 (23)
Study period			
	Before 2009	51 (49)	21 (49)
	2009-2019	33 (32)	15 (35)
	Not specified	20 (19)	7 (16)
Age of Participants			
	6-9 yrs	54 (52)	20 (47)
	10-12 yrs	45 (43)	22 (51)
	Both age groups	5 (5)	1 (2)
Intervention components			
	Sedentary behaviour	2 (2)	43 (100)
	Physical activity	55 (53)	37 (86)
	Physical fitness	47 (45)	6 (14)
Duration of intervention			
	<6 months	23 (22)	15 (34)
	6-12 months	49 (47)	14 (33)
	>12 months	32 (31)	14 (33)
Follow up[a]			
	Only post-intervention	72 (69)	27 (63)
	< 1 year	17 (16)	7 (16)
	>= 1 year	15 (15)	9 (21)
Duration of PA (min/week)			
	0	7 (7)	16 (37)
	1-120	41 (40)	14 (32)
	>=120	42 (40)	5 (12)
	Not specified	14 (13)	8 (19)
Intensity of PA			
	Low-to-moderate	23 (22)	2 (5)
	Moderate-to-vigorous	47 (45)	9 (21)
	Not specified	34 (33)	32 (74)
Diet component			
	Yes	65 (63)	31 (72)
	No	39 (37)	12 (28)
Parent involvement			
	Yes	50 (48)	33 (77)
	No	54 (52)	10 (23)
Additional setting			
	Yes	8 (8)	5 (12)
	No	97 (92)	38 (88)
Risk of bias			
	Low	18 (17)	18 (42)
	Moderate	56 (54)	15 (35)
	High	29 (29)	10 (23)

Legend: SB=sedentary behaviour; PA=physical activity; a follow-up period is given in months after the end of the intervention

Studies that included sedentary behaviour alongside PA or fitness component introduced some form of PA less frequently, and when they did, they delivered a smaller dose of PA compared to PA-only or fitness-only interventions. In addition, interventions that included sedentary behaviour involved parents more often (77% vs. 48%). Duration was similar in the two groups of interventions, as well as the share of interventions that included a diet component (mostly in the form of nutritional education or changes in food provision and environment). Around 1/3 of interventions extended over several years, with a couple of programmes spanning over 4-6 years. Finally, the sustainability of intervention effects was analysed in roughly 30% of the studies, although only about half of these studies followed participants for at least one year after the end of intervention.

3.3.2 Risk of bias

Risk of bias across domains for randomised and non-randomised studies is shown in Figures 2 and 3, respectively, while risk of bias assessment across individual studies is presented in Supporting Information – Tables S2 and S3. Almost all trials were considered to have low bias in blinding of outcome assessors domain as the outcomes were objectively assessed, and as only several outcome measures were subject to observer bias. In addition, no studies have been found to have a high likelihood of selective reporting. It was judged most of the trials as having low risk of bias concerning loss to follow up (72/82), incomplete outcome data (74/91) and baseline imbalance (61/82). Risk of bias was low for about half of the trials in terms of allocation concealment (48/91), random sequence generation (43/91) and adequate statistical analyses for clustered nature of the data (50/82). Conversely, there was unclear or high risk of other bias in almost 2/3 of trials, mostly relating to low intervention fidelity. Despite seemingly favourable results of risk of bias assessment, only 24/91 RCTs were judged as having an overall low risk of bias (according to criteria described in Methods).

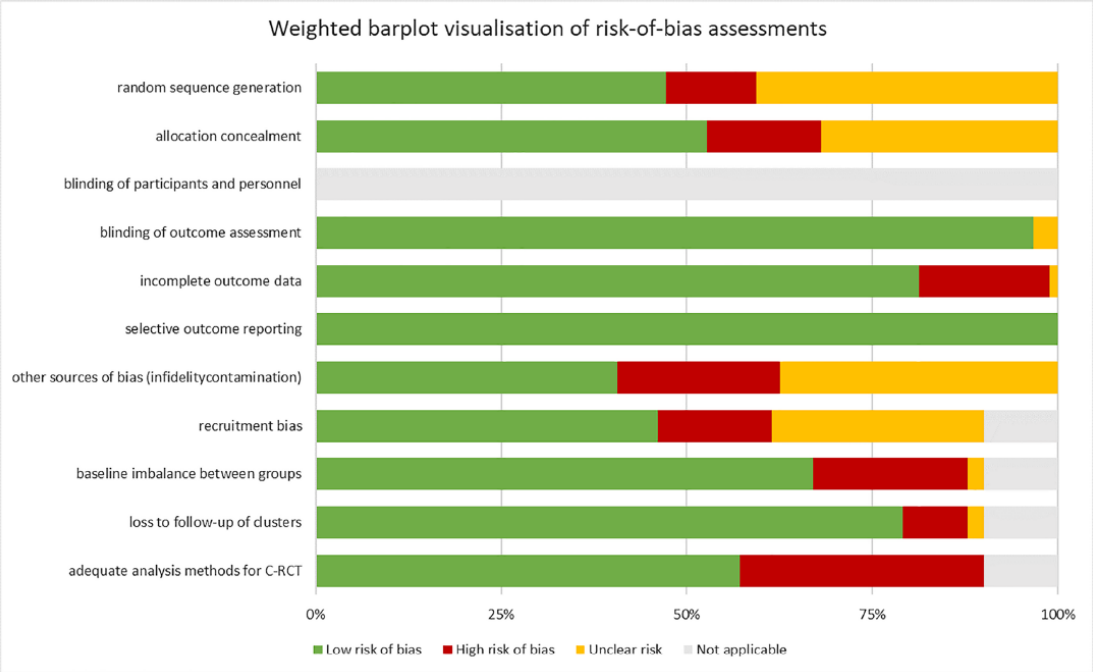

Figure 2. Risk of bias across domains for randomised controlled trials (Cochrane "Risk of bias" assessment tool for randomised studies, Higgins et al., 2011)

For non-randomised studies, the least bias was noticed for the outcome domain, where about 1/3 of the studies were awarded maximum points. On the other hand, in terms of selection domain only one study was given maximum points. Lastly, for comparability, an equal part of studies was assigned with 0, 1 or 2 points. Generally, 12/55 studies totalled at least 6/8 points and were, hence, considered to have low overall risk of bias.

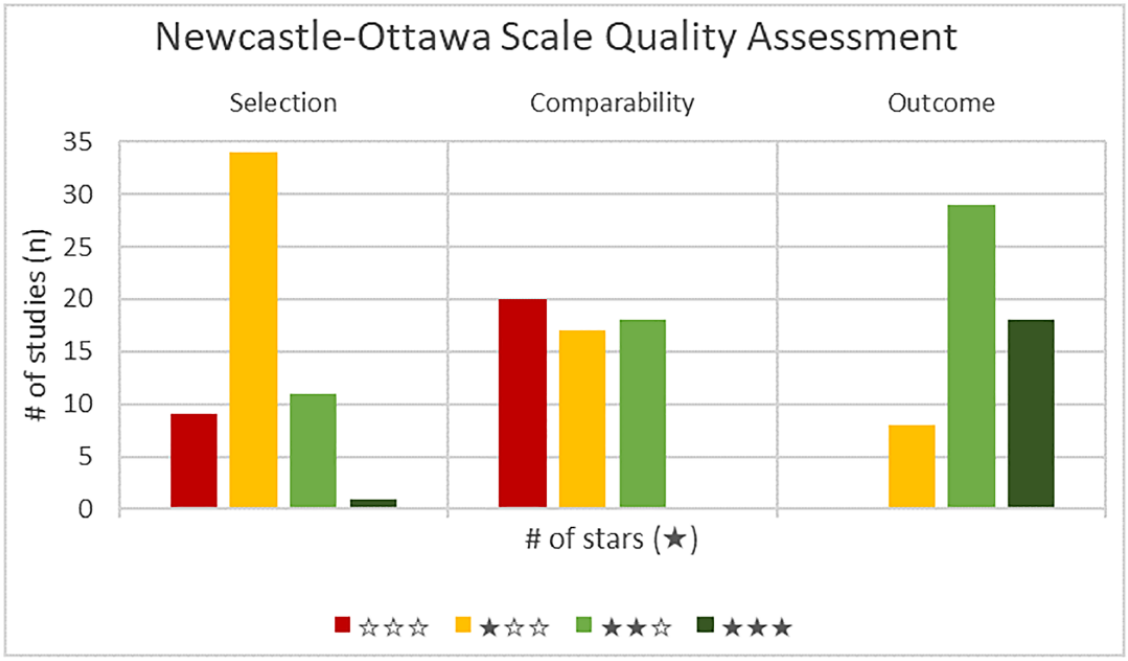

Figure 3. Risk of bias across domains for non-randomised study designs (modified Newcastle-Ottawa scale, Wells et al., 2008)

3.3.3 Results by intervention type

All in all, pooled effect sizes indicated that school-based PA interventions favourably affected all 3 outcomes analysed (BMI= -0.16 kg/m^2, 95%CI=-0.25 to -0.07; BMI z-score= -0.07, 95%CI= -0.10 to -0.05; %BF -0.34%, 95%CI= -0.55 to -0.13). Yet, it has to be noted that indices of heterogeneity were large for all outcomes and ranged from I^2=82% to I^2=92%.

When only studies that provided effects by gender are examined (n=22G and 21B for BMI, n=11G and 12B for BMI z-score, n= 13G and 13G for %BF), it becomes evident that gender is a significant moderator of the effectiveness of interventions analysed here. Specifically, interventions were effective or borderline effective in girls irrespective of the outcome assessed (BMI=-0.21 kg/m^2, -0.28 to -0.14; BMI z-score=-0.12, -0.27 to 0.03; %BF= -0.68%, -1.08 to -0.29), while in boys null pooled effect was noted for BMI (-0.01 kg/m^2, -0.08 to 0.05) and BMI z-score (-0.01, -0.05 to 0.06), and only borderline pooled effect was seen for %BF (-0.49%, -1.12 to 0.15, p=0.13).

Forest plots showing the standardised differences in mean (SMD) between the intervention group and the control group across individual interventions stratified by the content of the intervention are shown in Figures 4-6. All in all, the largest point estimates were found for interventions designed to improve physical fitness, with the differences being in favour of the intervention groups for all three outcomes assessed (BMI= -0.04 ;95%CI=-0.07 to -0.00; BMI z-score =-0.10; -95%CI=-0.16 to -0.03); %BF= -0.11; 95% CI=-0.26 to 0.04). Interventions that aimed to increase PA showed similar effect on BMI z-score (SMD=-0.09; 95%CI= -0.12, -0.06) and BMI (SMD=-0.04; 95%CI=-0.09, 0.02) but the effects on %BF (SMD=-0.04; 95%CI=-0.15, 0.06) were less pronounced than for fitness-oriented programmes. Lastly, as only two interventions that focused exclusively on reducing sedentary behaviours were included the pooled effects for this type of intervention were not computed.

Interventions designed to improve physical fitness while also aiming to reduce sedentary time proved to be unsuccessful in favourably affecting BMI (SMD=-0.01; 95% CI=-0.09 to 0.07), while reliable estimates for BMI z-score and %BF could not be computed due to limited number of studies. In contrast, pooled results for interventions aiming to increase PA while also trying to reduce sedentary behaviours favoured interventions for BMI (SMD=-0.07; 95%CI=-0.13 to -0.00), and BMI z-score (SMD=-0.06; 95%CI=-0.09 to -0.03), but not for %BF (SMD=-0.01; 95%CI= -0.08 to 0.06). Heterogeneity was still quite large in all four groups of interventions suitable for meta-analysis and ranged from I^2=76% to I^2=94%.

Modifications of the effects by intervention characteristics are displayed in Supporting Information – Table S4. Longer weekly PA duration translated to larger effects on BMI for both fitness-only and

fitness+sedentary behaviour interventions (SMD=-0.12, 95%CI=-0.21 to -0.03 and SMD=-3.8, 95%CI=-6.4 to -1.1, respectively). More intense PA was related to larger effects for fitness-only interventions (SMD=-0.15; 95%CI=-30 to -0.00 for BMI and SMD =-0.18, 95%CI=-0.30 to -0.05 for BMI z-score) and for PA+sedentary behaviour interventions (SMD=-0.63, 95%CI=-1.04 to -0.21 for BMI z-score). On the other hand, including a diet component improved only the effect of PA interventions on BMI z-score (SMD=-0.06, 95%CI=-0.12 to -0.01). Regarding other characteristics, parent involvement markedly improved the effect on %BF for fitness-only interventions. Similarly, the effects on %BF seem to be much larger in this group of interventions when the interventions extend to more than 1 academic year. At the same time, the effects of PA-only programmes were somewhat smaller in long-term compared to short-term for BMI z-score.

Mean pooled results comparing the effectiveness of different types of interventions by gender are presented in Supporting Information – Table S5. The number of studies included in these analyses was fairly small (n=3-7 for PA and n=2-10 for fitness), hence smaller power and large confidence intervals. Still, point estimates for interventions that aimed to increase PA were generally larger in girls for most outcomes, while for interventions that were designed to improve physical fitness the opposite was true.

Finally, findings from sensitivity analyses (see Supporting Information – Table S6) showed that the results were robust, except when considering study design for PA interventions and age group for fitness interventions, and only for BMI as the outcome. Specifically, the effects of PA interventions were lower in RCTs compared to studies that employed other designs. while the effects of fitness interventions were larger in the younger age group.

3.3.4 Effectiveness of interventions in vulnerable groups of children

The search identified 26 studies that included predominantly economically deprived children and reported data appropriate for a meta-analysis. In general, the effects on BMI were not seen when interventions were delivered to vulnerable groups of children (SMD=-0.01, 95%CI=-0.29 to 0.19), while interventions delivered to the general population seem to be effective (SMD=-0.05, 95%CI= -0.07 to -0.02). Of note, this holds for both interventions that focused on PA or fitness, and for interventions that additionally included sedentary behaviour modification. Namely, while both PA and fitness interventions favourably affected BMI in general child population with the same standardised difference between intervention and control groups (-0.05; 95%CI =-0.10 to -0.00), for interventions that exclusively involved disadvantaged children the pooled results showed non-significant MSD in BMI of 0.06 (95%CI =-0.20 to 0.32) for PA interventions and 0.00 (95%CI=-0.08 to 0.08) for fitness interventions. MSDs between intervention groups that were included in PA+sedentary behaviour programmes and controls amounted to -0.08 (95%CI=-0.15 to -0.00) in general population, while the

effects were lower in studies with primarily disadvantaged children involved (-0.04, 95%CI=-0.15 to 0.07).

On the other hand, the effects on BMI z-score in underprivileged children were more comparable to the ones noted for general population (low SES: -0.04, -0.09 to 0.00; general population: -0.08, -0.10 to -0.06). There was an indication that this effect was modified by the type of the intervention, with PA interventions being more successful in affecting weight change in disadvantaged groups compared with fitness interventions. Specifically, for PA interventions pooled results showed a very similar reduction in BMI z-score by -0.08 in deprived children (95%CI=-0.15 to -0.00) vs. -0.09 in the general population (95%CI=-0.12 to -0.06). On the other hand, pooled effects for fitness interventions point to a reduction in BMI z-score in the general population (-0.11, 95%CI=-0.18 to -0.04) and no effect on BMI z-score in underprivileged children (0.04, 95%CI=-0.34 to 0.40).

Comparisons of the effects on body fat were impeded by too few studies that focused on low SES and included body fat as an outcome. Still, estimates from the few studies available show no effect in disadvantaged children (standardised mean difference=-0.01, 95%CI=-0.13 to 0.12), and a trend to reduction in %BF in the general population (standardised mean difference=-0.01, 95%CI=-0.13 to 0.12).

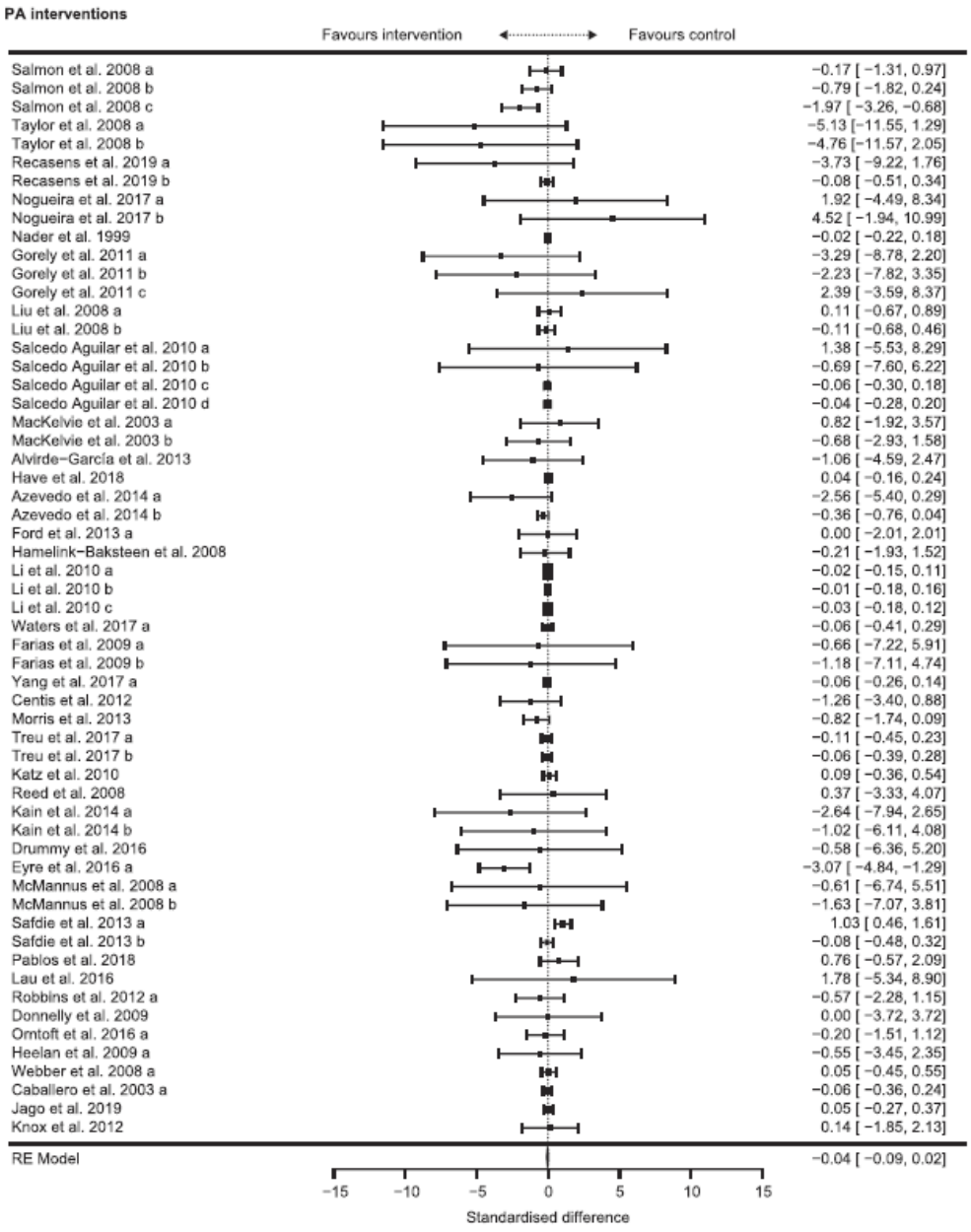

Figure 4a. Forest plot of standardised mean differences in change in body mass index between the intervention group and the control group for physical activity (PA) interventions.

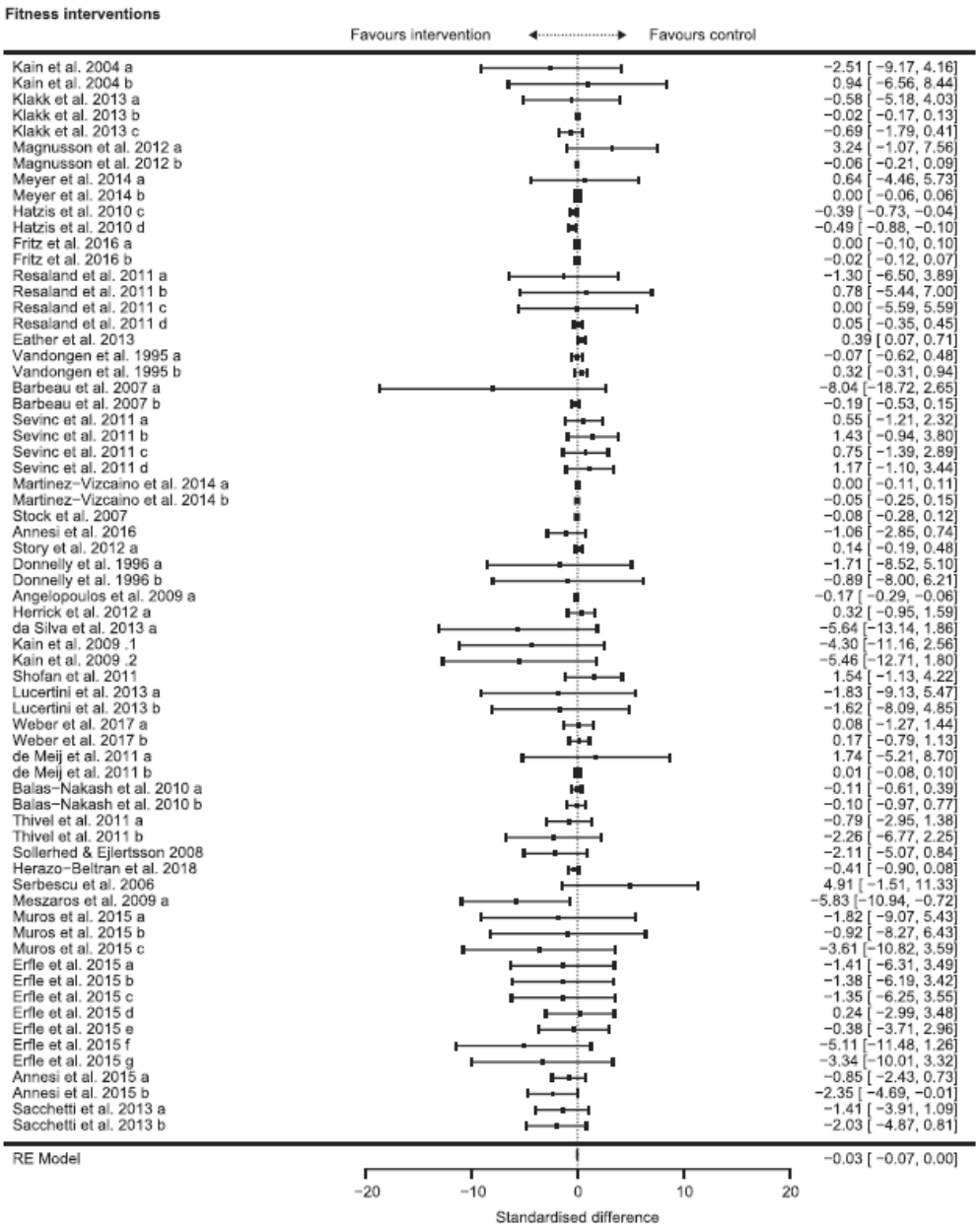

Figure 4b. Forest plot of standardised mean differences in change in body mass index between the intervention group and the control group for fitness interventions.

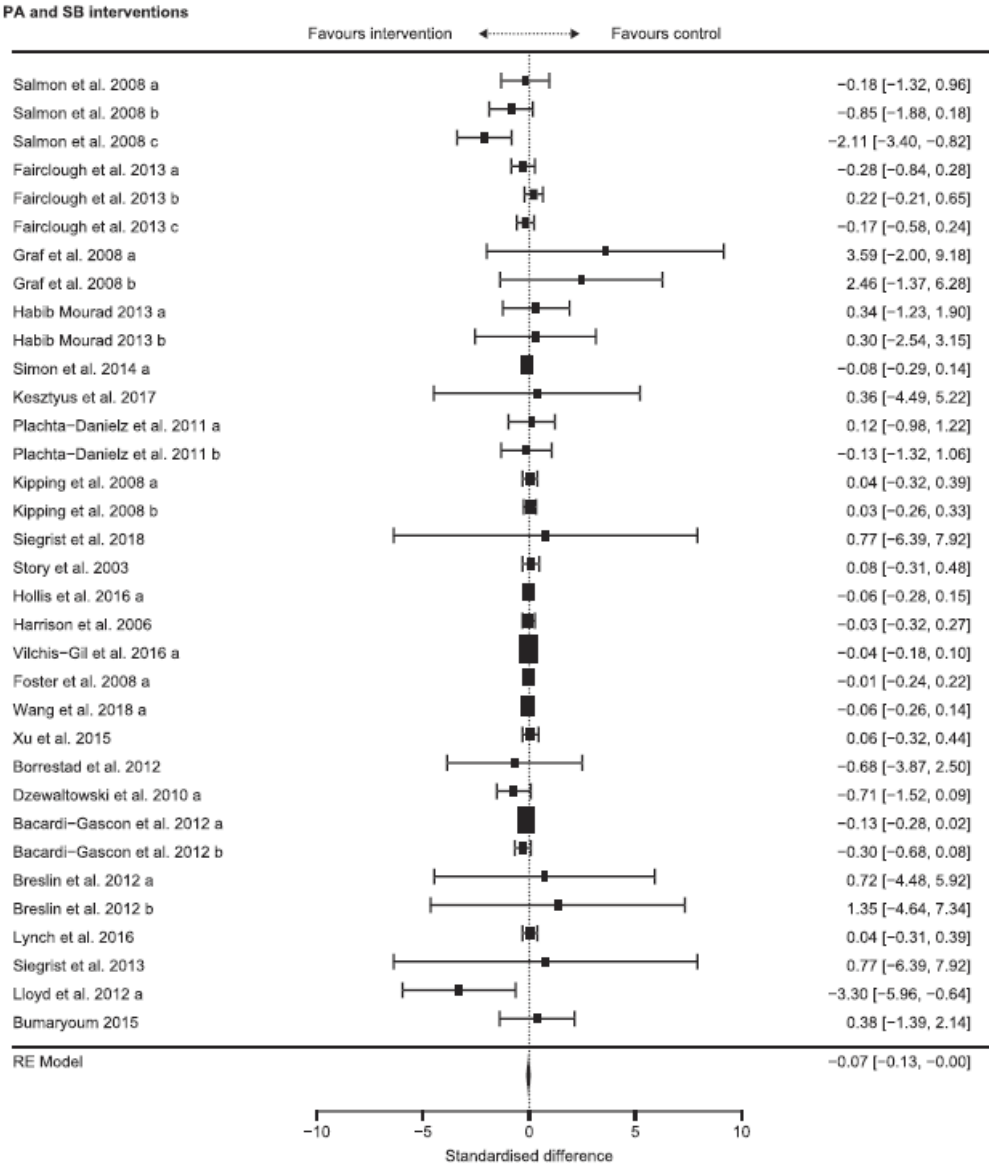

Figure 4c. Forest plot of standardised mean differences in change in body mass index between the intervention group and the control group for physical activity (PA) + sedentary behaviour (SB) interventions.

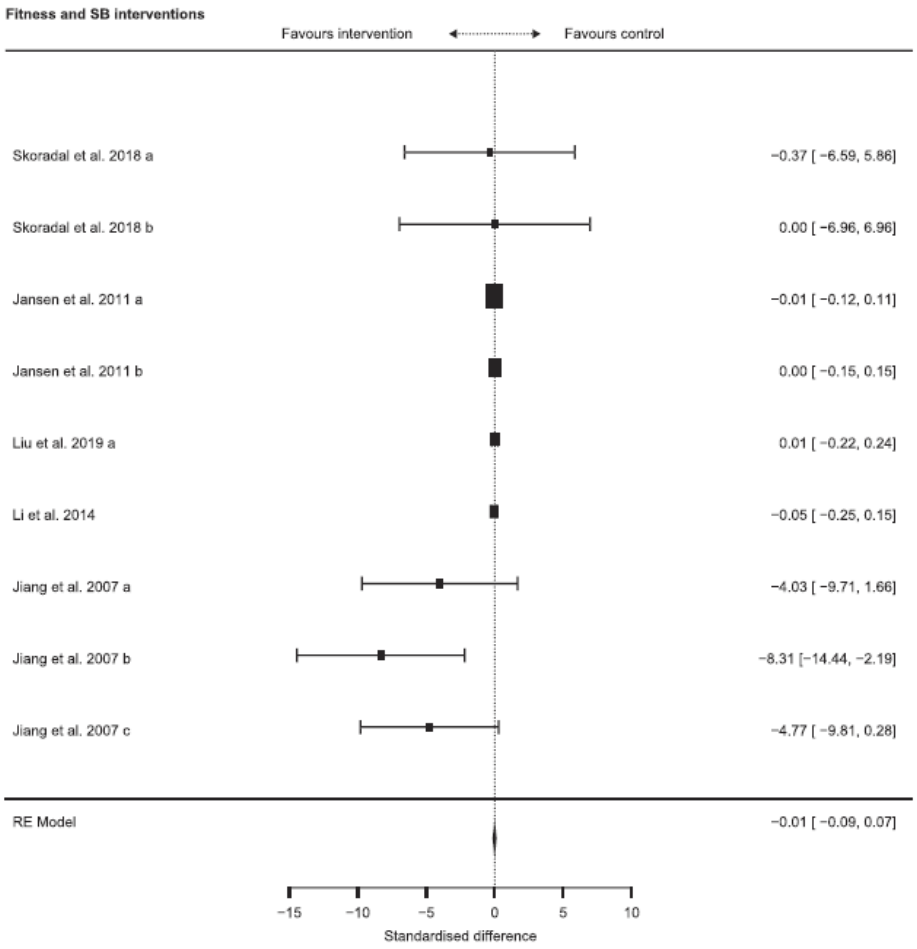

Figure 4d. Forest plot of standardised mean differences in change in body mass index between the intervention group and the control group for fitness + sedentary behaviour (SB) interventions.

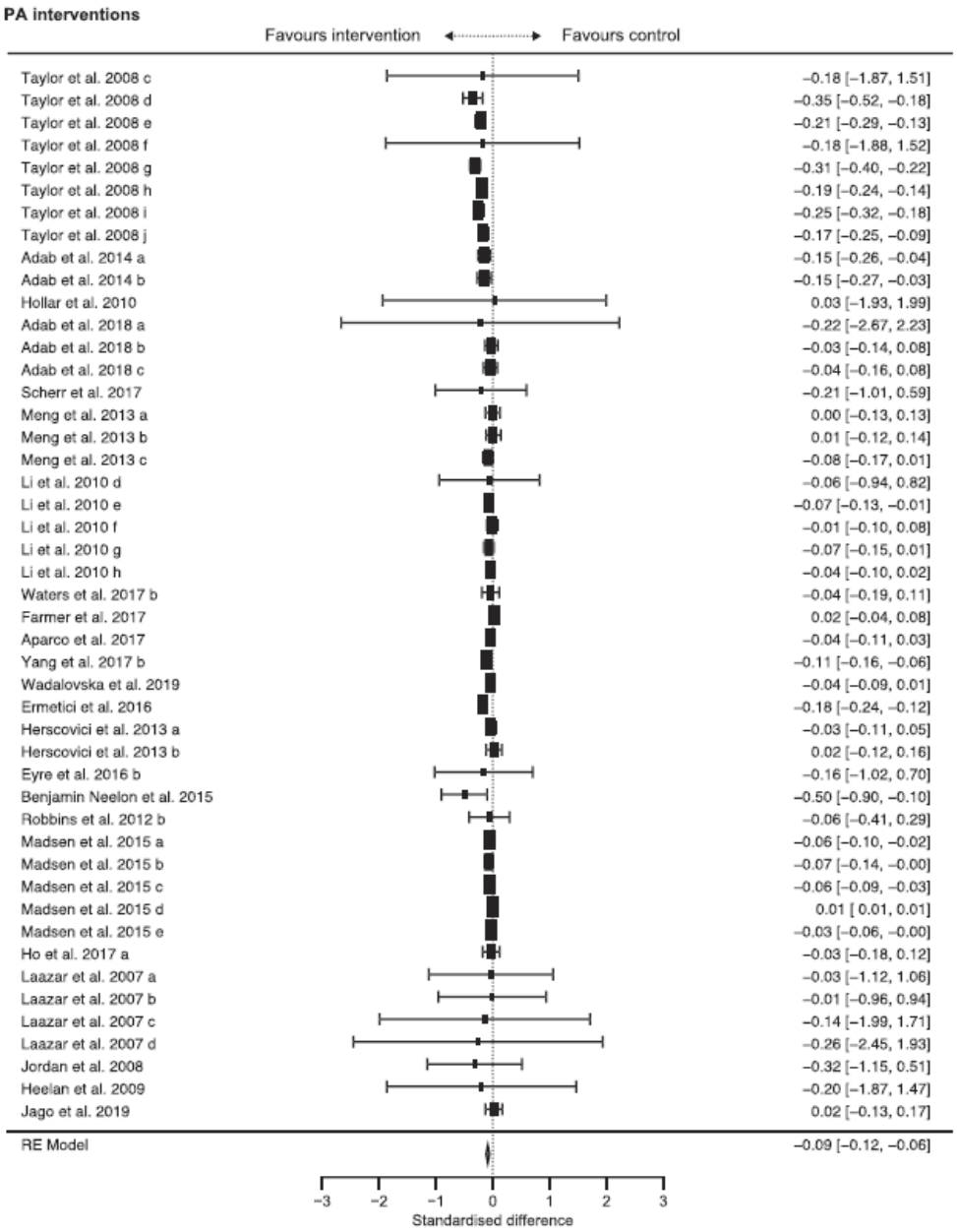

Figure 5a. Forest plot of mean differences in change in body mass index z-score between the intervention group and the control group for physical activity (PA) interventions.

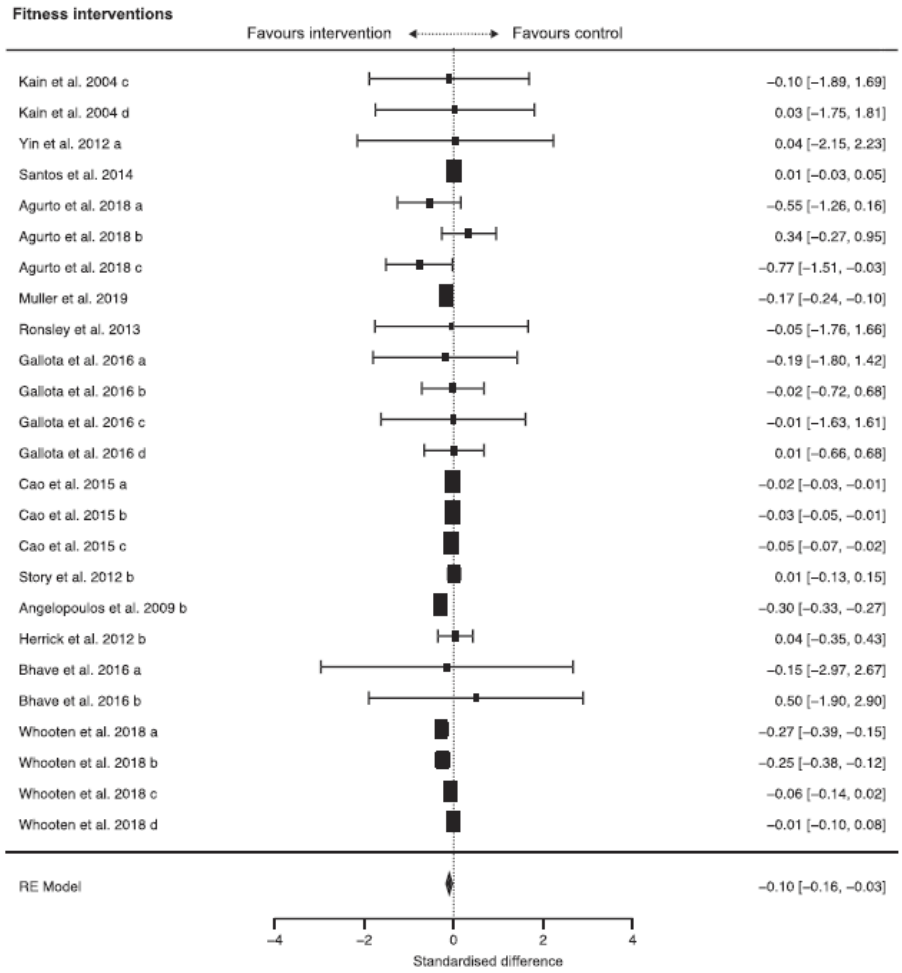

Figure 5b. Forest plot of mean differences in change in body mass index z-score between the intervention group and the control group for fitness interventions**.**

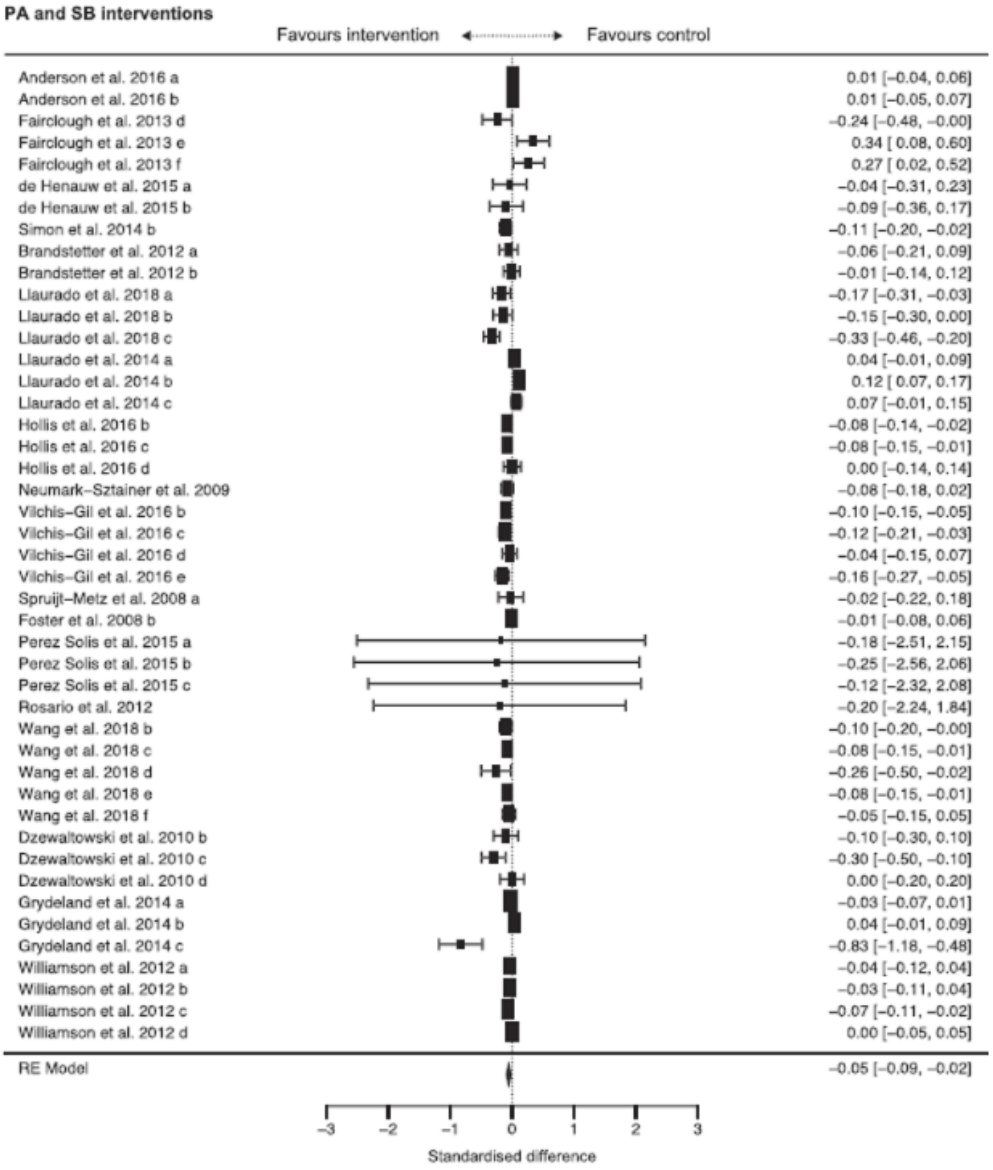

Figure 5c. Forest plot of mean differences in change in body mass index z-score between the intervention group and the control group for physical activity (PA) + sedentary behaviour (SB) interventions**.**

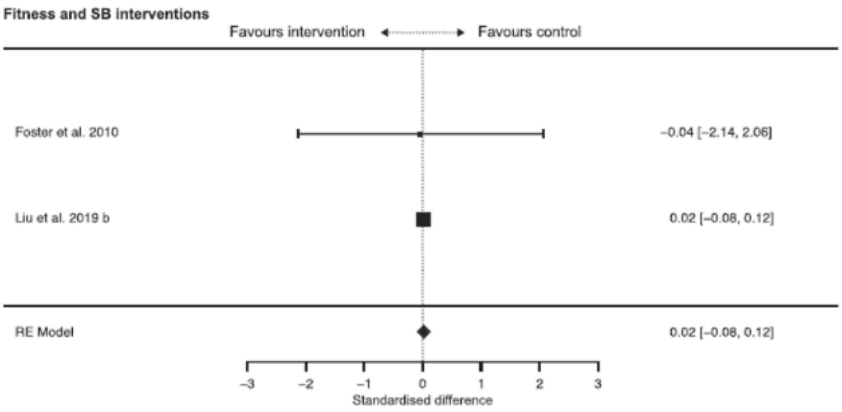

Figure 5d. Forest plot of mean differences in change in body mass index z-score between the intervention group and the control group for fitness + sedentary behaviour (SB) interventions.

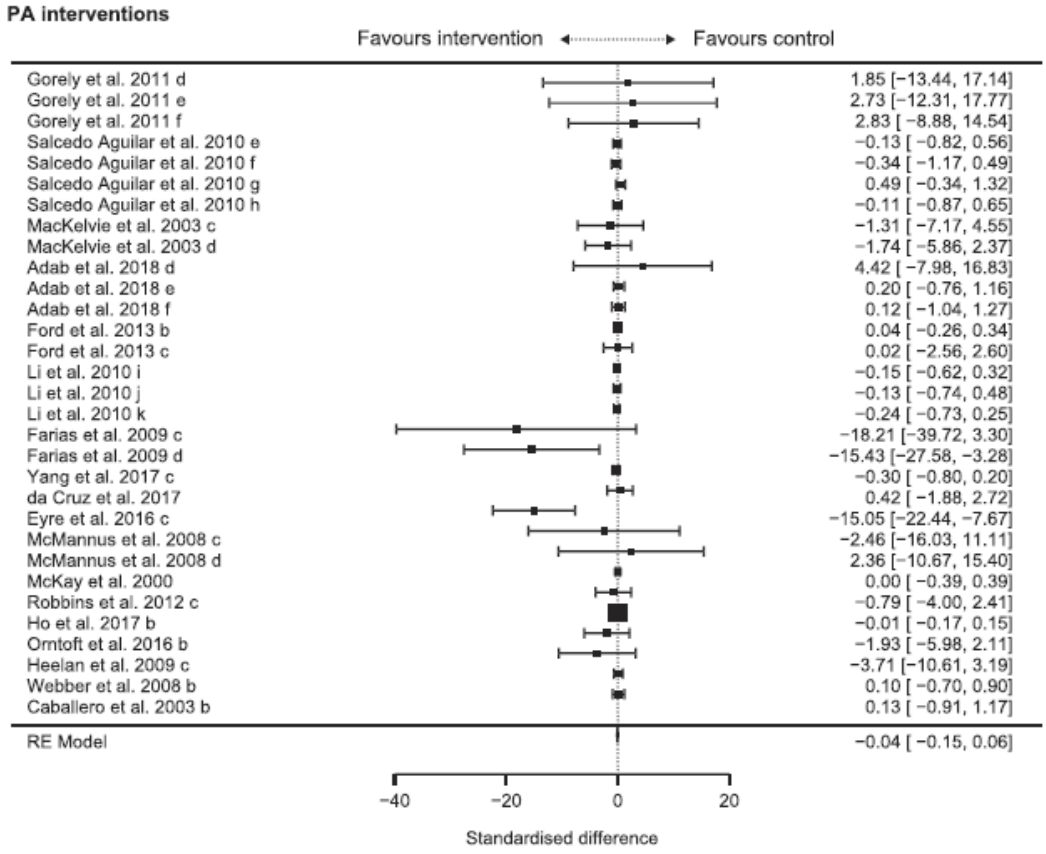

Figure 6a. Forest plot of standardised mean differences in change in percentage body fat between the intervention group and the control group for physical activity (PA) interventions.

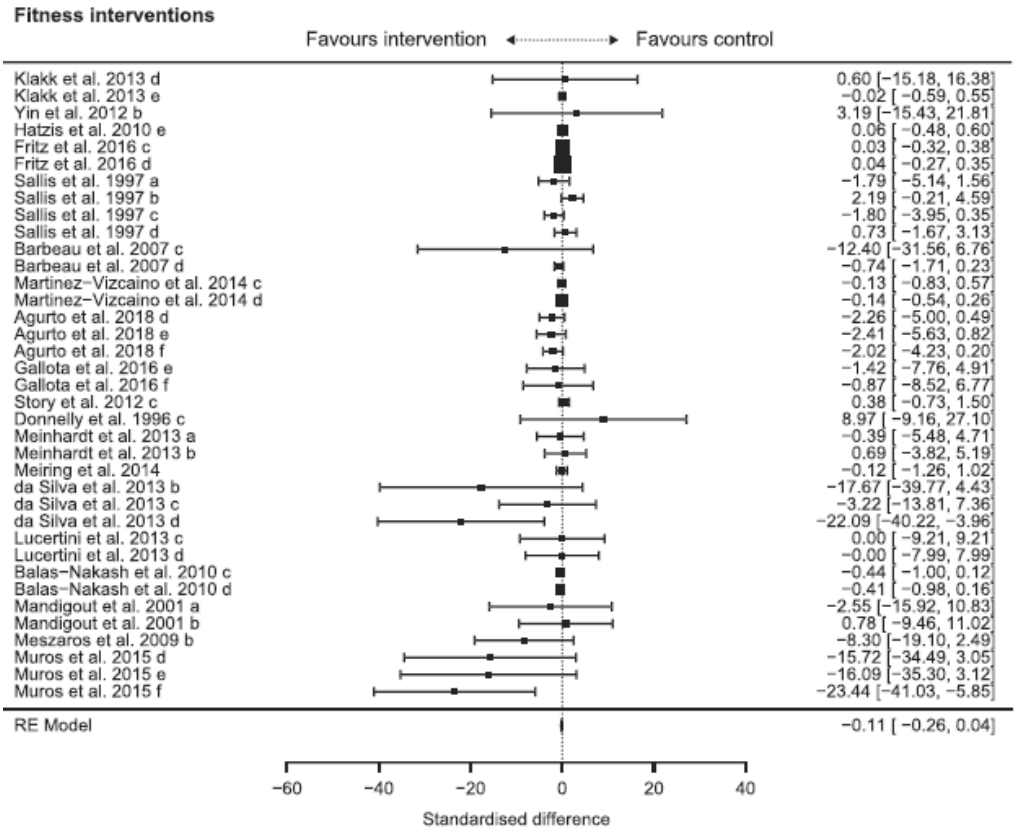

Figure 6b. Forest plot of standardised mean differences in change in percentage body fat between the intervention group and the control group for fitness interventions.

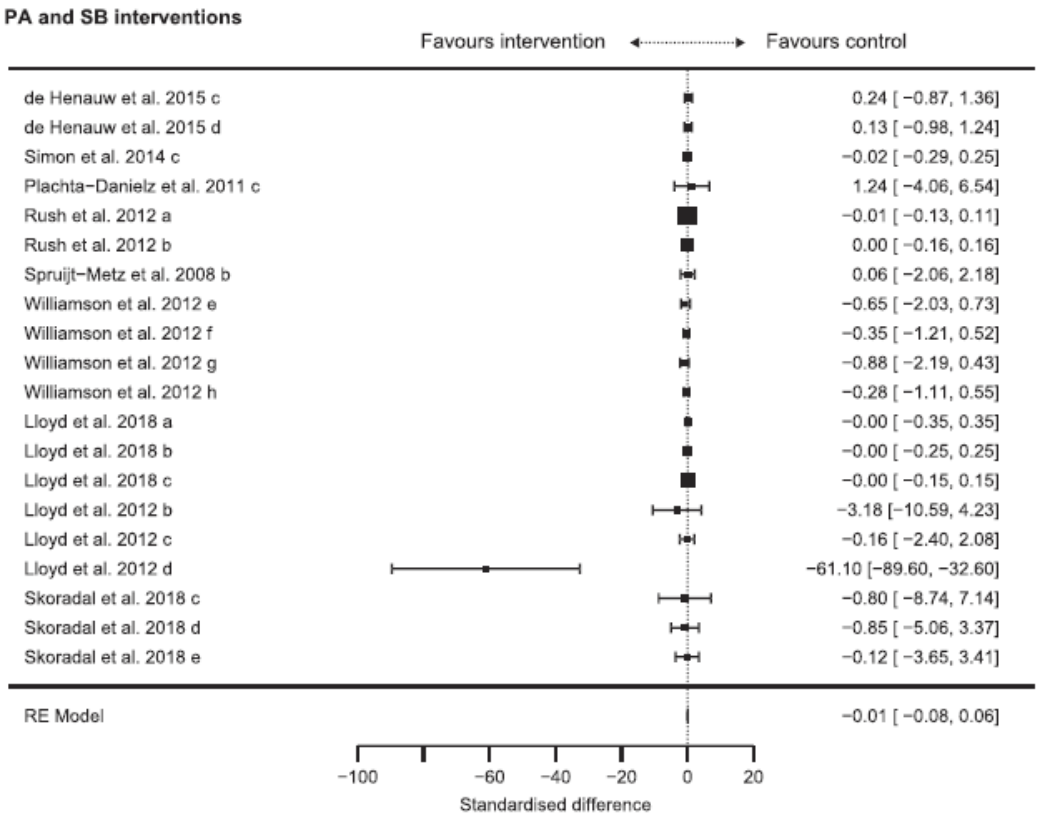

Figure 6c. Forest plot of standardised mean differences in change in percentage body fat between the intervention group and the control group for physical activity (PA) + sedentary behaviour (SB) interventions.

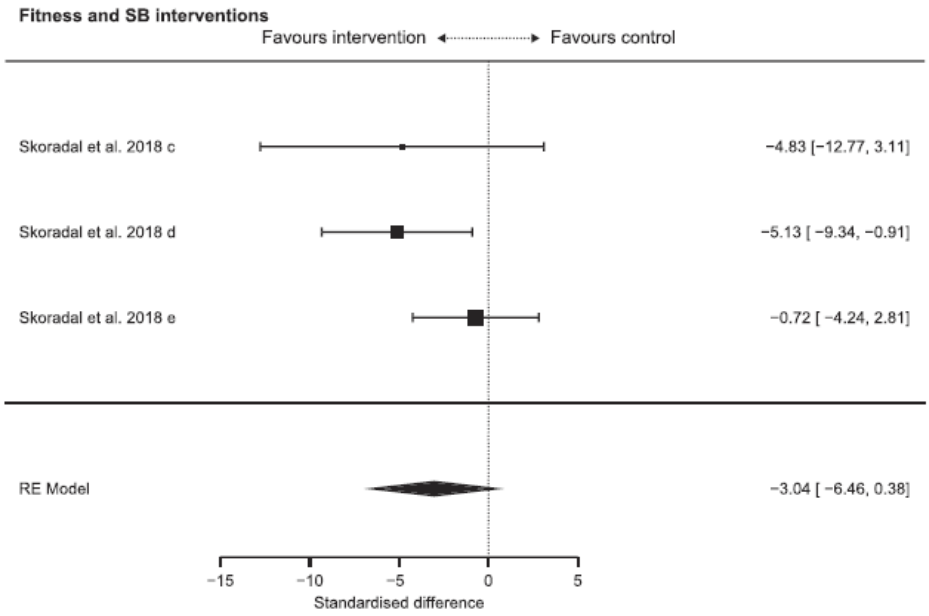

Figure 6d. Forest plot of standardised mean differences in change in percentage body fat between the intervention group and the control group for fitness + sedentary behaviour (SB) interventions **.**

3.3.5 Assessment of publication bias

A formal evaluation of all available results using Egger's regression did not show evidence of publication bias for neither BMI (z = -0.11, p = 0.91) nor BMI z-score (z = -1.36, p = 0.17), or %BF (z = -0.80, p = 0.42). Similarly, when stratified by the type of intervention (i.e., PA/fitness/PA+sedentary behaviour/fitness + sedentary behaviour), publication bias was not seen for any of the three outcomes analysed (p ranged from 0.12 to 0.96).

3.4 Discussion

In this systematic review, the effects of interventions that intended to increase PA with interventions that were designed to improve physical fitness and with interventions that aimed to reduce sedentary behaviour on obesity-related outcomes in 6-12-year-old children were compared. The main results of the study include: 1) school-based PA interventions appear to be an effective strategy in the primary prevention of childhood obesity among 6-12-year old children; 2) interventions that combined PA or fitness component with strategies to reduce sedentary behaviour were actually less effective in controlling weight gain compared to PA-only or fitness-only interventions; hence, including behavioural strategies to reduce sedentary behaviour to PA or fitness programmes does not provide additional benefits for primary prevention of obesity 3) interventions that were designed to improve physical fitness produced slightly larger effects than interventions that strived to increase PA; 4) intervention effects were generally larger in girls than in boys, especially for programmes that included both PA/fitness and a sedentary behaviour component; 5) interventions that were delivered exclusively to economically deprived children analysed here were less able to induce favourable effects on BMI compared with interventions conducted in more general settings.

The overall difference was in favour of the intervention group of -0.16 kg/m^2 for BMI (95%CI=-0.25 to -0.07), -0.07 for BMI z-score (95%CI= -0.10 to -0.05) and -0.34% for %BF (95%CI= -0.55 to -0.13). This overall effect size for all types of PA interventions reported here is notably larger than the overall effect of all kinds of school-based obesity prevention initiatives on BMI of -0.08 kg/m^2 (95%CI: -0.11, -0.05,) reported in a recent meta-synthesis of 10 different meta-analyses (28), but quite similar to the effect previously reported for school-based programmes that included PA (15, 16). Although clinical importance of the effect size reported here is probably trivial, such small shifts at the population level can produce significant public health benefits by reducing weight gain in normal-weight children. Plus, it is worth noting that the effects of the PA interventions are probably underestimated due to the well-known limitations of BMI in distinguishing fat from fat-free mass on one side, and the large measurement error of commonly used methods for assessing body composition on the other side.

In terms of characteristics that moderate the effectiveness of these type of interventions, the World Health Organisation has recommended that obesity prevention programmes should span over at least one year, include both PA and a diet component and involve parents, if possibly extending also to the home and community settings (29). The findings supplement these guidelines by indicating that interventions should be designed to improve fitness in order to maximise the effects on obesity prevention in 6-12-year old children. However, this finding needs to be corroborated in future studies as there was considerable overlap in confidence intervals of the effects of PA and fitness interventions studied here. Next, when analysing a smaller number of studies that reported effects by gender, this study provides evidence that fitness-oriented interventions are more effective than the ones directed to PA only in boys, but not among girls. Therefore, more evidence is needed that this applies to both genders. Still, epidemiological studies support evidence from trials described here by reporting stronger cross-sectional associations with cardiometabolic risk factors for fitness than for PA (10). Similarly, physical fitness has been identified as a moderator of the relationship between PA and cardiometabolic risk in children. More specifically, PA was associated with cardiometabolic risk factors in low fit children, but not in their fit peers (30).

The finding that the interventions that encompass several behaviours are not superior to programmes that focus on just one behaviour has already been reported for combination of PA with a diet component. Although evidence on this is not unequivocal, it was previously shown that diet+PA interventions in a variety of settings are not superior to programmes that target a single behaviour (28), and that these kinds of combined interventions have an even smaller impact on obesity-related outcomes than single component programmes when set in schools (15). Similarly, a meta-analysis of mostly non-school-based programmes showed that interventions targeting sedentary behaviour and PA simultaneously were not more effective in BMI reduction than interventions that focused exclusively on sedentary behaviour (31). The search strategy allowed for only 2 studies that focused only on reducing sedentary behaviour to be included in the quantitative synthesis. This precluded us from estimating reliable pooled effect sizes for any of the obesity-related outcomes assessed. However, the analysis of the study was able to estimate the impact of adding sedentary behaviour component to PA or fitness intervention programmes on the primary prevention of obesity and found no added value of including sedentary behaviour component. Prior studies that included a variety of settings and a wider age range also failed to show the effectiveness of these types of intervention in obesity prevention (31, 32). This is hardly surprising given the low intensity of these kinds of programmes, strong reliance on educational content only, and the high reinforcement of media use in today's cultures. Although it has been reported that these types of programmes can produce a significant decrease in sedentary behaviours, the effect size is too small to have an impact on weight regulation (32). Nevertheless, given

the unprecedented increase in exposure to screens faced by contemporary children (33), it is of paramount importance to increase the efforts in redesigning strategies for controlling the amount of time children spend in front of the screens. To this end, behavioural strategies that have been a cornerstone of strategies to reduce sedentary time up to now, should be supplemented with policies oriented at changes in the environment.

As about 2/3 of studies included in this review had included a diet component, it is difficult to ascribe positive findings of interventions reported here specifically to increase in energy expenditure. Yet, subgroup analyses provided only limited evidence for moderating effect of diet component in PA-directed programmes for one outcome measure and no such effect in fitness-oriented interventions. In addition, several previous reviews have found that diet-only interventions are less effective than the ones focused exclusively on PA (14, 15). Nevertheless, given the complex nature of the disease, multi-faceted interventions targeting both sides of the energy equation should be advocated as the most beneficial approach for primary prevention of obesity. Hence, delineating the effects of diet and PA strategies in real world setting is neither possible nor required.

Overall, mean pooled effects of interventions for primary prevention of obesity analysed in this review were larger in girls than in boys, especially for interventions aimed at both PA or fitness increase and a reduction in sedentary behaviours, although it has to be emphasised that the confidence intervals did not overlap only for BMI as an outcome measure. It is well known that school-aged girls are less physically active compared to boys (34). To that end, the amount of PA typically used in intervention studies probably contributes more to the overall daily PA of girls. This, in turn, might lead to larger effects on energy expenditure and weight regulation.

The increasing burden of obesity and inactivity across SES has been well-documented (35). The study found evidence that interventions that were delivered to economically deprived children analysed here were less able to induce favourable effects on each of the obesity-related outcomes studied than interventions in general population of children. However, this should be interpreted with caution, as these two groups of interventions differed is several characteristics. Namely, despite having similar characteristics in terms of components of movement behaviour included, involving parents and including a diet component, 35% of interventions directed to disadvantaged children were shorter that 6 months compared to only 22% such interventions addressed at general population. In addition, this group of interventions introduced less PA (median PA duration=60 min/week compared to 90 min/week in general population). Still, echoing the findings in 6-12-year-old children, a review of obesity interventions that focused on disadvantaged adolescents reported that only two out of six school-based obesity prevention initiatives managed to produce beneficial effects on BMI (36). As

parents of this group of children can be very hard to reach, schools and the community remain the settings that should be a focus of public health policies aimed at reducing health inequalities. On the other hand, it is obvious that school-based intervention strategies directed at underprivileged children need to be redesigned in order to achieve effects observed in more affluent children. To that end, a recent review that analysed the effects of obesity prevention programmes across socio-economic position, has shown that interventions targeting individual-level behaviour change may be less successful in disadvantaged children and that structural changes to the environment might be a better approach in reducing inequalities (22). In addition, addressing social determinants of health outside the school setting is mandatory to ensure a sustainable reduction in the socio-economic disparities in children's' health.

Finally, although only a handful of analysed studies provided data on adverse outcomes, no evidence was found for changes in body satisfaction, eating behaviours or underweight prevalence. In addition, the incidence of injuries was very low, even in studies with large volume of PA. Hence, school-based PA programmes can be considered very safe, regardless of the components used or PA volume implemented.

3.4.1 Strengths and limitations

This review has many strengths. First, it did not rely on search strategies set by prior reviews. Instead, eight databases were searched, including grey literature sources. Second, unlike most of the previous similar reviews, it did not limit the search to English language, thus increasing the probability of detecting evidence from low-to-middle income countries. Third, this review accepted different study designs instead of constraining to RCTs, whilst insisting on the control group to minimise bias. Fourth, it gathered very detailed data on the content of interventions, with a special reference to the frequency, intensity, duration, and type of PA. Fifth, it included measures of body composition instead of relying only on BMI, which is regularly critiqued as an imperfect measure of adiposity. Furthermore, BMI can be affected by PA through an increase in lean body mass which then typically leads to underestimation of intervention effects on adiposity.

Several limitations of this review are also worth noting. First, unlike prior reviews, this review extended the search beyond English language, however it could not include non-European languages, so it may have missed studies from Asia or Africa. Second, large variability in intervention characteristics led to statistical heterogeneity, which warrants caution when interpreting the results of meta-analysis. Third, over one third of studies that met inclusion criteria failed to provide all the data needed for a meta-analysis. Given the large number of studies included in the quantitative synthesis, a qualitative synthesis of these studies was not undertaken. Hence, there cannot inference that the results

of this additional qualitative evidence synthesis would agree with the conclusions. Fourth, a large number of studies describing PA interventions failed to document the exact duration of PA and even fewer studies have quantified the intensity of implemented activities. This limitation precludes describing the dose-response relationship. Fifth, although this review was restrained from pre-defining specific obesity related outcomes, sufficient number of studies for a meta-analysis were found only for BMI, BMI z-score and %BF. Both BMI and BMI z-score have often been criticised for inadequately assessing change in adiposity (37). Abundant evidence has emerged that supports replacing BMI or BMI z-score with alternative metrics that can better capture longitudinal changes in obesity (e.g. Percent Over BMI - BMI50 and BMI85) (38). Unfortunately, these alternative metrics are still seldomly considered when examining the effects of PA-intervention studies. Similarly, the large variability in reporting prevented us from analysing the effects of PA interventions on overweight prevalence and abdominal obesity. Next, a limited number of studies identified in some subgroups impeded the assessment of effect modification. Finally, as only two studies were found that focused exclusively on reducing sedentary behaviour, the ability to compute reliable estimates of the effects of such interventions on obesity-related outcomes was not possible.

3.4.2 Implications for future research

Important gaps in the evidence were uncovered by the analyses. For example, very few studies identified by the review focused exclusively on decreasing sedentary behaviour, and studies that added sedentary behaviour component to a PA or fitness-oriented programme rarely went beyond educational activities. Hence, there is a clear need for more trials with a strict focus on sedentary behaviours, particularly such that would use an innovative approach, aligned with interests and routines of today's children. To this end, this review did not find studies that have evaluated the effectiveness of wearable technology (e.g. activity trackers) or smartphones in obesity prevention. Preliminary evidence that interventions that used screen-based technology have successfully reduced screen time is already available (39). Next, poor reporting on the dose of PA introduced by obesity prevention interventions precluded us from detecting a “best-buy” quantity of PA that would provide optimal effects with as little time and resources invested as possible. To enable such dose-response analyses, future studies should include comprehensive assessment of PA volume introduced and ensure to report this in sufficient detail. Lastly, although several studies were found that focused on disadvantaged children, very few studies have examined how the effectiveness of PA interventions vary across different socio-economic strata. Such direct comparisons across populations are warranted to allow tailoring interventions to specific groups of children.

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Chapter 4

Publication 2

Effectiveness of a population-scaled, school-based physical activity intervention for the prevention of childhood obesity

Jurić P, Jurak G, Morrison SA, Starc G, Sorić M. Effectiveness of a population-scaled, school-based physical activity intervention for the prevention of childhood obesity. Obesity (Silver Spring). 2023 Mar;31(3):811-822. doi: 10.1002/oby.23695. PMID: 36811242.

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Contribution

Maroje Sorić and Gregor Starc formulated research questions and designed the study. Gregor Starc and Gregor Jurak developed the data collection system and Gregor Starc was responsible for data extraction and curation. Gregor Starc conducted data analyses with the help of Petra Jurić. Petra Jurić wrote the initial draft of the manuscript with the input from Maroje Sorić and Gregor Starc. All authors were involved in the interpretation of the data, and critically revised the manuscript for important intellectual content. All authors accept responsibility for the decision to submit for publication.

Abstract

Objective: To examine the effectiveness of a real-world, population-scaled, school-based physical activity intervention that provided 2-3 additional physical education lessons per week to children aged 6-14 in Slovenia.

Methods: Over 34,000 participants from >200 schools were compared to a similar number of nonparticipants from the same schools. Generalized Estimating Equations were used to estimate the effects of differing exposure to intervention (i.e., from 1-5 years) on Body mass Index (BMI) in children with normal weight, overweight or obesity at baseline.

Results: BMI was lower in the intervention group, irrespective of participation duration, or baseline weight status. The difference in BMI increased with programme duration, with maximal effects seen after 3-4 years of participation, and was consistently larger for children with obesity (peaking at 1.4 kg/m2; 95%CI=1.0-1.9 for girls with obesity, and 0.9 kg/m2; 95%CI=0.6-1.3 for boys with obesity). The programme started to be effective in reversing obesity after 3 years, while the lowest numbers needed to treat were observed after 5 years (NNT=17 for girls; 12 for boys).

Conclusion: Population-scaled, school-based physical activity intervention was effective in preventing and treating obesity. The effects were the greatest in children initially presenting with obesity, such that the programme was able to benefit children needing support the most.

Key words: children, adolescents, exercise, overweight, natural experiment.

Running title: Effectiveness of a scaled-up intervention

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Conflicts of interest: the current analysis was conducted within the STOP project, funded by the European Commission's Horizon 2020 research and innovation programme under Grant Agreement No. 774548. The content of this document reflects only the authors' views, and the European Commission is not liable for any use that may be made of the information it contains. Limited non-specific funding was provided also by the Slovenian National Research Agency programme P5-0142 Bio-psycho- social context of kinesiology. PJ's work was funded by Croatian Science Foundation, Grant Number DOK-2018-09-8532.

Acknowledgements: This study is a part of the Science and Technology for childhood Obesity Policy (STOP) that has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 774548. PJ's work is funded by the Croatian Science Foundation (grant No. DOK-2018-09-8532).

Ethics approval and consent to participate: the protocol, measurement procedures and data management of the SLOfit surveillance system were approved by the National Medical Ethics Committee of the Republic of Slovenia (No. 52/03/14) and is in accordance with the Helsinki Declaration. Healthy Lifestyle programme did not require ethical approval nor registration with a trial registry since it was not an experiment and was independently evaluated by the SLOfit system.

The Study Importance Questions

What is already known about this subject?

- The global prevalence of obesity has developed at a significant rate, ranging from 0.7% to 5.6% in boys and 0.9% to 7.8% in girls, between 1975 and 2016.
- The current lack of successfully implemented interventions in real world settings impedes the fight against childhood obesity pandemic.

What are the new findings in your manuscript?

- School-based PA intervention that provided additional Physical Education lesson remained effective in the prevention of obesity after scaling-up.
- The greatest effect was present in children initially presenting with obesity, such that the programme was able to benefit children needing support the most while the number needed to treat for obesity reversal decreased with intervention duration, emphasising the need for long-term PA programmes.

How might your results change the direction of research or the focus of clinical practice?

- To be effective at reducing obesity for children of both sexes aged 6-14, the intervention must last a minimum of 3 consecutive years, without funding interruption whereas even temporary disruptions in long-lasting interventions attenuate their long-term effectiveness.

- Policy-makers and funding bodies should be aware that obesity is a chronic condition that needs to be dealt with over a longer time frame, and that easy solutions and immediate effects are neither realistic, nor sustainable.

Glossary of terms

BMI - Body mass index
NCDs - Non-communicable diseases
PA - Physical activity
PE - Physical Education
NNT - Number needed to treat

4.1 Introduction

The global prevalence of childhood obesity has increased at a startling rate, moving from 0.7% to 5.6% in boys, and 0.9% to 7.8% in girls, between 1975 and 2016 (1). Projected obesity-related morbidity incidence rates and all-cause mortality are very high in addition to the anticipated costs for health care and economic losses (2). It is, therefore, critical to implement convenient and controlled approaches on a global scale in order to slow down and ultimately reverse this costly pandemic.

Most children and adolescents go to school daily, which means that school-based interventions can impact many children simultaneously, including hard-to-reach groups. Numerous systematic reviews have shown that school interventions involving physical activity (PA) produce larger effects on body weight than interventions without PA (3-5). Therefore, a school-based programme which includes PA can serve as an important contributing feature in childhood obesity management especially when lead by experienced Physical Education (PE) professionals (6). Moreover, fitness-oriented interventions that focus on improving the components of physical fitness and typically involve more vigorous PA (e.g. structured exercise) have demonstrated greater potential for improving body composition compared to other types of PA interventions, such as the ones focusing on merely increasing the volume of PA (e.g., providing more time for unstructured play) or interventions with exclusively educational content (e.g. providing information on the benefits of PA) (7).

Although the beneficial health effects of initiating PA intervention programmes during childhood are well documented, most of this evidence comes from short-term efficacy trials conducted in well-controlled settings, usually without implementing large scale, or scalable, population-based approaches. The current lack of successfully implemented school-based PA interventions in real world settings impedes the fight against the childhood obesity pandemic (8, 9). The present study leverages a natural experiment in Slovenia that provided the opportunity to examine the effectiveness of a real-world, population-based, longitudinal PA intervention Healthy Lifestyle on body mass index (BMI) in children aged 6-14, which was derived from a previous successful small-scale PA intervention in individual Slovenian schools that provided an above standard programme of one PE lesson per day delivered by PE specialist teachers, even in lower grades where this is not typical (10).

4.2 Methods

4.2.1 Intervention

Healthy Lifestyle was a nation-wide intervention, introduced in Slovenia from 2011-2018. The intervention provided two additional PE lessons in grades 1 to 6 and three in grades 7 to 9, thus providing one PE lesson per day to children aged 6 to 14 (Table 1). The additional lessons were not part of the obligatory curricula but were organized to take place immediately after the end of regular school hours and were thus within the time frame of an ordinary day. The intervention was financed by the European Social Fund with the aim to increase the first employment opportunities of recently graduated PE teachers. In order to get the funding, schools needed to employ recently graduated PE teachers who were the only teachers delivering the intervention lessons. The intervention was offered to all children in an individual school and was organized in the form of an elective course. After the children joined the programme upon their parental written consent, their participation became compulsory, but they were not graded as in regular PE classes. The maximum number of children per class was between 16 and 30 and the school was allowed to shape multiple joint classes of grades 1 to 3, 4 to 6, or 7 to 9, if the number of enrolled children per grade was lower than 16. The programme required teachers to provide at least twelve different sports per triennia, and they had to prioritize the three most established sports in the local environment. It also included the presentation of urban sports (such as in-line skating, parkour, and other sports, suitable in urban settings), currently not specifically covered in the PE curricula at the time, and PE specialist teachers also had to provide some information on healthy dietary and lifestyle habits regarding the energy balance, limiting the consumption of snacks and sugar sweetened beverages and promoting diverse diet. Teachers were free to choose how to provide this information, but they typically delivered it in a form of short group conversations at the beginning of the lessons or during short breaks between activities. Childhood obesity was not a specific target of the intervention per se. However, a helpful by-product of increasing overall PA by providing an additional two or three PE lessons was the opportunity to improve the energy balance and support the maintenance of healthy weights among participating children. All in all, the intervention was designed through a bottom-up approach meaning that schools were totally independent in selecting the contents and form of work. This approach was chosen to facilitate adaptation to local context and settings. Parents only provided consent for their children to be involved in the intervention, but did not receive any educational materials, and were not involved in the intervention programme in any other way.

New schools were joining the programme yearly so in the final year of implementation, the total number of involved schools was 216 (48% of the total number of primary schools). Only two schools decided to discontinue the intervention in the entire 2011-2018 period. On the other hand, the intervention faced a serious challenge in the school year 2015/16 when financing was suspended for several months, due to administrative reasons. This resulted in a considerable reduction of delivered lessons compared to previous years (Table 1).

Table 1. Participation in Healthy Lifestyle intervention and related costs in the period 2010-2018

School year	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18
Participants (N)	18,993	24,202	26,000	27,600	30,261	29,549	35,640	32,245
Lessons (N)	33,190	60,505	68,306	70,866	72,054	53,527	69,613	51,893
Annual costs (EUR)	1,156,322	1,754,087	2,007,291	2,026,940	2,070,681	1,752,964	2,618,384	2,341,557
Annual costs per child (EUR)	60.88	72.48	77.20	73.44	68.43	59.32	73.47	72.62

N- number; EUR - expressed in Euro currency

4.2.2 Study design and sample

The protocol, measurement procedures and data management of the SLOfit surveillance system was approved by the National Medical Ethics Committee of the Republic of Slovenia (No. 52/03/14) and was in accordance with the Helsinki Declaration. Healthy Lifestyle intervention did not require ethical approval since it was not an experimental study and was independently evaluated by the SLOfit system. This intervention was implemented at a national level but participation was voluntarily. This provided the opportunity to treat it as a natural experiment where weight outcomes in children receiving the intervention could be compared to those that didn't receive it. In Slovenia there are 451 primary schools, 216 of which volunteered to implement the intervention for at least one school year. Each year, the Slovenian Sports Office published a public call and schools were free to submit their applications. All the schools which applied in any of the years were granted the funding, and no school was ever refused the funding. Participating schools did not differ from non-participating schools in terms of regional distribution, size, or urbanization level, but participating schools did show higher levels of baseline obesity (data not shown). Between 18,000 and 35,000 children have been included in

the intervention in each single year and around 96 % of the children from participating schools were measured within the SLOfit system every year. Due to natural experiment design, intervention assignment on both the school and individual level were outside of the study's control (with schools joining in different years and children joining, leaving, and re-joining the intervention at different ages), which resulted in unfeasibly large number of durations to consider when evaluating the intervention effects. Hence, only children who participated in the intervention continuously over a certain period (1-5 years) were included. The analysis was also restricted to children who were enrolled in a participating school at least a year before the specific school joined the intervention to have true baseline values. These children were compared to a control group of children who attended participating schools but were not involved in the intervention at any time. All analyses were stratified by the number of consecutive years of participation or non-participation in the intervention. The longer the participation, less generations of children had the opportunity to join the intervention. This resulted in very low statistical power in models that were restricted to groups with 6, 7 and 8 years of participation. Hence, the analyses were restricted to five consecutive years of participation.

4.2.3 Anthropometric measurements

Height, weight, and triceps skinfold were obtained through the SLOfit system—the Slovenian national fitness surveillance system—in accordance with the standardized and uniform protocol (11) and in a blinded fashion regarding the intervention involvement. The SLOfit measurements are organized in all Slovenian schools every April, assuring identical time interval between measurements in all schools with standard equipment (12). The measurements in schools are performed by the regular PE teachers with the support of classroom teachers and all the schools are equipped with standard measuring equipment. All PE teachers in Slovenia are educated in a single 5-year study programme at the Faculty of Sport, University of Ljubljana, and are all thoroughly trained in measurement procedures in three different study courses.

The SLOfit systematic measurement protocol requires children to be tested barefoot and wearing only light clothes during the anthropometric measurements. Height is measured in the standing position with stadiometer to the nearest mm, and weight with medical scale to the nearest 0.1 kg. The measurements are sent to the Laboratory for Diagnostics of Somatic and Motor Development at the Faculty of Sport, where the data is checked for logistical errors, any

errors are communicated to teachers for immediate correction. The participation rate of children in SLOfit for the period studied here (i.e., 2010-2018) surpassed 94% in all years.

4.2.4 Statistical methods

Because the aim of this study was to examine the effects of an intervention scaled-up to a population level, a Generalized Estimating Equations (GEE) (13) formula was used – one of the population average models (or marginal models) that tests the average effects on population level, instead of examining individual-level effects. GEE models (14) also provide robust parameter estimates regardless of assumed variance-covariance correlation matrix and deal well with missing data. Unlike traditional basic regression models, GEE approach can handle multilevel, clustered and autocorrelated data, and does not require distributional assumptions (e.g., normally distributed data). The multilevel structure of the data was accounted for by considering clustering at the school level, but not at the exercise group level as this information was not available. The change in BMI was analysed using a linear scale response. Because of the balanced data, a first-order autoregressive correlation structure (AR-1) for all GEE models (14) was used. Time—as within-subject variable—was categorized into five categories, contrasting baseline versus 1^{st}, 2^{nd}, 3^{rd}, 4^{th}, and 5^{th} year of children's participation or non-participation in the intervention. Covariates were selected a-priori based on expert knowledge and each model was adjusted for age, baseline school obesity prevalence, economic affluence of local environment (Municipality Development Index), individual risk of obesity (baseline percentile of triceps skinfold thickness of an individual), proxy of individual maturation rate (body height percentile rank of an individual in certain year), and intervention disruption (designation whether an individual was exposed to disturbance of intervention in 2016). Since seeking to establish the possible differences in the effects of the intervention on BMI in children who had normal weight, overweight or obesity at baseline, stratified by sex, 30 different models were produced with all potentially moderating covariates included. The criteria for normal weight were BMI < 85^{th} percentile of national age and sex specific BMI values, calculated on the data of over 7.5 million measurements in the period 1989-2020. The overweight group criteria were defined as $85^{th} \geq$ BMI < 95^{th} percentile, and obesity group criteria was set at BMI $\geq 95^{th}$ percentile. As GEE does not contain an intuitive statistical effect size metric, the effect size in terms of clinical significance of observed effects (i.e., beta coefficients) and related uncertainty estimates (i.e., 95% CI) were reported and discussed. These effects denote differences in BMI between intervention and control group at a given time point.

The number of obesity cases reversed was calculated as the difference between the number of obesity cases at baseline year and final year for all five participation durations. Chi-square test was used to assess the difference in number of cases with obesity between the baseline and final year in each duration scenario. Cramer's V was calculated as a measure of effect size. Number needed to treat (NNT: number of children that need to be involved in the intervention to reverse one additional obesity case) was calculated using a modification to the standard equation. First, a difference between favourable clinical outcome rate between experimental and control was calculated (i.e., the difference between obesity reversal rate). In the next step, NNT was calculated as the inverse of this number and rounded up to the higher whole number (15).

Independent sample t-test was used to check baseline differences in age, triceps skinfold, height, BMI and school baseline obesity between the intervention and control group. All statistical analyses were stratified by sex, were performed with IBM SPSS 26.0 and statistical significance was set at $\alpha = 0.05$.

4.3 Results

There are 451 primary schools in Slovenia, out of which 216 (48 %) were part of the Healthy Lifestyle during the final year of the intervention. At baseline, the intervention cohort included 29152 children, and the control cohort included 34473 children. The number of participants in both the intervention and control cohort dropped continuously with duration of intervention and amounted to 2337 (8 %) and 4502 (13 %), respectively, in a 5-year participation scenario (Figure 1). This phenomenon was largely due to children finishing primary education, and in part due to children leaving the intervention. The differences between children that adhered to the intervention and their peers who dropped out at any point are shown in Tables S1 and S2. Children who dropped out were about 1 year older and came from schools with slightly lower levels of baseline obesity.

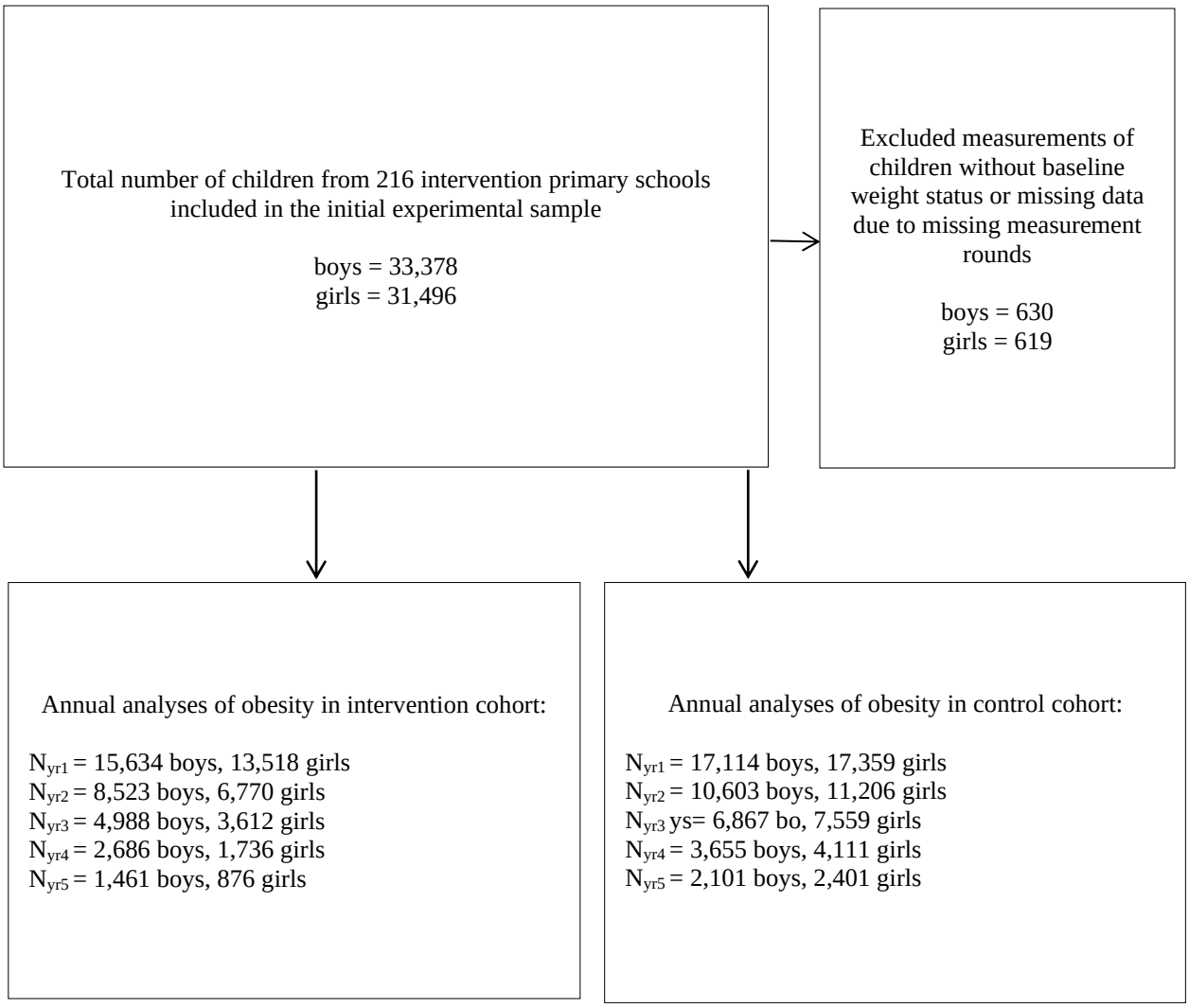

Figure 1. Study design and flowchart of the study sample

Characteristics of participants at baseline according to consecutive years of participation in the intervention are shown in Table 2. Age differences were apparent between the intervention and control in all five analysed participation durations, with the age difference declining between groups with longer participation duration. The intervention group had higher height percentile, BMI percentile and the prevalence of obesity in all five participation durations (Table 2).

Table 2. Characteristics of participants at baseline according to consecutive years of participation in the intervention.

Duration	Age (SD)	Height percentile (SD)	BMI Percentile (SD)	Triceps skinfold Percentile (SD)	School-level obesity in % (SD)
Baseline control	10.37 (2.26)*	52.43 (28.79)	52.41 (29.72)*	54.66 (28.85)*	7.12 (2.80)**
Baseline intervention	9.06 (2.25)*	52.32 (28.74)	52.94 (29.30)*	55.17 (28.63)*	7.65 (3.11)**
1 year control	11.37 (2.26)**	53.30 (28.78)*	52.32 (29.78)*	55.19 (28.66)	7.12 (2.80)**
1 year intervention	10.06 (2.25)**	53.93 (28.64)*	53.05 (29.46)*	55.47 (28.39)	7.65 (3.11)**
2 years control	11.98 (1.96)**	53.81 (28.69)**	52.24 (29.73)**	54.45 (28.91)**	7.04 (2.75)**
2 years intervention	10.55 (1.96)**	54.90 (28.41)**	53.72 (29.43)**	55.74 (28.81)**	7.99 (3.28)**
3 years control	12.42 (1.70)**	53.72 (28.86)**	51.68 (29.77)**	54.61 (28.95)*	7.03 (2.76)**
3 years intervention	11.19 (1.70)**	55.56 (28.38)**	53.46 (29.44)**	55.64 (28.61)*	8.22 (3.35)**
4 years control	12.82 (1.44)**	53.38 (28.79)**	50.66 (29.78)*	54.31 (28.87)	7.01 (2.78)**
4 years intervention	11.86 (1.46)**	55.86 (28.26)**	52.49 (29.74)*	54.94 (28.94)	8.42 (3.47)**
5 years control	13.19 (1.20)**	53.07 (28.73)**	50.16 (29.85)**	53.88 (28.66)*	7.03 (2.75)**
5 years intervention	12.60 (1.20)**	56.06 (28.10)**	53.23 (29.50)**	55.78 (29.34)*	8.49 (3.56)**

Data are presented as mean (SD). Difference between groups were tested by independent sample t-test; *significant difference between intervention and control group, $p < .05$; ** significant difference between intervention and control group, $p < .005$

Unadjusted prevalence of obesity that shows obesity trends in intervention schools compared to the trends in all other Slovenian schools which were never included in the intervention is presented in Figure 2. The schools that decided to join the intervention typically had higher than average prevalence of obesity (except for schools joining in 2014 and 2016). The prevalence of obesity declined in the years after joining the intervention in schools that joined the intervention before or after 2016, but not in schools that joined in 2016 when the intervention was disrupted due to delayed and reduced financing. Next, in schools that joined

the intervention from 2011 to 2015, a temporary increase of obesity prevalence in 2016 was seen, ranging from 0.2 to 0.3 percentage points. Lastly, despite much higher obesity prevalence at baseline, schools that joined the intervention in the first five years managed to achieve and sustain lower obesity rates than non-participating schools. The same was not seen for schools joining in 2016, 2017 or 2018.

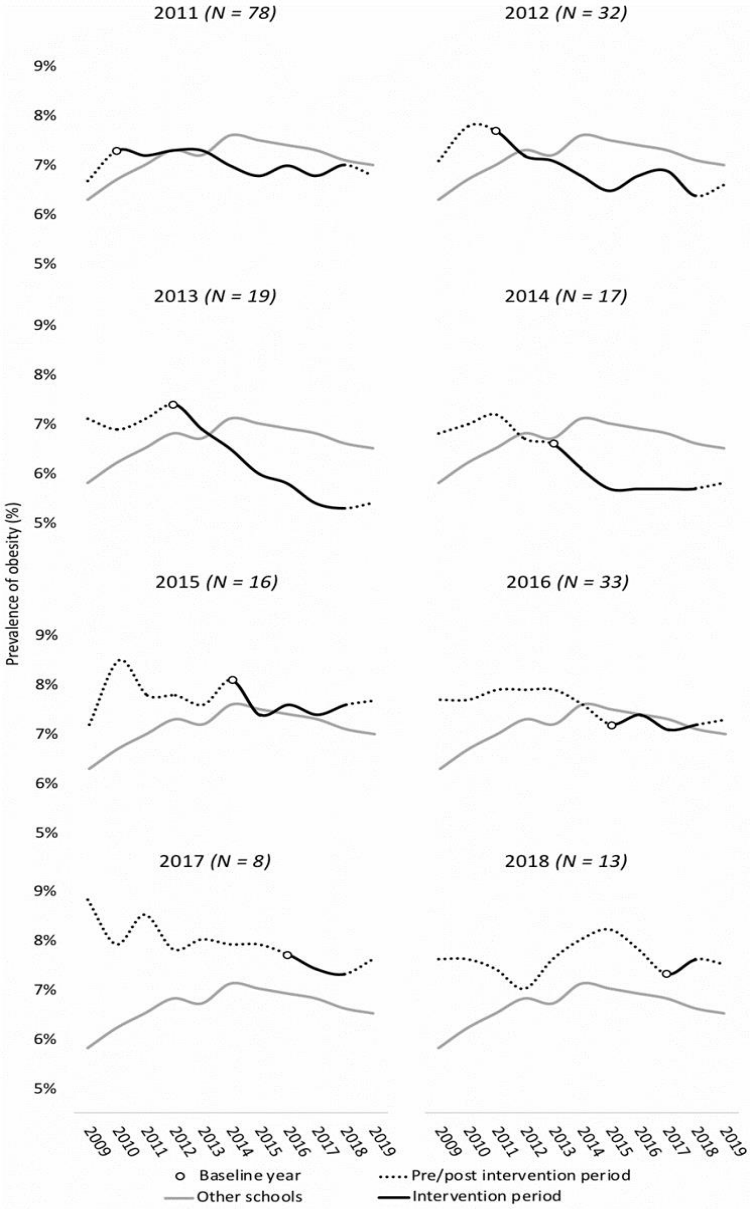

Figure 2. Time trends in obesity prevalence in intervention schools vs. other schools, stratified by intervention start year.

Next, the GEE analysis showed increasingly lower average BMI in intervention group compared to controls with longer participation in intervention in all three weight groups in both genders (Tables 3 and 4). Generally, in girls the magnitude of effects plateaued after 3 (girls with normal weight and girls with obesity) or 4 years of participation (girls with overweight) at around 1-1.4 kg/m^2 (girls with normal weight: B=0.937, 95%CI=0.845-1.029; girls with overweight: B=1.151, 95%CI=0.785-1.517; girls with obesity: B=1.417, 95%CI=0.959-1.875). In boys, the effects plateaued after 3 years at around 0.8-0.9 kg/m^2 (boys with normal weight: B=0.851, 95%CI=0.766-0.935; boys with overweight: B=0.766; 95%CI=0.542-0.989; boys with obesity: B=0.889, 95%CI=0.461-1.316).

Table 3. Generalised estimating equations analysis of effects on BMI change in control vs intervention in girls

Duration	B	SE	95% CI		Wald χ2	P value
			Lower	Upper		
Normal weight						
1 year	0.235	0.0219	0.192	0.278	114.487	<0.001
2 years	0.831	0.0341	0.764	0.898	595.722	<0.001
3 years	0.937	0.0467	0.845	1.029	402.059	<0.001
4 years	0.807	0.0665	0.677	0.938	147.313	<0.001
5 years	0.554	0.0875	0.383	0.725	40.130	<0.001
Overweight						
1 year	0.157	0.0437	0.071	0.242	12.876	<0.001
2 years	0.789	0.0742	0.644	0.935	113.004	<0.001
3 years	1.097	0.1264	0.84	1.345	75.330	<0.001
4 years	1.151	0.1867	0.785	1.517	37.966	<0.001
5 years	0.887	0.2293	0.437	1.336	14.959	<0.001
Obesity						
1 year	0.544	0.1212	0.306	0.781	20.115	<0.001
2 years	1.333	0.1858	0.969	1.698	51.519	<0.001
3 years	1.417	0.2338	0.959	1.875	36.744	<0.001
4 years	0.953	0.325	0.316	1.590	8.594	<0.001
5 years	0.397	0.4192	-0.424	1.219	0.898	0.340

$\boldsymbol{\beta}$=unstandardised regression coefficient; SE= standard error; CI=confidence interval

Table 4. Generalised estimating equations analysis of effects on BMI change in control vs intervention in boys

Duration	B	SE	95% CI		Wald χ2	P value
			Lower	Upper		
Normal weight						
1 year	0.219	0.0211	0.178	0.26	107.688	<0.001
2 years	0.717	0.0321	0.654	0.779	499.277	<0.001
3 years	0.851	0.0433	0.766	0.935	386.191	<0.001
4 years	0.807	0.0595	0.691	0.924	184.226	<0.001
5 years	0.574	0.0772	0.422	0.725	55.238	<0.001
Overweight						
1 year	0.413	0.0688	0.278	0.548	36.092	<0.001
2 years	0.413	0.0688	0.278	0.548	36.092	<0.001
3 years	0.766	0.1139	0.542	0.989	45.195	<0.001
4 years	0.591	0.1636	0.270	0.912	13.039	<0.001
5 years	0.240	0.2288	-0.209	0.688	1.099	0.295
Obesity						
1 year	0.272	0.1031	0.070	0.474	6.965	0.008
2 years	0.715	0.1514	0.419	1.012	22.344	<0.001
3 years	0.889	0.2182	0.461	1.316	16.584	<0.001
4 years	0.630	0.2964	0.049	1.211	4.514	0.034
5 years	0.834	0.3707	0.107	1.56	5.056	0.025

β=unstandardised regression coefficient; SE= standard error; CI=confidence interval

To assess the effect of the intervention on obesity, the transition of children with obesity at baseline (*N* = 4,063) to overweight or normal weight for each of the 5 participation durations were analysed. The results shown in Table 5 reveal that for the reversal of obesity the intervention was more effective in girls for whom statistically significant differences between the control and intervention group was seen after two years [p = 0.016, *Cramer's V* = 0.072], three years [p = 0.002, *Cramer's V* = 0.120], 4 years [p = 0.024, *Cramer's V* = 0.122], and five years of participation [p = 0.033, *Cramer's V* = 0.154]. On the other hand, in boys the intervention started to show effects a bit later, and the difference between the intervention and the control group reached significance threshold only in participation durations of three years [p = 0.011, *Cramer's V* = 0.092], and five years [p = 0.027, *Cramer's V* = 0.157]. In line with this, the NNT also decreased steadily with the duration of the programme in both sexes, with generally lower numbers for girls. The lowest NNTs were seen for 5 years of participation in the programme (NNT=17 and 12 for girls and boys, respectively).

Table 5. Number of reversed cases of children with obesity across five different durations of participation/nonparticipation

Duration	Sex	Control			Intervention			
		N of obesity cases	N of obesity cases reversed	Obesity reversal rate (per 10000)	N of obesity cases	N of obesity cases reversed	Obesity reversal rate (per 10000)	NNT
1 year	Boys	1111	9	81	1004	7	69	-886
	Girls	1119	1	8	829	2	24	659
2 years	Boys	666	9	135	573	10	174	254
	Girls	692	3	43	420	8	190*	68
3 years	Boys	428	10	233	338	20	591*	28
	Girls	466	5	107	203	10	492*	26
4 years	Boys	195	12	615	154	16	1038	24
	Girls	240	6	250	103	8	776*	19
5 years	Boys	104	5	480	94	13	1382*	12
	Girls	138	2	144	54	4	740*	17

*p<0.05; NNT – number needed to treat (number of children that should be involved in the intervention to reverse one additional obesity case)

4.4 Discussion

This study investigated the effectiveness of a scaled-up, population-based, long-lasting PA intervention on obesity-related outcomes in children aged 6-14 years, while using a complex analytical design to reflect diverse, real word scenarios. The principal result of the study was that children included in the Healthy Lifestyle intervention had significantly lower BMI rise than the control group. The difference in BMI was growing with years of participation in the intervention and was the largest in children initially with obesity. Furthermore, reversal of obesity was more common in the intervention group in cases where children were involved in the programme for at least 3 consecutive years, while maximal treatment effects were seen after four years of participation in girls and after five years of participation in boys.

The findings are in line with the observed (pre-pandemic) trends among Slovenian children, which shows that the increase in the prevalence of overweight and obesity has been decreasing over the last decade with larger reduction in boys compared to girls (16). The fact that childhood obesity has been declining in Slovenia throughout the period of the Healthy Lifestyle intervention at the population level (16), suggests that there were also other drivers that contributed to the reversal of the obesity trends.

It was observed that the effect of the intervention on BMI was generally larger in girls than boys, although this was more evident in those with overweight and obesity at baseline. Moreover, reversed obesity cases were also more frequent in girls and more consistent across different participation scenarios. The disparity between sexes in terms of different intervention effects could be due to differences in PA levels outside school environment. During leisure time girls are usually less active compared to boys (17), whereas PE participation is not related to overall PA levels for boys (18). This implies that in relative terms PA accumulated during the Healthy Lifestyle constituted a higher share of daily PA in girls, causing larger intervention effects than in boys. Contrary to this study, a recent meta-analysis of school-based PA programmes reported that fitness-oriented interventions such as the one analysed here produced larger effects in boys than in girls (7). Whether the Healthy Lifestyle intervention provided a larger stimulus for girls than for boys given their lower daily physical activity level remains to be confirmed in the future studies. Apart from the relative volume of PA delivered, boys and girls may need different types of PA to achieve the same effects, and the content of the intervention examined might have been more appropriate for girls than for boys. In addition, earlier maturation of girls might have confounded intervention effects on BMI although this was adjusted for in the analyses for height percentile to reduce this effect. Notwithstanding the increase in BMI of girls during puberty due to increase in subcutaneous fat, the reduction of BMI in this study was still more pronounced in girls than boys.

The Healthy lifestyle intervention produced very large and clinically meaningful differences in BMI compared to controls, particularly in children with overweight and obesity. At the same time, it has to be noted that BMI is not the most accurate estimate of adiposity due to a well-known limitation of its inability to distinguish between fat and muscle mass (19). Thus, PA interventions could have positive effects on children having overweight and obesity by changing their body composition and altering their risk for possible future health impairments associated with excess body fat even in the absence of changes in body weight. Thus, the effects of the Healthy lifestyle intervention on body composition may have been even higher than reported if fat mass could have been used as an outcome measure instead of BMI. A study including obese children aged 7-17 years showed that even a small reduction in BMI z-score (≥ 0.00-< 0.10) improved health markers such as insulin sensitivity which reduces the risk for future non-communicable (20). Standards for a BMI z-score reduction for each subgroup of children and adolescents depending on a different baseline weight status do not exist, which makes is difficult to evaluate the effectiveness of an intervention based exclusively on BMI

values without additional health markers. This limits the reliability of conclusions about the clinical effectiveness. Although maturation effect was adjusted for in the models, it cannot be ruled out the residual effect of growth could have resulted in the underestimation of the true effect of the intervention.

While the analyses focussed on weight-related outcomes, there are several other benefits incurred by a fitness-oriented PA programme such as the one analysed here. Unhealthy weight status is associated with increased risk for several chronic diseases including diabetes, cardiovascular diseases, osteoarthritis, and some types of cancer (21). Obesity is one of the main modifiable risk factors for insulin resistance in children and adolescents (22). Also, in children with obesity, adequate PA and fitness results in favourable cardiovascular health despite adiposity and good cardiovascular health can serve as a protective component from heart-related disease even in childhood (23).

The Healthy Lifestyle intervention was effective in reversing obesity, reaching its highest efficiency after five years of participation. Unsurprisingly, the longer the intervention lasts for a given child/youth, the more profound the potential treatment effect keeping in mind the concept of obesity as a chronic disease. Even though the intervention lasted eight years, the analyses was limited to five years of participation because the number of children who persisted more than five years was less than 800 in boys and less than 500 in girls. Hence, it remains to be seen if programmes that last more than five years are accompanied with a further reduction in NNT statistics. The findings are in line with a recent small-scale study from Denmark that provided NNT estimates of an intensive PE programme to prevent overweight or obesity in a cohort (N= 1009) of 5-12-years-old children (24). The authors calculated that 18 children, irrespective of their weight status, will need to participate in 270 min of PE per week for 2 years to prevent one additional case of overweight or obesity compared to the usual PE lasting 90 min/week (24). Although the study was not powered to detect effects exclusively in children with overweight, the fact that the effect was considerably higher when children with overweight were included in the analyses implies that there was also a significant treatment effect present. Taken together, these results along with a universal coverage and high participation rates, provide evidence for intensive compulsory PE as a viable and effective solution for childhood obesity prevention at the population level.

Scaling-up public health interventions into real world settings engrosses public health, where these interventions are vast in size and have an adequate extension to reach a larger proportion

of the targeted population (25). Drawbacks and risks associated with scale-up and real-world setting immersion are commonly related to lack of funding and consequently poor intervention implementation and loss of effectiveness (26). This is exactly what happened to the population-based, scaled-up intervention analysed in this study, when for one year (i.e., 2015/2016) funding was limited due to legislation impediment and was accompanied by a reduction of beneficial effects of an intervention on obesity related outcomes. On the other hand, only 2/216 schools voluntarily decided to discontinue the intervention. Moreover, a large dropout of children after 5 years of the programme noted in this study is mostly a natural phenomenon. Namely, many children who were in grade 4 when they started the programme, finished primary school after five years and continued their high school education. The sustainability of interventions across longer periods, while implemented in the entire population of school-aged children and adolescents must be ensured for favourable outcomes to be present continuously. This is supported by the World Health Organization's recommendation which emphasizes that interventions lasting more than a year provide larger effects in comparison to shorter ones (27). At the same time the results of our study show that the recommended one-year minimum might not be enough in reversing the current childhood obesity pandemic. Additionally, since the largest differences in BMI reduction between groups were present after 3 years of involvement, continuous all-in approach on every level of the intervention is crucial, including funding.

The successful implementation of the programme was supported by PE teachers, who possess more specific knowledge on PA, compared to classroom teachers. A meta-analysis of interventions focusing on PE lessons showed that an effective intervention approach included appropriate instruction alongside class organisation and management (28). Moreover, PE teachers were more successful compared to classroom teachers in terms of enhancing physical fitness of children through higher competences in planning and delivering PE lessons (29).

4.4.1 Strengths and limitations

This study has many strengths including: 1) a population-scaled-up intervention delivered in real-world settings; 2) a large number of children of diverse age which contributes to higher generalizability of these findings; 3) a longitudinal design implemented over a five-year period, which allowed for inferences about the casual relationship between the intervention and obesity-related outcomes, while also examining the sustainability of the effects over time; 4) analyses stratified by sex, providing even more specific insight into the effects of the

intervention; 5) models adjusted for several important covariates - baseline school-level obesity prevalence, economic affluence of local environment, individual baseline risk of obesity, and individual maturation rate; 6) controlling for the maturation effects which can blur the actual decline in body mass due to increased accumulation of subcutaneous fat before the growth spurt and due to increased gaining of muscle mass in boys and fat mass in girls entering puberty (30, 31); 7) programme was delivered by specialist PE teachers rather than by less competent (in terms of PA instruction), classroom teachers or other professional profiles.

There are also several limitations that deserve highlighting. First, BMI is not the most accurate estimate of adiposity due to a well-known limitation; its inability to distinguish between fat and muscle mass (19). However, BMI is considered a feasible outcome variable since it is non-invasive and an easily applicable method in the context of ethical requirements and legislative regulations. Second, the height percentile was used as a proxy to maturation rate, which is not ideal measure of maturation since it only shows the percentile deviation from the expected height (32, 33). Although higher percentiles at the time of the pubertal growth spurt are indicators of accelerated growth, this indicator is less reliable in preadolescents (34, 35). Third, this study was unable to collect information about dietary habits, PA outside the intervention or screen time, which represent important factors in childhood obesity management. In addition, there are also several other important determinants of obesity and weight change (other than diet and PA) which were not recorded in this study, and thus not included in analyses. Examples are genetic variation, epigenetics, endocrine disease, central nervous system pathology, sleep, infection, and socio-economic and cultural factors (36). Fourth, as this is a natural experiment and not a randomised control trial, the possibility of sampling bias due to the non-random, voluntary enrolment approach used in this study needs to be acknowledged. Thus, it is possible that some children and adolescents who may have been prone to behaviour change, would have wanted to be a part of this intervention, as opposed to children with the opposite characteristics. Nevertheless, baseline differences between the control and experimental group in terms of BMI and triceps skinfold thickness were small to trivial. In addition, the baseline risk of obesity, and school-level prevalence of obesity were included as covariates in all analyses to reduce the possible effects of sampling bias. Fifth, there was no information available on adherence, but the fact that the intervention was mandatory after enrolment underlined the importance of attending the predetermined program and guaranteed high attendance rates. Sixth, although additional PE lessons provided within this intervention were organized to take place immediately after the end of regular school hours, they were not integrated into obligatory

curriculum. While this fact has not affected participation rates in this context, it is acknowledged that this might create additional implementation barriers in other educational systems or contexts (e.g., transportation issues). Lastly, while horizontally scaling up the intervention, it was not possible to collect other implementation outcomes across the various schools and participation years.

4.5 Conclusion

A school based PA intervention that provided additional PE lessons remained effective in the prevention of obesity after scaling-up. The greatest effect was present in children initially presenting with obesity, such that the programme was able to benefit children needing support the most. The number needed to treat for obesity reversal decreased with intervention duration, emphasising the benefit of longer-term PA programmes. Policymakers and funding bodies should be aware that obesity is a chronic condition that needs to be dealt with over a longer time frame, and that easy solutions and immediate effects are neither realistic, nor sustainable. Lastly, the population-scaled PA intervention analysed here was shown to be more effective among girls than boys, particularly for children living with overweight or obesity at the start of the programme. The reasons for this sex inequality need to be elucidated to guide the design of more equitable future PA programmes in schools.

4.6 Acknowledgements

The authors thank the voluntary investigators, children, and parents involved in SLOfit, an ongoing, multidisciplinary population and citizen science fitness surveillance system. The data that support the findings of this study are available on request from the corresponding author [PJ]. The data are not publicly available due to restrictions related to information that could compromise the privacy of research participants.

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Chapter 5

Publication 3

Does incorporating high intensity interval training in physical education classes improve fitness outcomes of students? A cluster randomized controlled trial

Jurić P, Dudley DA, Petocz P. Does incorporating high intensity interval training in physical education classes improve fitness outcomes of students? A cluster randomized controlled trial. Prev Med Rep. 2023 Feb 4;32:102127. doi: 10.1016/j.pmedr.2023.102127. PMID: 36816767; PMCID: PMC9932703.

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Contribution

Petra Jurić was responsible for conceptualization, investigation, methodology, data curation, software, writing - original draft preparation. Dean A. Dudley was responsible for supervision, methodology, writing - reviewing and editing. Peter Petocz was responsible for methodology, software, writing - reviewing and editing.

Highlights:

- A 12-week low-dose HIIT program can improve cardiorespiratory fitness in youth.
- ITT analysis provides evidence of efficacy of the program when delivered in a group setting.
- HIIT paradigms that improve other components of fitness need to be examined.

Abstract

The aim of this study was to determine the efficacy of a high intensity interval training (HIIT) intervention lasting 12 weeks on fitness (cardiorespiratory fitness, muscular strength, muscular endurance, power, speed, flexibility, and balance) and adiposity of 10- to 15-year-old students implemented during their physical education (PE). The focus of this study was to compare two approaches to increasing fitness level among school-aged children, one approach focusing on regular PE sessions in accordance with the curriculum and another one on regular PE classes augmented by HIIT. A cluster-randomized controlled trial was conducted (February-May 2022, Zagreb, Croatia). The total number of students across both groups was 207. General linear models were used to compare fitness and adiposity changes in both groups based on the Eurofit test battery. A significant effect of the HIIT intervention was present for the 20-meter shuttle run test (p=0.001; d=0.31). The effect of the intervention compared to the control was estimated as an additional 181.2 meters, 95%CI (70.4 to 292.0). An additional intention-to-treat (ITT) analysis showed that the effect of the HIIT intervention on 20-meter shuttle run test remained statistically significant (p=0.011), though the magnitude of the estimated effect was reduced from 181.2 meters; SE=55.4 to 119.6 meters; SE=46.4). Whilst it appears HIIT had the opposite of the expected effect on body fat percentiles, the effect on body composition was inconsistent. The intervention is registered at the Australian New Zealand Clinical Trials Registry (ANZCTR) [ACTRN12622000209796].

Key words: cardiorespiratory, overweight, obesity, children, adolescents, intervention, school.

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Conflicts of interest: none

Acknowledgements: PJ's work is funded by the Croatian Science Foundation (grant No. DOK-2018-09-8532) and by supported by an Australian Government and International Macquarie Research Excellence Scholarship Program (iMQRES).

Ethical approval and consent to participate:

The study was performed according to the Declaration of Helsinki and the procedures were approved by the Ethics Committee of the Faculty of Kinesiology, University of Zagreb (No. 38./2021.). The intervention is registered at the Australian New Zealand Clinical Trials Registry (ANZCTR) [ACTRN12622000209796]. All children agreed to participate voluntarily and provided written consent from a parent or a guardian, including a health status report from the family doctor.

Glossary of terms

BMI – body mass index
CRF – cardiorespiratory fitness
HIIT – high intensity interval training
HR – heart rate
ITT – intention-to-treat
NCD – noncommunicable diseases
PA – physical activity
PE – physical education

5.1 Introduction

Physical activity (PA) is vital for optimum human body functioning, while lack of PA causes maladaptation in the human condition which may lead to poorer quality of life (1). Prolonged lack of PA is associated with impaired glucose metabolism and cardiometabolic disorders which consequently lead to increases in mortality worldwide (2). Globally, three in four adolescents aged 11-17 years do not currently meet the global PA recommendations for maintaining optimal health (3), putting them at risk for coronary heart disease, metabolic impairments, some types of cancer, and premature death (4). Despite available evidence in favour of PA, lack of PA among children and adolescents is extensive and contributes to adverse health outcomes (5, 6).

Widespread lack of PA is associated with declining fitness among children and adolescents (7), with trends most likely continuing into adulthood (8). Several studies demonstrate declining cardiorespiratory fitness (CRF) (9-11), flexibility (12), and strength (13). Nevertheless, poor fitness is a strong predictor for many noncommunicable diseases (NCD) in many countries (14-17). CRF, muscular fitness and speed are all inversely correlated with overall adiposity in children (18), and with abdominal adiposity among adolescents (19). The majority of NCDs start developing during youth (20), emphasizing the need for implementation of more effective solutions to enhance fitness tailored according to needs of children and adolescents.

High intensity interval training (HIIT) has been shown to be an efficacious and time efficient strategy for enhancing CRF and body composition in adolescents (21). When implemented in physical education (PE), HIIT can create enough time for learning opportunities while stimulating fitness (22). In comparison to low- and moderate-intensity activities, HIIT produces larger improvements in systolic blood pressure and CRF in youth with excess weight (23), further emphasizing its effectiveness (24). HIIT-based interventions also resulted in improvements in body composition among adolescents (21). Furthermore, HIIT stimulates greater neuromuscular and anaerobic development in comparison to other types of exercise (25). These benefits, however, are largely dependent on different types of HIIT designs.

Interventions within PE enable teachers to meet educative and health outcomes simultaneously (22, 26). Schools provide a convenient setting for fitness-based interventions as many have the human (peers, parents, and teachers) and built (buildings, equipment, outdoor space) infrastructure for such activities (27). Based on the inconsistency in findings that largely depend on different HIIT designs, with this trail we wanted to see if a short HIIT session lasting

only 10 minutes and performed only 2 times per week could be a supraliminal stimulus to facilitate positive changes in fitness and body composition outcomes. Therefore, the aim of this study was to determine the efficacy of a 12-week HIIT program implemented in PE on the health-related fitness and adiposity status of 10- to 15-year-old students.

5.2 Methods

5.2.1 Trial design

Using a cluster-randomized control trial design (pre-test/post-test), classes in one school were randomly allocated to the intervention or the control group using an unbiased coin randomization process by school personnel after baseline data had been collected. In each of grades 5-8, one whole class was allocated to the intervention and the other to the control. The focus of the trial was to compare two approaches to increasing fitness among school-aged children, one focusing on regular PE sessions in accordance with the curriculum, the other on regular PE classes augmented by HIIT. Baseline data were collected the week before the start of the trial and post-test data after the 12-week period. The study design and participant flow chart are shown in figure 1.

5.2.2 Participants

Children attending grades 5-8 were recruited for this trial with no exclusion criteria. All children in these classes agreed to participate voluntarily and provided written consent from a parent or a guardian, including a health status report from the family doctor. The trial was carried out with all students irrespective of their abilities in accordance with an intention-to-treat (ITT) principle (28). Fitness and adiposity outcomes were measured for all children who were present during initial and final measurements, regardless of their overall proportion of participation in the classes. The calculated sample size required for this intervention to detect statistical significance ($p<0.05$) at $d=0.3$ between groups was 87 students.

5.2.3 Intervention

The study was performed in Zagreb, Croatia (February-May 2022) according to the Declaration of Helsinki and the procedures were approved by the Ethics Committee of the Faculty of Kinesiology, University of Zagreb (No. 38./2021.). The intervention is registered at the Australian New Zealand Clinical Trials Registry (ANZCTR) [ACTRN12622000209796]. The intervention provided two 10-minutes HIIT sessions per week at the beginning of regular PE classes. The intervention lasted 12 weeks, offering 24 sessions across the whole semester to students involved in the HIIT program. One PE teacher delivered sessions to all participants.

An increase in overall intensity of PA was considered a beneficial approach not only for enhancing fitness, but also as a by-product, promoting a healthy weight. The HIIT program presented in Table 1 was followed, with almost all children completing the program during each HIIT session. Adherence in terms of frequency and intensity was consistent across all sessions. In a supportive environment following several lockdowns due to the COVID-19 pandemic, all children cooperated with the teacher and were highly motivated to improve their abilities and achieve health benefits.

Table 1. Intervention HIIT program

Lesson Phase	Example 1	Example 2	Example 3	Example 4
Prep Phase (2 mins)	Jumping Jacks x 10 Running in Place x 10 Rhythmic Jumping x 10 Repeat until time is up	Diamond Jumps x 10 High Knee Runs x 10 Speed Skaters x 10 Repeat until time is up	Power Jumping x 10 Mountain Climbers x 10 Tuck Jumps x 10 Repeat until time is up	Squat Jumps x 10 Burpees x 10 Plank Jacks x 10 Repeat until time is up
Passive Recovery Heart rate Check (30 sec)	Standing still take pulse (6 seconds x 10)	Standing still take pulse (6 seconds x 10)	Standing still take pulse (6 seconds x 10)	Standing still take pulse (6 seconds x 10)
Work Phase 1 (2 mins)	Push-ups x 10 5m Shuttle Sprint x 10 Squats x 10 5m Shuttle Sprint x 10 Repeat until time is up	Chair Triceps Dips x 10 5m Shuttle Sprint x 10 Reverse Lunge x 10 5m Shuttle Sprint x 10 Repeat until time is up	Twisting Push-ups x 10 5m Shuttle Sprint x 10 Plank Leg Raises x 10 5m Shuttle Sprint x 10 Repeat until time is up	Plank to Push-ups x 10 5m Shuttle Sprint x 10 V-Sit x 10 5m Shuttle Sprint x 10 Repeat until time is up
Passive Recovery Heart rate Check (30 sec)	Standing still take pulse (6 seconds x 10)	Standing still take pulse (6 seconds x 10)	Standing still take pulse (6 seconds x 10)	Standing still take pulse (6 seconds x 10)
Work Phase 2 (2 mins)	Twisting Push-ups x 10 5m Shuttle Sprint x 10 Plank Leg Raises x 10 5m Shuttle Sprint x 10 Repeat until time is up	Plank to Push-ups x 10 5m Shuttle Sprint x 10 V-Sit x 10 5m Shuttle Sprint x 10 Repeat until time is up	Push-ups x 10 5m Shuttle Sprint x 10 Squats x 10 5m Shuttle Sprint x 10 Repeat until time is up	Chair Triceps Dips x 10 5m Shuttle Sprint x 10 Reverse Lunge x 10 5m Shuttle Sprint x 10 Repeat until time is up
Active Recovery (2 mins)	Dynamic/static stretching.	Dynamic/static stretching	Dynamic/static stretching	Dynamic/static stretching
Body of Lesson	Teacher returns to the normal teaching program for the remaining lesson time	Teacher returns to the normal teaching program for the remaining lesson time	Teacher returns to the normal teaching program for the remaining lesson time	Teacher returns to the normal teaching program for the remaining lesson time

An example HIIT session comprised: preparation phase (2 minutes), passive rest (30 seconds), working phase (2 minutes), passive rest (30 seconds), working phase (2 minutes), and active rest (2 minutes). Working phases required maximal exertion, and during the following passive rests the heart beat was counted in a standing position for 6 seconds, subsequently multiplied by 10. Based on this, the load level was monitored. Students had one introductory session to learn how to carry out this self-assessment. If the heart rate (HR) was estimated as low, i.e., below 13 beats in 6 seconds (13x10=130 bpm), children were encouraged to increase the intensity of the exercise during working phases. HR monitors were not used, so no objective

measurements of HR were made, which precluded measures of exercise load or intensity. However, by self-assessment children were able to learn to approximately track their own exercise exertion without any necessary equipment, emphasizing the educative component of the intervention which contributed to positive feedback from children.

Regular PE classes were based on the embedded curriculum. An example regular PE class comprised: introductory warm-up (5 minutes); preparatory exercises (10 minutes); 'Part A' (15 minutes), elements specific to the sport of the day; 'Part B' (10 minutes), a relay game; final part (5 minutes) including stretching. The intervention group had HIIT instead of the introductory and preparatory sections and continued with Part A after the HIIT was completed.

5.2.4 Measurements

Participants were weighed barefoot wearing light clothes with a pre-calibrated digital scale to the nearest 0.1 kg. Height was taken to the nearest 0.1 cm using an anthropometer (GPM, Siber-Hegner & Co., Zurich, Switzerland). BMI was calculated as body weight in kilograms divided by body height in meters squared (kg/m2) (29). Body fat percentage was determined using a *Tanita* BC-418 Segmental Body Composition Analyzer with correction for light indoor clothing. The student stood barefoot with weight equally distributed between both legs on the analyzer and held a pair of handgrips, one in each hand (30). Although we used the Tanita analyser for the purpose of estimating body fat in our sample, there is still inconsistent evidence regarding the validity of this method (31-37).

The Eurofit test battery was used to assess fitness (38); it included flamingo balance test, plate tapping test, sit and reach test, standing long jump, handgrip test, sit-ups for 30 seconds, bent arm hang, 10 x 5 m shuttle run, and 20-meter shuttle run. The Eurofit test battery has reported acceptable levels of validity and reliability for fitness assessment in adolescents and has been widely used around the world (39, 40, 41).

5.2.5 Data Collection

Stations were used for fitness and adiposity assessments: (1) height, weight, body fat percentage and Eurofit tests except 20-meter shuttle run test were performed on the same day; (2) children were divided into small subgroups of up to four, and each subgroup started with a different test measurement; (3) after completion of a test, subgroups moved to the next test clockwise. Pre-test instructions were given to children visually without possibility of trying the test before the actual measurement. Children were encouraged and monitored to put maximal effort into each test. The supportive school environment provided additional external motivation for this

purpose. The 20-meter shuttle run test was performed separately during the same week but on a different day due to time restriction of 45 minutes per PE class. For the shuttle run test children were divided into two groups, each consisting of maximum 15 students. All tests were performed during one week or two regular PE classes. Two postgraduate kinesiology students trained to carry out fitness and adiposity measurements were present at each test, both blinded from group allocation; one student performed measurements and the other helped with transitions between tests.

5.2.6 Statistical methods

Independent samples t-tests were used to check the baseline differences in age, height, BMI, and body fat percentage. Body fat percentiles for the sample were calculated based on LMS values reported by a German study (42). Further, BMI percentiles and height percentiles were calculated using World Health Organization LMS values (43). General linear models were used to compare final fitness and adiposity values between intervention and control groups, adjusted for the baseline values of evaluated traits, baseline age, baseline body fat percentile values and sex using Minitab^{TM} statistical software (version 21, Minitab Ltd., www.minitab.com) (44). Changes in BMI values were examined using a Percent over BMI method (BMI50) and the Healthy Fitness Zone continuum (BMI85) which avoid the pattern of a positive mean change in BMI% in children at lower baseline BMI score, and a negative mean change in BMI% in ones at higher baseline BMI score (45).

Using an ITT principle, children randomized before the start of the trial were also included in final analyses regardless of the proportion of their participation in the intervention throughout the 12-week period. In this way, the true efficacy of the intervention implemented within a real-world environment could be assessed. Moreover, additional analyses were carried out to assess the effect of missing data due to absence of children from school during final measurements or their inability or reluctance to perform a specific test. IBM SPSS 28.0. Statistics (www.ibm.com/au-en/products/spss-statistics) was used for missing data management. Statistical significance was set at $p<0.05$.

5.3 Results

5.3.1 Recruitment

The number of children included in the intervention and control groups was 105 (mean age ± SD =12.1 ± 1.1) and 102 (mean age ± SD =12.5 ± 1.4). The study experienced a sample decline due to several reasons: absence of children from the school during final measurements,

reluctance to perform a specific test, or injury (figure 1). This was resolved by accounting for missing data.

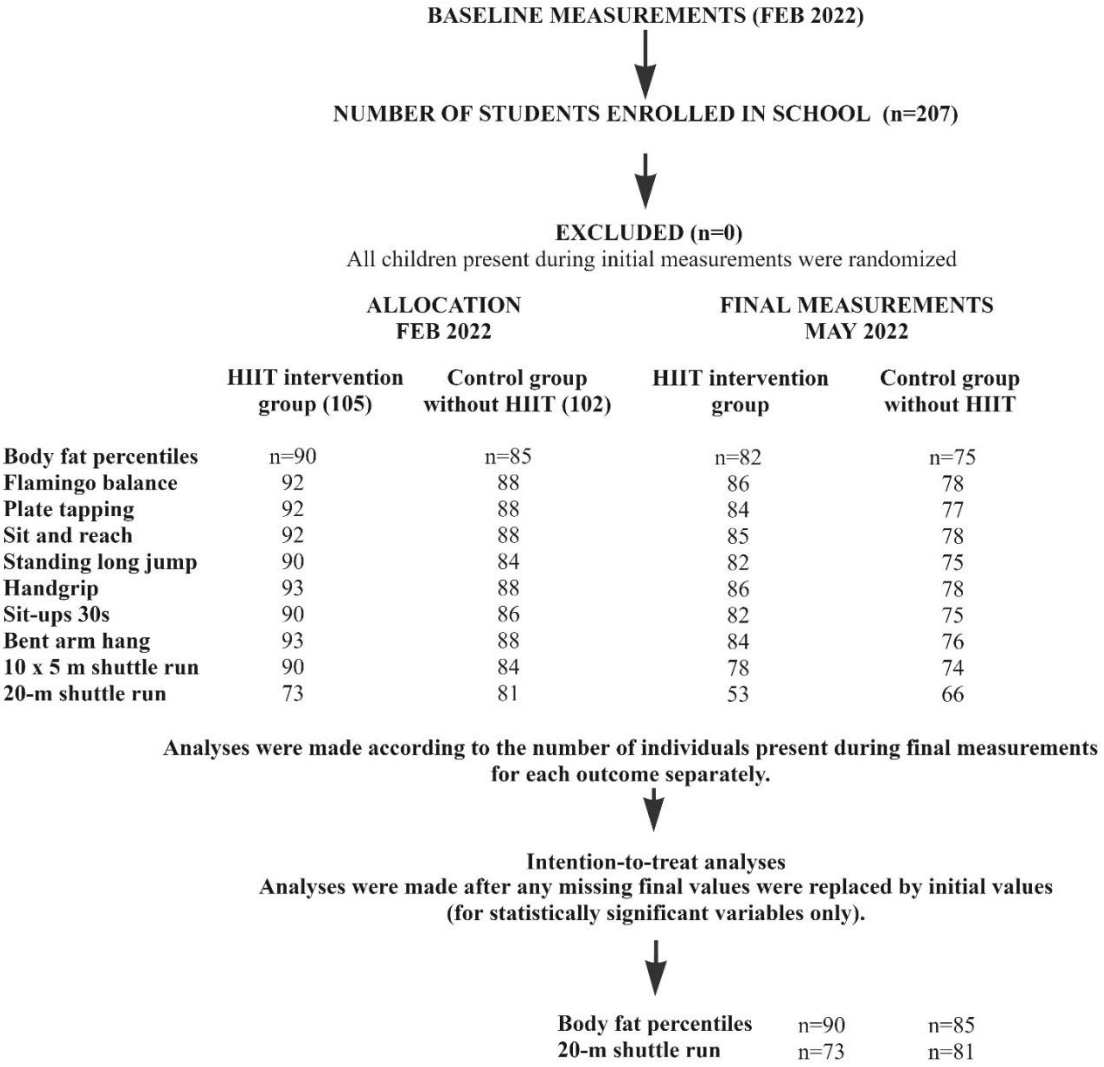

Figure 1. Study design and participant flow chart throughout the study

5.3.2 Baseline findings

At baseline the intervention group had a similar proportion of boys and girls, whereas the control group had a slightly higher proportion of boys (p=0.52). In girls, the baseline difference in age, height, BMI, and body fat percentage between groups was not statistically significant. In boys, a marginally significant difference between groups was present for age (p=0.04) and BMI (p=0.04), with higher baseline values among controls (table 2). According to the age and

sex-specific BMI cut-off points (46), 69.7% of the sample had normal weight, 23.4% had overweight and 6.9% had obesity. Further, for the 20-meter shuttle run test, the HIIT group had a distance much lower than the control group (592.1 meters compared to 755. 6 meters). Although we adjusted our analysis age, sex and baseline values, it is still worth noting this occurrence. Possible reasons could be an older control group (although not much older) or a slightly higher proportion of boys in the control group. However, when reanalyzing data, we did not observe any abnormality that would account for this unusual difference.

Table 2. Baseline differences in anthropometric values between the intervention and the control group.

	Intervention (n=105)	Control (n=102)	p-value
Age (years)	12.10 (1.11)	12.54 (1.35)	0.010
Height (cm)	159.44 (8.33)	161.00 (11.00)	0.306
BMI (kg/m^2)	20.09 (3.81)	20.58 (3.77)	0.393
Body fat (%)	21.52 (9.52)	22.14 (9.30)	0.662

Mean (standard deviation); Height – expressed in centimeters; BMI - body mass index - the ratio of body weight in kilograms and body height in meters squared; Body fat – determined using *Tanita* BC-418 Segmental Body Composition Analyzer.

5.3.3 Post-test findings

The general linear model analyses showed no significant effect of the HIIT intervention for fitness results which required balance, coordination, speed, flexibility, power, static strength, muscular endurance, or non-reactive agility. However, the HIIT intervention significantly improved student performance on the 20-meter shuttle run test with a small to medium effect (p=0.001; d=0.31) when adjusted for baseline age, sex, body fat percentiles and pre-intervention results. The effect of the intervention compared to the control is estimated as an additional 181.2 meters, 95%CI (70.4, 292.0), which translates to nine more sublevels attained by the group having the HIIT program (Table 3). Raw initial and final values for all fitness outcomes are displayed for both groups (Table 4).

Table 3. Post-intervention effects on fitness and body composition outcomes

TESTS	Change Coef	SE Coef	p-value	95% CI	partial etasq
Flamingo balance (n)	0.314	0.480	0.515	-0.636, 1.262	0.003
Plate tapping (sec)	0.034	0.220	0.878	-0.402, 0.470	0.0002
Sit and reach (cm)	-1.286	0.742	0.085	-2.749, 0.179	0.019
Standing long jump (cm)	-3.622	1.948	0.065	-7.47, 0.23	0.023
Handgrip (kg)	-0.160	0.656	0.809	-1.454, 1.136	0.0004
Sit-ups 30s (n)	0.580	0.356	0.106	-0.126, 1.285	0.018
Bent arm hang (sec)	0.712	1.918	0.711	-3.08, 4.50	0.0009
10 x 5 m shuttle run (sec)	0.186	0.294	0.530	-0.396, 0.766	0.003
20-m shuttle run (m)	181.2	55.40	0.001	71.4, 291.2	0.091
BMI (kg/m^2)	0.225	0.117	0.056	-0.006, 0.456	0.024
Body fat (%)	0.730	0.335	0.031	0.069, 1.391	0.030

Coef – Difference in the change coefficient from initial to final between intervention and control (+ indicates favor for the intervention group and – indicates favor for the control group); SE Coef - Standard errors; Flamingo balance test – number of touch downs; Plate tapping test – number of seconds for 25 repetitions; Sit and reach test – expressed in centimeters; Standing long jump – expressed in centimeters; Handgrip test – expressed in kilograms; Sit-ups for 30 seconds –number of repetitions in 30 seconds; Bent arm hang – expressed in seconds; 10 x 5 m shuttle run – expressed in seconds; and 20-m shuttle run – expressed in meters. BMI - body mass index - the ratio of body weight in kilograms and body height in meters squared; Body fat – determined using *Tanita* BC-418 Segmental Body Composition Analyzer. A significant improvement in 20-m shuttle run has been adjusted for age, sex and baseline values.

Table 4. Initial and final measurements for the intervention and control group

TESTS	Intervention Mean (SD)	Control Mean (SD)	Intervention Mean (SD)	Control Mean (SD)
	Initial measurements		Final measurements	
Flamingo balance (n)	11.45 (7.20)	10.25 (6.36)	4.68 (3.51)	4.29 (3.22)
Plate tapping (sec)	11.22 (1.64)	11.37 (1.93)	11.40 (2.02)	11.25 (1.57)
Sit and reach (cm)	5.84 (9.29)	5.27 (10.07)	4.79 (9.26)	5.52 (9.87)
Standing long jump (cm)	167.43 (27.26)	169.40 (30.94)	167.30 (28.31)	173.10 (29.07)
Handgrip (kg)	24.89 (6.07)	23.41 (8.15)	30.59 (5.92)	30.85 (6.81)
Sit-ups 30s (n)	22.72 (4.18)	22.05 (3.43)	21.45 (3.99)	20.84 (3.61)
Bent arm hang (sec)	23.78 (23.82)	22.05 (21.62)	24.07 (18.76)	22.59 (15.45)
10 x 5 m shuttle run (sec)	22.60 (2.27)	22.35 (2.85)	21.78 (2.45)	21.43 (2.43)
20-m shuttle run (m)	592.1 (311.5)	755.6 (389.9)	906.60 (457.50)	862.50 (416.10)

Mean (SD) – mean values and standard deviations for initial and final values for both groups; Flamingo balance test –number of touch downs; Plate tapping test –number of seconds for 25 repetitions; Sit and reach test – expressed in centimeters; Standing long jump – expressed in centimeters; Handgrip test – expressed in kilograms; Sit-ups for 30 seconds – number of repetitions in 30 seconds; Bent arm hang – expressed in seconds; 10 x 5 m shuttle run – expressed in seconds; and 20-m shuttle run – expressed in meters.

The HIIT intervention did not have any significant effect on BMI percentile values, BMI50 nor BMI85 when adjusted for age, sex, centile group, and initial BMI values. However, the

group having regular PE classes showed statistically significantly lower body fat percentile values after the 12-week period compared to the intervention group; though significant, the effect was negligible to small (p=0.025; d=0.17). The effect of the regular PE classes compared to HIIT intervention is estimated as 2.76 percentiles, 95% CI (0.3, 5.1), with lower values among controls. No adverse health outcomes were reported.

5.3.4 Sensitivity analyses

This study conducted ITT analyses for the 20-meter shuttle run test and the body fat percentile values, thus increasing the number of cases utilized in each analysis (from n=119 to n=154 for the shuttle run, and n=157 to n=175 for the body fat percentiles). The effect of the HIIT intervention remained statistically significant for the shuttle run test (from p=0.001 to p=0.011), though the magnitude of the estimated effect was reduced (from 181.2 meters; SE=55.4 to 119.6 meters; SE=46.4 in favor of the experimental group). The anomalous statistical significance of the regular PE on the body fat percentile results was also no longer evident following the ITT analysis (from p=0.03 to p=0.086).

It also carried out a complete imputation of missing data for all the outcome variables using the automated multiple imputation method, based on the characteristics of the data available. The completed imputed data set was then used to repeat the previous analyses. Again, the significance of the previous results was maintained, though the magnitude of the effects was reduced. For the shuttle run test, statistical significance changed from p=0.001 to p=0.003, and the effect from 181.2 meters; SE=55.4 to 122.9 meters; SE=41.4 in favor of the intervention group. For the body fat percentiles, statistical significance changed from p=0.025 to p=0.11, and the effect from 2.76 percentiles; SE=1.22 to 3.17 percentiles; SE= 1.97, in favor of the control group.

5.4. Discussion

This study investigated the efficacy of a 12-week HIIT intervention on health-related fitness and adiposity in children aged 10-15. Children included in the HIIT intervention significantly improved their performance in the 20-meter shuttle run test; a commonly used test in PE for assessing CRF (47). A small to medium effect remains relevant as cardiorespiratory impairment accounts for 31.5% of all deaths and 45% of all NCDs-related deaths annually worldwide (48).

The results are consistent with a recently published meta-analysis indicating that HIIT has a statistically significant effect on CRF among youth (49). Also, HIIT outperforms moderate intensity continuous PA for CRF among children and adolescents (50), including youth with obesity (51). HIIT is also considered a time-efficient strategy, allowing PE teachers to meet health and educative outcomes concurrently, thus increasing the quality of PE (22). Given that the intervention was short in duration, it further highlights the magnitude of the impact HIIT can have on CRF in youth. The sustainability and trajectories of HIIT effects on CRF should be the focus of future research since previous longitudinal studies have shown that the low level of CRF in adults is partly determined by fitness level during youth (52). Further, there was no estimate of $VO2_{max}$ change from the 20-meter shuttle run results, since many of the equations developed for this purpose for children and adolescents are lacking external validity of estimation when applied to different populations (53) and lack sufficient sensitivity to detect small changes in CRF in intervention studies of this size (54).

This intervention did not show any statistically significant effect on other fitness outcomes including balance, coordination, speed, flexibility, power, static strength, muscular endurance, or non-reactive agility. Although the HIIT protocol did not stimulate the necessary neuromuscular adaptations in children and adolescents for muscular performance (55), it did include activities that focused on different muscular groups normally used for strength, speed, power, non-reactive agility, and muscular endurance development. The pervasive lack of specificity in HIIT programs (21) should therefore be resolved in order for HIIT to allow for muscular and cardiorespiratory adaptations simultaneously. A meta-analysis focusing on the effects of resistance training in prepubertal and post pubertal healthy children and adolescents found that more exercise sessions per week cause larger strength development with longer interventions being more beneficial than short ones (56). Hence, short-term HIIT interventions with only two 10-minute-long sessions per week within PE may not provide enough stimulus for this broader degree of fitness enhancement. To reach such an efficacy threshold, long-term HIIT interventions appear to be required that have more frequent sessions but are still capable of providing sufficient youth engagement in PE. Implementation of short and small dose HIIT interventions within PE does not seem to have a demonstrable effect on fitness other than the cardiorespiratory gains. Furthermore, although all students undertook stretching at the end of each HIIT session, no statistically significant effect of the intervention was seen on flexibility. This is consistent with a recent meta-analysis that showed that HIIT has no impact on flexibility development (21).

Sensitive periods for developing different motor abilities must also be considered when planning HIIT intervention for different age groups (57), where this should represent a priority during HIIT implementation. Additionally, adaptations are generally larger for untrained individuals compared to trained ones (58). This also highlights the possible impact of children's participation in PA outside the school environment and their PA levels during the Covid-19 pandemic as this intervention was carried out after several lockdowns.

Although the effect was negligible to small, the group having regular PE classes without HIIT showed statistically significantly lower body fat percentile values after 12 weeks compared to the intervention group. This is the opposite of expected, since several studies have indicated significant improvements in body fat % following a 3-month HIIT intervention (59, 60). A recent meta-analysis of randomized controlled trials which included youth with obesity found no significant difference between HIIT and moderate intensity continuous exercise on body fat % (61). However, the results are supported by a recently published study on adolescent boys with obesity showing that although a 12-week school-based HIIT protocol significantly decreased visceral adiposity, moderate intensity continuous exercise significantly decreased body fat % (62). Such inconsistency among different studies is highlighted by a systematic review finding that the effectiveness of HIIT for improving body composition in both children and adolescents remains unclear (24). Nevertheless, school-based interventions that are fitness-oriented showed larger potential for improving body composition compared to other types of PA interventions (63), where optimal CRF represents a favorable cardiorespiratory predictor regardless of the level of adiposity in youth (64).

This study utilized the ITT principle whereby it analyzed data from all individuals regardless of their total participation time during the 12-week period. Excluding individuals who did not follow the planned protocol may introduce unnecessary bias and reduce the accuracy of conclusions about the efficacy of the intervention. Therefore, the ITT method provides a less biased interpretation of the outcomes at the level of adherence in the intervention (28). The largest drop out was for the 20-meter shuttle run test (Figure 1). The reason behind this smaller adherence could partly be explained by the fact that the 20-meter shuttle run test was performed separately during the same week but on a different day. Also, it is possible that children were intentionally absent from the final class when this test was conducted because they were aware of the physical exertion it requires. Still, the fact that the efficacy of the intervention was maintained after imputing missing data for the 20-meter shuttle run test, both by using an ITT

approach and by using imputation for all missing values, highlights HIIT as useful influence on CRF in children and adolescents. Additionally, after implementing an ITT approach the effect of a regular PE curriculum without HIIT intervention was no longer significant for body fat percentile values implying trivial occurrence.

5.4.1 Strengths and limitations

This study has many strengths including: 1) the cluster randomized controlled trial design which provides direct evidence of cause–effect relationships with minimal sampling bias; 2) the inclusion of classes from one school where the same PE teacher provided PE lessons across one school year thus bypassing possible hierarchical structures and correlations between different subgroups of classes; 3) using the ITT protocol; 4) accounting for missing data due to students' absence during final measurements; 5) the PE specialist delivered the intervention; and 6) including BMI50 and BMI85 as more appropriate outcomes for monitoring change.

There are also several limitations. First, the lack of objective heart rate assessment prevented precise load monitoring. Further, no ratings of perceived exertion were collected for analysis. Second, no information on the eating habits of students included in both groups, nor on the amount of PA outside the intervention, was collected. This was also the case for several other factors that impact fitness and adiposity, such as genetic disparities, epigenetics, endocrine impairments, sleep, infection, and socio-economic determinants (65). Third, most of the evidence comes from short-term, small-scale HIIT trials like this intervention. However, global low fitness levels during youth require long-lasting scaled-up interventions that are capable of increasing levels of PA in populations across different strata of society (66). Fourth, although it used the Tanita analyzer for the purpose of estimating body fat in the sample, inconsistent evidence regarding the validity of this method prevented us from confidently presenting body composition results. These data could have important implications for the lack of body composition findings (31-37).

5.5 Conclusions

We found that a 12-week HIIT intervention delivered in regular PE classes was effective for increasing CRF in youth when assessed via 20-meter shuttle run test. This effect occurred with a low dose of HIIT during PE undertaken twice a week with no adverse health outcomes

reported. The efficacy of the intervention on CRF was maintained even after using an ITT approach, making our conclusions even stronger. Hence, decision-making institutions and funding bodies should be aware that low CRF is a chronic condition that can be improved even with a short HIIT intervention. However, scaled-up long-term HIIT interventions could represent a better solution for overcoming poor CRF in children and adolescents.

5.6 Acknowledgements

The authors thank the voluntary investigators, children, and parents involved in HIIT intervention. The data that support the findings of this study are available on request from the corresponding author [PJ]. The data are not publicly available due to restrictions related to information that could compromise the privacy of research participants. PJ's work was funded by Croatian Science Foundation, Grant Number DOK-2018-09-8532.

5.7 Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. Declarations of interest: none.

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Chapter 6
Conclusion

6.1 General conclusion

This dissertation comprises three studies with related research questions and aims. All of these studies focused on strategies for the prevention and treatment of obesity and improvement of physical fitness in children and adolescents set in schools. In this dissertation, adiposity, PA, and physical fitness are regarded as closely related aspects of human health in that research about one cannot be fully understood without the other two.

First, this dissertation was intended to bridge an existing gap in which the specific characteristics of successfully implemented PA interventions were not well understood. A comparison of the effects of three groups of interventions was conducted: 1) programs that aimed to reduce sedentary behaviour, 2) interventions that were intended to increase PA, and 3) interventions that were designed to improve physical fitness. In order to cover a complete spectrum of PA interventions, all school-based interventions that targeted energy expenditure, regardless of the type or duration of the intervention, were included. The wide range of included interventions served to identify features that enhance the effectiveness of these programs in the primary prevention of obesity, with a special focus on the type of energy expenditure component targeted. This is what distinguishes this dissertation. In none of the previously published studies has there been an attempt to document and analyse specific elements of PA programs (18, 19, 20, 25, 26, 27, 28, 29). Moreover, several of these analyses might have missed large studies because they were restricted to randomised designs (26, 29). Others were restricted to high-income countries (19) or to a single obesity-related outcome (27, 28). The search identified 146 reports that provided relevant data for meta-analysis. Point estimates in % body fat were higher for fitness interventions compared with PA interventions. Including consideration of sedentary behaviour with a PA-oriented or fitness-oriented intervention was not accompanied by an increase in intervention effectiveness because the point estimates were slightly smaller compared with PA-only or fitness-only interventions. Overall, the effects tended to be larger in girls than in boys, especially for PA + sedentary behaviour interventions. There was some evidence of inequality in that the effects on BMI were seen when interventions were delivered in the general population but not in groups of disadvantaged children. Ultimately, school-based PA interventions appear to be an effective strategy in the primary

prevention of childhood obesity among 6- to 12-year-old children but targeting sedentary behaviour in addition to PA or fitness does not increase the effectiveness of an intervention. Overall, interventions that are specifically oriented toward improving physical fitness produce greater effects on obesity-related outcomes compared to interventions that are only oriented toward increasing PA levels without a specific focus on physical fitness. Thus, efficiency is achieved through specificity. Also, more intense PA in fitness-oriented interventions has been shown to have even greater effects on obesity-related outcomes, meaning that efficiency is also achieved with the intensity of PA. Therefore, if the intervention is aimed at improving physical fitness and encouraging intensity during the intervention, positive changes in obesity-related outcomes could be expected. However, maximizing programs for the public health benefit require population-based and long-term approaches, which is exactly what the intervention described.

Second, in this dissertation the effectiveness of a population-based, real-world, scaled-up, longitudinal PA intervention, *Healthy Lifestyle* on BMI, in children aged 6–14 in Slovenia is reported. This intervention was derived from a previous successful small-scale PA intervention in individual Slovenian schools that provided an above-standard program of one PE lesson each day, delivered by PE specialist teachers in lower classes of primary schools (149). In Healthy Lifestyle intervention schools were free to choose the contents of the intervention according to their possibilities, traditions, interests, etc. However, the contents had to be sporting activities, which means mostly vigorous activities. The intervention on a nation-wide scale would fail if the contents were prescribed since it would disable differentiation, which was necessary due to differences between different exercise groups. The common thing was that all children had five hours of PE per week and that the Healthy Lifestyle lessons were implemented by specialist PE teacher. It would be impossible to replicate the protocol regarding contents but not regarding the increase of PE lessons (additional time allocation) and quality of exercise (highly competent PE teachers). In this dissertation, I have used a complex analytical design that allowed for a comparison of different durations regarding years of involvement in the intervention. Models were adjusted for several important confounders such as baseline school-level obesity prevalence, economic affluence of the local environment, individual baseline risk of obesity, and individual maturation rate. The maturation effect was controlled because it can blur the decline in body mass due to increased accumulation of subcutaneous fat before the growth spurt and due to increased gaining of muscle mass in boys and fat mass in girls entering puberty (150, 151). The intervention was effective in both preventing and reducing obesity. Moreover, the

effect of the intervention on BMI was greatest in children initially presenting with obesity and smallest in children initially presenting with normal weight, implying that the PA intervention exerted the largest health benefit to those who needed it most. The data imply that, to be effective at reducing obesity for children of both sexes in this age group, the intervention must last a minimum of 3 consecutive years without any interruption in funding. Even temporary disruptions in extended interventions attenuate their long-term effectiveness. Furthermore, the number needed to treat for one obesity case reversal decreased with duration of the intervention, emphasising the need for long-term PA programs. It is worth discussing the large 95% CI for girls having obesity after five years (Table 3). Confidence interval tends to grow larger as the sample size decreases. This is because with a smaller sample size there is less information available to estimate the population parameter and so the estimate is likely to be less precise. As a result, the margin of error which determines the width of the confidence interval is larger with a smaller sample size. Every year the sample size was smaller due to a natural drop-out because children were finishing their primary school. However, it also should be noted that there were many more cases of obesity reversed in girls from the experimental group and this is why the number of obese girls declined (not because they dropped out). This increased the uncertainty of the estimate i.e., 95% CI. Therefore, we have too few of those who stayed that long in the program, but it is possible that a longer duration i.e., beyond 4 years does not contribute to the effectiveness of the program (those who respond well are cured, and the rest are resistant to this type of treatment program). However, policymakers and funding bodies should be aware that obesity is a chronic condition that needs to be dealt with over a long timeframe and that easy solutions and immediate effects are neither realistic nor sustainable. The intervention was more effective among girls than among boys, particularly for children living with overweight or obesity at the start of the program. This is in line with a meta-analysis described in the previous paragraph. Reasons for this sex inequality need to be elucidated in future studies to guide the design of more equitable future PA programs in schools.

In order to make the intervention more convenient to implement within the school system and PE, it was worth examining a time-efficient approach that enables fitness and educational results at the same time, such as high-intensity interval training. Moreover, because cardiorespiratory fitness is considered to be an even more important modifiable risk factor compared to obesity for many non-communicable diseases, this dissertation was intended to determine the efficacy of a high-intensity interval training (HIIT) intervention lasting 12 weeks on health-related fitness and adiposity of 10- to 15-year-old students implemented during their

PE classes. The focus was to compare two approaches for increasing fitness among school-aged children, one approach focusing on regular PE sessions in accordance with the curriculum and another on regular PE classes augmented by HIIT. A significant effect of the HIIT intervention was present for the 20-meter shuttle-run test scores. An additional intention-to-treat (ITT) (152) analysis showed that the effect remained statistically significant, although the magnitude of the estimated effect was reduced. Therefore, this intervention was effective for enhancing CRF in youth when assessed with 20-meter shuttle-run test scores. This effect occurred with a relatively low dose of HIIT during PE lessons undertaken twice a week with no adverse health outcomes reported. The fact that the efficacy of the intervention on CRF was maintained even after using an ITT approach, makes these conclusions stronger. Despite the strength of these findings when analysing adiposity, I noticed an outcome that contradicted expectations. The group having regular PE classes showed statistically significantly lower body fat percentile values after the 12-week period compared to the intervention group having HIIT; though significant, the effect was negligible to small. However, this anomalous result was no longer evident following the ITT analysis. There was no statistical reason for showing information on body fat percentile rather than body fat percentage. The percentile includes some adjustment for age while the percentage does not. While analysing data, I used body fat percentage in an early model that included age (allowance for age) and then replaced it with body fat percentile later. Since the effect was the same, only one outcome was presented for simplicity and brevity. In terms of gender, there were no significant effects from including gender in the models. As a result, separation by gender did not occur (though gender was accommodated for by including it in the models). These results indicate that decision-making institutions and funding bodies should be aware that low CRF is a chronic condition that can be improved with relatively low doses of an HIIT intervention. However, long-term improvement of CRF with short implementations is neither realistic, nor attainable, where scaled-up long-term HIIT interventions could represent a better solution for overcoming poor CRF in children and adolescents. Last but not least, it has to be noted that sometimes physical fitness tests stigmatize the least physically fit children in the school system which is why it is important to follow several psychological implications and practices during testing. Focusing on enjoyment during PA which leads to regular PA, integrating testing into PE curriculum, working in informal environment with a partner, active fitness development planning and tailoring testing to task-oriented (skill mastery) and ego-oriented students (challenges) with feedbacks from PE teachers is considered desirable (148).

The overall and final conclusion resulting from this dissertation is that school-based PA programs represent a powerful tool for obesity management and cardiorespiratory fitness enhancement. Tailoring interventions toward increasing fitness among children and adolescents should be a priority because these interventions have a twofold benefit: 1) they are effective in preventing and treating obesity, and 2) if implemented using an HIIT approach, they can effectively increase CRF in a relatively short period of time. A scaled-up, long-lasting approach should be the goal of any intervention because this approach was shown to be effective not only for preventing obesity but also for reversing obesity among children and adolescents. The longer the intervention lasts, the more effective it becomes, especially for individuals who need the intervention the most, that is, those who suffer from obesity.

6.2 Strengths and limitations of this dissertation

This dissertation has many strengths. By analysing the effects of different school-based PA programs on obesity prevention and physical fitness enhancement, in this dissertation I have: (1) identified the most effective programs in school environment aimed at combatting childhood obesity; (2) provided evidence for the effectiveness of a scaled-up, long-lasting PA program at the population level; and (3) offered evidence for a time-efficient HIIT intervention within PE as a tool to improve cardiorespiratory fitness among children and adolescents—even with a relatively low implementation dose. By analysing the effects of these programs in subgroups of children stratified by characteristics, this dissertation contains detailed information directed toward more precise organisation and implementation of future school-based PA programs. The results presented here will help target interventions for priority groups of children and tailor interventions according to the needs of specific groups of children and adolescents.

First, this dissertation includes qualities superior to similar studies for several reasons. When conducting a review and meta-analysis the search strategy did not rely on strategies exhibited in prior reviews. Instead, eight databases were searched, as were grey literature sources. Unlike most of the previous similar reviews, the search was not limited to the English language, thus increasing the probability of obtaining evidence from low-to-middle-income countries. Next, different study designs were included instead of constraining the search to RCTs, although control groups were required to minimise bias. Detailed data on the content of interventions is provided, with a special reference to the frequency, intensity, duration, and type of PA. Measures of body composition were included instead of relying only on BMI, which is regularly critiqued as an imperfect measure of adiposity. Furthermore, BMI can be affected by PA

through an increase in lean body mass which then typically leads to underestimation of intervention effects on adiposity.

Second, this dissertation includes a population-based, scaled-up intervention delivered exclusively by PE specialist teachers in real-world settings. A large number of children of diverse ages were included, which contributes to higher generalisability of the findings. A longitudinal design was implemented over a 5-year period. This allowed us to examine causal relationships between the intervention and obesity-related outcomes while also examining sustainability of the effects over a long intervention period. Moreover, analyses were stratified by sex, providing even more specific insights into the effects of the intervention. Models were adjusted for several important confounders: baseline school-level obesity prevalence, economic affluence of the local environment, individual baseline risk of obesity, and individual maturation rate. Control of the maturation effect was present, which can blur the decline in body mass due to increased accumulation of subcutaneous fat before the growth spurt as well as increased gaining of muscle mass in boys and fat mass in girls entering puberty. The program was delivered by PE specialist teachers rather than by less-qualified (in terms of PA instruction) classroom teachers or people with other professional profiles. In general, PE specialist teachers have more specific knowledge about physical activity, physical fitness and sports science. In our intervention, this showed to be a great benefit for the children and adolescents involved. This was not perceived as a limitation or an obstacle to a successful scale-up. However, in a situation where there is a lack of PE specialist teachers, this might be a limitation. Still, in terms of intervention delivery, PE specialist teachers have the best physical and sport specific knowledge which worked perfectly in our case given the fact that we had enough highly educated PE teachers.

Third, this dissertation includes a cluster RCT providing direct evidence of cause–effect relationships between the HIIT program and fitness outcomes with minimal sampling bias. Also, classes were included from one school where the same PE teacher provided PE lessons across one school year, thus bypassing possible hierarchical structures and correlations between different subgroups of classes. The ITT principle was used, resulting in children who were randomised also being analysed regardless of their amount of participation in the intervention even if they were not present during the final measurements. Missing data due to students' absence during final measurements were taken into account. The intervention was delivered by a PE specialist rather than by possibly less-competent classroom teachers. Although the intervention was not associated with any effect on BMI, it included BMI50 and BMI85 as

outcome variables to avoid the pattern of a positive mean change in BMI% in children with lower baseline BMI scores and a negative mean change in BMI% in children with higher baseline BMI scores.

This dissertation has some limitations. First, when conducting a meta-analysis studies written in non-European languages were not included, raising the possibility that studies from Asia or Africa were missed. Large variability in intervention characteristics led to statistical heterogeneity, which warrants caution when interpreting the results of a meta-analysis. More than one-third of the studies that met the inclusion criteria failed to provide all the data needed for a meta-analysis. Given the large number of studies included in the quantitative synthesis, qualitative synthesis of these studies was not performed. Therefore, it cannot be inferred that the results of this additional qualitative evidence synthesis would agree with conclusions based on a quantitative synthesis. Next, a large number of researchers failed to document the exact duration of PA and even fewer researchers conducting these studies quantified the intensity of the activities that were implemented. This limitation prevented us from describing a dose–response relationship. Although the study restrained from predefining specific obesity-related outcomes, a sufficient number of studies for a meta-analysis was found only for BMI, BMI z-score, and % body fat. Both BMI and BMI z-score have often been criticised for inadequately assessing change in adiposity. Abundant evidence has emerged that supports replacing BMI or the BMI z-score with metrics that can better capture longitudinal changes in obesity (e.g., percent over BMI (BMI50) and health fitness zone continuum (BMI85). Unfortunately, these alternative metrics are still seldom considered when examining the effects of PA-intervention studies. Additionally, the large variability in reporting prevented us from analysing the effects of PA interventions on overweight prevalence and abdominal obesity. Furthermore, a limited number of studies identified in some subgroups restricted the assessment of effect modification. Finally, because only two studies focused exclusively on reducing sedentary behaviour, it was not possible to compute reliable estimates of the effects of such interventions on obesity-related outcomes.

Second, BMI is not the most accurate estimate of adiposity due to its well-known inability to distinguish between fat and muscle mass. Still, BMI is considered a feasible outcome variable because it is non-invasive and an easily applicable method in the context of ethical requirements and legislative regulations. When evaluating *Healthy Lifestyle* intervention, height percentile as a proxy for maturation rate was used, which is not an ideal measure of maturation because it shows only the percentile deviation from expected height. Although higher percentiles at the

time of the pubertal growth spurt are indicators of accelerated growth, this indicator is less reliable in preadolescents. Information about dietary habits, PA outside the intervention, and screen time was not collected despite these variables being important in childhood obesity management. In addition, there are several important determinants of obesity and weight change (other than diet and PA) that were not recorded in this study, and thus were not included in the analyses. Examples are genetic variation, epigenetics, endocrine disease, central nervous system pathology, sleep, infection, and socioeconomic and cultural factors. Because *Healthy Lifestyle* intervention was a natural experiment, not a RCT, there is a possibility of sampling bias due to non-random, voluntary enrolment. Thus, it is possible that some children and adolescents who may have been prone to behaviour change would have wanted to be a part of this intervention, as opposed to children with the opposite characteristics, who might have been more likely to decline participation. Nevertheless, baseline differences between the control and experimental group in terms of BMI and triceps skinfold thickness were small to trivial; furthermore, baseline risk of obesity and school-level prevalence of obesity were included as confounders in all analyses to reduce the possible effects of sampling bias. Next, information on adherence is not available, but the fact that the intervention was mandatory after enrolment underlined the importance of attending the predetermined program and guaranteed high attendance rates. Although additional PE lessons provided within this intervention were organised to take place immediately after the end of regular school hours, they were not integrated into an obligatory curriculum. Although this did not affect participation rates in the context of the study, it is acknowledged that this might raise additional implementation barriers (e.g., transportation issues) in other educational systems. Lastly, despite horizontally scaling up the intervention, it failed to collect other implementation outcomes across the schools and participation years.

Third, when evaluating HIIT intervention the lack of objective heart-rate assessment prevented precise load monitoring, and no data on perceived exertion apart from the verbal feedback received from children during the intervention was collected. Further, no information about the eating habits of the students was obtained from either group, nor was amount of PA outside the intervention collected, despite these being important factors affecting adolescents' muscular and CRF and body composition. Several other variables that impact fitness and adiposity were also not assessed. These include genetic disparities, epigenetics, endocrine impairments, sleep, infection, and socioeconomic determinants. Moreover, the advantages of HIIT programs targeting school-aged youth are well documented, but most of the evidence

comes from short-term, small-scale trials similar to this intervention. This is problematic because, low fitness levels and unfavourable trends in body composition during childhood and adolescence require long-term, scaled-up interventions that are capable of increasing levels of PA and consequently levels of physical fitness in populations across different strata of society. Also, data on socioeconomic status do not exist, and consequently no analyses based on economic differences were made. Lastly, although the Tanita analyser was used to estimate body fat in the study's sample, inconsistent evidence regarding the validity of this method prevented the study from confidently presenting body composition results although these data could have important implications for the lack of body composition findings. Children's hydration status influenced by time of day, food and drink consumed, previous exercise or menstrual cycle could obscure accurate and real results (153-160). Unfortunately, there were no strict pre-test requirements such as no food or drink for 4 hours before the test, no caffeine consumption within 12 hours of the test, and no vigorous exercise within 12 hours of the test. The reason for this was that children did other pre-planned activities such as participating in sports and school lunches, so asking them to comply with these requirements would not be sustainable.

6.3 Perspectives for future research

Important gaps in the evidence were uncovered by the publications included in this dissertation. For example, by conducting a meta-analysis, very few studies were identified that focused exclusively on decreasing sedentary behaviour, and studies that added a sedentary behaviour component when assessing a PA or fitness-oriented program rarely went beyond educational activities. Therefore, there is a clear need for more trials with a strict focus on sedentary behaviours, particularly trials that use innovative approaches aligned with the interests and routines of today's young people. Trials that will use an active approach when addressing sedentary behaviour instead of a passive approach where children passively learn why excessive sedentary behavior is not consistent with improving health. Innovative approaches aligned with interests and routines of today's young people could be using variable technology which reminds children when it is time to move, using social media platforms and using play as a means to get children moving. Unfortunately, no studies in which researchers evaluated the effectiveness of wearable technology (e.g., activity trackers) or smartphones in obesity management were found. More research on sedentary behaviour interventions is needed, including the use of wearable technologies as interventions. Preliminary evidence that

interventions that used screen-based technology have successfully reduced screen time is already available (161). Next, poor reporting on the dose of PA introduced by obesity management interventions precludes detecting a "best-buy" quantity of PA that would provide optimal effects with as little time and resources invested as possible. To enable dose–response analyses, a comprehensive assessment of PA and reporting PA in sufficient detail is needed. Although a number of studies were found that focused on disadvantaged children, very few researchers examined how the effectiveness of PA interventions varies across different socioeconomic strata. Direct comparisons across populations are warranted to allow tailoring interventions to specific groups of young people.

School-based PA interventions should focus on implementing large-scale, or scalable, population-based approaches. A lack of previously successful interventions in real-world settings restricted the fight against the childhood obesity pandemic. Most of the evidence comes from small-scale interventions that include a limited number of children and usually fail to cover a complete spectrum of subgroups of children stratified by different characteristics. Thus, evidence reporting on real-life effectiveness of PA interventions beyond well-controlled settings is lacking. Furthermore, when designing an intervention that strives for change in obesity prevalence among children and adolescents, long-lasting approaches should be a priority. Longer PA interventions can serve as an excellent means for reversing obesity cases, in addition to their preventive role. However, longitudinal approaches are closely related to funding. Therefore, money provided, especially by an organisation or government, should remain constant and carefully managed until the end of the period for which interventions are planned alongside other important components like time, infrastructure and facilities. In our case the intervention sustainability was affected by a short-term (1 year cut-back in funding). Barriers such as funding have been highlighted by implementation and scale-up scientists (40). This highlights the research importance of regularly collecting information about external context for implementation and documenting challenges and facilitators using common process evaluation metrics.

When implementing PA interventions, increasing the physical fitness of children and adolescents must be the main target because those interventions are not only a more effective solution for childhood obesity management, but also for CRF enhancement. A time-efficient strategy, such as HIIT, allows for concurrent health and educative outcomes, which appears to be an ideal approach for increasing the quality of PE delivered to youth.

6.4 Policy and practice recommendations

Policy and practice recommendations based on evidence from all three studies included in this dissertation are listed below.

1. This research highlights the public health importance of investing in scaling up school-based approaches to address the childhood obesity pandemic. It also highlights the importance of sustaining interventions over time to have a greater impact. This sustainability is supported by a number of factors but in this research we highlighted one factor, funding; specifically the negative impact of a decrease in funding on child obesity-related outcomes. Thus, models that ensure sustained funding over time need to be considered.
2. School based physical activity interventions are important but our research showed the importance of enhancing physical fitness as one component of a school-based approach to manage childhood obesity. Fitness-oriented interventions also enhance cardiorespiratory fitness which is considered to be an even more important modifiable risk factor compared to obesity for many non-communicable diseases.
3. Children and adolescents are usually more sensitive than adults to outside influences, thus management interventions based on changes in the child/adolescent's environment are particularly attractive for changing behavior in this age group to achieve population-based management of obesity. By providing time, facilities and equipment, program implementation is facilitated, with supportive school environment providing additional external motivation.

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References for Chapters 1, 2 and 6

Entries in this list pertain to Chapters 1, 2, and 6

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APPENDIX A
SUPPORTING INFORMATION FOR PUBLICATION 1

Appendix A1

List S1: Medline search strategy

1. exp Obesity/

2. obes*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

3. exp Body Weight/

4. body weight.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

5. exp Body Weight/ or exp Weight Gain/

6. exp Body Weight Changes/

7. exp Body Fat Distribution/

8. body fat distribution.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

9. exp Body Composition/

10. body composition.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

11. Body Mass Index/ or BMI.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

12. exp Body Mass Index/

13. (body adj2 mass).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

14. overweight*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

15. exp Overweight/

16. overeat*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

17. over eat$.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

18. weight.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

19. (body adj2 fat).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

20. exp Waist Circumference/

21. waist circumference.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

22. exp Skinfold Thickness/

23. skinfold thickness.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

24. skin fold*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

25. (body fat and percent$).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

26. exp Weight Loss/

27. weight loss.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

28. adipos*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

29. exp Adipose Tissue/

30. (weight adj1 (prevent$ or reduc$ or los$ or control$ or manage$)).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word,

keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

31. (body weights and measures).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

32. exp Schools/

33. school$.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

34. (class or classes or classroom*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

35. exp child/

36. child$.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

37. preteen$.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

38. school$.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

39. boy*1.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept

word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

40. girl$.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

41. kid*1.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

42. p?ediatric$.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

43. 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42

44. exp Exercise/

45. exercise$.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

46. physical activit*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

47. physical inactivity.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

48. motor activit*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism

supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

49. exp "Physical Education and Training"/

50. physical education.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

51. physical training.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

52. (life style or lifestyle or life-style).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

53. leisure activit$.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

54. leisure activities/ or exp recreation/ or exp relaxation/

55. exp Weight Lifting/

56. weight lift$.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

57. exp sports/

58. exp Exercise Therapy/

59. exercise therapy.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism

supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

60. (physical$ adj5 (fit$ or train$ or active$ or endur$)).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

61. (physic$ adj (activ$ or fit$)).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

62. (phys$ adj3 education).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

63. (exercise$ adj5 (train$ or physical$ or activ$)).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

64. (walk$ or jog$ or swim$ or weight lift$ or danc$ or aerobics sport$).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

65. cycle$.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

66. ((chair or sitting or car or automobile or auto or bus or indoor or indoor or screen or computer) adj2 time).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

67. sedentar*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

68. exp Sedentary Behavior/

69. seat*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

70. sedentary lifestyle.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

71. ((chair or sitting or car or automobile or bus or indoor or in-door or screen or computer) adj time).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

72. low energy expenditure.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

73. exp energy intake/ or exp caloric restriction/

74. (screen based entertainment or screen-based entertainment or screen time).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

75. exp screen time/

76. bed rest.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

77. sitting.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

78. stationary behaviour.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

79. stationary behavior.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

80. standing.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

81. reclin*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

82. recumben*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

83. lying.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept

word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

84. bout*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

85. television viewing.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

86. computer viewing.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

87. television game*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

88. computer game*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

89. video game*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

90. exp physical fitness/ or exp cardiorespiratory fitness/

91. physical fitness.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

92. ((physic* or strength* or resist* or circuit* or weight or aerob* or cross or endurance or structur*) adj3 train*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

93. (physical conditioning or fitness).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

94. musculoskeletal fitness.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

95. cardiovascular fitness.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

96. 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 55 or 56 or 57 or 58 or 59 or 60 or 61 or 62 or 63 or 64 or 65 or 66 or 67 or 68 or 69 or 70 or 71 or 72 or 73 or 74 or 75 or 76 or 77 or 78 or 79 or 80 or 81 or 82 or 83 or 84 or 85 or 86 or 87 or 88 or 89 or 90 or 91 or 92 or 93 or 94 or 95

97. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31

98. 32 or 33 or 34

99. 43 and 96 and 97 and 98

100. limit 99 to yr="1994 -Current"

101. limit 100 to "all child (0 to 18 years)"

102. 100 not 101

103. exp Obesity/

104. obes*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

105. exp Body Weight/

106. body weight.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

107. exp Body Weight/ or exp Weight Gain/

108. exp Body Weight Changes/

109. exp Body Fat Distribution/

110. body fat distribution.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

111. exp Body Composition/

112. body composition.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

113. Body Mass Index/ or BMI.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

114. exp Body Mass Index/

115. (body adj2 mass).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism

supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

116. overweight*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

117. exp Overweight/

118. overeat*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

119. over eat$.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

120. weight.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

121. (body adj2 fat).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

122. exp Waist Circumference/

123. waist circumference.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

124. exp Skinfold Thickness/

125. skinfold thickness.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

126. skin fold*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

127. (body fat and percent$).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

128. exp Weight Loss/

129. weight loss.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

130. adipos*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

131. exp Adipose Tissue/

132. (weight adj1 (prevent$ or reduc$ or los$ or control$ or manage$)).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

133. (body weights and measures).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

134. exp Schools/

135. school$.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

136. (class or classes or classroom*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

137. exp child/

138. child$.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

139. preteen$.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

140. school$.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

141. boy*1.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

142. girl$.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

143. kid*1.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

144. p?ediatric$.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

145. 137 or 138 or 139 or 140 or 141 or 142 or 143 or 144

146. exp Exercise/

147. exercise$.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

148. physical activit*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

149. physical inactivity.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

150. motor activit*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

151. exp "Physical Education and Training"/

152. physical education.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism

supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

153. physical training.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

154. (life style or lifestyle or life-style).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

155. leisure activit$.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

156. leisure activities/ or exp recreation/ or exp relaxation/

157. exp Weight Lifting/

158. weight lift$.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

159. exp sports/

160. exp Exercise Therapy/

161. exercise therapy.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

162. (physical$ adj5 (fit$ or train$ or active$ or endur$)).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

163. (physic$ adj (activ$ or fit$)).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

164. (phys$ adj3 education).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

165. (exercise$ adj5 (train$ or physical$ or activ$)).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

166. (walk$ or jog$ or swim$ or weight lift$ or danc$ or aerobics sport$).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

167. cycle$.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

168. ((chair or sitting or car or automobile or auto or bus or indoor or indoor or screen or computer) adj2 time).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

169. sedentar*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

170. exp Sedentary Behavior/

171. seat*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

172. sedentary lifestyle.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

173. ((chair or sitting or car or automobile or bus or indoor or in-door or screen or computer) adj time).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

174. low energy expenditure.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

175. exp energy intake/ or exp caloric restriction/

176. (screen based entertainment or screen-based entertainment or screen time).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

177. exp screen time/

178. bed rest.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

179. sitting.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary

concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

180. stationary behaviour.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

181. stationary behavior.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

182. standing.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

183. reclin*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

184. recumben*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

185. lying.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

186. bout*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

187. television viewing.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

188. computer viewing.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

189. television game*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

190. computer game*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

191. video game*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

192. exp physical fitness/ or exp cardiorespiratory fitness/

193. physical fitness.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

194. ((physic* or strength* or resist* or circuit* or weight or aerob* or cross or endurance or structur*) adj3 train*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

195. (physical conditioning or fitness).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

196. musculoskeletal fitness.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

197. cardiovascular fitness.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

198. 146 or 147 or 148 or 149 or 150 or 151 or 152 or 153 or 154 or 155 or 156 or 157 or 158 or 159 or 160 or 161 or 162 or 163 or 164 or 165 or 166 or 167 or 168 or 169 or 170 or 171 or 172 or 173 or 174 or 175 or 176 or 177 or 178 or 179 or 180 or 181 or 182 or 183 or 184 or 185 or 186 or 187 or 188 or 189 or 190 or 191 or 192 or 193 or 194 or 195 or 196 or 197

199. 103 or 104 or 105 or 106 or 107 or 108 or 109 or 110 or 111 or 112 or 113 or 114 or 115 or 116 or 117 or 118 or 119 or 120 or 121 or 122 or 123 or 124 or 125 or 126 or 127 or 128 or 129 or 130 or 131 or 132 or 133

200. 134 or 135 or 136

201. 145 and 198 and 199 and 200

202. limit 201 to "child (6 to 12 years)"

203. limit 202 to yr="1994 -Current"

204. 102 or 203

Appendix A2

List S2: Studies included in and excluded from the quantitative synthesis

Studies included in the quantitative synthesis

1. Adab P, Pallan MJ, Cade J, et al. Preventing childhood obesity, phase II feasibility study focusing on South Asians: BEACHeS. BMJ Open. 2014;4(4).

2. Adab P, Pallan MJ, Lancashire ER, et al. Effectiveness of a childhood obesity prevention programme delivered through schools, targeting 6 and 7 year olds: Cluster randomised controlled trial (WAVES study). BMJ (Online). 2018;360.

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8. Annesi JJ, Walsh SM, Greenwood BL, Mareno N, Unruh-Rewkowski JL. Effects of the Youth Fit 4 Life physical activity/nutrition protocol on body mass index, fitness and targeted social cognitive theory variables in 9- to 12-year-olds during after-school care. J Paediatr Child Health. 2017;53(4):365-373.

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Appendix A3

Table S1: Characteristics of included and excluded studies

Studies included in the quantitative synthesis

Authors and year		Adab et al. 2014
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	4 schools in the intervention group and 4 schools in the control group
	Follow-up	1 year follow-up
	Country	UK
	Period	2007/2008
Participants	Number of participants at baseline and follow-up (intervention/control)	269 individuals in the intervention group and 305 individuals in the control group at baseline; 234 individuals in the intervention group and 254 individuals in the control group at follow-up
	Age	6-8 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity- predominantly South Asian; Socio-economic status- had a higher proportion of children eligible for free school meals (FSM), indicating higher deprivation.
Intervention	Description	The intervention targeted both diet and physical activity behaviours and consisted of two main strands: (1) increasing children's physical activity levels and promoting healthy eating through schools; a. 'Wake Up Shake Up': a short (10 min) organised daily dance or exercise routine to music. b. Organised playground activities at lunch and break times through the training of school staff to act as 'play leaders' c. 'Take 10': teaching resource which links 10 min physical activity in the classroom to curricular subjects

		d. Villa Vitality' day. Half the day is spent with Football Club coaches, exercising and learning football skills. (2) Increasing skills among family members through family educational activities. (3) Community volunteers were recruited through schools to become trained walk leaders. Training was provided to equip volunteers to organise and lead walks in their local community.
	Duration of intervention	12-months
	Frequency of PA	Not specified.
	Duration of PA	>50 min/week
	Intensity of PA	Not specified.
	Type of PA	/
	Parent involvement	Five-week courses on healthy cooking were delivered through schools to parents or other family members. Parents were given information on local sporting and leisure venues and events. They were invited to attend weekend taster sessions with their children, through school.
	Setting	School + community
	Who delivered the intervention	Trained school staff (including teachers, teaching assistants or lunch time assistants).
	Theoretical framework	Analysis Grid for Environments Linked to Obesity (ANGELO framework).
	Control	Not specified.
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI z-score (UK 1990 growth reference charts); physical activity (accelerometry); food intake (food diary analysis programme)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Adab et al. 2018
Methods and setting	Study design	Cluster RCT

	Unit of allocation	School
	Number of clusters	26 schools in the intervention group and 28 schools in the control group
	Follow-up	3 months post-intervention and 18 months post-intervention
	Country	UK
	Period	Recruitment took place between April and May 2011 (group 1 schools and pupils) and from January to May 2012 (group 2 schools and pupils); 2.5 years intervention
Participants	Number of participants at baseline and follow-up (intervention/control)	1134 individuals in the intervention group and 1328 individuals in the control group at baseline; 660 individuals in the intervention group and 732 individuals in the control group at follow-up
	Age	6-7 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity- Caucasian; Socio-economic status- The region includes a multi ethnic population from diverse socioeconomic backgrounds living in rural and urban areas.
Intervention	Description	The intervention programme comprised four overlapping components:(1) Thirty minutes of additional moderate to vigorous physical activity on each school day—at least 15 minutes to be outside of break times, although class teachers customised timing of delivery and exact activities undertaken according to their class circumstance (2) Termly cooking workshops during school time, which parents were invited to attend to participate in with their child and that were preceded by short classroom sessions for the children 3) A six week programme (Villa Vitality) developed to encourage healthy eating and increase physical activity and delivered by staff from an iconic sporting institution. School classes spent two days undertaking activities (indoor based movement routines, using dance mats, ball skills session, interactive nutritional sessions, and an opportunity to practise cooking skills) at an English premier league football club (4) Information sheets signposting children and their families on ways to be active over the summer (identical for all schools) and physical activity opportunities in their local area
	Duration of intervention	12-months
	Frequency of PA	5 times/week (every school day).
	Duration of PA	150 min/week.

	Intensity of PA	Not specified.
	Type of PA	Designed PA programs: Wake Up Shake Up (involves children following aerobic-type activity routines (5–10 minutes) to music (shown on a self-explanatory DVD)); Activate (involves progressive repeated patterns of movement to music); Positive Play (a resource designed to be used during school playtimes); Fit to Succeed (a resource that provides ideas with easy-to-follow guidance on how to incorporate 10- to 15-minute bursts of PA into a child's school day)
	Parent involvement	Yes, via school events and information sheets
	Setting	School
	Who delivered the intervention	Class teachers, teaching assistants or lunchtime supervisors (depending on school).
	Theoretical framework	Not specified.
	Control	Regular curriculum
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI z-score; body fat (BIA and sum of 4 skinflds); diet, physical activity and blood pressure (measured)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Aguilar et al. 2010
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	10 schools in the intervention group and 10 schools in the control group
	Follow-up	Post-intervention and at the half time during intervention
	Country	Spain
	Period	2004-2006
Participants	Number of participants at baseline and follow-up (intervention/control)	513 individuals in the intervention group and 606 individuals in the control group at baseline; 375 individuals in the intervention group and 546 individuals in the control group at follow-up
	Age	9-11 years

	Sex	Both boys and girls
	Other characteristics	Socio-economic status-main economic activities of population-farming, food processing and mechanical industries
Intervention	Description	After-School PA consisted of 3 weekly 90-minute sessions per week, during approximately 28 weeks every year. The physical activity sessions were planned by 2 qualified physical education teachers and were supervised by sports instructors.
	Duration of intervention	28 weeks/year (2 academic years)
	Frequency of PA	3 times/week
	Duration of PA	270 min/week
	Intensity of PA	LPA to MPA
	Type of PA	The activities included sports with alternative equipment (pogo sticks, frisbees, jumping balls, small parachutes, etc.), cooperative games, dance, and recreational athletics.
	Parent involvement	No
	Setting	School
	Who delivered the intervention	2 qualified physical education teachers
	Theoretical framework	Not specified
	Control	Regular school activities
	Intervention fidelity	The children attended 78.4% of the sessions in the first year and 71.6% of the sessions in the second year. Each student participated in an average of 54 physical activity sessions in the first year and in 57 sessions in the second year.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time,	BMI; %body fat (BIA, skinfolds); prevalence of overweight and obesity (IOTF)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Agurto et al. 2018
Methods and setting	Study design	Non-RCT

	Unit of allocation	Child
	Number of clusters	/
	Follow-up	Only post-intervention
	Country	Chile
	Period	NR
Participants	Number of participants at baseline and follow-up (intervention/control)	76 individuals in the intervention group and 77 individuals in the control group at baseline and at follow-up
	Age	8.4+-0.7 years
	Sex	Both boys and girls
	Other characteristics	/
Intervention	Description	A HIIT program was applied in Physical Education classes. The HIIT program was executed under the 30 ’x 1’ x 10 mode, that is, 30 seconds of intense exercise followed by 1 minute of passive rest, repeated 10 times.
	Duration of intervention	12-weeks
	Frequency of PA	2 times/week.
	Duration of PA	30 minutes/week
	Intensity of PA	High intensity (vigorous).
	Type of PA	Chase games, speed races and jump rope.
	Parent involvement	No.
	Setting	School.
	Who delivered the intervention	PE teachers.
	Theoretical framework	Not specified.
	Control	Regular school activities.
	Intervention fidelity	Those students who were not able to perform some type of physical activity and who missed more than 3 exercise sessions were excluded from the sample.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI z-score (WHO); %body fat (BIA); functional capacity (6 min test)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Alvirde-García et al. 2013
Methods and setting	Study design	Cluster RCT
	Unit of allocation	Community
	Number of clusters	1 community in the intervention group and 1C in the control group; 2 schools in the intervention group and 3 schools in the control group
	Follow-up	Only post-intervention
	Country	Mexico
	Period	2007-2010
Participants	Number of participants at baseline and follow-up (intervention/control)	1927 individuals in the intervention group and 755 individuals in the control group at baseline; 816 individuals in the intervention group and 408 individuals in the control group at follow-up
	Age	9.0+-1.7 years
	Sex	Both boys and girls
	Other characteristics	Semi-rural relations; 40% and 34% OW+OB at baseline
Intervention	Description	The CATCH program includes the modification of the school curriculum, changes in cooperatives, increased physical activity and exercises with the family. The proposals of the CATCH program on physical activity include organized actions that promote recreation in order to reach pre-established levels of moderate PA at vigorous during the break, in PE classes and in extracurricular actions (including exercise with the family).
	Sedentary time, physical activity or both	Not specified.
	Duration of intervention (months or weeks)	36-months
	Frequency of PA	Not specified.
	Duration of PA	Not specified.
	Intensity of PA	Not specified.
	Type of PA	Not specified.
	Parent involvement	Parents' society participated in meetings
	Setting	School.
	Who delivered the intervention	Not specified.
	Theoretical framework	Not specified.
	Control	Not specified.
	Intervention fidelity	Not specified.

Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time,	BMI
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Anderson et al. 2016
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	30 schools in the intervention group and 30 schools in the control group
	Follow-up	Post-intervention and 1 year after the immediate assessment
	Country	UK
	Period	2011
Participants	Number of participants at baseline and follow-up (intervention/control)	1064 individuals in the intervention group and 1157 individuals in the control group
	Age	9-10 years
	Sex	Both boys and girls
	Other characteristics	/
Intervention	Description	The AFLY5 intervention is a school based intervention that aims to increase children's self-efficacy and knowledge, together with motivating parents, to increase children's levels of physical activity, reduce sedentary behaviour, and increase consumption of fruit and vegetables. The intervention consists of 16 lessons, 10 homeworks, and school newsletter inserts. It is taught in normal lesson time, by the school teacher. Lessons include fitness measurements, safe workout instructions, nutrition education and analysis of TV time. The 16 lesson included 9 that were primarily related to how to be more active and less sedentary and why this was important, 6 to healthy nutrition and how to achieve this and 1 about reducing screen viewing
	Duration of intervention	12-months
	Frequency of PA	/
	Duration of PA	/.

	Intensity of PA	/
	Type of PA	/
	Parent involvement	Yes. Child-parent interactive homework plans, written materials for parents. The homework activities were designed to involve parents and other family members in the behavioural change process by reinforcing the messages delivered during lessons. The homework included activities such as "Freeze my TV," in which a time/programme normally spent watching television would be replaced with physically active play involving the parents and other family members that the child would write a log about.
	Setting	School.
	Who delivered the intervention	Teachers.
	Theoretical framework	Social Cognitive Theory.
	Control	No intervention
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	Moderate to vigorous physical activity per day (accelerometer); minutes of sedentary behaviour per day (accelerometer) and reported daily consumption of servings of fruit and vegetables
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Angelopoulos et al. 2009
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	13 schools in the intervention group and 13 schools in the control group
	Follow-up	Only post-intervention
	Country	Greece
	Period	January 2005 – January 2006
Participants	Number of participants at baseline and follow-up (intervention/control)	321 individuals in the intervention group and 325 individuals in the control group at baseline and at follow-up
	Age	10-11 years
	Sex	Both boys and girls

	Other characteristics	Greek children
Intervention	Description	A 12-month intervention programme was integrated in the existing school curriculum; primarily combined with Physical Education (PE) and Science and Environmental classes providing the less possible disturbance. The themes covered were self-esteem, body image, nutrition, physical activity, fitness and environmental issues. The material was implemented for 1–2 h per week. Several motivational methods and strategies were used for increasing knowledge (i.e. discussion, active learning, cues), increasing skills and self- efficacy (i.e. modelling, guided practice, enactment), achieving better self-monitoring (i.e. problem solving, goal setting), changing attitudes and beliefs (i.e. self-re-evaluation, environmental re-evaluation, arguments, modelling, direct experience) and changing social influence (i.e. modelling, mobilizing social support). Special emphasis was placed on increasing children's fun and excitement for exercise. This was achieved by children's participation in two 45-min PE sessions per week (a total of about 60 classes per year) which were delivered in the playground. The sessions were enjoyable, fitness-oriented (rather than motor-oriented) and of moderate intensity; Playgrounds and school yards were accessible for children to play after the end of the curricular programme
	Duration of intervention	12-months
	Frequency of PA	2 times/week.
	Duration of PA	90 min/week.
	Intensity of PA	MPA
	Type of PA	Enjoyable, fitness-oriented (rather than motor-oriented) activities.
	Parent involvement	Yes. Invited to meetings and advised to support their children in being physically active rather than to encourage sedentary behaviours.
	Setting	School.
	Who delivered the intervention	Trained school teachers.
	Theoretical framework	Theory of Planned Behaviour.
	Control	Not specified.
	Intervention fidelity	Parental attendance at the meetings was high with a mean rate of 86%
Outcomes	State the outcome and the method of assessment	BMI z score (CDC); The 24-h recall technique was used to collect dietary intake information for two consecutive week days and one weekend day;

	weight related outcomes, PA, fitness, sedentary time,	Physical activity during leisure time (standardized questionnaire completed by the children for two consecutive weekdays and one weekend day); blood pressure (measured)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Annesi et al. 2015
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	5 schools in the intervention group and 4 schools in the control group
	Follow-up	Post-intervention and at the half time during intervention
	Country	USA
	Period	/
Participants	Number of participants at baseline and follow-up (intervention/control)	72 individuals in the intervention group and 42 individuals in the control group at baseline and at follow-up
	Age	7.2+-1.1 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity-11.4 % White, 75.4 % African-American, 11.4 % Hispanic; Socio-economic status-median family income of US$62,200 was moderate
Intervention	Description	After-school PA program consisted of the daily sessions: -5 min: active warm-up and focus upon a specific movement for the week (e.g., skipping) – 10 min: the day's assigned "high-intensity activity" – 10 min: alternate days of either a "behavioural topic" (e.g., "positive self-talk") or "health topic" (e.g.,"what is a grain?") – 10 min: "content reinforcement" activity where the day's behavioural or health topic was bolstered by a structured physical activity (e.g., complete an assigned physical movement when a whole- vs. refined-grain food is named by a counsellor) – 10 min: "go-to game" consisting of a moderate- to high-intensity game selected by the counsellor from

		an approved list
	Duration of intervention	24-weeks
	Frequency of PA	4 times/week
	Duration of PA	100 min/week
	Intensity of PA	MVPA
	Type of PA	Running games
	Parent involvement	Yes; Letters explaining what was recently emphasized within the program, and how it might be supported outside of school, were sent to parents/guardians weekly
	Setting	School
	Who delivered the intervention	Counsellors (rarely had any formal training in physical education or health education methods)
	Theoretical framework	Social Cognitive Theory
	Control	Unsupervised PA was offered to children for 120min/week
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; BMI percentile (CDC); Muscular strength (number of push-ups completed while maintaining a 3-s pace per repetition); Cardiovascular fitness (running and/or walking for as long a distance as possible over a period of 3 min); Exercise barriers self-efficacy (five-item version of the Exercise Barriers Self-Efficacy Scale for Children); Physical self-concept-five designated "behaviour" items of the Physical Self-Concept subscale (PSC) of the Tennessee Self-concept Scale
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Annesi et al. 2016
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	Multiple sites
	Follow-up	At the half time during intervention and 3 months after intervention
	Country	USA
	Period	NR

Participants	Number of participants at baseline and follow-up (intervention/control)	86 individuals in the intervention group and 55 individuals in the control group at baseline and at follow-up
	Age	10.0+-0.9 years (9-12)
	Sex	Both boys and girls
	Other characteristics	Ethnicity- 31% White, 65% Black and 4% other; Socio-economic status- average
Intervention	Description	Daily lessons consisted of (i) a warmup of light movement and stretching (5 min), (ii) moderate-to vigorous physical activities via an assortment of structured tag, ball and mobility games and tasks (30 min) and (iii) self-management/self-regulatory skills or nutrition education where topics such as productive self-talk, recruiting social supports and the goal setting-progress feedback process were taught and reviewed, and information on healthy nutrition and hydration was supported by brief lectures and posters (10 min on alternate days).
	Duration of intervention	24-weeks
	Frequency of PA	4 times/week
	Duration of PA	180 min/week
	Intensity of PA	MVPA
	Type of PA	Cardiovascular activities were emphasised throughout the physical activity components, with body-weight resistance occasionally interspersed. Games and tasks were intended to be inclusive of deconditioned children by, for example, ensuring that the requisite physical skills to complete scheduled activities were manageable, avoiding elimination of participation from games because of lesser athleticism, and fostering an internal competition based on personal long-term goals (e.g. 'improve my endurance to be better at basketball') and short-term progress on those goals.
	Parent involvement	One-page letters were periodically sent or emailed to parents/guardians informing them of topics covered within Youth Fit 4 Life, and how they could support their child's physical activities (e.g. participating in physical activities with them; encouraging their being physically active every day) and healthy eating (e.g. providing foods and snacks that are consistent with government recommended nutritional standards; modelling and encouraging healthy selections when eating outside of the home).

	Setting	School
	Who delivered the intervention	Study staff, care counsellors
	Theoretical framework	Social Cognitive Theory
	Control	Regular programme
	Intervention fidelity	Study staff conducted structured fidelity checks during approximately 10% of sessions. Minor deviations from the required protocol were typically corrected through direct interactions between the study staff and after-school care counsellors
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; self-regulation for physical activity (five items); overall negative mood (6-items); exercise self-efficacy (The Exercise Barriers Self-Efficacy Scale for Children); cardiovascular endurance (walking or running for 3 min); muscle strength (push-ups while maintaining 3-s pace)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Aparco et al. 2017
Methods and setting	Study design	Non-RCT
	Unit of allocation	Education institutions
	Number of clusters	2 in the intervention group and 2 in the control group
	Follow-up	Only post-intervention
	Country	Peru
	Period	2008-2009
Participants	Number of participants at baseline and follow-up (intervention/control)	477 individuals in the intervention group and 377 individuals in the control group at baseline; 414 individuals in the intervention group and 282 individuals in the control group at follow-up
	Age	7.4 years
	Sex	Both boys and girls
	Other characteristics	/
Intervention	Description	1) Five educational sessions (three of healthy eating and two of physical activity) were developed. The structure of the session included the initial stage, in which educational materials (food models, sports and recreational equipment) were used for the collection of previous

		knowledge; then, the development of the contents (through the puppet theatre with scripts based on a pedagogical design that addressed the competencies of each session) and the closure (where the evaluation of learning and experiential activity was developed). The whole process lasted 50 min. The educational session was developed for each grade and section in each of the classrooms, with a monthly periodicity (except July and August for school holidays). 2) Physical activity component: Training of physical education teachers to develop classes with motivational and inclusive activities that allow all students to participate in physical activation. Identify "opportunities" to develop physical activity and provide sports equipment to develop physical activation. Twice a week a nutritionist and an educator visited the intervention school to develop a physical activation session during recess. For this, the physical activity kit was available to students and routines and contests were organized in the area of courtyard. 3) Dissemination of the health food standard in the school kiosk to food and beverage vendors within EI, as well as teachers and parents.
	Duration of intervention	8-months
	Frequency of PA	2 times/week.
	Duration of PA	Not specified
	Intensity of PA	Not specified.
	Type of PA	Not specified.
	Parent involvement	Yes, home visits with educational activities
	Setting	School + Home
	Who delivered the intervention	PE teachers, nutritionist and an educator, school agents of healthy eating.
	Theoretical framework	Not specified.
	Control	Not specified.
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI-z-score (WHO); WC (measured); OW and OB prevalence (WHO); nutrition and food (questionnaire); physical activity (questionnaire)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Azevedo et al. 2014
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	5 schools in the intervention group and 2 schools in the control group
	Follow-up	1 year
	Country	England
	Period	September 2010-March 2012
Participants	Number of participants at baseline and follow-up (intervention/control)	280 individuals in the intervention group and 217 individuals in the control group at baseline; 242 individuals in the intervention group and 203 in the control group at follow-up
	Age	11-13 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity – Caucasian
Intervention	Description	Dance mat systems were with the aim of promoting an innovative opportunity for physical activity. Apart from the initial 6 weeks when there was a more structured delivery of dance mats into the curriculum, intervention schools had the freedom to use the dance mats in whatever way they wanted. However, the local authority team who supported the implementation of the dance mats suggested that schools consider using them in scheduled physical education classes, during breaks and lunchtimes, and also outside of school hours as part of 'enrichment' activities. Records showed that the mats were mostly used during PE lessons and lunch time, but the use was very inconsistent and dropped over time.
	Duration of intervention	about 14 –months
	Frequency of PA	Not specified.
	Duration of PA	Not specified
	Intensity of PA	Not specified
	Type of PA	Exergame (exercise game).
	Parent involvement	No.
	Setting	School
	Who delivered the intervention	Teachers
	Theoretical framework	None.

	Control	Regular school programme
	Intervention fidelity	Contextual issues in the introduction of the dance mats moderated the overall intensity of effects downwards because of declining support for the initiative
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	Physical activity- (accelerometer); BMI; %body fat (DXA); aerobic fitness (20-m multistage shuttle run test); health-related quality of life (Kidscreen questionnaire); self-efficacy (children's physical activity self-efficacy survey); school attendance, focus groups with children and interviews with teachers were collected
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Bacardi-Gascon et al. 2012
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	2 schools in the intervention group and 2 schools in the control group
	Follow-up	Only-post intervention
	Country	Mexico
	Period	2008-2010
Participants	Number of participants at baseline and follow-up (intervention/control)	280 in the intervention group and 252 in the control group at baseline; 256 in the intervention group and 222 in the control group at follow-up
	Age	8.5±0.73 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity-Hispanic
Intervention	Description	The classroom curricula for 2nd and 3rd grades were designed to promote healthful eating behaviours and to increase physical activity. One 30-min interactive lesson was delivered by nutrition graduate students each week for 8 weeks during the academic year.
	Duration of intervention	Not specified
	Frequency of PA	Not specified
	Duration of PA	Not specified
	Intensity of PA	Not specified
	Type of PA	Not specified

	Parent involvement	Yes, 60-minute session delivered by nutrition professionals each month for 4 months
	Setting	School
	Who delivered the intervention	Nutrition graduate students
	Theoretical framework	Bronfenbrenner's Ecological Model
	Control	Not specified
	Intervention fidelity	Not reported.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time,	BMI; BMI z scores (WHO(2007) LMS parameters for sex and age); WC (measured); food inventory (questionnaire); Physical activity (self-reported questionnaire)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Balas-Nakash et al. 2010
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	1 schools in the intervention group and 1 schools in the control group
	Follow-up	Only post-intervention
	Country	Mexico
	Period	2008
Participants	Number of participants at baseline and follow-up (intervention/control)	179 individuals in the intervention group and 140 individuals in the control group; 105 (33%) dropped out at follow-up
	Age	8-12 years
	Sex	Both boys and girls
	Other characteristics	Socio-economic status-medium SES
Intervention	Description	Intervention compared the effects of two groups of exercise routines on cardiovascular disease risk markers. Routine A was the reference group, with 20 min of less intense activity and routine B was the new group with 40 min of aerobic exercises. Both routines included an initial-phase with warm-up exercises, a middle-phase with aerobic exercises and a final-phase for relaxation, in accordance with national guidelines.
	Duration of intervention	12-weeks

	Frequency of PA	5 times/week
	Duration of PA	200 min/week
	Intensity of PA	MVPA
	Type of PA	Aerobic exercises
	Parent involvement	No
	Setting	School
	Who delivered the intervention	PE teachers
	Theoretical framework	Not specified
	Control	100 min/week (less intense activity)
	Intervention fidelity	Not reported.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; WC (measured); %body fat (BIA); prevalence of overweight and obesity (CDC); physical fitness (PA questionnaire); biochemical measurements and blood pressure (measured);
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Benjamin et al. 2015
Methods and setting	Study design	Non-RCT
	Unit of allocation	Community
	Number of clusters	1 community in the intervention group and 1 community in the control group – 2 private and 2 public schools in each community
	Follow-up	6 months after the intervention
	Country	US
	Period	Summer 2011 – spring 2012
Participants	Number of participants at baseline and follow-up (intervention/control)	64 individuals in the intervention group and 40 individuals in the control group at baseline; 34 individuals in the intervention group and 18 in the control group at follow-up
	Age	7.8 (1.8) I; 8.3 (1.9) C
	Sex	Both boys and girls
	Other characteristics	Ethnicity- White intervention mean 49 (SD 76.6) control 34 (85.0), African American intervention 12 (18.8) control 5 (12.5), Other

		intervention 3 (4.7) control 1 (2.5), Hispanic or Latino/a intervention 4 (6.3) control 0 (0.0) Household income, yearly : <30000$ (mean 11 (SD 15.2) in the intervention group and 14 (35) in the control group); 30001-90000% (27 (42.2) in the intervention and 20 (50) in the control); >90001$ (26 (40.6) in the intervention and 6 (15) in the control)
Intervention	Description	The Mebane on the Move volunteers promoted PA through walking and running clubs in the elementary schools for children and in the community for families, Participating students in kindergarten through fifth grade run after school, learn about the components of a healthy lifestyle, and earn prizes for increasing their mileage; portable play equipment was provided to low-income families through home delivery food assistance programs, and sidewalks, crosswalks, and walking trails were installed throughout town; free community exercise programs were offered to children and adults at the recreation centre.
	Duration of intervention	6-months
	Frequency of PA	Not specified.
	Duration of PA	Not specified.
	Intensity of PA	Not specified.
	Type of PA	Walking and running.
	Parent involvement	Yes, via community exercise programs and play equipment
	Setting	School and community.
	Who delivered the intervention	Business leaders, faith communities, schools, government officials, and local health professionals trough community.
	Theoretical framework	Socioecological model.
	Control	No intervention
	Intervention fidelity	Some crosswalks and bike lanes were not installed owing to funding limitations and problems obtaining approval from the state department of transportation, and improvements to park equipment and greenery were not implemented due to funding constraints.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	Physical activity (accelerometer ActiGraph); BMI z-score (CDC)

Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Barbeau et al. 2007
Methods and setting	Study design	RCT
	Unit of allocation	Child
	Number of clusters	/
	Follow-up	Only post-intervention
	Country	USA
	Period	NR
Participants	Number of participants at baseline and follow-up (intervention/control)	278 at baseline; 118 individuals in the intervention group and 83 individuals in the control group at follow-up
	Age	8-12 years (mean=9.5)
	Sex	Girls only
	Other characteristics	Ethnicity-black
Intervention	Description	The intervention consisted of 30 minutes of homework time during which the subjects were provided with a healthy snack free of charge, and 80 minutes of PA. The PA component included 25 minutes of skills development (e.g., how to dribble a basketball), 35 minutes of MVPA, and 20 minutes of toning and stretching.
	Sedentary time, physical activity or both	PA
	Duration of intervention	10-months
	Frequency of PA	5 time/week
	Duration of PA	400 min/week
	Intensity of PA	MVPA (175 min/week)
	Type of PA	Regular PE activities
	Parent involvement	No
	Setting	School
	Who delivered the intervention	Teachers
	Theoretical framework	Not specified
	Control	Not specified
	Intervention fidelity	Not specified

Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; WC (measured); %body fat (DXA); CV fitness (was assessed using a multistage treadmill test); Free-living PA (was measured using a 7-day recall)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Bhave et al. 2016
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	1 schools in the intervention and control group and 1 school in the control group only
	Follow-up	Only post-intervention
	Country	India
	Period	2005/2006 – 2010/2011
Participants	Number of participants at baseline and follow-up (intervention/control)	375 individuals in the intervention group, 209 in the control group 1 and 374 in the control group 2 at baseline; 304 in the intervention group, 187 in the control group 1 and 374 in the control group 2 at follow-up
	Age	from 7-10 years until 12-15 years of age and children 12-15 years at the start of a study
	Sex	Both boys and girls
	Other characteristics	Ethnicity-Indian; Socio-economic status-"The Symbiosis School in Pune caters to children from high socioeconomic background and has a strong academic reputation."
Intervention	Description	A 5-year multi-intervention programme, covering three domains: physical activity, diet and general health, and including increased extra- and intra-curricular physical activity sessions; daily yoga-based breathing exercises; increasing PE sessions to 6/week and making PE a 'scoring' subject; offering attractive physical activity sessions (e.g., 'Bollywood dancing') during holidays; nutrition education; healthier school meals; fast-food seller were banned from outside the school gates. It aimed to introduce a health education programme about the

		importance of diet for health, activity and lifestyle, with weekly age-appropriate interactive 1-h sessions was introduced
	Duration of intervention	60-months
	Frequency of PA	6 times/week
	Duration of PA	240min/week
	Intensity of PA	Not specified.
	Type of PA	Daily yoga-based breathing exercises (‘pranayama’), and attractive physical activity sessions. Fitness modules were introduced to PE curriculum
	Parent involvement	Parents received regular fitness reports and opportunities to discuss these individually with nutritionists and doctors
	Setting	School
	Who delivered the intervention	PE teachers; nutritionist
	Theoretical framework	Not specified.
	Control	Regular school activities.
	Intervention fidelity	Neither the weekly health education sessions, nor the science modules could be sustained because of academic pressures.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; WC (measured); physical fitness (simple tests of strength, flexibility and endurance); diet and lifestyle indicators -time watching TV, studying and actively playing (questionnaire)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Borrestad et al. 2012
Methods and setting	Study design	RCT
	Unit of allocation	Child
	Number of clusters	/
	Follow-up	Only post-intervention
	Country	Denmark
	Period	2010

Participants	Number of participants at baseline and follow-up (intervention/control)	26 individuals in the intervention group and 27 individuals in the control group at baseline; 24 individuals in the intervention group and 22 in the control group at follow-up
	Age	10.8+-0.7 years
	Sex	Both boys and girls
	Other characteristics	/
Intervention	Description	The cycling group was encouraged to cycle to and from school on each school day during a period of 12 weeks from March to May in 2010. The researcher primarily facilitated the intervention; however, school staff and a specialist in cycling safety and parents were also involved. The intervention programme was performed at school during school hours in group sessions every second week, resulting in a total of six group sessions. Each session lasted approximately 30 minutes. When motivating children to cycle to school the intervention focused on raising awareness, countering passive transport, and helping parents support. Moreover, the intervention focused on health benefits from physical activity, especially cycling, and also road safety issues, including cooperation with the Norwegian Council for Road Safety.
	Duration of intervention	12-weeks
	Frequency of PA	/
	Duration of PA	/
	Intensity of PA	/
	Type of PA	/
	Parent involvement	All parents/ guardians for the intervention group were invited to a session at baseline focusing on information and encouraging cycling to school. Furthermore, all parents/guardians for the whole study group (intervention and control group) received four letters throughout the study providing information about the study.
	Setting	School
	Who delivered the intervention	Researcher, school staff, specialist in cycling
	Theoretical framework	Not specified
	Control	Regular school activities
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment	BMI; Prevalence of overweight (IOTF); Cardio respiratory fitness (electronically braked cycle ergometer (Monark 839 ergomedic))

	weight related outcomes, PA, fitness, sedentary time	
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Brandstetter et al. 2012
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	16 schools in the intervention group and 16 schools in the control group
	Follow-up	2 months follow-up
	Country	Germany
	Period	2006-2007
Participants	Number of participants at baseline and follow-up (intervention/control)	540 individuals in the intervention group and 579 individuals in the control group at baseline; 450 individuals in the intervention group and 495 in the control group at follow-up
	Age	7.6 +-0.4 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity- 30% migrants
Intervention	Description	The URMEL-ICE-intervention consists of material for 1 school year including 29 teaching units (each 30–60 min), 2 short blocks of physical activity exercises a day (each 5–7 min), 6 family homework lessons (tasks that cannot be accomplished by the child himself without the help of a parent) and materials for the training and information of the parents.
	Duration of intervention	10-months (1 school year)
	Frequency of PA	2 times/day
	Duration of PA	50-70 min/week
	Intensity of PA	Not specified
	Type of PA	Not specified
	Parent involvement	Yes, via 6 family homework
	Setting	School
	Who delivered the intervention	Classroom teachers
	Theoretical framework	Social Cognitive Theory
	Control	Not specified

	Intervention fidelity	75% teachers implemented two thirds or more of the required 29 teaching units over the intervention school year; on average 23.1 (SD = 6.3) teaching units were used
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; BMI z score (sex-specific BMI charts for Germany); WC (measured); body fat (subscapular and triceps skinfold); frequency of consuming sugar-sweetened beverages at school and at home, frequency of playing outdoors, frequency of participating in club sport and in other sport activity and time spent watching TV on weekdays and weekends (5-point Likert scale > parental questionnaires)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Breslin et al. 2012
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	12 schools in the intervention group and 12 schools in the control group
	Follow-up	Only post-intervention
	Country	Northern Ireland
	Period	September/October 2014 - January/February 2015
Participants	Number of participants at baseline and follow-up (intervention/control)	The sample for analysis contained 416 children; divided between the intervention schools (n=209) and the control schools (n=207); Mean (and SD) physical activity and sedentary accelerometer scores in minutes per day at baseline to follow-up – intervention n= 50, control n=34
	Age	8-9 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity- North Irish (Caucasian); Socio-economic status- lower socioeconomic backgrounds: Primary schools from areas of social and economic disadvantage were approached to participate in the study
Intervention	Description	Sport for LIFE (Sport is for Living, Integration, Fun and Education) is a 12-week physical activity and healthy eating programme. Purpose of the weekly sessions was increasing knowledge and understanding the benefits of regular participation in physical activity and sport and the

		importance of eating a healthy balanced diet. Each week for 1 hour, children were taught activities on the effects of physical activity on health, fun games for indoors and outdoors and nutrition The programme ended with a physical activity festival with an invited Olympic gold medal winning guest in attendance; this event was to enhance children's long term goals and motivation to be active.
	Duration of intervention	12-weeks
	Frequency of PA	/
	Duration of PA	/
	Intensity of PA	/
	Type of PA	/
	Parent involvement	No
	Setting	School.
	Who delivered the intervention	Sports outreach officers delivered the programme in partnership with the class teacher.
	Theoretical framework	Social Cognitive Theory.
	Control	Regular school activities.
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	Daily MVPA in the previous week (was measured using questions from the Health Behaviour in School-Aged Children (HBSC) survey); The KIDSCREEN-27 (Ravens-Sieberer et al., 2005) is a Health Related Quality of Life (HRQoL) measure which has previously been used to assess wellbeing
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Bumaryoum, 2015
Methods and setting	Study design	CBA
	Unit of allocation	School
	Number of clusters	7 schools in the intervention group and 6 schools in the control group
	Follow-up	Only post-intervention
	Country	USA
	Period	NR

Participants	Number of participants at baseline and follow-up	166 individuals in the intervention group and 88 individuals in the control group at baseline; 140 individuals in the intervention group and 76 individuals in the control group at follow-up
	Age	mean age=10.8 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity: Caucasian 82.9%, American Indian 6.7%, Asian 0.6%, African American 2.4% , Mexican American 4.3%, Other 3.0%; Urban/rural: 54.6% rural
Intervention	Description	KQ program; Teen teachers taught nutrition and physical activity lessons within five schools; SNAP-ED taught the nutrition lessons in two schools; The same curriculum was taught by both SNAP-ED and TT using hands on nutrition education and physical activities. The following topics were covered in the six lessons: (1) Introduction, Label Lingo and Think Your Drink, (2) Eating Out, Portion Sizes and Snacks, (3) Fruits and Veggies, (4) Grains and Breakfast, (5) Dairy Intake, (6) Consumer Connections, Median Messages and Wrap-up. A physical activity lesson was incorporated into all six sessions.
	Duration of intervention	4-6 months
	Frequency of PA	1-2x /month
	Duration of PA	10-15 min/session
	Intensity of PA	Not specified
	Type of PA	Not specified
	Parent involvement	Yes; via newsletters
	Setting	School
	Who delivered the intervention	Teen teachers (TT) and SNAP-ED educators
	Theoretical framework	Not specified
	Control	Regular activities, no education
	Intervention fidelity	Not reported
Outcomes		BMI cut-off (CDC); Blood pressure (OMRON Intelli Sense Digital BP Monitor); lipid levels cut-off -age specific standards set, haemoglobin - HemoCue Photometer Hb201+
Adverse outcomes		NR

Authors and year		Caballero et al. 2003
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	21 schools in the intervention group and 20 schools in the control group
	Follow-up	Only post-intervention
	Country	USA
	Period	NR
Participants	Number of participants at baseline and follow-up (intervention/control)	879 individuals in the intervention group and 825 individuals in the control group at baseline; 727 individuals in the intervention group and 682 individuals in the control group at follow-up
	Age	7.6 ± 0.6 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity-American Indian; 47% of the children in the intervention school - BMI greater than the 85th percentile of the Centres for Disease Control and Prevention's reference values and 48% of children in the control school - BMI exceeded this cut off at baseline
Intervention	Description	The intervention had 4 components: *1*) change in dietary intake, *2*) increase in physical activity, (a PE program implemented 3x/wk. for 30 min and based on the SPARK (Sports, Play and Active Recreation for Kids) program plus exercise breaks of 2–10 min in the classroom) *3*) A classroom curriculum focused on healthy eating and lifestyle (two 45-min lessons were delivered by teachers each week for 12 wk.) , and *4*) a family-involvement program.
	Duration of intervention	36 months
	Frequency of PA	3 times/week

	Duration of PA	90 min/week
	Intensity of PA	MPA or VPA
	Type of PA	Not specified
	Parent involvement	Yes
	Setting	School
	Who delivered the intervention	PE teachers
	Theoretical framework	Social learning theory
	Control	Regular school activities
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; body fat (skinfold); Physical activity (measured with the use of both a motion sensor and a self-reported activity questionnaire); knowledge, attitudes, and behaviours related to diet and physical activity (questionnaire); Food intake during school lunch (measured by direct observation)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Cao et al. 2015
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	7 schools in the intervention group and 7 schools in the control group
	Follow-up	First follow-up at 1st year (January 2012), second at 2nd year (January 2013) and third at 3rd year (January 2014)

	Country	China
	Period	2011-2014
Participants	Number of participants at baseline and follow-up (intervention/control)	965 individuals in the intervention group and 889 individuals in the control group at baseline; 985 individuals in the intervention group and 828 in the control group at last follow-up
	Age	7 +-0.4 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity-Asian
Intervention	Description	FIS-based comprehensive intervention model combined models of family- and school-based interventions and had three aspects: health knowledge, dietary behaviour, and exercise behaviour. Family-based PA: A strip of skipping rope provided to each student and appropriate level of physical activity at home supervised and monitored by parents. School-based PA: 20-meter music shuttle run 2–3 times per week; Ensure the participation rate of regular school physical education and extracurricular activities; More than 1-hour physical activity time each school day; Featured sports activities such as rope skipping and football. Health education: 6-hour health education course per semester. Dietary intervention: Teachers' control of eating speed for students during lunch and advice on eating less junk foods; Reducing fat content of food at canteens and making more fruits and vegetables available.
	Duration of intervention	33-months
	Frequency of PA	5 times/week
	Duration of PA	> 5 hours/week

	Intensity of PA	Not specified
	Type of PA	Shuttle run, sports activities(rope skipping and football)
	Parent involvement	Parents' participation of obesity prevention lectures. Instructions to parents about healthy eating habits of children. A strip of skipping rope provided to each student and appropriate level of physical activity at home supervised and monitored by parents. Parents' completion of "Students' Extracurricular Physical Activity Registration Form" during summer and winter vacations, including frequency, duration, intensity, and other information of physical activity.
	Setting	School, family
	Who delivered the intervention	Teachers and parents
	Theoretical framework	Not specified
	Control	Regular school activities
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI z-score (WHO); prevalence of overweight and obesity (China group for obesity standards)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Centis et al. 2012
Methods and setting	Study design	Non-RCT
	Unit of allocation (child, classroom, school…)	School

	Number of clusters	7 schools
	Follow-up	3 months
	Country	Italy
	Period	2008-2009
Participants	Number of participants at baseline and follow-up (intervention/control)	103 individuals in the intervention group and 106 in the control group at baseline; 98 in the intervention and 100 in the control group at follow-up
	Age	9.4+-0.4 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity-10% migrants
Intervention	Description	The intervention in the experimental arm was extended to include three fortnightly meetings with the children during curricular hours, by experts of the Faculty of Exercise and Sports Sciences, University of Bologna, specifically trained in the practice of physical activity in young children. Their intervention was finalized to implement new recreational physical activities to be performed in the course of the following weeks. Children were given step counters to stimulate and measure their daily activity. The nutritional intervention consisted in a meeting to stimulate children to the correct nutritional practice of breakfast. The meeting, conducted by a physician and an expert of motivational activities, consisted in a brief theoretical lesson and an active didactics, in which every child worked with food to prepare his/her own breakfast in a funny way.
	Duration of intervention	5-months
	Frequency of PA	Not specified
	Duration of PA	Not specified
	Intensity of PA	Not specified
	Type of PA	Not specified

	Parent involvement	Yes, three motivational meetings focusing on the benefits of healthy diet and physical activity. The parents were taught about the food pyramid, correct food choices and cooking, the advantages of physical activity, and the emotional aspects of food. The parents received weekly telephone calls for the first 4 months. The telephone contact with the parents allowed continuous check of ongoing habit changes(breakfast, snacks, fruit and vegetable consumption, meals composition, and physical activity).
	Setting	School + Home
	Who delivered the intervention	Teachers
	Theoretical framework	Not specified
	Control	Not specified
	Intervention fidelity	Not reported
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time,	BMI SDS (Italian reference); body fat (triceps skinfold); WC (measured)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Contardo Ayala et al. 2016
Methods and setting	Study design	Non-RCT
	Unit of allocation (child, classroom, school…)	Class
	Number of clusters	1 class in the intervention group and 1 class in the control group
	Follow-up	Only post-intervention

	Country	Australia
	Period	March – October 2016 (8 months)
Participants	Number of participants at baseline and follow-up (intervention/control)	20 individuals in the intervention group and 21 individuals in the control group at baseline; Valid activPAL data were obtained from 95% of the participants who wore the monitors in both groups at baseline, and 95% in the CC and 90% in the IV at follow-up. Additionally, valid ActiGraph data was obtained from 100% of the participants who wore the monitors in the CC and 95% in the IV at baseline, and 33% and 83% at follow-up, respectively. Anthropometric measures were obtained from 100% of participants at baseline and from 90% in the CC and 95% in the IV at follow-up. The musculoskeletal pain/discomfort questionnaire was answered by 95% in the CC and 100% in the IV at baseline and from all the participants at follow-up
	Age	11-12 years
	Sex	Both boys and girls
	Other characteristics	Australian children
Intervention	Description	Each participant in the intervention class was provided with a manually height-adjustable workstation (LearnFit Ergotron Pty Ltd., Sydney, Australia) that allowed them to complete classwork in either a seated or standing position. Original classroom chairs were replaced with stools (Furnwear Bodyfurn Lab stool, Melbourne, Australia) high enough to allow a comfortable seated position for all participants when the desk was lowered. Prior to commencement of the intervention, a professional development session was delivered to the teacher in the intervention classroom, adapted largely from the Transform-Us! program. The pedagogical strategies recommended that extended classroom teaching blocks (of at least 60 min) be interrupted every 30 min with a two-minute guided light-intensity active break from sitting (e.g., bean-bag throwing between students while spelling/counting in a standing position). The teacher also delivered 9 key messages in the curriculum about the importance of reducing sitting and increasing physical activity.

		In addition, the teacher was asked to deliver at least one 30-min standing lesson each day.
	Duration of intervention	8-months.
	Frequency of PA	/
	Duration of PA	/
	Intensity of PA	/
	Type of PA	Standing;
	Parent involvement	No.
	Setting	School
	Who delivered the intervention	Teachers.
	Theoretical framework	Not specified.
	Control	The control class followed standard pedagogical practice and retained traditional classroom furniture.
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time,	Physical activity (Children wore an activPAL inclinometer (PAL Technologies Ltd., Glasgow, UK) at the mid-point on the front of their right thigh during waking hours for eight consecutive days and ActiGraph GT3X accelerometer (ActiGraph LLC, Pensacola, FL, USA)); Systolic and diastolic BP (measurements were taken three times on the participant's right arm using an OMRON HEM-907 automatic digital blood pressure machine with a paediatric cuff); Children's height (measured to the nearest 0.1 cm using portable stadiometers), and their body mass was measured to the nearest 0.1 kg using portable calibrated electronic scales); WC (measured); BMI (kg/m2) and WC z-scores were calculated from raw anthropometric data using Stata functions (based on Cole (1990) method) [50]. Children's BMI was categorised according to the International Obesity Task Force definition of healthy weight or

		overweight/obese; Questions related to the perception of musculoskeletal pain/discomfort
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		da Silva et al. 2013
Methods and setting	Study design	CBA
	Unit of allocation	School
	Number of clusters	Individuals in the intervention group from 3 public schools and individuals in the control group from 7 public schools.
	Follow-up	Only post-intervention
	Country	Brazil
	Period	NR
Participants	Number of participants at baseline and follow-up (intervention/control)	108 individuals in the intervention group and 130 individuals in the control group at baseline; 80 individuals in the intervention group and 122 in the control group at follow-up
	Age	6-11 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity – Brazilian
Intervention	Description	Two parallel activities comprised the program, one was nutritional education and the other was programmed physical activity. In addition to the activities of the intervention program, other complementary activities were developed involving students and family: a lecture on childhood obesity and two gymkhanas with games and play activities.

		The nutrition education occurred once a week for 50min duration. Eighteen topics were addressed and the curriculum included reinforcement activities about knowledge of food content and healthy nourishment. The content was delivered through talks, movies, ludopedagogical activities and snack preparation by the students. The students took part in extra classroom-structured physical activities twice a week (50 min each). The classes were designed by the Assistant Manager of Fitness from the Cooper Institute (Dallas, TX, USA) and were given by trained teachers. The classes were structured according to a previous plan, with several activities, with 10 min of warm-up, 20 min of cardiovascular activity, 15 min of muscle endurance work and 5 min of flexibility exercises.
	Duration of intervention	28-weeks
	Frequency of PA	2 times/week.
	Duration of PA	100 min/week.
	Intensity of PA	Not specified.
	Type of PA	Cardiovascular activity, muscle endurance and flexibility exercise.
	Parent involvement	No.
	Setting	School.
	Who delivered the intervention	Trained teachers.
	Theoretical framework	Not specified.
	Control	Regular school activities
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment	Body composition (skinfolds by means of a Lange adipometer (in the triceps area and on the calf) according to the manual for Fitnessgram/Activitygram); BMI (was evaluated using the 2007 World Health Organization growth curve as a reference); Physical activity (recall

	weight related outcomes, PA, fitness, sedentary time	questionnaire on recorded activities for every 30 min, between 0700 and 2200 of the previous day); fitness tests: PACER—progressive aerobic cardiovascular endurance run; the push-up test evaluates strength and resistance of the upper body muscles; the curl-up test evaluates abdominal strength and resistance; the back-saver sit and reach test evaluates flexibility.
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Deborah et al. 2018
Methods and setting	Study design	CBA
	Unit of allocation	School
	Number of clusters	1 intervention school and 1 control school
	Follow-up	Post-intervention
	Country	US
	Period	2012-2013
Participants	Number of participants at baseline and follow-up (intervention/control)	There were 130 fourth-grade youth at the control school and 174 fourth-grade youth at the intervention school who participated in the study. Of these participants, 92 youth (n=38 control; n=54 intervention) wore the Polar Active monitor for at least 2 days during both pre- and post-assessments and were included in the analyses.
	Age	9-10 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity – 37% of youth at the control school and 65% at the intervention school identified as non-white.

		Socio-economic status - "82% of parents at the control school and 91% at the intervention school had at least a high school degree or General Equivalency Development and household income was > $100,000 for 37% at the control school and 26% at the intervention school."
Intervention	Description	The goals of the SHCP included (1) increasing Five overlapping components comprised the SHCP: (1) nutrition education and promotion, (2) family and community partnerships, (3) supporting regional agriculture, (4) foods avail-able on the school campus, and (5) school wellness committees and policies. These components were addressed through the implementation of nutrition education, cooking demonstrations, school gardens, family newsletters, health fairs, salad bars, procurement of regional produce, and school-site wellness committees.
	Duration of intervention	9-months
	Frequency of PA	/
	Duration of PA	/
	Intensity of PA	/
	Type of PA	/
	Parent involvement	via family newsletters and health fairs.
	Setting	School.
	Who delivered the intervention	UCCE nutrition educator.
	Theoretical framework	Social-ecological model.
	Control	Regular programme.
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment	Physical activity (Polar Active monitors (Polar, Lake Success, NY))

	weight related outcomes, PA, fitness, sedentary time	
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		de Cruz et al. 2017
Methods and setting	Study design	Group RCT
	Unit of allocation	School
	Number of clusters	2 schools in the intervention group and 2 schools in the control group
	Follow-up	Only post-intervention
	Country	USA
	Period	School year 2014/2015 (not exactly reported)
Participants	Number of participants at baseline and follow-up (intervention/control)	Subsample of the GOTM study sample, 150 participants with 72 individuals in the intervention group and 78 individuals in the control group
	Age	12.1+-1.03 years
	Sex	Only girls
	Other characteristics	Ethnicity- The majority of guardians identified the participants as Black or African American (56.3%), followed by White or Caucasian and then Multi-Racial; Socio-economic status- The majority of participants were eligible for free and reduced lunch (81.4%)
Intervention	Description	Participants in the intervention groups received a comprehensive 17-week school-based intervention aimed at increasing participants' minutes of MVPA. The intervention group participated in an after-school PA club

		offered three days per week for 90 minutes each day. The club offers enjoyable PA designed to provide the girls with sixty minutes of MVPA and to help them improve PA skills.
	Duration of intervention	17-weeks
	Frequency of PA	3 times/week.
	Duration of PA	270 min/week.
	Intensity of PA	MVPA (180 min).
	Type of PA	1) Fun games (e.g. tag, kickball, boot camp stations, hula hoops, jump ropes, and capture the flag); 2) dance/aerobics (e.g. dance video games projected on a large screen, Zumba and other dance fitness routines, line dances popular among girls, aerobics, and Pilates); 3) walking or sport skills (e.g. soccer, basketball, volleyball, lacrosse, running, tennis, martial arts, track, floor hockey, badminton; ultimate disc).
	Parent involvement	No.
	Setting	School.
	Who delivered the intervention	Not specified.
	Theoretical framework	Not specified.
	Control	Regular school activities.
	Intervention fidelity	Participants in the GOTM afterschool program attended an average of 50.6% (26.28) of the 49-50 intervention sessions provided.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; %body fat (BIA)

Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		de Henauw et al. 2015
Methods and setting	Study design	Non-RCT
	Unit of allocation	Country with schools as the primary unit of selection; matched by size of the communities and the overall socio-demographic and socioeconomic profile of the populations
	Number of clusters	8 countries
	Follow-up	Only post-intervention
	Country	Multi- country (Sweden, Germany, Estonia, Hungary, Cyprus, Italy, Spain and Belgium)
	Period	2007-2010
Participants	Number of participants at baseline and follow-up (intervention/control)	8482 individuals in the intervention group and 7746 individuals in the control group at baseline; 5727 individuals in the intervention group and 5314 individuals in the control group at follow-up
	Age	6.0+-0.017 years
	Sex	Both boys and girls
	Other characteristics	/
Instagram	Description	IDEFICS intervention programme targeted diet, physical activity and stress-related lifestyle factors. Six intervention modules were targeting the children in the school environment (aimed at improving the food environment and physical activity opportunities and at educating children on a healthy lifestyle). This included health-related physical education curricula, creation of active playgrounds and classroom education on lifestyle.

		One complementary module was developed specifically for involving parents in the school interventions and for guiding them in their efforts to improve their children's lifestyle. Finally, three modules were designed to enhance awareness on healthy lifestyle in the community at large, to involve the local media and to start a process of public authorities-driven short-term and long-term changes in the community environment aimed at facilitating healthy lifestyle (e.g. free access to table water in the schools, improving community facilities and infrastructure for safe outdoor playing and for cycling).
	Duration of intervention	24 months
	Frequency of PA	Not specified
	Duration of PA	Not specified
	Intensity of PA	Not specified
	Type of PA	Not specified
	Parent involvement	Parents received educational folders and videos to learn about parenting strategies that can remove barriers and facilitate them in their ability to create health-promoting family environments.
	Setting	School and community
	Who delivered the intervention	Not specified
	Theoretical framework	Socio-Ecological Model
	Control	Not specified
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI SDS (IOTF); body fat (skinfolds); WHtR (measured); prevalence of overweight and obesity (IOTF)

Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		de Meij et.al 2011
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	9 schools in the intervention group and 10 schools in the control group
	Follow-up	Only post-intervention
	Country	Netherlands
	Period	Measurements - beginning of the school year September to October 2006 - end of the first school year May to June 2007 – end of the second school year May to June 2008; The intervention duration was 8 months in the first year (from November to June) and 9 months in the second year (September 2007 to May 2008)
Participants	Number of participants at baseline and follow-up (intervention/control)	1199 individuals in the intervention group and 1258 individuals in the control group at baseline; 1156 in the intervention group and 1207 in the control group at 8-month follow-up; 841 in the intervention group and 983 in the control group at 20-month follow-up
	Age	6-12 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity-'Dutch,' 'Turkish,' 'Moroccan' and 'Surinamese' were included in the analyses as separate groups, because those ethnicities were most prevalent in the sample. The remaining ethnicities were coded as 'other western' or 'other non-Western.'

		Socio-economic status - a majority of pupils with low socio-economic status
Intervention	Description	JUMP-in incorporates policy, environmental and individual components, and involves primary schools, municipal authorities, local sport services, sports clubs and youth healthcare. Longer-term objectives are the prevention of overweight and improvement of physical fitness through increased PA levels. Components of JUMP-in programme: (1) School sports activities (Easy accessible school exercise activities are offered in or near to the school premises); (2) Pupil follow-up system (PE teacher monitors the pupils once a year, in order to stimulate pupils in a structured way in their development in the areas of sport and physical activity and in attaining the physical activity recommendation for youth); (3) The Class Moves! (Programme offers during normal lessons regular breaks for physical activity, relaxation and posture exercises); (4) Choose your Card! (Card game approach that works with assignments to be done in the class and at home. The method is especially aimed at raising awareness on the importance of physical activity for health and one's own physical activity behaviour, self-efficacy, social support, planning skills, of both the children and their parents; (5) Parental information service (The importance of physical activity and sports for children and the role played by parents in supporting and stimulating such activity among their children is emphasized.); (6) Activity-week (In the Activity-week some components of JUMP-in are brought together. Parents play an important role in this week.); (7) Children who have motor and movement disabilities or who experience hampering factors in their PA behaviour (such as overweight), receive additional adapted physical education lessons (Club Extra) or motor remedial teaching. If necessary, parents of overweight or obese children receive an invitation for consultation from the youth healthcare or hospital.
	Duration of intervention	10-months (one school year)
	Frequency of PA	Offered on daily basis. Participation not reported
	Duration of PA	Not specified.

	Intensity of PA	Not specified.
	Type of PA	Not specified.
	Parent involvement	Information meetings, courses and sports activities for parents.
	Setting	School
	Who delivered the intervention	Not specified.
	Theoretical framework	Precede Proceed model; The Intervention Mapping protocol
	Control	Regular school activities
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; Daily physical activity (Actigraph accelerometer (Actigraph 7164 or Actigraph GT1M)); Sports participation (assessed in a personal interview); Weight status was divided into normal weight, overweight and obesity (based on internationally acknowledged BMI cut-off points for children as defined by Cole et al); waist and hip circumference (measured); Aerobic fitness (shuttle run test (SRT) – 18 m instead of 20 m)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Donnelly et al. 1996
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	1 schools in the intervention group and 1 school in the control group
	Follow-up	Only post-intervention
	Country	USA

	Period	1992-1994
Participants	Number of participants at baseline and follow-up (intervention/control)	236 individuals in the intervention group and 102 individuals in the control group at baseline; 44 individuals in the intervention group and 64 in the control group with laboratory data
	Age	9.2+-1.0 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity- 94% white; Socio-economic status- 44% free or reduced lunch; body fat baseline-> subjects with 22% or greater body fat- 11 in the intervention group and 25 in the control group
Intervention	Description	Project was designed to provide a nutrition and physical activity intervention for grade school children to reduce obesity and improve physical and metabolic fitness. Existing classroom teachers delivered activities designed to promote energy expenditure. Activities were designed to use large muscle groups for 30 to 40 minutes, 3 days per week. Aerobic activities that can be easily incorporated into the individuals lifestyle were emphasized at the expense of competitive games. Activities such as hopping, skipping, and aerobic games are examples of activities Nutrition education was delivered in modules using trained, classroom teachers. Eighteen grade-specific modules (9 per year) were developed. Meals were planned with the existing kitchen staff to reflect the Lunchpower! program.
	Duration of intervention	24-months
	Frequency of PA	3 times/week
	Duration of PA	90-120 min/week

	Intensity of PA	Not specified
	Type of PA	Hopping, skipping, and aerobic game
	Parent involvement	No.
	Setting	School
	Who delivered the intervention	Classroom teachers
	Theoretical framework	Not specified
	Control	Regular school PA programme
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; %body fat (underwater weighing); The level of physical activity in the classroom (SOFIT procedure); peak aerobic Capacity (the subject walked to volitional exhaustion on a motor-driven treadmill); blood samples (enzymatic methods in kits provided by Sigma Diagnostics); Systolic and diastolic blood pressure (was measured after a 5-minute rest using appropriate size cuffs for children such that the rubber bladder encircled at least two-thirds of the arm); Twenty-four-hour energy intake (interview)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Drummy et al. 2016
Methods and setting	Study design	Cluster RCT
	Unit of allocation	Classroom
	Number of clusters	7 classes in the intervention group and 7 classed in the control group

	Follow-up	Only post-intervention
	Country	Northern Ireland
	Period	NR
Participants	Number of participants at baseline and follow-up (intervention/control)	120 at baseline; 54 in the intervention group and 53 in the control group at follow-up
	Age	9-10 years
	Sex	Both boys and girls
	Other characteristics	/
Intervention	Description	The teachers in the intervention group were asked to lead a 5-min activity break three times per day for 12 weeks. The researcher met with teachers and principals prior to the beginning of the study to provide information packs on the activity breaks which included detailed instructions for approximately 40 exercises.
	Duration of intervention	12-weeks
	Frequency of PA	15 times/week
	Duration of PA	75 min/week
	Intensity of PA	MVPA
	Type of PA	Hopping, jumping and running on the spot, scissor kicks.
	Parent involvement	No
	Setting	School
	Who delivered the intervention	Teachers
	Theoretical framework	Not specified
	Control	Not specified

	Intervention fidelity	Not reported.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time,	BMI; Body fat % (sum of 4 skinfolds); Physical activity (Actigraph accelerometer)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Dzewaltowski et al. 2010
Methods and setting	Study design	RCT
	Unit of allocation	School
	Number of clusters	4 schools in the intervention group and 3 schools in the control group
	Follow-up	Post-intervention
	Country	US
	Period	2005-2006 baseline assessment; intervention year 1 2006-2007; intervention year 2 2007-2008
Participants	Number of participants at baseline and follow-up (intervention/control)	148 individuals in the intervention group and 125 individuals in the control group at baseline; 134 individuals in the intervention group and 112 individuals in the control group at follow-up
	Age	Approximately 9 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity - "American Indian/Alaska Native, Asian, Black/African American, Hispanic/Latino, Native Hawaiian/Pacific Islander, White, Other"

Intervention	Description	The HOP'N intervention was designed to target the development of the skills and efficacy of adult leaders and children to build healthy after school environments. The after-school program at each site was approximately 2.5 hours per day. The quality elements included an organized daily PA session for at least 30minutes, a daily healthful snack that included a FV, and a weekly nutrition and PA education experience. 1) Every day, staff had the goal to implement 30 minutes of organized PA following the CATCH Kids Club PA principles. The project provided the CATCH Kids Club curriculum box and PA equipment. The CKC physical activity box included a variety of activities including warm-ups, main activities (walk/run/jog and aerobic recreation games) and cool-downs. CKC physical activities underscored simple generalizable skills such as gross motor movement (throwing, catching and kicking) and large muscle movement, while heavily emphasising student enjoyment. 2) After-school program staff was directed to work with their school's food service to provide FV with every snack. 3) A weekly social-cognitive-theory based curriculum was delivered for 60 minutes once a week. Child behavioural goals were: Be physically active every day; eat FV at every meal or snack; drink less soda and juice drinks; and cut back on TV and video games
	Duration of intervention	12-months
	Frequency of PA	5 times/week
	Duration of PA	150 min
	Intensity of PA	Not specified
	Type of PA	Not specified
	Parent involvement	Yes. They participate in signing home environment change contract with their kids
	Setting	School and home

	Who delivered the intervention	After-school staff and extension assistant
	Theoretical framework	Social Cognitive Theory
	Control	Regular school activities
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI z-score (CDC); BMI; PA (was assessed during afterschool programs with ActiGraph GT1 M accelerometers (Shalimar, FL))
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Erfle et al. 2015
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	30 schools in the intervention group and 9 schools in the control group
	Follow-up	Only post-intervention
	Country	USA
	Period	2009-2010
Participants	Number of participants at baseline and follow-up (intervention/control)	9722 individuals in the intervention group and 4881 in the control group at baseline; 6693 in the intervention group and 3513 in the control group at follow-up
	Age	11-14 years
	Sex	Both boys and girls

	Other characteristics	/
Intervention	Description	The intervention group propose and implement its own PE program to implement 30 minutes of daily PE throughout 1 academic year (September 2009 to June 2010), and to conduct pre- and post-assessments during this time period (fall 2009 and spring 2010). The control group maintained its normal schedule of nondaily PE throughout 1 academic year (September 2010 to June 2011) and was provided with funding from Active Living Research to conduct pre- and post-assessments during this time period (fall 2010 and spring 2011).
	Sedentary time, physical activity or both	PA
	Duration of intervention	10-months
	Frequency of PA	5 times/week
	Duration of PA	150 min/week
	Intensity of PA	Not specified
	Type of PA	Not specified
	Parent involvement	No
	Setting	School
	Who delivered the intervention	PE teachers
	Theoretical framework	Not specified
	Control	Regular school activities
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time.	BMI; BMI percentile (CDC); physical activity (mile run, curl-ups, and push-ups)

Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Ermetici et al. 2016
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	2 schools in the intervention group and 3 schools in the control group
	Follow-up	At half time during intervention and post-intervention
	Country	Italy
	Period	2009-2011
Participants	Number of participants at baseline and follow-up (intervention/control)	262 individuals in the intervention group and 225 individuals in the control group at baseline; 242 individuals in the intervention group and 220 individuals in the control group at follow-up
	Age	12.5+-0.4 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity-95% white; Socio-economic status- average income of the households was about 35,000 euros; The parental educational levels included mainly middle-school and high-school certificates.
Intervention	Description	Intervention included changes in the school environment (alternative healthy vending machines, educational posters) and individual reinforcement tools (school lessons, textbook, text messages, pedometers, re-usable water bottles). All traditional vending machines were replaced with machines containing healthy foods and beverages, including fresh fruit and vegetables, dried fruit, fruit juices, smoothies without added sugar, and drinkable yogurt, all from local farms, carefully evaluated by

		our expert nutritionist team. Educational posters adapted from The Healthy Eating Plate conveying messages promoting healthy diet, water consumption, and daily exercise were posted in schools. The schools were asked to create more opportunities for exercise during breaks. Pupils were allowed to leave their classrooms and walk in the corridors or outdoor play areas or a total of one additional hour a week.
	Duration of intervention	24-months
	Frequency of PA	Not specified
	Duration of PA	60min/week
	Intensity of PA	Not specified
	Type of PA	Walking, free play
	Parent involvement	Automated text messages promoting a healthy diet and daily exercise were sent to the students and their parents three times a week throughout the two school years including school vacations.
	Setting	School
	Who delivered the intervention	Expert nutritionists
	Theoretical framework	Not specified
	Control	Regular school activities
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI z-score (CDC); WHtR (measured); physical activity (questionnaire and pedometer); food and beverages consumption (questionnaire)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Eyre et al. 2016
Methods and setting	Study design	Non-RCT
	Unit of allocation	Child
	Number of clusters	/
	Follow-up	6 weeks follow-up post-intervention
	Country	UK
	Period	March – July 2013
Participants	Number of participants at baseline and follow-up (intervention/control)	94 individuals in the intervention group and 40 individuals in the control group; 55 individuals in the intervention group and 30 individuals in the control group at follow-up
	Age	mean age 9.48, SD = 0.62 years (intervention group); mean age 11.12 years, SD = 0.32 years (control group)
	Sex	Both boys and girls
	Other characteristics	Ethnicity - "Indian, Pakistani, and Bangladeshi"; Socio-economic status - "The school 4th school within the most deprived ward (index of multiple deprivation score = 5.57) of Coventry (Coventry City Council, 2010; Department for Communities and Local Government, 2010) was recruited via cluster sampling at ward and school level."
Intervention	Description	The intervention group undertook a 6-week, school-based pedometer intervention using an integrated curriculum model. There were two stages to this intervention; the first stage was designed to increase PA through increasing opportunities to be active throughout the school day by using a pedometer challenge which was linked to the curriculum. The

		children were challenged to achieve total daily steps of 18,000. To increase adherence to the pedometer challenge, each child was taught to skip (15 minute lesson) and provided with a personal skipping rope. This was included to encourage free play at school and outside of school. Additionally, afterschool activity sessions were held with a shorter duration (45 minutes), once a week: Warm up (5 minutes); Plyometric and skill drill circuits (15 minutes); Playground games (15 minutes); Cool down (5 minutes); Secondly, the curriculum was modified, topics in Science (i.e. 'keeping healthy' (Year 5) and 'journeys' (Year 4)), were developed and delivered to varied education/ability needs. A themed health week was held, where all subject lessons related to the theme.
	Duration of intervention	6-weeks.
	Frequency of PA	1 time/week.
	Duration of PA	45 min/week.
	Intensity of PA	Not specified.
	Type of PA	Rope skipping in free play. Athletics, games, dance, gymnastics in PE.
	Parent involvement	No.
	Setting	School.
	Who delivered the intervention	Teachers and research staff.
	Theoretical framework	Integrated curriculum model.
	Control	Regular school programme.
	Intervention fidelity	Not specified.

Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI-for-age and sex (was assessed as kg/m2 based on British reference curves 1990 for children and young people); %body fat (BIA); physical activity (pedometers); WC (measured)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Fairclough et al. 2013
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	6 schools in the intervention group and 6 schools in the control group
	Follow-up	Post-intervention and 10 weeks post-intervention
	Country	England
	Period	November 2010- March/April 2011
Participants	Number of participants at baseline and follow-up (intervention/control)	318 children from Wigan Borough in north-west England, UK 166 individuals in the intervention group and 152 individuals in the control group at baseline; 104 individuals in the intervention group and 117 in the control group at follow-up
	Age	10-11 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity- Caucasian (Approximately 95% of the children were of white British ethnicity, which is representative of the school age population

		in Wigan; Socio-economic status- area of high deprivation and health inequalities
Intervention	Description	The CHANGE! curriculum consisted of 20 weekly lesson plans worksheets, homework tasks, lesson resources, and a CD-ROM. The lessons were of 60 minutes duration and provided an opportunity for children to discuss, explore, and understand the meaning and practicalities of PA and nutrition as key elements of healthy lifestyles. The core message of the PA and sedentary behaviour components was "move more, sit less" with no specific prescription given as to what forms of PA the children should do. The nutrition components focused on topics such as, energy balance, macronutrients, and eating behaviours. The homework tasks supplemented the classroom work and targeted family involvement in food and PA related tasks
	Duration of intervention	20-weeks
	Frequency of PA	/
	Duration of PA	/
	Intensity of PA	/
	Type of PA	/
	Parent involvement	Yes. via homework tasks
	Setting	School
	Who delivered the intervention	Teachers
	Theoretical framework	Social Cognitive Theory
	Control	Regular school programme
	Intervention fidelity	Not reported

Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; WC (measured); physical activity (objectively assessed for 7 consecutive days using ActiGraph GT1M accelerometers); food intake (24 hour recall food intake questionnaire); BMI cut-points (IOTF)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Farias et al. 2009
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	1 in the intervention group and 1 in the control group
	Follow-up	Only post-intervention
	Country	Brazil
	Period	2006-2007
Participants	Number of participants at baseline and follow-up (intervention/control)	186 individuals in the intervention group and 197 individuals in the control group at baseline and at follow-up
	Age	12.3+-1.1 years
	Sex	Both boys and girls
	Other characteristics	Socio-economic status- 7,5% low SES
Intervention	Description	Both groups were submitted to two 60-minute physical education classes per week, totalling 68 classes during the school year. Control group students performed physical activities considered routine in the school. Meanwhile, case group students were submitted to programmed

		physical activity, with the maximum heart rate (HRmax) of each student monitored by the heart rate monitors.
	Duration of intervention	10-months (one school year).
	Frequency of PA	2 times/week.
	Duration of PA	120 min/week.
	Intensity of PA	Initially, the case group performed light intensity physical activities, with 40 to 55% HRmax, for a maximum period of 1/3 of the study, time needed to allow it to jump to 55 to 75% HRmax.
	Type of PA	Classes consisted of three sections: first, aerobic activity (flexibility exercises, jumping rope, walking, alternating running, jumping in continuous rhythm, recreational games) for 30 minutes; second, playing sports (volleyball, indoor soccer, handball, swimming) for 20 minutes; and, third, stretching for 10 minutes.
	Parent involvement	No.
	Setting	School.
	Who delivered the intervention	Not specified.
	Theoretical framework	Not specified.
	Control	Control group students performed physical activities considered routine in the school, such as playing games, calisthenics, learning the fundamentals of particular sports, and playing sports.
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time,	BMI; body fat (triceps and subscapular skinfolds); %BF (Slaughter); Fat and lean masses (kg) (using the formula from Behnke e Wilmore); obesity prevalence (CDC)

Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Farmer et al. 2017
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	8 schools in the intervention group and 8 schools in the control group
	Follow-up	Post-intervention and 1 year post-intervention
	Country	New Zealand
	Period	Baseline data - March to December 2011 and 2-year data collection was completed in December 2013.
Participants	Number of participants at baseline and follow-up (intervention/control)	418 individuals in the intervention group and 422 individuals in the control group at baseline; 391 individuals in the intervention and 369 individuals in the control at Year 1; 344 individuals in the intervention and 325 in the control at Year 2
	Age	2nd and 4th grade children
	Sex	Both boys and girls
	Other characteristics	/
Intervention	Description	The researchers, play worker and school community worked together to develop a playground action plan that met the needs of each school community. Following baseline evaluations of their play space, each intervention school was provided with a list of tailored suggestions for improvements. This was specific to each school but could include the addition of more interactive play equipment, and alterations to school rules and policies that may limit risk-taking during play (for example,

		no tree climbing, separation of older and younger children into physically separate play areas), with all alterations meeting playground safety standards. Although intervention schools were provided with initial start-up funds of NZD$15 000, the majority of recommendations involved no to little cost, such as leaving trees that had been cut down in pieces or letting the grass grow long to encourage imaginative play, re-purposing real-estate signs for sledding down hills, purchase of raincoats and gumboots to allow outside play when wet, and using plastic piping and sand for water play.
	Duration of intervention	14-15 months
	Frequency of PA	Not specified.
	Duration of PA	Not specified.
	Intensity of PA	Not specified.
	Type of PA	Not specified.
	Parent involvement	No
	Setting	School.
	Who delivered the intervention	Researchers, play worker and school community.
	Theoretical framework	Not specified.
	Control	Control schools were asked not to change their play environment.
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; WC (measured); BMI z-score (WHO); Physical activity (accelerometer (ActiGraph GT3X, Actigraph Corp, Pensacola, FL, USA) 24 h a day for 7 days)

Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Ford et al. 2013
Methods and setting	Study design	RCT
	Unit of allocation	Child
	Number of clusters	/
	Follow-up	Post-intervention and 15 weeks after
	Country	England
	Period	NR
Participants	Number of participants at baseline and follow-up (intervention/control)	174 at baseline; 77 individuals in the intervention group and 75 individuals in the control group at follow –up
	Age	5-11 years
	Sex	Both boys and girls
	Other characteristics	/
Intervention	Description	The walkers took part in the accumulated brisk walking programme during school time, which involved walking at a brisk intensity around the school grounds for 15 min in the morning and afternoon. The morning and afternoon walking session began at the start of the school day and immediately after the lunch break, respectively. Participants were led around the school field.
	Duration of intervention	15-weeks
	Frequency of PA	3 times/week

	Duration of PA	90 min/week
	Intensity of PA	MPA
	Type of PA	Walking at a brisk intensity
	Parent involvement	No
	Setting	School
	Who delivered the intervention	Teaching assistants and the principal investigator
	Theoretical framework	Not specified
	Control	Regular school activities
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; body fat (BOD POD, skinfolds)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Foster et al. 2008
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	Schools in the intervention group and 5 schools in the control group
	Follow-up	Only post-intervention

	Country	USA
	Period	NR
Participants	Number of participants at baseline and follow-up (intervention/control)	749 individuals in the intervention group and 600 individuals in the control group at baseline; 479 individuals in the intervention group and 365 individuals in the control group at follow-up
	Age	11.2+-1.0 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity: 44%black, 17%Asian, 22%Hispanic, 11%white; Socio-economic status-schools that had >50% of children eligible for federally subsidized, free, or reduced-price meals; 40 % OW or OB, 25% OB at baseline
Intervention	Description	The study included the following components: (1) school self-assessment; (2) nutrition education; (3) nutrition policy; (4) social marketing; and (5) parent outreach. All of the school staff in the intervention schools was offered 10 hours per year of training in nutrition education. At these trainings, staff received curricula and supporting materials such as Planet Health and Know Your Body. The goal was to provide 50 hours of food and nutrition education per student per school year. Its purpose was to show how food choices and physical activity are tied to personal behaviour, individual health, and the environment. In each of the intervention schools, all sodas, sweetened drinks, and snacks that did not meet the standards set by the were removed from the vending machines and the cafeteria line.
	Duration of intervention	24-months
	Frequency of PA	/
	Duration of PA	/

	Intensity of PA	/
	Type of PA	/
	Parent involvement	Yes, via home and school association meetings, report card nights, parent education meetings, and weekly nutrition workshop
	Setting	School
	Who delivered the intervention	Teachers
	Theoretical framework	Not specified
	Control	Regular school activites
	Intervention fidelity	Teachers provided an average (SD)of 48.0 (27.1) and 44.0 (18.3) hours of nutrition education during each year of the intervention.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; BMI z –score (CDC); overweight and obesity incidence (Institute of medicine); dietary intake (Youth/Adolescent Questionnaire); Physical activity and sedentary behaviour, specifically television viewing (measured by the Youth/Adolescent Activity Questionnaire)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Fritz et al. 2016
Methods and setting	Study design	CBA
	Unit of allocation	School
	Number of clusters	1 school in the intervention group and 3 schools in the control group
	Follow-up	Children were followed in the intervention group with school start 1998 and 1999 with annual follow-up measurements for the following 5 years

		while the children with school start 2000 had their second measurement done after 3 years and then additional measurements after 4 and 5 years, respectively. Children in the control group had their second measurement done after 2 years and then additional measurements after 3, 4 and 5 years, respectively
	Country	Sweden
	Period	Children who started the intervention school 1998–2000; children who started the control schools 1999–2000; The study then followed children in the intervention group with school start 1998 and 1999 with annual follow-up measurements for the following 5 years while the children with school start 2000 had their second measurement done after 3 years and then additional measurements after 4 and 5 years, respectively. Children in the control group had their second measurement done after 2 years and then additional measurements after 3, 4 and 5 years, respectively.
Participants	Number of participants at baseline and follow-up (intervention/control)	807 individuals in the intervention group and 1580 individuals in the control group at baseline; 743 individuals in the intervention group and 1538 individuals in the control group at follow-up
	Age	6-9 years at the start of the study
	Sex	Both boys and girls
	Other characteristics	Ethnicity - Swedish (Caucasian)
Intervention	Type	Extra hours of PE.
	Description	In the intervention school the amount of physical education (PE) in the school curriculum was increased from 60 minutes PE/week to 40 minutes/school day (200 minutes per week) for three years. The intervention consisted of a variety of activities such as jumping, running, playing and ball games, i.e. the regular Swedish school curriculum for PE but with an extended duration.
	Duration of intervention	36-months

	Frequency of PA	Every school day. 5 times/week.
	Duration of PA	200 min/week.
	Intensity of PA	Not specified.
	Type of PA	Variety of activities such as jumping, running, playing and ball games
	Parent involvement	No.
	Setting	School.
	Who delivered the intervention	Classroom teachers.
	Theoretical framework	Not specified.
	Control	Regular school activities (Regular PE 60 min/week).
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI: Muscle strength (Two physiotherapists performed lower limb concentric isokinetic Peak Torque (PT) measurements using Biodex System); Leg lean and fat mass (DXA); Lifestyle and physical activity habits (a non-validated questionnaire)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Gallota et al. 2016
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	3 schools-16 classes

	Follow-up	Only post-intervention
	Country	Italy
	Period	NR
Participants	Number of participants at baseline and follow-up (intervention/control)	78 individuals in the experimental group 1, 83 individuals in the experimental group 2, 69 individuals in the control group
	Age	8-11 years
	Sex	Both boys and girls
	Other characteristics	Overweight prevalence- 21 overweight/obese children in experimental group 1, 20 in the experimental group 2 and 12 in the control group at baseline
Intervention	Description	Changes to PE content were introduced. Two programs differed in type and mode of physical activities in which children were engaged but they were equivalent in structure, overall duration and intensity, and consisted of two 1 h sessions per week. The exercise intensity of both programs was monitored using an OMNI scale (Utter et al., 2002) to avoid possible differences in intensity between the two types interventions. Each lesson of both interventions included 15 min of warm-up, 35 min of moderate-to-vigorous physical activities (MVPA) within a range of 5 < RPE < 8 (OMNI RPE scale) and 10 min of cool down and stretching. The nutritional intervention was based on the nutritional program ``European School Fruit Scheme'' of the European Commission of Agriculture and Rural Development. The intervention consisted of topics like fruit and vegetables characteristics, nutritional values, biodiversity, seasonality, and territoriality. The topics were taught monthly through methodologies that are linked to children's system of learning (short lectures/talks, games and sensory workshops). In addition, a properly trained staff provided one free piece of fresh fruit (or vegetable) to children each school week, as a snack at mid-morning or mid-afternoon break. Every child consumed fruits or vegetables at

		least 36 times during the program, and at least ten different kinds of fruit or vegetable.
	Duration of intervention	5-months
	Frequency of PA	2 times/week
	Duration of PA	60 min/week
	Intensity of PA	MVPA
	Type of PA	Intervention 1: endurance, strength, flexibility exercises and circuit training for cardiovascular health (e.g., fast walking, running, skipping). Intervention 2: coordination and dexterity of the participants (e.g., bouncing, throwing, and/or receiving a ball). The sport-games module: handball, mini-volleyball, mini-basketball). The rhythmic activities module: rhythmic and time perception abilities. The gymnastics module: general movement development. The fitness activities module: strength, endurance, speed and flexibility.
	Parent involvement	An information campaign targeted at parents was conducted by producing and distributing informative material and by creating a specific web site section
	Setting	School
	Who delivered the intervention	Specialist PE teacher + generalist teacher
	Theoretical framework	Not Specified
	Control	Regular PE program delivered by a generalist teacher
	Intervention fidelity	Not Specified
Outcomes	State the outcome and the method of assessment	BMI z-score (IOTF); body fat (BIA); physical activity level (Italian version of the Physical Activity Questionnaire for Older Children (PAQ-

	weight related outcomes, PA, fitness, sedentary time	C)); sedentary time (parental proxy interview); eating habits (7-day diet record)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Gorely et al. 2011
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	4 schools in the intervention group and 4 schools in the control group
	Follow-up	10 and 20 months post-intervention (IG); 8 and 18 months post-intervention (CG)
	Country	UK
	Period	NR
Participants	Number of participants at baseline and follow-up (intervention/control)	310 individuals in the intervention group and 279 individuals in the control group at baseline; 206 individuals in the intervention group and 215 individuals in the control group at follow-up
	Age	7-11 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity - The majority of participants were of white British ethnicity (intervention 94.8%, control 96.5%). Socio-economic status - intervention group being of lower socio-economic status than the control group when measured by the IMD for the postcode defined ward in which each participant resided. These differences were paralleled in household income with income in

		intervention schools being significantly lower (it is worth noting though that over 50% of parents chose not to supply this information)
Intervention	Description	The programme aimed to increase children's activity levels through PE lessons that taught the skills of running. Healthy food choices were explained and encouraged in a holistic approach to children's health education. The programme was multifaceted and comprised: 1. a CD-ROM learning and teaching resource for teachers; 2. two highlight events (1 mile run/walks) to give the children a goal for increasing their physical activity; 3. an interactive website for pupils, teachers and parents to raise awareness of the need for physical activity and healthy eating; 4. a local media campaign employing regional radio and print media to maintain interest and create excitement; 5. a summer activity wall planner and record.
	Duration of intervention	10 months
	Frequency of PA	Not specified
	Duration of PA	Not specified
	Intensity of PA	Not specified
	Type of PA	Running/walking events
	Parent involvement	Yes, homework tasks (activity planner)
	Setting	School
	Who delivered the intervention	School teachers
	Theoretical framework	Social Cognitive Theory
	Control	Regular PE and health curriculum
	Intervention fidelity	Not specified.

Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; body fat (Subscapular and triceps skinfold); WC (measured); Physical activity (Digiwalker SW200 pedometer, 50% of children also wore an ActiGraph GT1M accelerometer)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Graf et al. 2008
Methods and setting	Study design	CBA
	Unit of allocation	School
	Number of clusters	12 schools in the intervention group and 5 schools in the control group
	Follow-up	Only post intervention
	Country	Germany
	Period	2001-2005
Participants	Number of participants at baseline and follow-up (intervention/control)	433 individuals in the intervention group and 178 individuals in the control group at baseline; 410 individuals in the intervention group and 170 in the control group at follow-up
	Age	6.8+-0.4 years
	Sex	Both boys and girls
	Other characteristics	/
Intervention	Description	One education lesson per week (20–30 min) provided by teachers. The main topics of the health education dealt with biological background, nutrition, and self-management. Additionally, physical activity breaks (5 min each) should be allowed during lessons once a morning.

		Furthermore, pupils were given physical activity opportunities during breaks and their physical education lessons were optimized by training the teachers.
	Duration of intervention	48-months
	Frequency of PA	5 times/week
	Duration of PA	25 min/week
	Intensity of PA	Not specified
	Type of PA	Not specified
	Parent involvement	via brochures and parent-teacher meetings
	Setting	School
	Who delivered the intervention	Teachers
	Theoretical framework	Combination of the Theory of Planned Behaviour and the Precaution Adoption Process Model.
	Control	Not specified
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; Obesity (was defined as body mass index 97th percentile, using the definition of the International Task Force on Obesity in Childhood and population-specific dana); endurance performance (Six-minute run); motor development (body coordination test)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Grydel et al. 2014
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	12 schools in the intervention group and 25 schools in the control group
	Follow-up	Only post-intervention
	Country	Norway
	Period	The data collections took place at each school in September 2007 (baseline) and in May 2009 (post-intervention)
Participants	Number of participants at baseline and follow-up (intervention/control)	527 individuals in the intervention group and 958 individuals in the control group at baseline; 491 in the intervention group and 870 in the control group at 20-month follow-up
	Age	11.2+-0.3 years
	Sex	Both boys and girls
	Other characteristics	/
Intervention	Description	Multiple intervention efforts were orchestrated to promote a healthy diet and to increase awareness of healthy choices, to increase participants' physical activity during school hours and leisure time, and to reduce screen-time: (A) Lessons with student booklet:1. Diet and physical activity, 2. Meals, 3. 5 a day, 4. Sugar-rich beverages, 5. Your choice - monthly; (B) Posters for classrooms: Key messages, A4-size, placed on a larger 'frame-poster' including the HEIA logo – monthly; (C) Fruit and vegetable (FV) break: Cutting equipment per class provided, students brought FV – weekly (D) Physical activity (PA) break:10 min of PA conducted in regular classrooms – weekly; (E) Sports equipment for recess activities:1–2 large boxes per school. Examples of content:

		Frisbees, jump-ropes, elastic bands, hockey-sticks, a variety of ball – available daily; (F) Active commuting campaigns: Register days with active transport to/from school for 3 weeks (5 campaigns); (G) One class-set per school to be used in PE(SPARK), as tasks at school, as home assignment and active commuting; (H) Computer tailored individual advice:1. Fruit, 2. Vegetables, 3. Physical activity, 4. Screen time, 5. Sugar sweetened beverages + 1-week action plans for each topic (instruction on what, where and when to do the suggestions for behaviour change)
	Duration of intervention	10-months (one school year)
	Frequency of PA	1 day/week.
	Duration of PA	10 min/week
	Intensity of PA	Not specified.
	Type of PA	Not specified.
	Parent involvement	Yes, through fact sheets and brochures. Participation in practical tasks/challenges for leisure time/weekends.
	Setting	School (class), home,
	Who delivered the intervention	Classroom teachers
	Theoretical framework	Socio-ecological model
	Control	Not specified.
	Intervention fidelity	„Unpublished process evaluation data indicate that the level of implementation of the components decreased from midway to post intervention, thus reducing both the reach and dose received by the participants“

Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; BMI z-score (WHO); WC (measured); waist-to-height ratio - WTHR (measured); pubertal status (self-reported and parental education was self-reported by the parents)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Habib Mourad. 2013
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	4 schools in the intervention group and 4 schools in the control group
	Follow-up	3 weeks post-intervention
	Country	Lebanon
	Period	2009-2010
Participants	Number of participants at baseline and follow-up (intervention/control)	193 individuals in the intervention group and 181 individuals in the control group at baseline; 188 individuals in the intervention group and 175 in the control group at follow-up
	Age	9-11 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity-Arab; OW+OB>40% at baseline
Intervention	Type	Lifestyle curriculum.
	Description	'Health-E-PALS' had three coordinated intervention components:

		1) Culturally appropriate classroom sessions designed to promote healthy eating and physical activity. (The 45 minute sessions were delivered each week for 12 weeks.) Pedometers were distributed to students and they were instructed on method of use. They were encouraged to use it at home with their families. 2) A family programme which introduces the intervention to families and assists them in creating a supportive environment at home for healthy lifestyle behaviours. (Parents meetings, School events, Take home pamphlets. Frequency not specified). 3) A food service intervention targeting the school shop and the lunch boxes sent by the family.
	Sedentary time, physical activity or both	Both.
	Duration of intervention	12-weeks
	Frequency of PA	/
	Duration of PA	/
	Intensity of PA	/
	Type of PA	/
	Parent involvement	Yes. parent meetings, School events and Take home pamphlets
	Setting	School.
	Who delivered the intervention	Nutritionists.
	Theoretical framework	Social Cognitive Theory.
	Control	Regular school activities.
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment	BMI; WC (measured); dietary, physical activity, and sedentary behaviour habits (questionnaire)

	weight related outcomes, PA, fitness, sedentary time	
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Hamelink-Baksteen et al. 2008
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	8 schools in the intervention group and 1 schools in the control group
	Follow-up	Only post-intervention
	Country	Netherlands
	Period	2005-2007
Participants	Number of participants at baseline and follow-up (intervention/control)	393 individuals in the intervention group and 80 individuals in the control group at baseline; 349 individuals in the intervention group and 77 individuals in the control group at follow-up
	Age	2nd and 6th grade
	Sex	Both boys and girls
	Other characteristics	12% OW at baseline
Intervention	Description	Program consisted of 6 parts. 1. Healthy food consumption carried by teachers. The children eat fruit and vegetables in the classroom for two days a week. 2. Health education curriculum for prevention of overweight (5 weeks program about breakfast, snacks and exercise).

		3. Curriculum that promote sport and healthy lifestyle (3-week program, conducted by the teacher, tries to make children enthusiastic about an active lifestyle and a sport choice that suits them) 4. The 'Shop Game' was an educational information tool, also carried out by the teacher, and consists of a recreated supermarket for children. 5. Members of the multidisciplinary project team organized "Healthy on Weight information evenings for parents and teachers. 6. The weight management course "Okido! a secondary preventive intervention of 9 weeks. This is intended for overweight children from 9 to 12 years old and their parents. The course consisted of dietary guidance and exercise instruction
	Duration of intervention	Not specified
	Frequency of PA	Not specified
	Duration of PA	Not specified
	Intensity of PA	Not specified
	Type of PA	Not specified
	Parent involvement	Yes, education evenings about healthy lifestyle and weight.
	Setting	School
	Who delivered the intervention	Teachers
	Theoretical framework	Not specified
	Control	Regular school programme
	Intervention fidelity	Not reported.

Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; overweight and obesity prevalence (IOTF)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Herrick et al. 2012
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	3 schools in the intervention group and 3 schools in the control group
	Follow-up	Only post-intervention
	Country	USA
	Period	2009
Participants	Number of participants at baseline and follow-up (intervention/control)	48 individuals in the intervention group and 52 individuals in the control group at baseline and 47 individuals in the intervention group and 51 individuals in the control group at follow-up
	Age	10.3+-0.6 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity- Asian 50%, Latino 27%, white 4%, black 4%; socio-economic status- 60% free or reduced lunch
Intervention	Description	SPARK program consists of 3 primary features: an active curriculum, staff development, and follow-up support.

		A typical SPARK lesson lasted 30 minutes and had two parts: health-fitness activities (15 minutes) and skill-fitness activities (15 minutes). Ten health-related activity units included aerobic dance, aerobic games, walking/jogging, and jump rope. Progression was developed by modifying the intensity, duration, and complexity of the activities. Although the main focus was on developing cardiovascular endurance, brief activities to develop abdominal and upper body strength were included. To enhance motivation, students self-assessed and recorded their own fitness levels monthly. Nine sport units that developed skill-related fitness included basketball and soccer. These sports and games had the potential for promoting cardiovascular fitness and generalizing to the child's community (e.g., Frisbee games). Low activity games, such as softball, were modified to make them more active.
	Duration of intervention	5-months
	Frequency of PA	5 times/week
	Duration of PA	150 min/week
	Intensity of PA	Not specified
	Type of PA	Basketball, soccer, aerobic dance, aerobic games, walking/jogging, and jump rope.
	Parent involvement	No
	Setting	School
	Who delivered the intervention	After-school physical activity coordinator
	Theoretical framework	Not specified
	Control	Regular school programme
	Intervention fidelity	Not reported

Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; BMI z-score (CDC); Cardiorespiratory fitness (VO2) (validated 20-m shuttle test); Physical activity (uniaxial GT1M accelerometer (Actigraph, LLC, Fort Walton Beach, FL))
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Harrison et al. 2006
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	5 schools in the intervention group and 4schools in the control group
	Follow-up	Only post-intervention
	Country	Ireland
	Period	2003
Participants	Number of participants at baseline and follow-up (intervention/control)	182 individuals in the intervention group and 130 individuals in the control group at baseline; 91% successfully followed up post intervention
	Age	10.2±0.7 years
	Sex	Both boys and girls
	Other characteristics	Socio-economic status- all schools were in areas of greatest social disadvantage
Intervention	Description	Children were taught how to use an ‘activity points system’ in conjunction with a project diary to keep track of the time spent inactive

		and screen pursuits. One point was awarded for every 5 min of physical activity with one point deducted for every 15 min of screen time. An explanation of the system was placed on a poster in every classroom
	Duration of intervention	16-weeks
	Frequency of PA	Not specified
	Duration of PA	Not specified
	Intensity of PA	Not specified
	Type of PA	Not specified
	Parent involvement	The diaries formed part of the child's homework and were signed by parents. Parents were encouraged in writing to support children in their attempts to switch off and get active and to verify behaviour by signing diaries.
	Setting	School
	Who delivered the intervention	Teachers
	Theoretical framework	Social Cognitive Theory
	Control	Control schools did not receive the 'Switch Off—Get Active' intervention but were promised first refusal should the intervention be extended to the rest of the health authority region.
	Intervention fidelity	The programme was implemented with fidelity in all schools. Implementation was verified by checking completed workbooks (evidence of lesson delivery) and pupil diaries (evidence of continuous self-monitoring and goal setting).
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; Physical activity and screen time (measured using the 1-day Previous Day Physical Activity Recall (PDPAR) instrument validated with this age group); Physical activity self-efficacy (previously validated instrument, with minor modifications-this tool contained 10 Likert-type statements with a three-category response to each);

		prevalence of overweight (International Obesity Task Force definitions); Aerobic fitness (20 m shuttle test).
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Hatzis et al. 2010
Methods and setting	Study design	CBA
	Unit of allocation	School
	Number of clusters	24 schools in the intervention group and 16 schools in the control group
	Follow-up	Re-evaluation of the program was performed at 3, 6 and 10 years after its initiation
	Country	Greece
	Period	1992-1998
Participants	Number of participants at baseline and follow-up (intervention/control)	602 individuals in the intervention group and 444 individuals in the control group at baseline; 331 individuals in the intervention group and 303 individuals in the control group at follow-up (around 550 analysed depending on outcome)
	Age	6.3+-0.4 years
	Sex	Both boys and girls
	Other characteristics	50% urban, 50% rural
Intervention	Description	The health and nutritional components of the program were conducted by classroom teachers and incorporated 13 to 17 h of teaching over the academic year. The physical fitness and activity component of the program included practical sessions as well as classroom sessions (4 to 6 h of classroom material per year). The practical part was delivered in

		the playground where enjoyable, fitness oriented (rather than motor-oriented). Little attention was placed on competition and verbal rewards were given for all levels of effort and ability. When weather conditions did not permit outdoor physical activity sessions, the time was devoted to indoor health education intervention activities. Also, three to five workbook exercises per year were completed at home by pupils together with their parents.
	Duration of intervention	36-months
	Frequency of PA	2 time/week
	Duration of PA	90 min/week
	Intensity of PA	MPA
	Type of PA	All sessions consisted of a short initial warm-up period with stretching exercises, followed by activities such as skipping, fitness stations, and several aerobic group games.
	Parent involvement	Pupils together with their parents completed Three to five workbook exercises per year at home. Furthermore, parents were encouraged to modify their own dietary habits, where appropriate, in addition to those of their children.
	Setting	School
	Who delivered the intervention	Classroom teachers, PE teachers
	Theoretical framework	Not specified
	Control	Regular school activities
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment	BMI; %body fat (skinfolds); WC (measured); Diet (was analysed using an electronic food database, based on the USDA food database and chemical analyses of 120 Greek foods undertaken by the Wageningen Agricultural University and TNO Voeding in the Netherlands); Systolic

	weight related outcomes, PA, fitness, sedentary time	and diastolic blood pressure (measured); Biochemical measurements; Physical fitness (endurance 20-m shuttle run test (20mSRT) as described by the EUROFIT Tests Protocol)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Have et al. 2018
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	6 schools in the intervention group and 6 schools in the control group
	Follow-up	Only post-intervention
	Country	Denmark
	Period	2012-2013
Participants	Number of participants at baseline and follow-up (intervention/control)	294 individuals in the intervention group and 211 individuals in the control group at baseline; 268 individuals in the intervention group and 182 individuals in the control group – dropout rate: 8.8% in the intervention group and 13.7% in the control group at follow-up
	Age	7.2±0.3 years
	Sex	Both boys and girls
	Other characteristics	/
Intervention	Description	The intervention group received classroom-based PA incorporated into math lessons for one school year. Subjects in the intervention group received an average of 6 math lessons of 45 minutes per week during the intervention. Each 45-minute lesson consisted of at least 15 minutes of

		PA spread over the lesson, and sedentary activities were limited to bouts of maximum 20 minutes.
	Duration of intervention	10-months (1 school year)
	Frequency of PA	6 times/week
	Duration of PA	At least 90 min/ week
	Intensity of PA	Not specified
	Type of PA	One example: Skipping rope
	Parent involvement	No
	Setting	School
	Who delivered the intervention	Teachers
	Theoretical framework	Theory of Embodied Cognition
	Control	Subjects in the control group received regular classroom instruction, also with an average of 6 math lessons of 45 minutes per week.
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; physical activity level (accelerometry); aerobic fitness (Andersen test)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Heelan et al. 2009

Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	2 schools in the intervention group and 1 school in the control group
	Follow-up	Only post-intervention
	Country	USA
	Period	2004-2006
Participants	Number of participants at baseline and follow-up (intervention/control)	201 individuals in the intervention group and 123 individuals in the control group at baseline and at follow-up
	Age	8.1±1.7 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity-90% White, 7%Hispanic
	Description	The study promotes a physical activity and reduces the prevalence of overweight in children. By supporting them to walk to and from school every day. The concept of WSB programs is that children walk to school in groups along a set route (and with set stops along with way). An adult WSB leader (a paid college student) met the neighbourhood children at these designated walk-stops at specified times each morning and walked the group of children to their school and back to the walk stop in the afternoon. Eight routes were created for the 2 WSB schools.
	Duration of intervention	104-weeks
	Frequency of PA	10 times/week
	Duration of PA	Not specified
	Intensity of PA	Not specified
	Type of PA	Walking

	Parent involvement	No
	Setting	School and home
	Who delivered the intervention	WSB leader (a paid college student)
	Theoretical framework	Not specified
	Control	Regular school-based PE
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; BMI z-score; body fat % (skinfolds); physical activity (accelerometer Acti-Graph)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Herazo-Beltran et al. 2018
Methods and setting	Study design	RCT
	Unit of allocation	Child
	Number of clusters	/
	Follow-up	Only post-intervention
	Country	Colombia
	Period	2017
Participants	Number of participants at baseline and follow-up (intervention/control)	27 children in the intervention group and 29 children in the control group at baseline and at follow-up

	Age	9.4 +- 0.6 years
	Sex	Both boys and girls
	Other characteristics	/
Intervention	Description	An aerobic exercise program was designed with a frequency of three times per week, with a duration of 60 minutes for 3 months at moderate intensity (60–70% of the heart rate frequency). 10 min warm-up, 40 min exercise and 10 min cool-down
	Duration of intervention	3-months
	Frequency of PA	3 times/week.
	Duration of PA	180 min/week.
	Intensity of PA	60 – 70% HR.
	Type of PA	Aerobic exercise
	Parent involvement	Yes, via workshops on diet and PA
	Setting	School.
	Who delivered the intervention	Not specified.
	Theoretical framework	Not specified.
	Control	Not specified.
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; WC (measured)

Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Ho et al. 2017
Methods and setting	Study design	RCT
	Unit of allocation	Child
	Number of clusters	/
	Follow-up	1 month
	Country	Hong Kong, China
	Period	2013-2014
Participants	Number of participants at baseline and follow-up (intervention/control)	692 at baseline; 333 individuals in the intervention group and 331 individuals in the control group at follow-up
	Age	12.3+-0.76 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity-Asian
Intervention	Description	The intervention was divided into 2 similar parts (each with 9 sessions) that were separated by a school examination period and holiday from December to January. Each part started with 1.5 sessions (135 minutes) of introduction and warm up, during which the mentor introduced the chosen sport through deliberate play. Then, a half-session (45 minutes) goal setting followed, in which the students discussed what kind of sporting goal they would like to achieve. After setting the goals, the students spent 6.5 sessions (585 minutes) building their sporting skills with the support of the mentors and peers, during which the mentors infused problem-solving techniques through experiential learning.

		Lastly, a 45-minute debriefing was conducted for skill consolidation and self-reflection.
	Duration of intervention	From October 2013 to June 2014, excluding 3 months of school holiday and an examination period. The program had 18 weekly sports mentoring sessions, each lasting for 90 minutes.
	Frequency of PA	1 time/week
	Duration of PA	90 min/week
	Intensity of PA	Not specified
	Type of PA	After-school sports mentorship: chosen sports included basketball, volleyball, or kickboxing.
	Parent involvement	No
	Setting	Schools and Community centres
	Who delivered the intervention	The intervention deliverers (mentors) were sports coaches with relevant certificates from local sports associations.
	Theoretical framework	The intervention framework was based on the 8 PYD principles of the National Research Council and Institute of Medicine. Emphasis was put on the youth-cantered environment.
	Control	Students randomly assigned to the control group were provided with exclusive access to a Web-based health education game with 400 questions on healthy lifestyle during the same period. These students were instructed to log onto the Web site individually for 90 minutes per week for 18 weeks. The quiz game was previously shown to improve health-related knowledge and attitude.
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment	BMI z score (standard formula); body fat (BIA); physical and mental well-being (measured by Chinese version of SF-12v2); physical fitness (1-minute sit-up test, handgrip test, standing long jump, sit-and-reach

	weight related outcomes, PA, fitness, sedentary time,	test, Y-balance test; physical activity level-self-rated Physical Activity Rating Questionnaire for Children and Youth)
Adverse outcomes	State the outcome and the method of assessment	1 minor foot injury

Authors and year		Hollar et al. 2010
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	4 schools in the intervention group and 1 school in the control group
	Follow-up	Post-intervention
	Country	US
	Period	2-year period (2004–2005 and 2005–2006)
Participants	Number of participants at baseline and follow-up (intervention/control)	3769 individuals in both intervention schools and control school
	Age	Average age was eight years (range 4–13)
	Sex	Both boys and girls
	Other characteristics	Socio-economic status - Low income; Ethnicity - Just over one half (50.2%) of the study sample was Hispanic, 33.4% White, 8.0% Black, and 8.4% other (multi-ethnic, Asian, American Indian).
Intervention	Description	Components: (1) modified dietary offerings (school menus were modified to include more high fiber items, such as whole grains, fresh fruits, and vegetables; fewer items with high-glycaemic effects, such as high-sugar cereals and processed flour goods; and lower amounts of total, saturated, and trans fats. (2) nutrition/lifestyle educational curricula for students, parents, teachers, staff (monthly educational programming

		for making healthy lifestyle choices) used 1-2h x week for kindergarten through second grade and less intense in grades three through five); (3) physical activity component; and (4) wellness projects (e.g., cultivating fruit and vegetable gardens). The physical activity component consisted of increased opportunities for physical activity during school; The amount and types of physical activity varied among intervention schools throughout the study period. During the second year of the study, students were provided with pedometers and tracking books so they could track the number of steps they took each day. However, the pedometers broke easily, and students tended to lose them. Therefore, the use of pedometers was discontinued. Instead, schools were encouraged to implement daily physical activity in the classroom using a 10–15 minute desk-side physical activity program (TAKE10! or WISERCISE©) during regular teaching time. These desk-side physical activities are matched with core academic areas, such as spelling and math, to encourage adoption of daily physical activity, in addition to recess and physical education time.
Intervention	Duration of intervention	24-months
	Frequency of PA	Daily for classroom PA
	Duration of PA	10-15 min/day
	Intensity of PA	Not specified
	Type of PA	Not specified
	Parent involvement	Yes, via newsletters
	Setting	School
	Who delivered the intervention	Classroom teachers
	Theoretical framework	Not specified
	Control	Usual curriculum

	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; BMI percentile (CDC); blood pressure and pulse (measured using WelchAllyn® Spot Vital Signs automated measurement machine); academic scores (The Florida Comprehensive Achievement Test (FCA))
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Hollis et al. 2016
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	5 schools in the intervention group and 5 schools in the control group
	Follow-up	Outcome data at 12 and 24 months
	Country	Australia
	Period	NR
Participants	Number of participants at baseline and follow-up (intervention/control)	645 individuals in the intervention group and 505 in the control group at baseline; 592 in the intervention group and 459 in the control at 12-month follow-up; 560 in the intervention and 425 in the control at 24-month follow-up.
	Age	12 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity – Australian; Socio-economic status - schools from socio-economically disadvantaged communities

Intervention	Type	Enhanced PE, Active recess, Extracurricular PA, Lifestyle Curriculum.
	Description	The intervention included the following seven physical activity intervention strategies: 1) Teaching strategies to maximise student physical activity in health and physical education (PE) lessons; recommended procedures for fitness testing and 'personal best 'days. 2.'Development and monitoring of student physical activity plans within PE lessons'. 3.'. All students participated in a 10-week enhanced school sport programme during school sport. The 10 physical activity and nutrition messages were selected because they represent the behaviours that are commonly associated with lower levels of disease risk and maintaining a healthy weight and included the following: (1) Keep track of your physical activity (using goals/diary); (2) Every step counts; (3) Reduce your time spent watching television, using the computer, and playing electronic games immediately after school; (4) Be active with friends and family, (5) Identify excuses for not being active, (6) Keep track of fruit and vegetable intake (using goals/diary), (7) Aim for two pieces of fruit and five servings of vegetables each day, (8) Drink more water and swap sugary drinks for diet drinks, (9) Reduce your portion sizes and eat at the dinner table, and (10) Reduce your junk food snacks 4. School policies were established or modified with the aim of enhancing students' physical activity. For example; incorporating pedometer-based lessons with PE, offering the enhanced school sport programme as a standard school sport option, routinely providing physical activity information to parents. 5.'Physical activity programmes during school breaks'. Schools were provided with physical activity equipment and encouraged to offer supervised physical activity on at least 2 days per week during recess and lunch breaks.

		6. Schools hosted a physical activity expo that promoted local physical activity providers to students in Grade 8. Community physical activity providers were also promoted in school newsletters. 7.'Parent engagement'. Information was regularly sent to the parents via existing school newsletters, the school website and PA4E1 newsletters on physical activity recommendations, school-based physical activity strategies, promotion of community physical activity providers and strategies to support their child's physical activity. Four of the seven intervention strategies were implemented during the first 12 months (strategies 1, 2, 5 and 7 above). The remaining strategies were implemented over the next 12 months, with delivery of the initial strategies being maintained.
	Duration of intervention	19 – 24 months
	Frequency of PA	Active recess at least 2 times /week. Other activities not specified.
	Duration of PA	Not specified.
	Intensity of PA	Not specified.
	Type of PA	Not specified.
	Parent involvement	Yes, via newsletters on physical activity recommendations, school-based physical activity strategies, promotion of community physical activity providers and strategies to support their child's physical activity.
	Setting	School.
	Who delivered the intervention	Not specified.
	Theoretical framework	Social cognitive theory and socio-ecological theory.
	Control	Usual programmes.
	Intervention fidelity	Not specified.

Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; BMI z-score (WHO); Physical activity (accelerometer (Actigraph GT3X+ and GT3X models))
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Jago et al. 2019
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	6 schools in the intervention group and 6 schools in the control group
	Follow-up	Only post-intervention
	Country	England
	Period	2017-2018
Participants	Number of participants at baseline and follow-up (intervention/control)	170 individuals in the intervention group and 165 in the control group at baseline; 139 in the intervention group and 113 in the control group at follow-up
	Age	8-10 years
	Sex	Both boys and girls
	Other characteristics	/
Intervention	Description	Extracurricular PA; The sessions began with fun warm-up activities, and then moved through a series of small sided games and activities with a focus on fun and participation while also improving fundamental

		movement skills such as running, catching, throwing and use of space in invasion games.
	Duration of intervention	15-weeks
	Frequency of PA	2 times/week
	Duration of PA	120 min/week
	Intensity of PA	Not specified
	Type of PA	Games
	Parent involvement	No
	Setting	School
	Who delivered the intervention	Trained teaching assistants
	Theoretical framework	Self-determination theory
	Control	Regular school activities
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time,	BMI; BMI-z score; physical activity (PAQ-C); PA motivation (5-point Likert scale); Health-related quality of life (KIDSCREEN-10, ChildHealth Utility 9D questionnaires)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Jansen et al. 2011
Methods and setting	Study design	Cluster RCT

	Unit of allocation	School
	Number of clusters	10 schools in the intervention group and 10 schools in the control group
	Follow-up	Only post-intervention
	Country	Netherlands
	Period	From September-October 2006 to May – June 2007
Participants	Number of participants at baseline and follow-up (intervention/control)	1240 individuals in the intervention group and 1382 individuals in the control group; 1149 individuals in the intervention group and 1267 individuals in the control group at follow-up
	Age	All children in grades 3 through 8 (6 – 12 years of age)
	Sex	Both boys and girls
	Other characteristics	Dutch, but, the majority of pupils had a non-Dutch ethnic background, multi-ethnic; socio-economic status - low income inner-city neighbourhoods
Intervention	Description	(1) three additional PE sessions a week by a PE teacher (2) additional sport and play activities by PE teacher outside school hours which can be attended on a voluntary basis. (3) A third component is classroom education with three main lessons on healthy nutrition, active living and healthy lifestyle choices adapted for each grade. Children and parents receive a scorecard with the results, including the weight status of the child. (4) Local sports clubs are given the opportunity to present them- selves during PE classes and outside school hours. (5) Fitness assessment. Children receive a score card to take home with their test results compared with reference scores. When their BMI is above age and gender specific thresholds for overweight parents receive

		a letter and are offered individual counselling by the school nurse. When needed motoric remedial teaching is offered.
	Duration of intervention	24-months
	Frequency of PA	3 times/week. Plus optional 3-5 times/week of PA outside school hours
	Duration of PA	135min/week PE + 3-5h/week for play activities outside school hours
	Intensity of PA	Not specified.
	Type of PA	Dance and rope skipping for play outside school hours.
	Parent involvement	Besides the homework assignments and fitness score card, parents are involved by providing them with written information on the intervention and inviting them for a gathering at the beginning of the school year. During this gathering information is provided by the school nurse or a dietician about a healthy lifestyle, focusing on reducing sedentary activities (watching TV and playing on the computer), promotion of outdoor play, and reduction of sugar-sweetened beverage intake and promotion of having breakfast daily.
	Setting	School
	Who delivered the intervention	PE teachers; classroom teachers Staff of local sport clubs.
	Theoretical framework	Theory of planned behaviour and the ecological model of Egger and Swinburn.
	Control	Control schools continued with their usual curriculum.
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; non-overweight, overweight or obese (based on the cut-offs published by the IOTF); WC (measuring tape (SECA 201) over the naked skin half-way between the lower rib and the top of the iliac crest); Fitness (20 m shuttle run)

Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Jiang et al. 2007
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	2 schools in the intervention group and 3 schools in the control group
	Follow-up	Only post-intervention
	Country	China
	Period	NR
Participants	Number of participants at baseline and follow-up (intervention/control)	1056 individuals in the intervention group and 1433 individuals in the control group at baseline; 1029 individuals in the intervention group and 1396 in the control group at follow-up
	Age	8.4+-1.4 intervention; 8.2+-1.5 control
	Sex	Both boys and girls
	Other characteristics	11.7% obese in the intervention group at baseline and 11.5% obese in the control at baseline; Ethnicity-Asian; Beijing urban area
Intervention	Description	The main component of the intervention programme was nutrition education aimed at both the children and their parents. The intervention aimed to increase physical activity as well. All the overweight and obese children, along with the children who failed to pass routine school physical education tests were asked to run for 20 min after class.
	Duration of intervention	36-months
	Frequency of PA	4 times/week day. (for OW children only
	Duration of PA	80 min/week
	Intensity of PA	Not specified.
	Type of PA	Running.
	Parent involvement	Yes. via education lessons
	Setting	School.
	Who delivered the intervention	Researchers and PE teacher.
	Theoretical framework	Not specified.

	Control	Regular school activities
	Intervention fidelity	The attendance rate at running sessions was 50–70%, ; More than 86% of the children who consented to join the intervention programme attended the meeting every time
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; prevalence of obesity and overweight (IOTF)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Jordan et al. 2008
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	2 schools in the intervention group and 2 schools in the control group
	Follow-up	Only post-intervention
	Country	USA
	Period	2005-2006
Participants	Number of participants at baseline and follow-up (intervention/control)	577 individuals at baseline and 411 individuals at follow-up
	Age	9.0+-1.6 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity-86% White, 7%Hispanic, 7%other
Intervention	Description	Gold Medal Schools program supports the adoption of school policies that provide opportunities for nutritious food choices, regular physical activity and tobacco prevention. The policies on PA include: •Teaching physical activity each week using the Utah State Office of Education's (USOE) physical education core curriculum; include methods to ensure faculty awareness of the policy • all K-12 physical education and physical activity are overseen by certified Physical Education (PE) teachers •Discouraging withholding PE or recess as a punishment;

		•Establishing a Gold Medal Mile waking program on or around school grounds and a goal for student participation •Offering a variety of competitive and non-competitive physical activity programs accessible to all students •Participating in various physical activity community events (e.g. the Walk Your Child to School Day, American Diabetes Association's School Walk for Diabetes, American Heart Association's physical activity and community service programs, Jump Rope for Heart or Hoops for Heart) •Allowing students to use physical activity facilities outside school hours Various policies on nutrition are also implemented (e.g. the Health Education core curriculum, Food is not to be used as a reward or as a punishment for students, "heart healthy" food choices outside the school meal services, limited access to vending machines, school stores, snack bars, and other food outlets)
	Duration of intervention	12-months
	Frequency of PA	Not specified
	Duration of PA	Not specified
	Intensity of PA	Not specified
	Type of PA	Not specified
	Parent involvement	No.
	Setting	Schools
	Who delivered the intervention	Not specified
	Theoretical framework	Not specified
	Control	Regular school curriculum
	Intervention fidelity	Following study completion, the two intervention schools achieved gold medal status
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI z score (CDC/WHO)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Kain et al. 2009
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	3 schools in the intervention group and 3 schools in the control group
	Follow-up	At 9 months; 15 months; 21 months
	Country	Chile
	Period	2003-2004
Participants	Number of participants at baseline and follow-up (intervention/control)	1759 individuals in the intervention group and 671 in the control group at baseline; 1466 in the intervention group and 573 in the control group at follow-up
	Age	9.8 +- 2.3 years
	Sex	Both boys and girls
	Other characteristics	Socio-economic status- proportion of children participating in the School Lunch Program as an indirect measure of poverty; for the control school it was 36 % while the mean for the intervention schools was comparable at 32%
Intervention	Description	The intervention included activities in nutrition and physical activity. Children got 10 hours in first and 4 hours in second year contents on healthy eating from trained teachers. Children got 90 min of additional weekly PE classes in both years..
	Duration of intervention	24-months
	Frequency of PA	Not specified
	Duration of PA	90 min/week
	Intensity of PA	Not specified
	Type of PA	Not specified
	Parent involvement	Yes, two educational lessons by the nutritionist.
	Setting	School
	Who delivered the intervention	Teachers
	Theoretical framework	Not specified
	Control	Not specified
	Intervention fidelity	Fully applied the first year and partially in the second one. In summary, the intervention changed during the second school year for reasons beyond the control of the investigators. It is evident that a weaker

		nutrition educational component was in place, while the physical activity component was more specifically focused to 1st and 2nd graders.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; BMI z-score (CDC); WC (measured); body fat (triceps skinfold); obesity prevalence (CDC)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Kain et al. 2014
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	5 schools in the intervention group and 4 schools in the control group
	Follow-up	3 months
	Country	Chile
	Period	2011-2012
Participants	Number of participants at baseline and follow-up (intervention/control)	651 individuals in the intervention group and 823 individuals in the control group at follow-up – 76.6% of original sample
	Age	6.6+-1.1 years (range 6–8)
	Sex	Both boys and girls
	Other characteristics	Socio-economic status-low income children; Obesity % lower at baseline in both intervention and control in boys and in the control in girls
Intervention	Description	The intervention included classroom nutrition education, increasing physical education (PE) class time, and increasing time children were moderately active during those classes. Teachers of PE classes were trained on how to increase MVPA during the class. In addition, 45 min of PE were added to the existing 135 min/week. Classroom education consisted of a brief theoretical part about healthy nutrition and practical work in the form of activities like painting and puzzles.
	Duration of intervention	12-months
	Frequency of PA	2x/week

	Duration of PA	180 min
	Intensity of PA	MPA or VPA
	Type of PA	Not specified
	Parent involvement	Yes, once a month motivational sessions about education and health food
	Setting	School
	Who delivered the intervention	PE teachers
	Theoretical framework	Not specified
	Control	Regular school activities
	Intervention fidelity	Minutes of MVPA and consequently % of class time children engaged in MVPA were very low and declined in control classes (24.5 to 16.2% of MVPA) while remaining unchanged in classes conducted by trained teachers (24.8 and 23.7%).
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time,	BMI; BMI z score (WHO reference); Prevalence of overweight and obesity; Moderate to vigorous activity (pedometers (New Life Style 1000))
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Kain et al. 2004
Methods and setting	Study design	CBA
	Unit of allocation	School
	Number of clusters	3 schools in the intervention group and 2 schools in the control group
	Follow-up	Only post-intervention
	Country	Chile
	Period	March/April – November 2002
Participants	Number of participants at baseline and follow-up (intervention/control)	3577 individuals at baseline; 2141 individuals in the intervention group and 945 individuals in the control group at both baseline and follow-up
	Age	10.6 years
	Sex	Both boys and girls
	Other characteristics	Chilean; Low socio-economic status (approximately 35% of children receiving School Lunch Program)

Intervention	Description	Intervention program has two components: 1) Food and nutrition: applied the educational program developed by INTA/FAO, whose objective is to incorporate nutrition education into the 3rd to 8th grade curriculum. 2) Physical activity intervention included three aspects: (i) Canadian active living challenge a practical behavioural resource designed to instill health and activity The research PE teacher was responsible for its application and could only do it once a week (ii) Provision of an extra 90 min per week of physical activity to children from 3rd to 8th grades during 6 months: These were mainly oriented toward a certain sport (soccer, basketball and volleyball) and were conducted by the school PE teacher/classroom teacher or research team PE teacher. (iii) Active recess: During one daily recess (15 min per day), music was played at recess time, so children were encouraged to dance, play ping-pong, basketball or volleyball as recreation, using the equipment provided by the study. This activity was implemented for approximately 3 months, during the second half of the intervention period. (iv) Extra program: During the implementation of the PE program, the research team promoted activities beyond those planned originally. These were based on the individual interest of the PE teacher and varied according to the schools' facilities).
	Duration of intervention	6-months
	Frequency of PA	Not specified
	Duration of PA	90 min/week + 1dditional 75/week during 3 months
	Intensity of PA	Not specified
	Type of PA	Not specified
	Parent involvement	Two meetings directed at healthy eating, obesity prevention and to reinforce national food-based dietary guidelines.
	Setting	School
	Who delivered the intervention	Teachers (trained by a nutritionist) and PE teachers
	Theoretical framework	Not specified
	Control	Regular school activities
	Intervention fidelity	Not specified

Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	Triceps skinfold thickness (TSF) and waist circumference (WC) (measured); BMI; physical fitness (two health-related tests: the first one assesses flexibility of the lower back by reaching as far as possible from a standing position, while the other one is the endurance 20 m shuttle run test (20m SRT or Leger and Lambert test), which indirectly determines aerobic capacity by running at an increasing speed back and forth a distance of 20 m); dietary assessment questionnaire; attitudes and behaviour related to healthy eating and physical activity: these were assessed on children from 4th to 8th grade and consisted in a self-registered questionnaire
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Katz et al. 2010
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	3 schools in the intervention group and 2 schools in the control group
	Follow-up	Only post-intervention
	Country	USA
	Period	2007-2008
Participants	Number of participants at baseline and follow-up (intervention/control)	655 individuals in the intervention group and 559 individuals in the control group at baseline; 603 individuals in the intervention group and 508 individuals in the control group at follow-up
	Age	7-9 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity- predominantly white; socio-economic status- 62% free and reduced-price meals
Intervention	Description	The physical activity component, ABC (Activity Bursts in the Classroom) for Fitness incorporates brief bursts of activity in the classroom throughout the day at the discretion of the teacher. The project also features parental education and community involvement. ABC for Fitness aims to provide fun and creative activities that are non-competitive, age-appropriate, and gender-neutral to promote an

		interest in physical activity. Ideally, the activity bursts added at least 30 minutes of daily physical activity. Each burst had 3 components: 1) Warm-up: stretching or light aerobic activity (e.g., walking, arm circles, muscle stretching), 2) Core activity: strength activities or aerobic activities (e.g., hopscotch, lunges, squats, star jumps, jogging, walking quickly, hopping, dancing to music, skipping), 3) Cooldown: stretching or low-intensity activity.
	Duration of intervention	Not specified.
	Frequency of PA	5 times/week.
	Duration of PA	At least 150 min/week.
	Intensity of PA	Not specified.
	Type of PA	strength activities or aerobic activities
	Parent involvement	The intervention also included a family/parental component in which fitness experts helped families learn how to be more active together.
	Setting	School + Family
	Who delivered the intervention	Classroom and PE teachers.
	Theoretical framework	Not specified.
	Control	Normal curricular activities
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; BMI percentile (CDC); endurance, strength, and flexibility (Fitnessgram); Aerobic capacity (The Pacer, a 15- or 20-meter progressive, multistage shuttle run set to music); VO2max (was measured as a proxy for general fitness by using the recommended calculation based on the number of laps completed and child's age); Abdominal strength (curl-ups, upper-body strength-90-degree push-ups, back extensor strength-trunk lift, and flexibility-back-saver sit and reach); Classroom behaviour (was assessed by the work and social skills component of the ISD progress report for the 2007-2008 school year); Student attitudes toward physical activity (subset of the School Physical Activity and Nutrition (SPAN) Questionnaire); Academic performance (was assessed by comparing post-intervention Missouri Academic Performance (MAP) scores of fourth-grade students with their pre-intervention MAP scores from third grade (2006-2007 school year))
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Kesztyus et al. 2017
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	43 schools in the intervention group and 41 schools in the control group
	Follow-up	Only post-intervention
	Country	Germany
	Period	2010-2011
Participants	Number of participants at baseline and follow-up (intervention/control)	1964 at baseline; 1844 at follow up; 1733 data for analysis
	Age	7.1±0.6 years
	Sex	Both boys and girls
	Other characteristics	Socio-economic status-12% low income families
Intervention	Description	The three main topics of the program are the promotion of physical activity, the reduction in intake of sugar-sweetened beverages and the reduction of screen media consumption. All intervention materials were integrated into the regular curriculum; no extra lessons were required. As well as course materials for the teachers, the intervention materials include materials for children (e.g. activity breaks). Furthermore, the intervention consists of two physical activity exercises which are performed every school day ("active breaks", each exercise takes between 5 and 7 minutes).
	Duration of intervention (months or weeks)	24-months
	Frequency of PA	5 times/week
	Duration of PA	50-70 min/week (“active breaks”)
	Intensity of PA	Not specified
	Type of PA	Not specified
	Parent involvement	Yes, via family homeworks and parent evenings
	Setting	School.
	Who delivered the intervention	32 experienced teachers (extra trained).
	Theoretical framework	Intervention mapping approach, Social cognitive theory and the socio-ecological model.
	Control	Regular school curriculum

	Intervention fidelity	Not reported.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time,	BMI percentile (German reference values); waist-to-height ratio –WHtR (measured); Incidence of abdominal obesity (WHtR>0.5)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Kipping et al. 2008
Methods and setting	Study design	Cluster-RCT
	Unit of allocation	School
	Number of clusters	10 schools in the intervention group and 9 schools in the control group
	Follow-up	Only post-intervention
	Country	England
	Period	February-June 2006
Participants	Number of participants at baseline and follow-up (intervention/control)	331 individuals in the intervention group and 348 individuals in the control group at baseline; 249 individuals in the intervention group and 223 individuals in the control group at follow-up
	Age	In year 5 9–10 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity- English (Caucasian)
Intervention	Description	Planet Health lifestyle curriculum involving sixteen lessons on healthy eating, increasing physical activity and reducing TV viewing were adapted by two primary school teachers. Materials included lesson plans for nine physical activity lessons, six nutrition lessons and one lesson about screen viewing.
	Duration of intervention	5-months
	Frequency of PA	/
	Duration of PA	/
	Intensity of PA	/

	Type of PA	In the physical activity lessons, the children played games based on the food groups using photographs of food that reinforced the theory taught in the nutrition lessons.
	Parent involvement	No
	Setting	School
	Who delivered the intervention	classroom teachers
	Theoretical framework	Social cognitive theory
	Control	usual curriculum
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time,	Screen-based activities (questionnaire); mode of transport to and from school defined as walking/cycling or being driven or going by bus to school (questionnaire); Obesity was defined using the BMI above the 95th centile of the reference curve for the age and gender of each child (UK National BMI classification)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Klakk et al. 2013
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	6 schools in the intervention group and 4 schools in the control group
	Follow-up	Only post-intervention
	Country	Denmark
	Period	2008-2010
Participants	Number of participants at baseline and follow-up (intervention/control)	415 individuals in the intervention group and 327 individuals in the control group at baseline; 351 individuals in the intervention group and 281 individuals in the control group at follow-up
	Age	7.7-12 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity – Caucasian
Intervention	Description	Curricular physical education was increased from 90 to 270 min per week distributed across at least three school days.
	Duration of intervention	24-months

	Frequency of PA	>=3 times/week.
	Duration of PA	270 min/week.
	Intensity of PA	Not specified.
	Type of PA	Play, exercise and games. The focus on technical and coordinative skills was increased as children entered adolescence.
	Parent involvement	No.
	Setting	School.
	Who delivered the intervention	PE teachers.
	Theoretical framework	Not specified.
	Control	Regular school activities (PE 90 min per week).
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; overweight and obesity prevalence (IOTF); body fat (DXA); pubertal stage (SAQ)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Knox et. al. 2012
Methods and setting	Study design	CBA
	Unit of allocation	Grade
	Number of clusters	1 intervention and 2 control
	Follow-up	Only post-intervention
	Country	UK
	Period	NR
Participants	Number of participants at baseline and follow-up	115 individuals in the intervention group and 77 in the control group at baseline; 101 in the intervention group and 66 in the control group at follow-up
	Age	12.4 ± .5 years intervention; 12.1 ± 1.1 years control
	Sex	Both boys and girls
	Other characteristics	/
Intervention	Description	School-based cross-curricular physical activity intervention Activity Knowledge Circuit was designed to increase school time physical

		activity by additional 2 hours. 3200 m of brisk walking was introduced during a 60-minute subject (normally classroom-based) lesson.
	Duration of intervention	18-weeks
	Frequency of PA	2 intervention lessons/week
	Duration of PA	2 x 60 minutes/week
	Intensity of PA	HR=130 beats per minute walking speed; one beep equating one step
	Type of PA	Aerobic – walking
	Parent involvement	No
	Setting	School
	Who delivered the intervention	Subject teacher, researcher, and/or member of the physical education department
	Theoretical framework	Not specified
	Control	Regular school activities
	Intervention fidelity	Not specified
Outcomes		BMI; waist and hip circumferences; skinfold thickness (biceps, triceps, subscapular, suprailiac) with calliper; blood pressure (automated blood pressure monitor); lipids, lipoproteins, glucose, insulin, high-sensitivity C-reactive protein, high-molecular-weight adiponectin (blood samples from the antecubital vein); aerobic fitness (20-m multistage fitness test); physical activity behaviour (Physical Activity Questionnaire for Adolescents (PAQ-A))
Adverse outcomes		NR

Authors and year		Laazar et al. 2007
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	14 schools in the intervention group and 5 schools in the control group
	Follow-up	Only post-intervention
	Country	France
	Period	NR
Participants	Number of participants at baseline and follow-up (intervention/control)	197 individuals in the intervention group and 228 individuals in the control group at baseline and 99% at follow-up
	Age	7. 4±0.8 years (range 6-10)

	Sex	Both boys and girls
	Other characteristics	Socio-economic status-representative of community; 13,9% of children were obese at the baseline within intervention and 9,6% within control group
Intervention	Description	A playful physical practice and 45 min of dynamic exercise within 1 h of PA, based on traditional games
	Duration of intervention	6-months
	Frequency of PA	2 times/week
	Duration of PA	120 min/week
	Intensity of PA	Not specified
	Type of PA	Traditional games
	Parent involvement	No
	Setting	School
	Who delivered the intervention	Sport science students (tutored by PE teachers)
	Theoretical framework	Not specified
	Control	Regular school activities
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; BMI-z-score; WC-measured; body fat (skinfolds); prevalence of obesity (French centiles); FFM (skinfold thicknesses, Brook equation)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Lau et al. 2016
Methods and setting	Study design	RCT
	Unit of allocation	Child
	Number of clusters	/
	Follow-up	Only post-intervention
	Country	Hong Kong
	Period	NR
Participants	Number of participants at baseline and follow-up (intervention/control)	40 individuals in the intervention group and 40 individuals in the control group at baseline and at follow-up

	Age	8-11 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity – Asian
Intervention	Description	Active videogames (AVG) intervention. The Kinect sensor is compatible with all the Xbox 360 models and this technology uses a webcam-style sensor device, allowing participants to play the game without any joystick or hand controller.. Xbox Sport Season Series 1 and 2 that comprise six different sport games in each season were adopted in the intervention. The two Seasons feature both team-based and individual sports, including 10-pin bowling, boxing, track and field, table tennis, beach volleyball, and association football in Season 1 and golf, darts, baseball, skiing, tennis, and American football in Season 2. The player controls the sports by mimicking how the sports are played in real life without the equipment that usually is associated with them. The intervention was held after school in a large function room that allowed all children in the intervention group to play at the same time. Team games were played with two children sharing one Xbox 360. This was designed to provide a better motivational climate compared with individual-based gameplay.
	Duration of intervention	12-weeks.
	Frequency of PA	2 times/week.
	Duration of PA	120 min/week.
	Intensity of PA	MPA (4 METs)
	Type of PA	Physically active videogames mimicking sports
	Parent involvement	No.
	Setting	School.
	Who delivered the intervention	Investigators
	Theoretical framework	Not specified.
	Control	Regular school activities
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; aerobic fitness (Progressive Aerobic Cardiovascular Endurance Run (PACER) 20-m shuttle run performance test); PA (ActiGraph GT3X+ accelerometer); Psychological correlates (multiple-item scales)

Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Li et al. 2010
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	Randomly selected two districts, DongCheng and Chong Wen, from the eight in urban Beijing. 10 primary schools from each district were randomly chosen and assigned to be either an intervention or control group.
	Follow-up	1 year
	Country	China
	Period	2005-2006
Participants	Number of participants at baseline and follow-up (intervention/control)	At baseline (2005) control n=2371 (1194 boys and 1177 girls), intervention n=2329 (1264 boys and 1065 girls); at the end of intervention (2006) control n=2115 (1065 boys and 1050 girls), intervention n=2072 (1115 boys and 957 girls); at 1-yr follow up (2007) control n=2092 (1031 boys and 1061 girls), intervention n=2028 (1087 boys and 941 girls)
	Age	8-11 years
	Sex	Both boys and girls
	Other characteristics	/
Intervention	Description	Happy 10 program consisted of two daily 10-min physical activity sessions conducted in the break between classes. The program provided a variety of safe, moderate, age-, and space-appropriate exercises. Teaching materials included activity cards, video demonstrations, tracking posters, and stickers. Each activity card introduced one exercise and explained how to perform it.
	Duration of intervention	12-months
	Frequency of PA	10 times/week (2 times/day).
	Duration of PA	20 min/day or 100 min/week.
	Intensity of PA	MVPA (60 to 70 kcal/ school day).
	Type of PA	PA card games.

	Parent involvement	Parents were encouraged to develop new activity models.
	Setting	School
	Who delivered the intervention	Classroom teachers
	Theoretical framework	Not specified.
	Control	Regular school activities
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI z-score (WHO); body fat (BIA)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Li et al. 2014
Methods and setting	Study design	Non-RCT with cluster sampling
	Unit of allocation	School
	Number of clusters	4 public schools
	Follow-up	Only post-intervention
	Country	China
	Period	September 2012-January 2013
Participants	Number of participants at baseline and follow-up (intervention/control)	388 individuals in the intervention group and 533 individuals in the control group at baseline; 365 individuals in the intervention group and 488 individuals in the control group at follow-up
	Age	7-15 years
	Sex	Both boys and girls
	Other characteristics	/
Intervention	Description	The intervention program included three PA components: PE improvement, extra-curricular PA for overweight/obese students, and family PA with parent involvement. Schools were required to improve content, intensity and schedule of PE, to ensure that students have three compulsory 45-minute PE per week, with at least 30-minute MVPA in each class.

		On days without PE, PA at home for 20 to 30 minutes as a part of homework was required (rope jumping, jogging etc.). Extracurricular PA for overweight and obese students were organized by PE teachers during breaks, at noon, or after school hours, mainly being MVPA such as aerobics, jogging, rope jumping and kinds of games. Though this part was not compulsory, overweight and obese students were encouraged for participation for at least 3 days per week and a total of 30-min MVPA each day were guaranteed. Three health education lectures for students were given by the study team members in each school. The con-tents of lectures included the cause and harms of child-hood obesity, BMI reference for screening overweight and obesity in Chinese school-age children, healthy eating (increasing consumption of vegetables and fruits, reducing consumption of meat, snacks, western fast foods and eating in restaurants, avoiding sugary drinks), and physical activity (intensity, duration, reducing sedentary. At family setting, family PA guidance was provided and parents' encouraging and supervising function was promoted.
	Duration of intervention	12-weeks
	Frequency of PA	PE 3 times/week.
	Duration of PA	PE 135 min/week + 40-60 min/week homework PA for days without PE; + extra 90 min MVPA/week for OW and OB students
	Intensity of PA	MVPA (64%-94% of their age-predicted maximum heart rate).
	Type of PA	For elementary students of Grade 2 and 3, rope jumping and light throwing were mainly practiced; for those of Grade 4 and 5, sprint, endurance running (50 m*8 shuttle run) and rope jumping were practiced; and for middle school students, endurance running (1000 m for boys and 800 m for girls), long jumping and basketball were practiced. For overweight and obese students: aerobics, jogging, rope jumping and kinds of games.
	Parent involvement	Yes, via health education lesson
	Setting	School
	Who delivered the intervention	PE teachers, field professionals
	Theoretical framework	Social Ecological Model.
	Control	Usual practice.

	Intervention fidelity	In 720 PE of two schools, the attendance rate reached 95%-100%; 82.7% reached at least moderate PA level; Among 128 overweight and obese students who were encouraged to take part in extracurricular PA, 100% had participation of 3 times per week. In 60 extracurricular PA, 87.5% reached at least moderate PA level. Each intervention school had three health education lectures for students, each lasting for 30 to 40 minutes, with attendance rate of 95%-100%, and one health education lecture for parents, lasting 25-30minutes, with attendance rate of 100%. Distribution rate of educational materials was 100%.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI - "BMI Reference for Screening Overweight and Obesity in Chinese School-age Children" developed by Working Group on Obesity in China; WC (measured); skinfold thickness (triceps, subscapular and abdominal); serum lipids (total cholesterol, HDL-C, LDL-C and triglycerides); fasting blood glucose (measured); duration of MVPA (self -administered questionnaires)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Liu et al. 2008
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	1 school in the intervention group (14 classes) and 1 school in the control group (12 classes)
	Follow-up	Only post-intervention
	Country	China
	Period	2004-2005
Participants	Number of participants at baseline and follow-up (intervention/control)	328 individuals in the intervention group and 425 individuals in the control group at baseline and at follow-up
	Age	1st to 5th grade
	Sex	Both boys and girls
	Other characteristics	/

Intervention	Description	The Happy 10 programme is a classroom-based physical activity programme for primary-school students. Many safe and age- and space-appropriate physical activities are included in the programme materials. The Happy 10 programme was actually organized and implemented by teachers among students in grades 1–5 in the intervention school, taking about 10 min at least once every school day from October 2004 to June 2005. A tracking poster and stickers were used to illustrate the progress of each class.
	Duration of intervention	9-months
	Frequency of PA	5x/week
	Duration of PA	10 min
	Intensity of PA	average METs value per PA session ranged from 4.8 to 6.2 kcal/kg/h
	Type of PA	Not specified
	Parent involvement	Not specified
	Setting	School
	Who delivered the intervention	Teachers
	Theoretical framework	Not specified
	Control	Regular school activities
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; prevalence of overweight and obesity (Group of China Obesity Task Force)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Liu et al. 2019
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	6 schools in the intervention group and 6 schools in the control group
	Follow-up	At the half of the intervention and post-intervention
	Country	China
	Period	October 2013 – September 2014

Participants	Number of participants at baseline and follow-up (intervention/control)	930 individuals in the intervention group and 959 individuals in the control group at baseline; 1837 (97.2%) at 6-month follow-up; 1839 (97.4%) at 12-month follow-up
	Age	7-11 years
	Sex	Both boys and girls
	Other characteristics	Chinese
Intervention	Description	The intervention had 4 components: *1*) school-level policies, *2*) health education activities, *3*) improvement of physical activity, and *4*) improvement of school lunches. 1) Throughout the intervention period, students were told not to drink sugar-sweetened beverage or eat unhealthy snacks in schools, and drinking water was advocated. They were also told not to play electronic products (e.g., smart phones and tablet computers) in schools. Children were encouraged to perform at least 60 minutes of MVPA each day. 2) A total of four health education lessons were delivered to children in the first semester, with one 40-min lesson delivered once every 2 weeks. Students were asked to keep diaries of behaviours in relationship to diet and physical activity for a week (from Monday to Sunday) once a month. 3) ensuring sufficient time and intensity of physical activity in PE course (duration, frequency, and intensity described below). Sport equipment was provided to support extracurricular PA. Sport club was offered to students with overweight 4) practical suggestions to the managers of school lunch to improve children's dietary intake at school three times during the intervention (at baseline, midpoint, and end of the intervention).
	Duration of intervention	12-months
	Frequency of PA	3 times/week (PE curriculum), 3 times/week (sport club for students with OW)
	Duration of PA	135 min/week (PE curriculum), 90 min/week (sport club for students with OW)
	Intensity of PA	MPA or VPA
	Type of PA	PE courses were implemented according to national PE criteria in China. Instruction manuals were distributed for extracurricular activities, which provided suggestions on types of activities (e.g., rope jumping and shuttlecock kicking) children could engage in.

	Parent involvement	Yes. Parents were involved in discussions and interviews. Additionally, extracurricular activities for overweight/obese children were encouraged by parents.
	Setting	School
	Who delivered the intervention	Classroom teachers (health education), PE teachers (PA)
	Theoretical framework	Analysis Grid for Environments Linked to Obesity, Social Cognitive Theory, National PE criteria.
	Control	Regular school activities
	Intervention fidelity	The quantity of intervention delivery was 80%–100% for intervention elements among most intervention schools.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI z-score (WHO); knowledge and behaviour related to energy balance (questionnaire); dietary intake (questions based on the validated Block Kids Food Screener); duration of MVPA (7-day physical activity questionnaire (PAQ))
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Llaurado et al. 2014
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	5 schools with 18 classrooms in the intervention group and 11 schools with 23 classrooms in the control group
	Follow-up	Only post-intervention
	Country	Spain
	Period	2011-2013; 22 months during first, second and third academic year
Participants	Number of participants at baseline and follow-up (intervention/control)	413 individuals in the intervention group and 503 individuals in the control group at baseline; 320 individuals in the intervention group and 370 individuals in the control group at follow-up
	Age	8.04±0.6 years at baseline
	Sex	Both boys and girls
	Other characteristics	Ethnicity-78% Western European
Intervention	Description	The intervention program consisted of three components: 1) classroom practice by the Health Promoter Agents (HPA) to highlight eight healthy

		lifestyle habits, termed educational intervention activities; 2) teaching practice by the HPA using specially designed booklets which focused on the same lifestyle topics presented as educational activities; 3) parental activities to be included with that of their children. The educational activities focused on lifestyle topics to improve nutritional food item choices, healthy habits such as teeth-brushing and hand-washing and, overall, adoption of activities that encourage physical activity (walking to school, playground games) and to avoid sedentary behaviour. The intervention was carried out in 12 activities which were disseminated over 12 sessions (1h/activity/session) and implemented as four activities per school year. The activities were implemented every two weeks over two-month period each school year.
	Duration of intervention	30-months (three school years).
	Frequency of PA	/
	Duration of PA	/
	Intensity of PA	/
	Type of PA	/
	Parent involvement	Educational nutritional activities. The intention was to have parents and their children interact in the healthy nutrition and lifestyle choices.
	Setting	School, classroom.
	Who delivered the intervention	Teachers.
	Theoretical framework	Not specified.
	Control	Not specified.
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	Obesity prevalence (IOTF); BMI z-score (WHO); Dietary habits and lifestyle (questionnaire)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Llaurado et al. 2018
Methods and setting	Study design	Cluster RCT

	Unit of allocation	School
	Number of clusters	High schools in Reus (intervention group), Salou, Cambrils and Vilaseca (control group).
	Follow-up	4 years
	Country	Spain
	Period	2007-2010
Participants	Number of participants at baseline and follow-up (intervention/control)	1550 allocated to intervention and 800 allocated to control; 349 individuals in the intervention group and 154 individuals in the control group at follow-up
	Age	13-15 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity- Caucasian (Spanish)
Intervention	Description	The intervention program consisted of three components: 1) classroom practice to highlight eight healthy lifestyle habits including PA and nutrition, termed educational intervention activities; 2) teaching practice using specially-designed booklets (as teaching aids) which focused on the same lifestyle topics presented as educational activities 3) parental activities to be included with that of their children. All the activities had the same following format: 5–10 min of funny theory about nutritional characteristics or health benefits; 15 min of play based on the theory of this activity (for example, memory cards); 30 min of experimental activity (children played and tasted the food that related to the activity); and 5–10 min of discussion and to answer questions. These intervention activities were based on 12activities (1 h/activity/session) conducted 4 per year every15 days in the third trimester of a Spanish academic course (April to June) over 15 weeks per academic year
	Duration of intervention	28-months (3x15 weeks over 3 academic years)
	Frequency of PA	/
	Duration of PA	/
	Intensity of PA	/
	Type of PA	/
	Parent involvement	Yes, educational nutritional activities.
	Setting	School

	Who delivered the intervention	PE teachers
	Theoretical framework	Not specified
	Control	Regular school curriculum
	Intervention fidelity	"The fidelity of the schools was great"
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	OB prevalence measured as BMI (according to IOTF and World Health Organization criteria); BMI z-score (WHO); dietary habits (enKid questionnaire); after-school PA in hours/week and sedentary lifestyles (AVall questionnaire)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Lloyd et al. 2012
Methods and setting	Study design	Exploratory cluster RCT
	Unit of allocation	School
	Number of clusters	2 schools with 3 classes in the intervention group and 2 schools with 4 classes in the control group
	Follow-up	6 months and 12 months after the intervention
	Country	UK
	Period	October/November 2008 – October/November 2010
Participants	Number of participants at baseline and follow-up (intervention/control)	80 individuals in the intervention group and 122 individuals in the control group at baseline; 74 in the intervention group and 119 in the control group at first follow-up; 73 in the intervention group and 114 in the control group at second follow-up
	Age	9-10 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity- mix in the South West, with the majority of the population being white; Socio-economic status for the area is higher than average; within Exeter, there are some areas with quite severe deprivation."
Intervention	Description	The Healthy Lifestyles Programme (HeLP) is school-based intervention that aims to deliver a general healthy lifestyle message encouraging a healthy energy balance. Within this context, three key behaviours are emphasised: a decrease in the consumption of sweetened fizzy drinks, an increase in the proportion of healthy snacks (HS) to unhealthy snacks

		consumed and a reduction in television (TV) viewing and other screen-based activities.
	Duration of intervention	12-months
	Frequency of PA	/
	Duration of PA	/
	Intensity of PA	/
	Type of PA	/
	Parent involvement	Yes. Assist with goals setting.
	Setting	School and family environment.
	Who delivered the intervention	Not specified.
	Theoretical framework	Information, Motivation and Behavioural Skills Model.
	Control	Not specified.
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; WC (measured); body fat SDS (Tanita SC330 portable body composition analyser); physical activity (GT1M Actigraph); television (TV) viewing/screen time (Children's TV Viewing Habits Questionnaire); food intake (Food Intake Questionnaire)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Lloyd et al. 2018
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	16 schools in the intervention group and 16 schools in the control group
	Follow-up	9 and 15 months
	Country	UK
	Period	2013-2014
Participants	Number of participants at baseline and follow-up (intervention/control)	676 individuals in the intervention group and 648 in the control group baseline; 628 individuals in the intervention group and 616 in the control group follow-up
	Age	9.8+-0.3 years (9-10)
	Sex	Both boys and girls

	Other characteristics	Socio-economic status: >half of the schools in the trial with at least the national average proportion of pupils eligible for free schools meals (19% at the time of recruitment of schools); average Child index of multiple deprivation=16 060 (12347–21957)
Intervention	Description	The programme delivered a general healthy lifestyle message with a focus on behaviours such as the consumption of sugar-sweetened beverages, healthy and unhealthy snacking, physical activity, and reducing screen time. An overarching message promoted was the 80/20 rule, which recommended eating healthily and being active at least 80% of the time . It included dynamic and interactive activities such as physical activity workshops, education sessions delivered by teachers with short homework tasks, drama sessions, and setting goals to modify behaviour (with parental support and one-to-one discussions with HeLP coordinators).
	Duration of intervention	12-months
	Frequency of PA	Not specified
	Duration of PA	Not specified
	Intensity of PA	Not specified
	Type of PA	Dance, games
	Parent involvement	Yes, via parent events
	Setting	School
	Who delivered the intervention	Teachers
	Theoretical framework	Not specified
	Control	Regular school activities
	Intervention fidelity	All schools in the intervention group completed or nearly completed the whole programme and the quality of delivery in all schools was at or above the established appropriate level. 629 (93%) of the 676 children in the intervention group were categorised as compliers (i.e., they received at least four of the five drama sessions and the one-to-one goal-setting discussion in phase 3) 353 (52%) of the 676 children had family attending at least one parent event.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time.	BMI SDS score (LMS method); body fat% (measured); WC (measured); body fat (BIA); physical activity (measured using accelerometry); self-reported scores for the number of different types of energy-dense snacks, healthy snacks, healthy foods (positive food markers), and unhealthy

		foods (negative food markers) consumed per day (Food Intake Questionnaire (FIQ))
Adverse outcomes	State the outcome and the method of assessment	1 adverse event related to child's eating and activity behaviour (over-exercising and restricting food intake)

Authors and year		Eather et al. 2013
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	2 schools in the intervention group and 2 schools in the control group
	Follow-up	Post-intervention and 23 weeks after intervention
	Country	Australia
	Period	2011
Participants	Number of participants at baseline and follow-up (intervention/control)	118 individuals in the intervention group and 108 individuals in the control group at baseline; 109 individuals in the intervention group and 104 individuals in the control group at follow-up
	Age	10.72 +- 0.6 years
	Sex	Both boys and girls
	Other characteristics	/
Intervention	Description	The **Fit4Fun programme** included three major components that were based on the HPS Framework: **Curriculum programme:** The programme was designed to improve the knowledge, skills and understanding of students in relation to HRF and also focused on developing skills in assessing and monitoring HRF components. **Family partnership:** Children, their parents and family members were given an 8-week home activity programme designed to improve HRF levels using a range of engaging and enjoyable fitness activities, small-sided games and fitness challenges. **School environment:** Schools were provided with activity task cards outlining the rules and organization of a range of fun and vigorous games (e.g. small-sided invasion games, skipping challenges) and a variety of equipment for use during break-times.
	Duration of intervention	8-weeks (HPE curriculum program) & 8-weeks (home activity program)

	Frequency of PA	1 time/week; 3 times/week; /
	Duration of PA	60 min/week; 60 min/week (3x20 min); /
	Intensity of PA	Not specified
	Type of PA	Range of fun and vigorous games (e.g. small-sided invasion games, skipping challenges) and a variety of equipment for use during break-times. The break-time activities were optional for students and involved enjoyable games, activities and fitness challenges.
	Parent involvement	There were goal setting activities and reflection tasks for students to complete with their parents at the end of each week, enabling them to set personal fitness goals, monitor their achievement and to reflect on their progress.
	Setting	School and home
	Who delivered the intervention	The member of the research team (an experienced physical educator);
	Theoretical framework	Social Cognitive Theory and Competence Motivation Theory
	Control	The control group participated in their usual 60 min/week HPE lesson over the 8-week intervention period delivered by their normal classroom teacher.
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI Z-score (Fitnessgram); CRF (measured using the 20 m shuttle run test); Muscular fitness (measured using the Standing jump, 7-stage sit-up, basketball throw and push-up tests); Flexibility (measured using the sit and reach test); Physical activity (Yamax SW700 pedometers)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Lucertini et al. 2013
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	1 school in the intervention group A; 1 school in the intervention group B; 1 school in the control group
	Follow-up	3 months post-intervention
	Country	Italy
	Period	NR

Participants	Number of participants at baseline and follow-up (intervention/control)	38 individuals in the intervention group A; 37 individuals in the intervention group B and 26 individuals in the control group at baseline and at follow-up
	Age	9.5 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity - Caucasian (Italian)
Intervention	Description	A six-month, twice-a-week PE program. Before the workout period of each class, children were randomly divided into two groups performing alternatively basic motor abilities (BMA) and health-related abilities (HRA) exercises, dealing predominantly with basic motor skills, coordination, rhythm, etc. and predominantly with endurance, strength, flexibility, etc., respectively. Both experimental groups underwent the same exercise program, except for the HRA phase, although HRA workout was designed to approximately produce the same training load for both experimental groups. Group A trained strength and endurance with specifically designed cardiovascular and resistance devices (the ‘‘Kid’s System’’, Panatta Sport, Apiro, MC, Italy), while group B by means of either traditional or non-conventional devices (e.g. light dumbbells, elastic bands, plastic water bottles, etc.).
	Duration of intervention	6-months
	Frequency of PA	2 times/week.
	Duration of PA	120 min/week
	Intensity of PA	
	Type of PA	Group A trained strength and endurance with specifically designed cardiovascular and resistance devices (the ‘‘Kid’s System’’, Panatta Sport, Apiro, MC, Italy), while group B by means of either traditional or non-conventional devices (e.g. light dumbbells, elastic bands, plastic water bottles, etc.).
	Parent involvement	No.
	Setting	School
	Who delivered the intervention	A and B groups were supervised by two specialised PE teachers
	Theoretical framework	Not specified.
	Control	Program not structured and lead by teacher generalist.
	Intervention fidelity	Children’s attendance and participation was higher than 75%

Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; Body fat (skinfolds); fitness- tests from EUROFIT and (Italian Olympic Committee (2003) batteries; basic motor abilities – motoric tests; health-related abilities – tests
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Lynch et al. 2016
Methods and setting	Study design	Cluster RCT
	Unit of allocation	Classroom
	Number of clusters	4 classrooms in the intervention group and 4 classrooms in the control group
	Follow-up	Only post-intervention
	Country	USA
	Period	2014
Participants	Number of participants at baseline and follow-up (intervention/control)	29 individuals in the intervention group and 22 individuals in the control group at baseline and at follow-up
	Age	8 years
	Sex	Both boys and girls
	Other characteristics	Socio-economic status-71% free or reduced-price lunch; ethnicity-white (non-Hispanic) = 47%, black (non-Hispanic) = 20%, Hispanic = 19%, Asian/Pacific Islander = 14%, limited English proficient = 34.5%, free or reduced-price lunch = 70.9%
Intervention	Description	Lesson Topic 1. Weight trends in America & Plate Method 2. 5- Fruits and Vegetables 3. 2- Hours or Less of Recreational Screen Time 4. 1- Hour of Physical Activity 5. 0- Sugary Drinks 6. 9- Hours of Sleep & Healthy Breakfast 7 .Portion Sizes & Healthy Snacks 8. Wrap Up/Review Duration of intervention 4 months

	Duration of intervention (months or weeks)	Not specified
	Frequency of PA	Not specified
	Duration of PA	Not specified
	Intensity of PA	Not specified
	Type of PA	Not specified
	Parent involvement	No
	Setting	School
	Who delivered the intervention	Nursing student, a public health nurse, or a patient education specialist
	Theoretical framework	Not specified
	Control	Not specified
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; number of steps/day (pedometer)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		MacKelvie et al. 2003
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	7 schools in the intervention group and 7 schools in the control group
	Follow-up	Only post-intervention
	Country	Canada
	Period	1999-2001
Participants	Number of participants at baseline and follow-up (intervention/control)	87 individuals in the intervention group and 92 individuals in the control group in Y1 analysis; 32 individuals in the intervention group and 43 individuals in the control group in Y2 analysis
	Age	5^{th} and 6^{th} grade (8.8–11.7 years old)
	Sex	Girls only
	Other characteristics	Ethnicity-34% Hong Kong Chinese, 57%, white, 5% East Indian, and4% other

Intervention	Description	Program provided a progressive, 10 to 12-minute program of diverse weight-bearing exercises during regularly scheduled PE classes (2 times per week) and on 1 other day during the week. Teachers facilitated circuit-training that included 5 different jumping activities with ground-reaction forces that ranged from 3.5 to 5 times body weight. Children progressed from 50 to 100 jumps per session across 3 (10-week) levels of difficulty.
	Duration of intervention (	2 x 7 months (two school years).
	Frequency of PA	3 times/week
	Duration of PA	30 – 36 min/week
	Intensity of PA	Not specified.
	Type of PA	Weight-bearing exercises. Circuit training that included 5 different jumping activities with ground-reaction forces that ranged from 3.5 to 5 times body weight
	Parent involvement	No.
	Setting	School.
	Who delivered the intervention	Teachers.
	Theoretical framework	Not specified.
	Control	regular PE programme
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; %body fat (DXA); dynamic power (long and vertical jump); dietary intake of calcium (food frequency questionnaire); Moderate to vigorous physical activity during the previous 7 days (was determined by a modified version of the Physical Activity Questionnaire for Children (PAQ-C))
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Madsen et al. 2015
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	4 schools in the intervention group and 2 schools in the control group
	Follow-up	Only post-intervention

	Country	US
	Period	2011-2012; 2012-2013
Participants	Number of participants at baseline and follow-up (intervention/control)	583 (77%) in intervention schools and 296 (75%) in control schools provided parental consent and enrolled in the study; at follow-up 78% of students with baseline accelerometer data n=450; 77% of students with baseline fitness data n=461 and baseline dietary surveys n=400; and 78% of students with baseline BMI n=676
	Age	3rd, 4th and 5th grade
	Sex	Both boys and girls
	Other characteristics	Ethnicity- 19 Asian, 20 Black, 150 Latino, 31 Multiracial, 17 White, 38 other
Intervention	Description	Intervention school received one part-time registered dietitian (RD) coach and one full-time Play works coach. The RD coach delivered a 12- week nutrition and energy balance education curriculum that included food tastings, PA games to reinforce nutrition messages, and strategies to help students meet their nutrition and PA goals. The Play works coach structured recess activities before and during school hours to encourage active participation from all students. The Play works coach also led a PA session with individual classes every other week and led four afterschool sports leagues throughout each year.
	Duration of intervention	24-months
	Frequency of PA	Not specified.
	Duration of PA	Recess PA 45 min (anything else not specified).
	Intensity of PA	Not specified.
	Type of PA	Class games, recess games. Other not specified.
	Parent involvement	Yes. via newsletters and lectures for parents.
	Setting	School + community
	Who delivered the intervention	Registered dietitian and Play work coach.
	Theoretical framework	Social Cognitive Theory.
	Control	Delayed intervention
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI z-scores (2000 CDC Growth Charts); Physical activity (accelerometer Actigraph GT1M or GT3X; cardiorespiratory fitness- 1-mile run); fruit and vegetable consumption (digital images); dietary behaviours (School Physical Activity and Nutrition Questionnaire and

		the Child Food Consumption Questionnaire); dietary knowledge (6 questions); school food offering
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Magnusson et al. 2012
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	3 schools in the intervention group and 3 schools in the control group
	Follow-up	Only post-intervention
	Country	Iceland
	Period	2006-2008
Participants	Number of participants at baseline and follow-up (intervention/control)	128 individuals in the intervention group and 138 individuals in the control group at baseline; 90 individuals in the intervention group and 76 individuals in the control group at follow-up
	Age	7 years at baseline
	Sex	Both boys and girls
	Other characteristics	Ethnicity - about 97% of native children- Caucasian-white; obesity and overweight baseline - 16 (13%) in the intervention group and 22 (16%) in the control group; Mothers with university degree - 62/119 (52%) in the intervention and 73/116 (63%) in the control; Fathers with university degree - 50/114 (44) in the intervention and 48/104 (46) in the control; Families in lowest category for income - 11/100 (11) in the intervention and 12/86 (14) in the control
Intervention	Description	The primary objective of the physical activity intervention was to progressively increase the amount of physical activity behaviour at school such that all children in the intervention schools would have the opportunity to engage in some form of physical activity for a minimum of 60 minutes during school hours. The students enrolled were to have opportunities to engage in physical activity during PE lessons, recess and also during classes where physical activity was to be integrated into various subjects on the general curriculum. This included more frequent outdoor teaching, organized fieldtrips, promotion of active commute to

		and from school, one extra physical education lesson per week and more. The main focus of the dietary intervention was on increasing fruit and vegetable intake, with both educational material and homework assignments
	Duration of intervention	20-months (2 school years).
	Frequency of PA	5 times/week.
	Duration of PA	30 to 60 min/day.
	Intensity of PA	Not specified.
	Type of PA	Not specified.
	Parent involvement	No.
	Setting	School.
	Who delivered the intervention	PE teachers and classroom teachers.
	Theoretical framework	Social Cognitive Theory.
	Control	Regular school activities.
	Intervention fidelity	Teacher-reported mean PA during school ranged from 35-70 min/day.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; %body fat (DXA); Cardiorespiratory fitness (W/kg) (Monark ergometer bike using the study protocol from the European Youth Heart study); WC (measured); skinfolds (measured) (mm)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Mandigout et al. 2001
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	1 school in the intervention group and 1 school control group
	Follow-up	Only post-intervention
	Country	France
	Period	NR
Participants	Number of participants at baseline and follow-up (intervention/control)	35 individuals in the intervention group and 50 individuals in the control group at baseline and at follow-up
	Age	10-11 years

	Sex	Both boys and girls
	Other characteristics (SES, ethnicity, OW_ prevalence…)	Ethnicity-Caucasian
Intervention	Description	The training was predominantly aerobic and consisted of one interval (repeated work-recovery bouts over short distances: 10 x 100 m, 6 x 200 m, 4 x 600 m) and one continuous long-distance (around 15– 20 min, 1500–4500 m) running session, and one session with other aerobic activities (swimming, soccer, basket- ball).
	Duration of intervention	13-weeks
	Frequency of PA	3 times/week
	Duration of PA	180 min/week
	Intensity of PA	>80% maximal HR
	Type of PA	Endurance running training programme
	Parent involvement	No
	Setting	School
	Who delivered the intervention	PE teachers
	Theoretical framework	Not specified
	Control	Regular school activities
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	Body fat (skinfolds- Durnin eq); sexual maturation of the children was evaluated at the pre and post-test only from the puberty stages set out by Tanner; VO2max (continuous and progressive exercise test to exhaustion on bicycle ergometer)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Martinez-Vizcaino et al. 2014
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	10 schools in the intervention group and 10 schools in the control group
	Follow-up	Only post-intervention
	Country	Spain
	Period	September 2010 – May 2011

Participants	Number of participants at baseline and follow-up (intervention/control)	489 individuals in the intervention group and 581 individuals in the control group at baseline; 420 individuals in the intervention group and 492 individuals in the control group at 1- academic year follow-up
	Age	7-10 years
	Sex	Both boys and girls
	Other characteristics	Spanish children
Intervention	Description	The program included two extra-curricular 90-minute PA sessions during the weekdays and one 150-minute session on Saturday morning each week.
	Duration of intervention	9 months
	Frequency of PA	3 times/week
	Duration of PA	330 min/week
	Intensity of PA	The children's average heart rate in each session was 151 beats/min
	Type of PA	Basic sports games, traditional games, and other outdoor activities such as cycling
	Parent involvement	Yes, promoting healthy lifestyles at home (wall calendar with tips on PA, and with green stickers to indicate the days that children attended the MOVI-2 program and red for when they failed to attend)
	Setting	School
	Who delivered the intervention	Monitors with technical qualifications in PA and sports, physical education teachers, or PA science graduates, specifically engaged and adequately trained for the program
	Theoretical framework	Socio-Ecological Model
	Control	Regular school activities (Regular PE 2 h/week)
	Intervention fidelity	66.7% of schoolchildren attended more than 70% of the program sessions
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; body fat (Triceps skinfold thickness); WC (measured); % body fat (BIA); Systolic and diastolic blood pressures (OMRON-M5-I automatic tensiometer); blood samples (analysed); Energy expenditure (using oxygen consumption as measured by a portable gas analyser (Cosmed® K4b2, Rome, Italy)); Daily PA (accelerometry in a subsample of 200 randomly selected children from eight of the participating schools (2 CG and 6 IG))

Adverse outcomes	State the outcome and the method of assessment	Dizziness during baseline venipuncture occurred in 2% of the children at baseline, and in 1.1% of the children at the end of the study. No other adverse events were reported by students during health examinations. Two minor ankle sprains occurred during the sessions of the program (9 months incidence risk: 0.4 %). One boy was expelled from the program for aggressive behaviour toward peers; his parents and the School Board made the decision by consensus.

Authors and year		McKay et al. 2000
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	10 schools - Schools were stratified by student number per school as either large, medium or small. Within each tier, schools were randomized to either the exercise of control group
	Follow-up	Only post-intervention
	Country	Canada
	Period	1997-1998
Participants	Number of participants at baseline and follow-up (intervention/control)	210 at baseline; 63 individuals in the intervention group and 81 individuals in the control group at follow-up
	Age	6.9-10.2 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity-30% Asian, 70%White
Intervention	Description	Teachers chose an activity from a variety of games, circuit training, or dances. Activities included a minimum of 10 minutes of loading, and were consistent with the 5 movement categories mandated in the Canadian Integrated Resources Package for Physical Education (dance, gymnastics, individual and dual activities, alternate environment activities, and games). To ensure a baseline amount of loading, children also performed 10 tuck jumps at the beginning of each PE class and once weekly in the classroom. Children were instructed to jump using both legs together and to grab their knees, bringing them as close to the chest as possible. Children rested for 1 second between jumps to maintain the quality of each jump.

	Duration of intervention	8-months
	Frequency of PA	3 times/week
	Duration of PA	From 30 to 90 min/week
	Intensity of PA	Not specified
	Type of PA	School-based jumping program: tuck jumps and incorporated jumping, hopping, and skipping.
	Parent involvement	Parents were asked to complete a health history questionnaire for their children.
	Setting	School (2x within PE, 1x in the classroom)
	Who delivered the intervention	Classroom teachers
	Theoretical framework	Not specified
	Control	Regular school activities.
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time,	Body fat (DXA); bone mineral (bone densitometry scans); calcium intake and physical activity (questionnaire); health history (health history questionnaire completed by parents)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		McMannus et al. 2008
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	1 school in the educational program (EP), 1 school in no-educational program (noEP) and 1 school in the control group (C)
	Follow-up	6 months after the end of the intervention
	Country	Hong Kong
	Period	2006
Participants	Number of participants at baseline and follow-up (intervention/control)	67EP, 61noEP and 69C at baseline; 63EP, 60noEP and 66C at follow-up
	Age	10.4 +- 0.85 years
	Sex	Both boys and girls
	Other characteristics	/

Intervention	Description	All groups have the same PA (only difference was that two groups use Polar for feedback, and one of this two groups had educational program 2 weeks before the program started). Content included heart-rate monitor skills plus education about heart health, goal-setting and role-play. Heart-rate monitor skills and goal-setting included information about activity targets (light, moderate, vigorous), daily activity accumulation to achieve a 30–60 min of moderate-to-vigorous intensity activity (MVPA), and how to use a heart-rate monitor for feedback about progression to this goal. The content was taught using an active games approach, which allowed appropriate physical activity modelling. A take-home booklet reinforced the taught content
	Duration of intervention	6-months
	Frequency of PA	Not specified
	Duration of PA	Not specified
	Intensity of PA	Not specified
	Type of PA	Not specified
	Parent involvement	No
	Setting	School
	Who delivered the intervention	Not specified
	Theoretical framework	Health Belief Model, Social Cognitive Theory, and the Diffusion of Innovation Theory
	Control	Regular school activities
	Intervention fidelity	Not reported.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; body fat (BIA); WC (measured); heart rate (The Polar Team System (Polar Electro Oy, Finland)); weekday physical activity (heart rate telemetry at baseline (1 week), during heart-rate feedback (2 weeks), during no heart-rate feedback (2 weeks) and 6-months later (1 week)); Attraction to physical activity (the Children's Attraction to Physical Activity Scale (CAPA)); Systolic blood pressure (SBP) and diastolic blood pressure (DBP) (were measured manually); Peak oxygen uptake (peakVO2) (was assessed from a walk-run treadmill test to volitional exhaustion)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Meinhardt et al. 2013
Methods and setting	Study design	RCT
	Unit of allocation	Child
	Number of clusters	/
	Follow-up	Post-intervention and 3 months post intervention
	Country	Switzerland
	Period	NR
Participants	Number of participants at baseline and follow-up (intervention/control)	54 individuals in the intervention group and 48 individuals in the control group at baseline and at follow-up
	Age	11.9 (10.3–13.9) girls and 12.3 (10.1–14.1) boys
	Sex	Both boys and girls
	Other characteristics	/
Intervention	Description	The intervention took place during 2 of 3 regular PE classes and consisted of 45 minutes of individualized strength training for the whole body following the recommendations of the American Academy of Pediatrics, Committee on Sports Medicine and Fitness.
	Duration of intervention	19-weeks
	Frequency of PA	2 times/week.
	Duration of PA	90 min/week
	Intensity of PA	60% of 1 RM (repetition maximum)
	Type of PA	Strength exercise.
	Parent involvement	No.
	Setting	School.
	Who delivered the intervention	PE teacher.
	Theoretical framework	Not specified.
	Control	Regular school activities.
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	Lean body mass (LBM) and fat mass (FM) (measured by dual energy radiograph absorptiometry); physical activity energy expenditure (PAEE) (objectively measured for 7 consecutive days by a body-fixed triaxial accelerometer (RT3, Stayhealthy, Monrovia, CA)); The maximum strength of the lower body (was determined on a seated leg

		press and for the upper body on a Cybex smith press by 1 repetition maximum testing)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Meiring et al. 2014
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	2 schools in the intervention group and 1 school in the control group
	Follow-up	Only post-intervention
	Country	South Africa
	Period	2012
Participants	Number of participants at baseline and follow-up (intervention/control)	25 individuals in the intervention group and 12 individuals in the control group at baseline; 12 individuals in the intervention group and 10 individuals in the control group at follow-up
	Age	9.7+-1.2 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity- 100% black; socio-economic status- low-middle income
Intervention	Description	Each exercise session involved completing an exercise circuit consisting of five activities. A warm up of five minutes consisted of stretching the upper and lower body. Each activity was then performed for five minutes before moving on to the next activity in the circuit. A competition within two or three of the activities was held for the next 10 minutes. A cool-down was then performed for another five minutes which again involved upper and lower body stretches
	Duration of intervention	20-weeks
	Frequency of PA	2 times/week
	Duration of PA	90 min/week
	Intensity of PA	Not specified
	Type of PA	Sprinting, running and jumping to catch a 1kg medicine ball, ladder hopping, weight-bearing exercise, jumping rope
	Parent involvement	No.
	Setting	School

	Who delivered the intervention	PE Teacher
	Theoretical framework	Not specified
	Control	Regular school programme
	Intervention fidelity	Not reported.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	% body fat (DXA); BMI percentile-for-age (was calculated using software available from the WHO); Bone mineral content and bone area (DXA); Scans of 2.3 mm thickness of the non-dominant lower leg were made at the 4%, 38% and 65% sites of the tibia (using pQCT); analysis of urinary cross-linked N-telopeptides of Type I collagen (NTX)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Meng et al. 2013
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	3 schools in the nutrition intervention group, 3 schools in the physical activity intervention group and 3 schools in the control group in Beijing; in other 5 cities: 3 schools in the combined nutrition education and PA intervention and 3 schools in the control group (15 schools in combined intervention and 15 schools in the control group in other 5 cities)
	Follow-up	Only post-intervention
	Country	China
	Period	2009-2010
Participants	Number of participants at baseline and follow-up (intervention/control)	590 individuals in the physical activity group; 615 individuals in the nutrition group and 490 individuals in the control group in Beijing; 3356 combined intervention and 3280 in the control group in other 5 cities
	Age	70% 7-10 years; 30% 10-14 years
	Sex	Both boys and girls
	Other characteristics	Socio-economic status- approx. 11% low income; Urban area
Intervention	Description	Three means of intervention were included in the present study: nutrition education, physical activity intervention and combined intervention. A classroom-based physical activity program for elementary students

		named “Happy 10” was used in PA intervention. In each school day, the students were conducted “Happy 10” led by teachers to do a 10-minute segment moderate intensity, age- and space-appropriate exercises. Furthermore, education about physical activity was provided to students, parents, health workers and teachers Within nutrition intervention classes on nutrition and health were given 6 times for the students, 2 times for the parents and 4 times for teachers and health workers. The menu for students of school lunch cafeteria was evaluated periodically and specific nutrition improvement was suggested accordingly
	Duration of intervention	10-months (one school year).
	Frequency of PA	5-10x/week
	Duration of PA	100 min/week.
	Intensity of PA	MPA.
	Type of PA	Game, dance or rhythmic gymnastics.
	Parent involvement	Involvement in classes about nutrition, health and PA.
	Setting	School (classroom).
	Who delivered the intervention	Teachers.
	Theoretical framework	Not specified.
	Control	Regular school activities.
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; BMI z-score (Working Group for Obesity in China); OW+OB prevalence (Working Group for Obesity in China)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Meszaros et al. 2009
Methods and setting	Study design	CBA
	Unit of allocation	Classroom
	Number of clusters	NR
	Follow-up	Only post-intervention

	Country	Hungary
	Period	2002-2006
Participants	Number of participants at baseline and follow-up (intervention/control)	116 boys in the intervention group and 405 boys in the control group at baseline and at follow-up
	Age	6.5-7.5years
	Sex	Only boys
	Other characteristics	/
Intervention	Description	Eight sessions (of 45 minutes each) in the morning and two afternoon sessions (of 90 minutes) for each 10-day cycle of school education. In the morning sessions these children practised the general requirements of the PE curriculum, the afternoon sessions focussed on the development of cardio-respiratory fitness and special skills.
	Duration of intervention	48 months
	Frequency of PA	5 times/week
	Duration of PA	270 min/week
	Intensity of PA	Not specified
	Type of PA	In the morning PE curriculum, the afternoon sessions focussed on the development of cardio-respiratory fitness and special skills
	Parent involvement	Yes
	Setting	School
	Who delivered the intervention	PE specialists
	Theoretical framework	Not specified
	Control	Regular school activities
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; body fat (skinfolds); speed and coordination skills (30m dash); cardio-respiratory endurance (400m run); explosive strength and co-ordination skills (standing long jump)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Meyer et al. 2014
Methods and setting	Study design	Cluster RCT

	Unit of allocation	Class
	Number of clusters	16 classes from 9 schools in the intervention group and 12 classes from 6 schools in the control group
	Follow-up	Post- intervention and 3 years post-intervention
	Country	Switzerland
	Period	2005-2006
Participants	Number of participants at baseline and follow-up (intervention/control)	297 individuals in the intervention group and 205 individuals in the control group at baseline; 191 individuals in the intervention group and 110 individuals in the control group at follow-up
	Age	1th and 5th grade; 6.9 (0.3); 10.9 (0.5) years
	Sex	Both boys and girls
	Other characteristics	Ethnicity- 15-30% migrants, 70-85% Swiss
Intervention	Description	Briefly, children in both groups had three physical education lessons per week (45 minutes each) given by the usual classroom teachers. The intervention group had two additional physical education lessons (45 minutes each) on the remaining school days that were taught by physical education teachers. The curriculum for all physical education lessons for the intervention group was prepared by a team of expert physical education teachers and the same curriculum aiming at increasing quality of physical education and quantity of at least moderately intense physical activity was provided to all intervention classes. In addition, three to five short activity breaks (two to five minutes each) were introduced every day during academic lessons, comprising motor skill tasks such as jumping or balancing on one leg. The children also received daily physical activity homework of about 10 minutes.
	Duration of intervention	11-months
	Frequency of PA	2 times/week
	Duration of PA	90 min/week
	Intensity of PA	≥ MPA
	Type of PA	PE program; Motor skill tasks such as jumping or balancing on one leg
	Parent involvement	No
	Setting	School
	Who delivered the intervention	PE teachers
	Theoretical framework	Socio-ecological conceptual model
	Control	Regular school programme

	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI and WC (measured); body fat (skinfolds); Aerobic fitness (20 m shuttle run test); physical activity (accelerometer (MTI/CSA 7164/GT1M, Actigraph, Shalimar, FL, USA) + questionnaire); quality of life (questionnaire); blood pressure (measured); blood samples (measured)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Morris et al. 2013
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	2 schools in the intervention group and 4 schools in the control group
	Follow-up	3 months after the start of the intervention and post-intervention
	Country	England
	Period	2008-2009
Participants	Number of participants at baseline and follow-up (intervention/control)	177 individuals in the intervention group and 201 individuals in the control group at baseline; 167 individuals in the intervention group and 144 in the control group at follow-up
	Age	9.75 ± 0.82 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity-60% white, 20% Asian, 10% black; Socio-economic status - low Index of Multiple Deprivation = 44%
Intervention	Description	Intervention comprised of: preparation for and participation in 3 highlight events (a dance festival, a walking event and a running event); an interactive website for pupils, teachers and parents; and vacation activity planners
	Duration of intervention	7-months
	Frequency of PA	Once (dance festival (DF), walking event (WE) and a running event (RE))
	Duration of PA	DF / , WE 3km, RE 1 mile
	Intensity of PA	Not specified
	Type of PA	Dancing, walking, running

	Parent involvement	The “Great Activity Universe” was described in a pamphlet sent to parents and teachers at the start of the intervention. In addition to the website parents also received regular correspondence about the programme and events. Parents were invited to attend several events including a seminar explaining the programme, the GreatFun2Dance finale, and the GreatFun2Walk event. In addition, twelve telephone interviews were conducted with parents (1–3 from each class at each intervention school) to establish their views of the programme and its impact.
	Setting	School
	Who delivered the intervention	Specific team leader (or their representative) of the Great Activity programme, appointed by Great Run.
	Theoretical framework	Social Cognitive Theory
	Control	Regular school activities
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; BMI z-scores (1990 UK reference); body fat (skinfolds); WC (measured); physical activity (Digiwalker SW200 pedometer, 54% ActiGraph GT1M accelerometer); food and beverage intake (one-on-one interviews); knowledge of healthy lifestyles (10-item multiple choice test); perceived sport competence (subscale from the Physical Self Perception Profile (PSPP-C; Whitehead, 1995))
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Muller et al. 2019
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	1 schools in the PA intervention, 1 school in the PA + HE intervention; 1 schools in the PA + HE + NU intervention, 1 schools in HE + NU intervention and 4 schools in the control group
	Follow-up	Only post-intervention
	Country	South Africa

	Period	February 2015 to May 2016 (16 months)
Participants	Number of participants at baseline and follow-up (intervention/control)	82 individuals in the intervention PA, 148 individuals in the intervention PA + HE, 70 individuals in the intervention PA + HE + NU, 97 individuals in the intervention HE + NU and 76/70/121/82 individuals in control groups at baseline; 67 individuals in the intervention PA, 136 individuals in the intervention PA + HE, 61 individuals in the intervention PA + HE + NU, 74 individuals in the intervention HE + NU and 37/31/71/41 individuals in control groups at follow-up
	Age	4th grade classes
	Sex	Both boys and girls
	Other characteristics	Ethnicity - The study population consisted of coloured children (mixed race ancestry), usually Afrikaans speaking, and black African children, mainly Xhosa speaking; socio-economic status - middle SES
Intervention	Description	Multidimensional physical activity intervention programme consisted of four components (i) two 40 min PE lessons per week; (ii) one weekly 40 min moving-to-music lesson; (iii) regular in-class PA breaks incorporated into the main curriculum; and (iv) enhancement of the school environment (e.g., installation of activity stations and a variety of painted games). The physical education classes were taught outside on either grass or cemented areas and most children wore light sports clothing. Sports equipment for the lessons was donated to the schools. In addition to the physical activity intervention, two supplementary programmes were conducted in selected schools. The first one was a health and hygiene education programme to increase children's awareness for communicable diseases and the second one a nutrition education and supplementation programme to contribute to the awareness of healthy diet
	Duration of intervention	20-weeks (two times 10 weeks).
	Frequency of PA	Daily
	Duration of PA	At least 120 min/week.
	Intensity of PA	Not specified.
	Type of PA	Dancing and other non-specified activities

	Parent involvement	No.
	Setting	School.
	Who delivered the intervention	Teachers designated to provide the physical education were assisted by a trained physical education coach for one of the two weekly lessons, while the teachers thereafter taught the subsequent lesson on their own. Dance lessons were provided by students.
	Theoretical framework	Not specified.
	Control	Regular school activities
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	Height and BMI (defined as weight [kg]/height [m]2) were standardised according to WHO guidelines, resulting in HAZ (height for sex and age) and BMIZ (BMI for sex and age) scores; Cardiorespiratory fitness (20 m shuttle run test); body fat (skinfold thickness); Hb concentration (measured once to the nearest 0.01 g dL 1 with a HemoCue® Hb 301 system (HemoCue®AB; Ängelholm, Sweden)); Kato-Katz technique was used on the stool samples to identify and count the number of soil-transmitted helminth eggs that were reported for each species separately
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Muros et al. 2015
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	4 school in the intervention group and 1 school in the control group
	Follow-up	Only post-intervention
	Country	Spain
	Period	2012
Participants	Number of participants at baseline and follow-up (intervention/control)	41 in the control group, 28 in the physical activity (PA) intervention group; 21 in the nutritional education (NE) intervention group, 25 in the PA and NE intervention group, 20 in the PA, NE and replacement to extra virgin olive oil intervention group
	Age	10.6±0.5 years
	Sex	Both boys and girls
	Other characteristics	/
Intervention	Description	The intervention consisted of 60 minutes sessions of physical activity held twice a week as well as nutritional education sessions.
	Sedentary time, physical activity or both	PA
	Duration of intervention	6-months
	Frequency of PA	2 times/week
	Duration of PA	120 min/week
	Intensity of PA	Vigorous extracurricular physical activity (VEPA) [80% of maximum heart rate (MHR) for 35 to 40 minutes, 60% to 70% of the MHR for 10 to 15 minutes, and 50% to 60% for 5 to 10 minutes]
	Type of PA	Motor skills, games and sports
	Parent involvement	Yes. For parents, there were 6 classes of nutritional education, each lasting approximately 2 hours. One session was provided each week for the first 6 weeks of intervention.
	Setting	School
	Who delivered the intervention	Experts in education and sports science
	Theoretical framework	Not specified
	Control	Not specified

	Intervention fidelity	Pupils were considered fit to participate in the study if they participated in over 75% of the school physical activity sessions, attended the 2 sessions on nutritional education, and had at least 1 parent attend over 75% of the parental educational sessions. Out of a total of 75 pupils, 58 fulfilled these conditions (77.3%).
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time.	BMI; WC (measured); Body fat (sum of 8 skinfolds); VO2max (estimated using a 20 m incremental-maximum shuttle run field test); venous blood parameters (measured); systolic and diastolic blood pressure (OMROM M7 monitor (Omrom Health Care, Ukyo-ku, Kyoto, Japan); dietary changes (2 dietary intake diaries)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Nader et al. 1999
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	56 schools in the intervention group and 40 schools in the control group
	Follow-up	3 years follow-up
	Country	US
	Period	1991-1997
Participants	Number of participants at baseline and follow-up (intervention/control)	2989 individuals in the intervention group and 2117 individuals in the control group, 1991 trough 1997
	Age	6^{th}, 7^{th} and 8^{th} grade
	Sex	Both boys and girls
	Other characteristics	Ethnicity- The ethnic composition of the baseline cohort of students was 69% white, 14%Hispanic, 13% African American, and 4% other
Intervention	Description	The CATCH intervention consisted of the Eat Smart school food service program, CATCH PE (physical education), classroom curricula, and parental involvement programs. Eat Smart was a school-level intervention designed to incorporate the current dietary recommendations into the schools' food service program." The goal was to provide children with reduced fat,

		saturated fat, and sodium in meals while maintaining recommended levels of essential nutrients and calories, as well as maintaining school meal participation. CATCH PE was designed to increase the amount of time students spent in enjoyable moderate-to-vigorous physical activity (MVPA) at school during PE, as well as to teach students appropriate activities for other times of the day that could be maintained throughout life.
	Duration of intervention	30-months
	Frequency of PA	Not specified
	Duration of PA	Not specified
	Intensity of PA	Not specified
	Type of PA	CATCH intervention program (Eat Smart & CATCH PE)
	Parent involvement	Not specified
	Setting	School- and family-based
	Who delivered the intervention	Not specified
	Theoretical framework	Social Cognitive Theory
	Control	Not specified
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	Blood samples (measured); Systolic and diastolic blood pressure and heart rate (Dinamap automatic device); body fat (triceps and subscapular skinfolds); BMI (measured); psychosocial variables (The Health Behavior Survey); food intake (The Food Checklist); physical activity (The Self-Administrated Physical Activity Checklist)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Neumark-Sztainer et al. 2009
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	2 schools in the intervention group and 2 schools in the control group
	Follow-up	4 months post-intervention

	Country	USA
	Period	2006-2007
Participants	Number of participants at baseline and follow-up (intervention/control)	108 children and 73 parents at baseline; 96 children (51 in the intervention group and 45 in the control group) and 61 parents (30 in the intervention group and 31 in the control group) at follow-up
	Age	10.3+-1.1 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity- 55% black, 15% Asian, 7% white, 22% other Socio-economic status- 90% free or reduced price lunch; 43% OW at baseline
Intervention	Description	Ready. Set. ACTION!' is an after-school theatre program designed to reach ethnically diverse and low-income elementary school children and their parents with messages of relevance to obesity prevention. Fourteen 2-hour after-school theater sessions were conducted. Each session included (i) a 'check- in which children were given an opportunity to share any behavioural changes they had made over the past week (such as eating more fruits and vegetables. (ii) easy-to-prepare healthy snacks; (iii) a movement component with activities that are fun, easy and require minimal resources (e.g. dancing or walking) and (iv) theatrical ACTivities
	Duration of intervention	Not specified
	Frequency of PA	Not specified
	Duration of PA	Not specified
	Intensity of PA	Not specified
	Type of PA	Dance.
	Parent involvement	Yes. Weekly Fun and Fitness packs were sent home that included a healthy food with a simple recipe or fitness incentives for the family + two family events
	Setting	School and home
	Who delivered the intervention	Not specified
	Theoretical framework	Social Cognitive Theory
	Control	Theater-based intervention, which involved performing a play focused on environmental health issues using a prepared script

	Intervention fidelity	More than half of the children (59%, n = 33) had consistent attendance and participated in at least 75% of the initial theater sessions. Only a third of the children attended at least 75% of the booster sessions following the play performance (39%, n = 22).
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; BMI z-score (CDC); Dietary intake (was assessed using a 1-day 24-hour recall); children were individually interviewed at school by trained research staff; Physical activity (was assessed with the Past Day Physical Activity Recall); Television viewing (questions); Response to satiety cues (multiple choice); Child personal factors (multiple choice)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Nogueira et al. 2017
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	1 school in the intervention group and 1 schools in the control group
	Follow-up	Post-intervention and 1 years post-intervention
	Country	Australia
	Period	2004-2005
Participants	Number of participants at baseline and follow-up (intervention/control)	175 individuals in the intervention group and 136 individuals in the control group at baseline; 155 individuals in the intervention group and 85 individuals in the control group at follow-up
	Age	10.6+-0.6 years
	Sex	Both boys and girls
	Other characteristics	/
Intervention	Description	The exercise intervention program was based on capoeira and a combination of medium- to high-impact manoeuvres for upper and lower limb loading, performed continuously for 10 minutes, 3 times per week. Initially (first 2 months), a typical session was composed of learning how to perform the ginga, followed by around 60 jumps, 20 kicks, and 15 cartwheel and handstand attempts. Repetition and intensity

		was progressively increased over the course of the year, such that a typical session in the final stages would entail a warm up with the ginga, followed by an average of 120 jumps, 30 kicks and 20–30 inverted movements such as handstands or cartwheels. Children were occasionally given small prizes such as sports balls and game vouchers to reward participation and performance.
	Duration of intervention	9-months
	Frequency of PA	3 times/week
	Duration of PA	30 min/week
	Intensity of PA	MVPA
	Type of PA	Capoeira -specific movements and combination for upper and lower limb loading
	Parent involvement	No
	Setting	School
	Who delivered the intervention	Researcher
	Theoretical framework	Not specified
	Control	Usual school activities
	Intervention fidelity	Not reported.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; WC (measured); Parameters of bone strength (quantitative ultrasonometry); Muscle power (maximal vertical jump test using a yardstick); Aerobic capacity (20-m shuttle run test); Both resting heart rate (bpm) and resting blood pressure (mm Hg) (were measured using standard procedures inside the school hall after a resting interval of 10 minutes)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Orntoft et al. 2016
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	9 schools
	Follow-up	One week post intervention
	Country	Denmark

	Period	August – December 2015
Participants	Number of participants at baseline and follow-up (intervention/control)	402 individuals in the intervention group and 144 individuals in the control group at baseline; 386 individuals in the intervention group and 140 in the control group at follow-up
	Age	11-12 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity - Caucasian (Danish)
Intervention	Description	Two times per week regular PE teaching content was substituted with football content provided by FIFA programme. Each session consisted of a 45 min play football period (teaching football skills and playing 3v3 football games) and a 45 min play fair period (teaching a health message and healthy behaviours related to an NCD)
	Duration of intervention	11-weeks
	Frequency of PA	2 times /week.
	Duration of PA	45 min/week.
	Intensity of PA	Not specified.
	Type of PA	Ball games.
	Parent involvement	No.
	Setting	School.
	Who delivered the intervention	Teacher.
	Theoretical framework	Not specified.
	Control	Regular school activities
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	Systolic blood pressure (measured), mean arterial blood pressure (measured); BMI; %body fat (DXA); physical performance (YYIR1C, 20m sprint, horizontal jump length, flamingo balance test)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Pablos et al. 2018
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School

	Number of clusters	4 schools in total - each school as intervention or control
	Follow-up	Only post-intervention
	Country	Spain
	Period	NR
Participants	Number of participants at baseline and follow-up (intervention/control)	82 individuals in the intervention group and 76 individuals in the control group at baseline; out of 190 children, 30 children were excluded because of missing administrative data or absence from school when the measurements were taken. Complete data were collected for 158 children total.
	Age	10.66 ± 0,7 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity- Spanish (Caucasian); socio-economic status- middle socioeconomic status, determined using the PISA index of economic, social and cultural status
Intervention	Description	The intervention was in the form of a free extracurricular activity. It lasted for 8 months and was carried out in the form of sessions twice a week lasting for a total of 150 minutes per week. All the sessions were led by the same specifically-trained teacher. The physical activities gradually increased in intensity and duration throughout the intervention. The intensity level of the activities was intended to be moderate to high.
	Duration of intervention	8-months
	Frequency of PA	2 times/week
	Duration of PA	150 min/week
	Intensity of PA	MVPA
	Type of PA	Themed games for the first 22 sessions and modified sports for the rest of the sessions, which provided the motivational ingredient without restrictive rules or technical demands that could exclude less able students.
	Parent involvement	Signing homework worksheets. Three 45-minute talks for parents and teachers about healthy habits for school children.
	Setting	School.
	Who delivered the intervention	Specifically-trained teacher.
	Theoretical framework	Not specified.
	Control	Daily activities without participating in the healthy habits program.

	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time,	BMI; blood samples (measured using validated portable Accutrend automated analysers); blood pressure (Blood pressure was measured using a digital sphygmomanometer); The Cardiovascular Fitness Indicator (was assessed using 1 item of the Eurofit physical fitness test battery); health habits (Inventory of Healthy Habits); physical activity level (activity monitor (GT3X+,ActiGraph LLC, Pensacola, FL, USA))
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Perez Solis et al. 2015
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	1 school in the intervention group and 1 schools in the control group
	Follow-up	Only post-intervention
	Country	Spain
	Period	2006-2008
Participants	Number of participants at baseline and follow-up (intervention/control)	151 individuals in the intervention group and 231 individuals in the control group at baseline; 120 individuals in the intervention group and 220 individuals in the control group at follow-up
	Age	8.2+-1.5 years
	Sex	Both boys and girls
	Other characteristics	OW+OB>40% at baseline
Intervention	Description	Activities consisted of (1) workshops on healthy nutrition for students, (2) educational talks for the parents, (3) workshop on healthy cooking and nutrition, (4) monthly teachers meetings to study healthy lifestyle, (5) printed informational materials for parents, (6) promotion of physical activity, e.g. of traditional outdoor games. The use of mobile phones was prohibited during school-time
	Sedentary time, physical activity or both	PA
	Duration of intervention	20-months (2 school years).
	Frequency of PA	/

	Duration of PA	/
	Intensity of PA	/
	Type of PA	Traditional outdoor games for children.
	Parent involvement	Yes, through workshops and talks.
	Setting	School.
	Who delivered the intervention	Teaching staff of the school under the guidance of the paediatricians of the research team.
	Theoretical framework	Not specified.
	Control	Regular school activities.
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI z-score (WHO); OW+OB prevalence (IOTF); abdominal obesity prevalence (WC); physical activity (Escala de Actividad Física-questionnaire)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Plachta-Danielzik et al. 2011
Methods and setting	Study design	CBA
	Unit of allocation	School
	Number of clusters	14 of 32 schools in the intervention group; the following years former intervention schools served as control
	Follow-up	8 years
	Country	Germany
	Period	Within KOPS intervention 1996-2001; intervention 2-3 weeks within the second term of the first school year
Participants	Number of participants at baseline and follow-up (intervention/control)	4997 at baseline; 240 individuals in the intervention group and 952 individuals in the control group at follow-up
	Age	median (IQR) = 6.3 (5.9–6.5) years
	Sex	Both boys and girls
	Other characteristics	Socio-economic status - low/middle/high: 46.8/20.7/32.5%
Intervention	Description	All first graders of 'intervention schools' were addressed by 6 nutrition units performed within the second term of the first school year. Messages were i) to eat fruit and vegetable every day, ii) to

		reduce intake of high fat foods, iii) to keep active at least 1 h a day, and iv) to decrease TV consumption to less than 1 h per day. Messages were conveyed by use of nutrition fairy tales, interactive games as well as by preparing a healthy breakfast. After each unit, running games were offered for 20 min on the school yard.
	Duration of intervention	2-3 weeks
	Frequency of PA	2/week
	Duration of PA	20 min
	Intensity of PA	Not specified
	Type of PA	running games
	Parent involvement	No
	Setting	School
	Who delivered the intervention	Nutritionist
	Theoretical framework	Not specified
	Control	Not specified
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI SDS (German BMI reference percentiles); FM z score (BIA, KOPS cohort)t; WC z score (KOPS cohort); prevalence of overweight (German BMI reference percentiles); food intake (food frequency questionnaire); blood pressure (age-specific 95th percentile for systolic and/or diastolic blood pressure by Second Task Force on Blood Pressure Control in Children)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Rausch Herscovici et al. 2013
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	4 schools in the intervention group and 2 schools in the control group
	Follow-up	Only post-intervention
	Country	Argentina
	Period	2008

Participants	Number of participants at baseline and follow-up (intervention/control)	405 at baseline; 205 individuals in the control group and 164 in the control group at follow-up
	Age	9.6+-0.8 years
	Sex	Both boys and girls
	Other characteristics	Socio-economic status- neighbourhoods in which macroeconomic conditions are compatible with very-low, low, and lower-middle income standards
Intervention	Description	The participating grades took part in four workshops: three for the children (Healthy Eating, Body in Motion, and Healthy Body); and one for their parents/ caregivers.
	Sedentary time, physical activity or both	PA
	Duration of intervention	6-months (4 workshops x 40 min over 6 months)
	Frequency of PA	Not specified
	Duration of PA	Not specified
	Intensity of PA	Not specified
	Type of PA	Not specified
	Parent involvement	The fourth workshop aimed to provide dietary education to the children's parents/ caregivers and emphasized the importance of physical activity.
	Setting	School
	Who delivered the intervention	Not specified
	Theoretical framework	Not specified
	Control	Regular school activities
	Intervention fidelity	Because the children's workshops took place during school hours, attendance was the same it would be for a normal school day and was not considered exclusion criteria. Parents' and/or caregivers' attendance was 53% and was not considered exclusion criteria.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; BMI z-score (CDC)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Recasens et al. 2019
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	16 schools
	Follow-up	8 years follow-up post-intervention
	Country	Spain
	Period	2006-2008 intervention
Participants	Number of participants at baseline and follow-up (intervention/control)	272 individuals in the intervention group and 237 individuals in the control group at baseline 2006 and at follow-up 2008; 225 in the intervention and 201 in the control at follow-up 2010; 216 in the intervention group and 181 in the control at follow-up 2012; 156 in the intervention and 122 in the control at follow-up 2016
	Age	1st and 2nd grade primary school children
	Sex	Both boys and girls
	Other characteristics	Ethnicity - Caucasian (Spanish)
Intervention	Description	The intervention promoted healthy eating habits and physical activity in the school setting through the investigation, vision, action and change (IVAC) educational methodology. Every classroom used 3 h a week to develop activities related to health food habits and/or physical activity. Activities related to healthy habits, integrated into regular content (e.g. math, science, language, knowledge of the environment) through mechanisms such as posters, food tables, games, crafts, cooking workshops or games on the school playground.
	Sedentary time, physical activity or both	Both
	Duration of intervention	20-months (2 school years)
	Frequency of PA	Not specified
	Duration of PA	Not specified
	Intensity of PA	Not specified
	Type of PA	Not specified
	Parent involvement	the families received periodic newsletters with news about project progress, books and reading recommendations related to diet

		and physical activity for families and children, as well as monthly recipes using healthy seasonal foods adapted for the whole family
	Setting	School
	Who delivered the intervention	Classroom teachers
	Theoretical framework	investigation, vision, action and change (IVAC) educational methodology
	Control	Regular school activities
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	Children's weight and height (measured 2006, 2008, 2010, 2012 and 2016) and levels of physical activity (questionnaire); BMI cut-point values (IOTF)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Reed et al. 2008
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	6 schools in the intervention group and 2 schools in the control group
	Follow-up	Only-post intervention
	Country	Canada
	Period	2003-2004
Participants	Number of participants at baseline and follow-up (intervention/control)	178 individuals in the intervention group and 90 individuals in the control group at baseline; 156 individuals in the intervention group and 81 individuals in the control group at follow-up
	Age	9-11years
	Sex	Both boys and girls
	Other characteristics	/
Intervention	Description	Teachers in intervention schools were asked to deliver 15 min of moderate to intense physical activity daily to achieve 75 min of extra physical activity per week (in addition to 2×40 min PE classes).
	Duration of intervention	12-months

	Frequency of PA	5 times/week
	Duration of PA	75 min/week
	Intensity of PA	MVPA
	Type of PA	Not specified
	Parent involvement	No.
	Setting	School
	Who delivered the intervention	PE teachers
	Theoretical framework	Active school framework
	Control	Regular school activities(PE 2 × 40 min)
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time,	BMI; Cardiovascular fitness (Leger's 20-m incremental shuttle run); Blood pressure (automated sphygmomanometer and appropriately sized cuff after 5-10 min rest in a supine position); Blood samples (from antecubital vein) ; Physical activity (PAQ-C); Physical maturity (line drawings and descriptions of pubic hair and breast stage (girls) based on Tanner Staging)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Resaland et al. 2011
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	1 school in the intervention group and 1 school in the control group
	Follow-up	Only post-intervention
	Country	Norway
	Period	NR
Participants	Number of participants at baseline and follow-up (intervention/control)	125 individuals in the intervention group and 131 individuals in the control group at baseline; 92 in the intervention group and 82 in the control group at follow-up
	Age	9.2+-0.3 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity- >95% white

Intervention	Description	The intervention consisted of a 60-min daily PA lesson and was implemented over two school years for each of the two age groups in the I-school. Each lesson was planned to include a variety of activities that were enjoyable and exciting for the children. Approximately 5 of the 60 min on teachers' explanations, organizing the children and various other low intensity activities. For the remaining 55 min, the teachers were told to carry out moderate to vigorous-intensity PA, of which 15 min was planned to be at vigorous intensity, meaning that the children should be sweating and out of breath. The vigorous PA component was tried and accomplished by selecting a variety of activities such as running, relay racing, obstacle courses and various forms of active play of high intensity. Nevertheless, most activities were non-competitive.
	Duration of intervention	20-months (2 school years)
	Frequency of PA	5 times/week
	Duration of PA	300 min/week
	Intensity of PA	MVPA; at last 15 min of VPA daily
	Type of PA	Ballgames (accounting for 19.4% of the PA time over the 2 intervention years) were the most frequent activity, with football and basketball as the two most dominant. Brisk walking (13.1%) was usually carried out every school day, and often at a relatively fast pace. Active play (12.1%) included a variety of fun activities and games. Skiing (10.7%) was mainly cross country, and the children spent 11 full school days skiing and thereby compensating for the 5 min lost every day to explanations, organizing, etc., in the other activities. Gymnastics (9.6%) included a variety gymnastics exercises. Relay race (8.5%) also included completing obstacle courses. The term others (10.7%) describes miscellaneous activities, such as orienteering, cycling, jumping rope and ice skating.
	Parent involvement	No
	Setting	School
	Who delivered the intervention	Expert PE teachers
	Theoretical framework	Not specified
	Control	Regular school activities
	Intervention fidelity	On average, the mean (SD)

		absence from school was 12 (9) days over the 2 years, corresponding to 4% mean absence annually. Only one child from I group was excluded because of an absence of >15%
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time,	BMI; WC (measured); blood sampling, blood pressure (measured); VO2 peak (MetaMax I analyser)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Robbins et al. 2012
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	1 school in the intervention group ad 1 school in the control group
	Follow-up	Only post-intervention
	Country	USA
	Period	2009
Participants	Number of participants at baseline and follow-up (intervention/control)	38 individuals in the intervention group and 35 individuals in the control group at baseline; 37 individuals in the intervention group and 32 in the control group at follow-up
	Age	11.5 (0.8)
	Sex	Girls only
	Other characteristics	Ethnicity- 65% black; 24% Hispanic; 8% white; Socio-economic status- 76% free or reduced lunch
Intervention	Description	The intervention involved two components: (1) a 90-min after-school physical activity club offered at the middle school 5 days a week for 6 months (total of 98 sessions) and (2) a face-to-face motivational, individually tailored counselling session with a registered (school) nurse during the school day every other month over the 6 months. Each Physical Activity Club session was to include a five-minute warm-up including stretching; 60 minutes of MVPA; a five-minute cool-down including stretching; and 20- minute group discussion on

		healthy eating and physical activity one day per week. A healthy snack (e.g., fruit, vegetable, smoothie, low-fat cheese or yogurt) was served at each session. The Physical Activity Club instructors encouraged the girls to exercise at their own pace, but to increase the intensity over time, and engage in MVPA on their own outside the club
	Duration of intervention	6-months
	Frequency of PA	5 time/week
	Duration of PA	350 min/week
	Intensity of PA	MVPA
	Type of PA	Not specified
	Parent involvement	No
	Setting	School
	Who delivered the intervention	Physical activity club instructors
	Theoretical framework	Health Promotion Model
	Control	Not specified
	Intervention fidelity	The Physical Activity Club was conducted over 24 weeks; but, due to several no-school days, girls had the opportunity to attend on 98 different days, resulting in the club being available on average 4.1 days per week during the intervention. The 37 girls in the intervention group attended an average of 1.6 days per week.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; BMI z-score (CDC); WC (measured); %body fat (BIA); Perceived benefits of and barriers to physical activity (measured as the mean response to the 12-item Perceived Benefits scale); Perceived physical activity self-efficacy (17-item Perceived Physical Activity Self-Efficacy scale); Enjoyment of physical activity (16-item Physical Activity Enjoyment scale); Minutes of MVPA per hour (The Actigraph GT1M, a small, lightweight accelerometer); Cardiovascular fitness (Progressive Aerobic Cardiovascular Endurance Run (PACER), 20-m shuttle run)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Robinson, T. N.; 1999
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	1 school in the intervention group and 1 school in the control group
	Follow-up	2-months follow-up
	Country	US
	Period	September 1996 – April 1997
Participants	Number of participants at baseline and follow-up (intervention/control)	106 individuals in the intervention group and 121 in the control group at baseline; 92 individuals in the intervention group 100 individuals in the control group at follow-up
	Age	8.9 years
	Sex	Both boys and girls
	Other characteristics	/
Intervention	Description	Children in 1 elementary school received an 18-lesson (of 30 to 50 minutes), 6-month classroom curriculum to reduce television, videotape, and video game use. The entire curriculum consisted of approximately 18 hours of classroom time. Lessons included self-monitoring and self-reporting of TV, videotape, and video game use; following by TV turnoff for 10 days. After turnoff children were encouraged to follow a 7-hour per week budget. Additional lessons taught children to become intelligent viewers. To help with budgeting, each household also received an electronic television time manager. This device locks onto the power plug of the television set and monitors and budgets viewing time for each member of the household through use of personal identification codes.
	Duration of intervention	6-months
	Frequency of PA	/
	Duration of PA	/
	Intensity of PA	/
	Type of PA	/
	Parent involvement	Yes

		Newsletters for parents to motivate their children were distributed to parents. Parents were asked to estimate the amount of time their children spent watching TV, videotapes, and videogames during school day and weekend.
	Setting	School
	Who delivered the intervention	Regular classroom teachers
	Theoretical framework	Bandura's Social Cognitive Theory
	Control	Regular school activities
	Intervention fidelity	Teachers reported teaching all lessons, although data determining whether the lessons were delivered as they were intended were not collected. Ninety-five (90%) of 106 stun-dents in the intervention school participated in at least some of the television turnoff and 71 (67%) completed the entire 10 days without watching television or videotapes or playing videogames. During the budgeting phase of the intervention, 58 (55%) of the students turned in at least 1 signed parent confirmation that they had stayed below their television and videotape viewing and video game playing budget for the previous week. Forty-four parents (42%) returned response cards reporting they had installed the TV Allowance
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; subcutaneous body fat (triceps skinfold); Waist and hip circumferences (measured); The waist-to-hip ratio (calculated as a measure of body fat distribution); food and sedentary behaviour parameters (reports); The maximal, multistage, 20-m,shuttle run test (20-MST) was used to assess cardiorespiratory fitness
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Ronsley et al. 2013
Methods and setting	Study design	CBA
	Unit of allocation	School
	Number of clusters	2 schools in the intervention group and 1 school in the control group
	Follow-up	Only post-intervention
	Country	Canada

	Period	September 2009- June 2010
Participants	Number of participants at baseline and follow-up (intervention/control)	118 individuals in the intervention group and 61 individuals in the control group at baseline and at follow-up
	Age	10.9+-3.5 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity-The Tsimshian Nation (Aborigin)
Intervention	Description	Healthy Buddies™ includes 3 main components: physical activity (PA) (‘‘Go Move!’’), healthy eating (‘‘Go Fuel!’’), and healthy body image (‘‘Go Feel Good!’’). Healthy Buddies™ includes 3 main components: physical activity (PA) (‘‘Go Move!’’), healthy eating (‘‘Go Fuel!’’), and healthy body image (‘‘Go Feel Good!’’). Briefly, the program is a whole school model, based on prescribed learning outcomes from the BC Ministry of Education, that includes 21 lessons and 6 fitness loops, each of which is 30 minutes in length. At the beginning of each lesson, the older students are taught the concepts by their teachers. Designation of ‘‘older’’ and ‘‘younger’’ buddy classes are decided on an individual basis by school administrators. The older students then teach the younger students (their ‘‘buddies’’) the lesson. Healthy eating is targeted through lesson plans about nutritious and non-nutritious foods and beverages. Fitness loops are done twice weekly and are designed to be done with 2 classes in the gymnasium at 1 time (1 older class and their younger ‘‘buddy’’ class). Each loop includes a circuit of stations containing exercises that are designed to be done by children of every fitness level, be fun and promote vigorous exercise (examples include jump rope, hole-hoop, stretches, sprints, push-ups, and sit-ups). Healthy body image is targeted through teaching about healthy growth and development, media awareness and through social skill development facilitated by the buddy system.
	Duration of intervention	10-months
	Frequency of PA	2 times/week
	Duration of PA	60 min/week
	Intensity of PA	VPA

	Type of PA	Structured aerobic fitness sessions, called fitness loops. Each fitness loop incorporated a circuit, with a series of stations, designed around a theme (e.g., transportation fitness loop)
	Parent involvement	No
	Setting	School
	Who delivered the intervention	Teacher; Students (from 4th to 7th grade) acted as educators, teaching their kindergarten to 3rd grade friends.
	Theoretical framework	Not specified; Peer-teaching model
	Control	Regular school activities
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI z-score (CDC); WC (measured); prevalence of overweight (CDC); Blood pressure (measured); knowledge of healthy living (The Healthy Buddies Questionnaire); food intake (The Food Frequency Questionnaire); physical activity (PAQ-C and PAQ-A)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Rosario et al. 2012
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	3 schools in the intervention group and 4 schools in the control group
	Follow-up	Only post-intervention
	Country	Portugal
	Period	October 2008 - March 2009
Participants	Number of participants at baseline and follow-up (intervention/control)	233 individuals in the intervention group and 231 individuals in the control group at baseline; 151 individuals in the intervention group and 143 individuals in the control group at follow-up
	Age	8.3+-1.2 years
	Sex	Both boys and girls

	Other characteristics	Portuguese
Intervention	Description	Teachers of the intervention group had 12 sessions of three hours each with the researchers during six months, which included the following contents: session 1, how to promote health and prevent disease, lifestyle determinants of health, obesity; session 2, key concepts in food and nutrition; sessions 3 and 4, dietary guidelines (the Portuguese Food Wheel), healthy eating advice for children, covering the five main food groups, and interventions to help children and their families to consume healthy foods and plan well-balanced meals and snacks; session 5, teach children about the importance of water, and teaching strategies to replace consumption of sugar-sweetened beverages with water; sessions 6 and 7, appropriate physical activity levels and healthy eating behaviours such increasing fruit and vegetable intake and decreasing energy-dense micronutrient-poor foods; session 8, teaching strategies and learning theory in the classroom; session 9, strategies to reduce screen exposure time; session 10, global assessment of the training program; sessions 11 and 12, healthy cooking and strategies to get children and their families involved in healthy cooking. After each session, teachers delivered the learnt contents and developed creative and engaging classroom activities about the addressed topic.
	Duration of intervention	6-months.
	Frequency of PA	/
	Duration of PA	/
	Intensity of PA	/
	Type of PA	/
	Parent involvement	No.
	Setting	School.
	Who delivered the intervention	Trained teachers.
	Theoretical framework	Health Promotion Model and Social Cognitive Theory.
	Control	Not specified.
	Intervention fidelity	The implementation of the program occurred as planned. All the children of the intervention schools had contact with trained teachers. Teachers taught the components of the program as prescribed and the researchers were always available to answer any question. In

		addition, teachers reported they were enthusiastic about the training, and had a total attendance in the sessions with the researchers.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; The prevalence of underweight, normal weight, overweight and obesity (IOTF); Dietary intake (24-h dietary recall obtained by nutritionists and/or trained interviewers); physical activity (parents were asked five questions with four answer choices (4-point scale) ranging from 1 to 4 about children's activity)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Rush et al. 2012
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	62 schools in the intervention group and 62 schools in the control group
	Follow-up	Only post-intervention; 2 years after baseline
	Country	New Zealand
	Period	2004-2006
Participants	Number of participants at baseline and follow-up (intervention/control)	692 individuals in the intervention group and 660 individuals in the control group at baseline and at follow-up
	Age	5–7 years old and 10–12 years old
	Sex	Both boys and girls
	Other characteristics	/
Intervention	Description	Each school programme is individualised to the school, and is based on a needs assessment informed largely by the school's stock-take and individual key priorities identified by the specific school. Team Energize staff 'modelled' classes and supported the usual class teacher. Classes modelled included fundamental movement skill training, ideas for 'huff and puff' fitness activities, modified games, and ball activities and sport-related games, where keeping children moving as much as possible throughout each session was the focus. Teachers requested and were provided with ideas for management and control of children during physical activity sessions.

		Energizers promoted active transport, lunchtime games and bike days. Energizers were also available to assist each school with arrange of healthy-eating initiatives. These included canteen makeovers to remove pastry-based pies and 'big cookies 'and add filled rolls, fruit and low-fat yogurt. 'Home play challenge', aimed to increase movement and water intake and reduce sedentary time in the home. Activities also targeted the local community through events such as gala open days and edible gardens.
	Duration of intervention	10-months (one school year)
	Frequency of PA	Not specified
	Duration of PA	Not specified.
	Intensity of PA	Not specified.
	Type of PA	Sports games, active play, active lunchtime, active transport, bike days.
	Parent involvement	Yes, via educational lessons and evenings with dieticians
	Setting	School + community
	Who delivered the intervention	Energizers (trained nutrition and physical activity specialists).
	Theoretical framework	Not specified.
	Control	No intervention
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	% body fat (BIA); BMI standard deviation score (SDS) (calculated using the British 1990 reference population); %BF SDS (using the McCarthy–Cole fat Centiles and BP SDS using the Jackson BP centiles; resting blood pressure (measured)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Sacchetti et al. 2013
Methods and setting	Study design	Cluster RCT
	Unit of allocation	Classroom
	Number of clusters	26 3rd-grade classes

	Follow-up	Only post-intervention
	Country	Italy
	Period	2006-2009
Participants	Number of participants at baseline and follow-up (intervention/control)	247 individuals in the intervention group and 250 in the control group at baseline; 212 in the intervention group and 216 in the control group at follow-up
	Age	8-9 years
	Sex	Both boys and girls
	Other characteristics	/
Intervention	Description	Extra hours of PE consisted of 60 minutes a day, moderate or vigorous physical activity in order to prevent obesity and cardiovascular risk factors (for intervention group)
	Duration of intervention	36-months
	Frequency of PA	5 times/week
	Duration of PA	300 min/week
	Intensity of PA	MPA or VPA
	Type of PA	Exercises, games, circuits,
	Parent involvement	No
	Setting	School
	Who delivered the intervention	PE teachers
	Theoretical framework	Not specified
	Control	Regular school-based PE (2 PE lessons of around 50 minutes a week)
	Intervention fidelity	Not reported
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; physical activity (self-administered questionnaire, modified from the Physical Activity Questionnaire for children aged 8-14 (PAQ-C)); physical fitness (Sit & Reach test, 2 kg medicine-ball forward throw test, standing long jump test, 20 m running speed test, forward roll test)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Safdie et al. 2013
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	8 schools in the basic intervention, 8 schools in the plus intervention and 11 schools in the control; 1 plus intervention school lost to follow up after year 1
	Follow-up	Post-intervention, during intervention at the end of 7 months and 11 months
	Country	Mexico
	Period	2006-2008
Participants	Number of participants at baseline and follow-up (intervention/control)	886 at baseline; 252 in the basic intervention group, 224 in the plus intervention group and 354 in the control group at follow-up (analysis)
	Age	9.7+-0.7 years
	Sex	Both boys and girls
	Other characteristics	Socio-economic status-low; Ethnicity-Hispanic
Intervention	Description	The basic program was limited to using existing school infrastructure and resources. The plus program included additional financial investment and human resources. The aim of the nutrition intervention component was to improve the prevailing food environment by increasing availability of healthy food and beverages (particularly water), by reducing the availability of energy-dense foods and SSB, and reducing the number of eating opportunities during the school day. The PA intervention included: Promotion of PA during recess and free time using an activity box, improving the quality of PE, improving sport infrastructure and providing equipment. In plus schools only, PE teachers were hired to teach one additional PE class per week (50 min) and to offer 15 to 20 minutes of moderate physical activity (calisthenics) referred to as “activation period” after the morning civics ceremony four days of each week. In the 2. intervention year morning PA was introduced to basic schools also.
	Duration of intervention (months or weeks)	18-months
	Frequency of PA	5 x/week (plus program)

	Duration of PA	110-120 min/week (plus program)
	Intensity of PA	MPA (plus program)
	Type of PA	Calisthenics (plus program)
	Parent involvement	No
	Setting	School
	Who delivered the intervention	Specialized PE teachers (plus program)
	Theoretical framework	Not specified
	Control	Regular school activities
	Intervention fidelity	The changes in MVPA in children during PE classes and recess were not significantly different from control schools; over 30% of the scheduled PE classes were cancelled.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time,	BMI; prevalence of overweight and obesity (IOTF); level of physical activity (SOFIT(System for Observing Fitness Instruction Time) a standardized direct observation instrument); physical activity (steps taken) at school (Nl-1000 pedometers)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Sallis et al. 1997
Methods and setting	Study design	Non-RCT
	Unit of allocation	Class
	Number of clusters	2 schools in specialist-led PE; 2 schools in teacher-led and 3 schools in control group
	Follow-up	Only post-intervention
	Country	USA
	Period	1990-1993
Participants	Number of participants at baseline and follow-up (intervention/control)	1538 at baseline; 264 students in specialist-led, 331 in teacher-led, and 360 in control conditions at follow-up
	Age	9.5 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity- 82%white, 12% Asian/Pacific Islander, 4% Latino, 2% African American

Intervention	Description	**Physical education program**: SPARK physical education classes were designed to promote high levels of physical activity, teach movement skills, and be enjoyable. SPARK lesson had two parts: health-fitness activities (15 minutes) and skill-fitness activities (15 minutes). **Self-management program:** The self-management program taught behaviour change skills to help children generalize regular physical activity outside of school. Self-management was taught in weekly 30-minute classroom sessions, and skills included self-monitoring, goal setting, stimulus control, self-reinforcement, self-instruction, and problem solving.
	Duration of intervention	20-months (2 school years)
	Frequency of PA	3 times/week
	Duration of PA	90 min/week
	Intensity of PA	Not specified
	Type of PA	Ten health-related activity units included aerobic dance, aerobic games, walking/jogging, and jump rope. Nine sport units that developed skill-related fitness included basketball and soccer.
	Parent involvement	Homework and monthly newsletters were intended to stimulate parent-child interaction and support for physical activity
	Setting	School
	Who delivered the intervention	Three certified physical education specialists; Trained classroom teacher
	Theoretical framework	Not specified
	Control	Regular school activities
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	Body fat (triceps and subscapular skinfolds); Out of-school physical activity (1-day recall in a checklist format); physical activity (accelerometer); health-related physical fitness (Fitness and anthropometric measures, Adaptations of the FHTFNESSGRAM protocols); Cardiovascular endurance (the mile-run test); muscular strength and endurance (the number of bent knee sit-ups in 60 seconds); upper body strength (The number of pull-ups); flexibility (sit-and-reach test)

Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Salmon et al. 2008
Methods and setting	Study design	Group RCT
	Unit of allocation	Class
	Number of clusters	1 class in the BM intervention, 1 class in the FMS intervention, 1 class in the BM/FMS intervention and 1 class in the control group
	Follow-up	Post-intervention, 6-month follow-up and 12-month follow-up
	Country	Australia
	Period	March to November 2002
Participants	Number of participants at baseline and follow-up (intervention/control)	66 individuals in the BM intervention, 74 individuals in the FMS intervention, 93 individuals in the BM/FMS intervention and 62 individuals in the control group at baseline; 59, 72, 84, 63 post-intervention; 59, 60, 78, 49 at 6-month follow-up; 60, 69, 84, 55 at 12-month follow-up
	Age	Average age 10 years 8 months
	Sex	Both boys and girls
	Other characteristics	Australian; low socioeconomic areas
Intervention	Description	The primary goal of the intervention ('Switch-Play') was to develop and compare three approaches towards the achievement of healthy weight maintenance among 10-year-old children: (1) behavioural modification (2) fundamental movement skills development; or (3) through a combination of these two strategies. (A) Behavioural modification lessons were delivered in the classroom and incorporated: self-monitoring; the health benefits of physical activity; awareness of the home and community physical activity, and sedentary behaviour environments; decision-making and identifying alternatives to screen behaviours that included designing their own physical activity games; intelligent TV viewing and reducing viewing time; advocacy of reduced screen time through poster displays and role plays; use of pedometers; and group games;

		Children completed a weekly contract undertaking to switch off one television programme per week over the 4-week period. (B) The Fundamental movement skills lessons were delivered either in the indoor or outdoor physical activity facilities at each school. Through games and activities developed for this intervention, these lessons focused on mastery of six skills including three object control skills (overhand throw, kick and strike) and three locomotor skills (run, dodge and vertical jump).
	Duration of intervention	9-months.
	Frequency of PA	19 sessions
	Duration of PA	40 – 50 min/session.
	Intensity of PA	Not specified.
	Type of PA	The FMS intervention focused on six skills, including three object control skills (overhand throw, kick and strike) and three locomotor skills (run, dodge and vertical jump).
	Parent involvement	in BM condition parents were encouraged to help their child maintain the switch-off of TV.
	Setting	School
	Who delivered the intervention	All intervention components were delivered by one intervention specialist (a qualified Physical Education teacher) across all three schools.
	Theoretical framework	Social cognitive theory and behavioural choice theory
	Control	Regular school activities
	Intervention fidelity	For the BM and FMS lessons there was an average attendance of 88% among the children. For the activities where children had to complete a task at home (i.e. the physical activity and sedentary behaviour self-monitoring sheets) the children completed 57 and 62% of the sheets, respectively. However, 92% of tasks undertaken in class were completed. Out of the 838 'Switch- Off' contracts developed for children in the BM or BM/FMS conditions to complete over the 4-week period, 588 were returned signed by a parent (70% participation rate). There was not a substantial decline in the percentage of contracts being returned from week one (75%) to week four (69%).
Outcomes	State the outcome and the method of assessment	BMI; Children were categorized as healthy or overweight/obese (IOTF definitions); Physical activity (Manufacturing Technology

	weight related outcomes, PA, fitness, sedentary time	Inc. (MTI), Florida, USA, Actigraph Model, AM7164-2.2C accelerometers); Self-reported screen behaviours (questionnaire); Self-reported enjoyment of physical activity (assessed with a modified version of an existing instrument, using a five-point Likert scale); Fundamental movement skills (an established protocol was used to assess children's FMS); food intake (food-frequency questionnaire consisting of 22 common food/drink items that were identified from National Nutrition Survey (NNS))
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Santos et al. 2014
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	10 schools in the intervention group ad 10 schools in the control group
	Follow-up	Only post-intervention
	Country	Canada
	Period	October 2009 - May 2010 (one school year)
Participants	Number of participants at baseline and follow-up (intervention/control)	340 individuals in the intervention group and 347 individuals in the control group at baseline; 340 individuals in the intervention group and 307 in the control group at follow-up
	Age	6 to 12 years
	Sex	Both boys and girls
	Other characteristics	Canadian
Intervention	Description	The program content focused on physical activity, promoting healthy foods, and having a healthy body image using the slogans: "Go Move!" (activity), "Go Fuel!" (nutrition), and "Go Feel Good!" (body image). The "Go Move!" aspect included two 30-minute structured aerobic fitness sessions per week, called fitness loops, with the student pairs. The "Go Fuel!" component included lessons about distinguishing nutritious from unhealthy (nutrient- poor, energy-rich) foods and beverages. As part of the "Go Feel Good!" component,

		students were taught to value themselves and classmates based on individual traits rather than peer influence.
	Duration of intervention	10-months (one school year).
	Frequency of PA	2 times/week.
	Duration of PA	60 min/week.
	Intensity of PA	Vigorous
	Type of PA	Aerobic fitness sessions.
	Parent involvement	No.
	Setting	School.
	Who delivered the intervention	Teachers.
	Theoretical framework	Not specified.
	Control	Regular school activities
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; WC (measured); BMI z-score (CDC); healthy living (questionnaire); Physical activity (daily logs of step counts obtained from a waist-mounted pedometer (StepsCount SC-01) worn for 7 days); Cardiorespiratory fitness (Léger 20-m shuttle run in the older students only)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Scherr et al. 2017
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	2 intervention schools and 2 control schools
	Follow-up	Only post-intervention
	Country	USA
	Period	2012-2013 academic year
Participants	Number of participants at baseline and follow-up	249 individuals in the intervention group and 235 individuals in the control group
	Age	Fourth grade students: 9-10 years
	Sex	Both boys and girls

	Other characteristics	Ethnicity: mostly Asian/Pacific Islander; Caucasian/white, and Latino/Hispanic Household income <$40,000: 18% in the control and 19.5% in the intervention group
Intervention	Description	The goals of the SHCP included (1) increasing Five overlapping components comprised the SHCP: (1) nutrition education and promotion, (2) family and community partnerships, (3) supporting regional agriculture, (4) foods avail-able on the school campus, and (5) school wellness committees and policies. These components were addressed through the implementation of nutrition education, cooking demonstrations, school gardens, family newsletters, health fairs, salad bars, procurement of regional produce, and school-site wellness committees.
	Duration of intervention	9-months
	Frequency of PA	/
	Duration of PA	/
	Intensity of PA	/
	Type of PA	/
	Parent involvement	via family newsletters and health fairs.
	Setting	School.
	Who delivered the intervention	UCCE nutrition educator.
	Theoretical framework	Social-ecological model.
	Control	Regular programme.
	Intervention fidelity	Not specified.
Outcomes		BMI percentile; BMI Z-score; waist-to-height ratio; nutrition knowledge; basic science process skills; vegetable identification and preferences; reported fruit and vegetable intake
Adverse outcomes		NR

Authors and year		Serbescu et al. 2006
Methods and setting	Study design	RCT
	Unit of allocation	School
	Number of clusters	Randomisation at individual level

	Follow-up	Only post-intervention
	Country	Romania
	Period	The intervention ran from early December 2003 to early May 2004
Participants	Number of participants at baseline and follow-up (intervention/control)	198 individuals in the intervention group and 172 individuals in the control group at baseline and at follow-up
	Age	B: 9.59+-0.8 years G: 9.69+-0.4 years
	Sex	Both boys and girls
	Other characteristics	Socio-economic status-urban, middle class; ethnicity-Caucasian
Intervention	Description	Extra-curricular training programme consisted of 10 min of warm-up (mild running, stretching and callisthenic exercises); 30 min workout: moderate to vigorous activities (lower-limb-strengthening exercises; various games comprising high-impact running games, speed courses, slaloms, plyometric jumps, jumps over various obstacles, drop jumps, broad jumps, object manipulations, gymnastic routines, climbing); and 10 min of cool-down.
	Duration of intervention	6-months
	Frequency of PA	2 times/week
	Duration of PA	100 min/week
	Intensity of PA	MVPA
	Type of PA	impact-loading and weight-bearing exercises
	Parent involvement	No
	Setting	School
	Who delivered the intervention	Classroom teachers
	Theoretical framework	Not specified
	Control	Regular school activities
	Intervention fidelity	All children achieved the minimal acceptance rate of 75%
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; body fat (skinfolds); enhancement in motor test performance (EUROFIT tests)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Sevinc et al. 2011
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	From the low- and high-value SES regions, 3 schools each (a total of 6 schools) were selected by using a simple random sampling method. These schools were randomly divided into 3 groups consisting of 1 school from the low and 1 school from the high SES level. Of these groups, 2 were again randomly selected as intervention groups and the remaining 1 as the control group. As a result, intervention group 1, intervention group 2, and the control group, each consisting of 2 schools, were formed.
	Follow-up	Only post-intervention
	Country	Turkey
	Period	NR
Participants	Number of participants at baseline and follow-up (intervention/control)	1932 individuals in the intervention 1, 1989 individuals in the intervention 2, 2926 individuals in the control group at baseline and at follow-up
	Age	Grades were grouped as 1-3 and 4-7
	Sex	Both boys and girls
	Other characteristics	Ethnicity-Turkish; socio-economic status - 3132 (50.8%) of them were the children of low-income families, 1812 (29.4%) were from middle-income families, and 1220 (19.8%) of them were from high-income families.
Intervention	Description	There were 2 intervention groups 2. First intervention group had extra PE hours and healthy nutrition education. Second intervention group had healthy nutrition education only.
	Duration of intervention	8-months
	Frequency of PA	3 x /week.
	Duration of PA	180 min/week.
	Intensity of PA	Not specified.
	Type of PA	Not specified.
	Parent involvement	Yes. via healthy nutrition education.

	Setting	School.
	Who delivered the intervention	Personnel of the Health Training Division of the City Health Administration.
	Theoretical framework	Not specified.
	Control	Not specified.
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Shofan et al. 2011
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	Two adjacent elementary schools, each school consisting of 350 students from the same socio-economic background were chosen
	Follow-up	Only post-intervention
	Country	Israel
	Period	2004-2006
Participants	Number of participants at baseline and follow-up (intervention/control)	91 individuals in the intervention group and 27 in the control group at baseline; 91 individuals in the intervention group and 25 in the control group at follow-up
	Age	9-11 years
	Sex	Both boys and girls
	Other characteristics	/
Intervention	Description	At baseline, the normal physical education classes consisted of two lessons of 45 min each of medium intensity training with an estimated aerobic component of 25%. During the 2 years of the program, the study group received eight nutritional education lessons and double the physical education hours as compared with the control

		group. This activity was directed as intense aerobic activity designed to increase the aerobic component by 50%. At regular parents meetings, which occurred once a month for one hour per session for 10 months a year, the pediatrician and the dietitian encouraged healthy dietary habits.
	Duration of intervention	24-months
	Frequency of PA	2 times/week.
	Duration of PA	180 min/week.
	Intensity of PA	High
	Type of PA	Aerobic activity.
	Parent involvement	Yes. Participated in monthly meetings where they were taught about healthy dietary habits.
	Setting	School.
	Who delivered the intervention	Not specified for PA. Pediatrician and dietitian for diet topics.
	Theoretical framework	Not specified.
	Control	Regular school activities
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Siegrist et al. 2013
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	4 schools in the intervention group and 4 schools in the control group
	Follow-up	Only post-intervention
	Country	Germany
	Period	2006-2007

Participants	Number of participants at baseline and follow-up (intervention/control)	486 in the intervention group and 340 in the control group at baseline; 427 in the intervention group and 297 in the control group at follow-up
	Age	8.4+ 0.7 years
	Sex	Both boys and girls
	Other characteristics	Socio-economic status was assigned as the highest academic level achieved by either parent (low: <9 years, middle: 10–12 years, and high: >13 years of school education); 7.9% children were underweight,78.2% were of normal weight, 7.1% were overweight and 6.8% were obese baseline
Intervention	Description	School environmental settings (e.g. the physical environment, organization of school breaks, playing during school time, and sports facilities) were altered to promote more physical activity. These changes were designed to increase physical movement,promote healthier food availability and choices (more vegetables and fruits and less energy-dense food), and reduce media consumption. The program consisted of monthly lessons lasting 45 min with three parts: a warm-up of 10 min with running, playing running games at high intensity, 30 min exercises to improve body awareness and self-esteem with conversation in class about health-related topics, and 5 min relaxation exercises.
	Sedentary time, physical activity or both	PA
	Duration of intervention	10-months
	Frequency of PA	1 time/month
	Duration of PA	45 min/month
	Intensity of PA	Not specified
	Type of PA	Running, playing running games, exercises to improve body awareness, relaxation exercises
	Parent involvement	Yes, attended two educational health-related lessons
	Setting	School
	Who delivered the intervention	PE teachers
	Theoretical framework	Not specified
	Control	Regular school activities
	Intervention fidelity	Not reported.

Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time.	BMI; BMI SDS (LMS method); WC (measured); moderate to vigorous physical activity (measured as the number of days per week in which physical activity was performed for 60 min minimum (questionnaires)); media use (questionnaires); Physical fitness (measured by the Munich fitness test)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Siegrist et al. 2018
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	8 schools in the intervention group and 7 schools in the control group
	Follow-up	Only post-intervention
	Country	Germany
	Period	NR
Participants	Number of participants at baseline and follow-up (intervention/control)	426 children in the intervention group and 366 individuals in the control group at baseline; 243 individuals in the intervention group and 191 individuals in the control group at follow-up
	Age	11.1 ± 0.6 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity- Caucasian
Intervention	Description	Weekly lifestyle lessons aimed to increase physical activity in and outside of school by regular physical exercise in sports lessons and additional physical activity in school (active breaks during the lessons, active school breaks). Furthermore the school prevention program intended to improve the eating pattern (less sweetened drinks, more healthy meals at school, healthy breakfast) and the health behaviour (reduction of media use and inactivity) of the pupils.
	Duration of intervention	18-months
	Frequency of PA	Not specified.
	Duration of PA	Not specified.
	Intensity of PA	Not specified.
	Type of PA	Not specified.

	Parent involvement	Receiving newsletters regarding the topics of the lifestyle lessons and were invited to a parental training program (2–3 times a year).
	Setting	School.
	Who delivered the intervention	School teachers.
	Theoretical framework	Social cognitive theory.
	Control	Regular school activities
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI SDS (LMS method); blood samples (measured); diameters of retinal arterioles and venules (were measured using a Static Retinal Vessel Analyser); Physical activity (was assessed by two validated questions to determine the amount of moderate-to-vigorous physical activity); Physical fitness (was measured by a 6-item-test battery. The standardized test comprised 6 items (step test, jump-and-reach, flexed arm hanging, ball bouncing, goal throwing, stand-and-reach)).
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Simon et al. 2014
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	4 schools in the intervention group and 4 schools in the control group
	Follow-up	30 months follow-up
	Country	France
	Period	Baseline survey took place between September and October 2002; annual surveys at the end of each of the 4 school years of intervention (between May and June)
Participants	Number of participants at baseline and follow-up (intervention/control)	479 individuals in the intervention group and 475 individuals in the control group at baseline; 374 individuals in the intervention group and 358 in the control group completed the trial; 275 in the intervention and 256 in the control at 30-month follow-up
	Age	The study participants had an initial mean (SD) age of 11.6(0.6) years; (range 9.9–13.8 years)

	Sex	Both boys and girls
	Other characteristics	French
Intervention	Description	A multilevel program, directed at modifying the personal, social and some environmental determinants of PA, is used to promote PA inside and outside school, including during everyday life. (A) The program includes an educational component focusing on PA and sedentary behaviours. The choice of physically active options in everyday life, such as active commuting to and from school or climbing stairs instead of taking the elevator, is emphasized. The fun of being physically active, the pleasure of sharing activities with friends, the health-related benefits, and the fact that PA helps staying fit and in good shape are underlined (B) New opportunities for PA during school hours (lunch pause, breaks) and after-school hours are offered, considering the obstacles to being active (lack of time, poor accessibility or unsafe recreational areas, inappropriate open time, nobody to drive the adolescents to and from the activities, cost, lack of physical capacity, etc.). Various physical activities attractive to youth are organized: either informal (organized games during breaks), innovative (hip-hop, dance, capoeira, etc.) or more academic, but in all cases, without any restrictive competitive aspect or intensity guidelines. Also, sporting events as well as bicycle and on-foot school transfers supervised by the intervention staff are organized. (C) Policy makers of local communities are requested to provide a supportive environment that promotes enjoyable PA. Low-cost or free of charge entry to safe accessible facilities, such as swimming pools and sport areas, have been proposed to implement ICAPS activities. To overcome the distance and transport barrier and to reassure the parents, transfers to the PA areas have been organized and supplementary busses made available when necessary.
	Duration of intervention	40-months (four school years).
	Frequency of PA	Not specified.
	Duration of PA	Not specified.
	Intensity of PA	Not specified.
	Type of PA	Various types.

	Parent involvement	Meetings are regularly organized with the parents, teachers and educators. These actors are encouraged to provide support to enhance the PA level of the adolescents by themselves adopting a physically active lifestyle, by limiting the time devoted by their child to sedentary pursuits and by letting him/her walk or cycle to school, for example. To renew interest, regular information on the ongoing actions and results are given with the help of parents' organizations and the academic staffs.
	Setting	School + community + home
	Who delivered the intervention	Sport-qualified instructors.
	Theoretical framework	Socio-Ecological Theory.
	Control	Control students followed their usual school curriculum without any intervention.
	Intervention fidelity	In the first six months, all the students were exposed to at least two educational classes or debates devoted to PA, organized in groups of 15 pupils on school time with teacher collaboration. Concerning PA, a mean of 10 different weekly activities was provided on each site. About 50% of the students participated in at least one weekly activity. Parental attendance at the meetings was low, especially in poor economic environments (25% to 40% of the parents, depending on the school).
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; BMI z-score and fat mass index (FMI calculated as fat mass (kg) divided by the square of the height (m2)) were used as adiposity indicators; Overweight (IOTF gender-age-cut-offs); Body fat (BIA); Self-reported LPA (Modifiable Activity Questionnaire for adolescents); time spent per week in supervised leisure PA (LPAT excluding physical education classes) and regular participation in sports clubs (yes/no) were considered; Time spent in front of the TV/video (TVT) and in active commuting between home and school/worksite was recorded; TVT was expressed in minutes per day or in two categories (less or more than 2 h per day). Active commuting was categorized in less or more than 20 min per day. Self-efficacy, intention and social support toward exercise (inverse scores were considered so that higher scores indicate better outcomes) were

		assessed using the Stanford Adolescent Heart Health Program's questionnaire
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Skoradal et al. 2018
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	9 schools in the intervention group and 3 schools in the control group
	Follow-up	1 week
	Country	Faroe Island
	Period	2017
Participants	Number of participants at baseline and follow-up (intervention/control)	292 in the intervention group and 100 in the control group at baseline; 33 of the 392 children did not complete the full test battery (at follow-up)
	Age	11.1+-0.3years (range 10-12)
	Sex	Both boys and girls
	Other characteristics	/
Intervention	Description	Intervention was set to substitute math or English lessons with PA. Football-based games and activities were implemented to teach the children football skills, teamwork, and respect. Small-sided games (3v3, 4v4) were included in every session.
	Duration of intervention	11-weeks
	Frequency of PA	2 times/week
	Duration of PA	90 min/week
	Intensity of PA	Not reported
	Type of PA	Football elements
	Parent involvement	No
	Setting	School
	Who delivered the intervention	FIFA 11 trained teachers
	Theoretical framework	Not specified
	Control	Regular school activities

	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; body fat (Bioelectrical Impedance Analysis); FFM (Bioelectrical Impedance Analysis); Resting blood pressure and heart rate (measured); Physical performance (horizontal jumping and postural balance performance)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Sollerhed et al. 2008
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	1 schools in the intervention group and 1 school in the control group
	Follow-up	Only post-intervention
	Country	Sweden
	Period	2000-2003
Participants	Number of participants at baseline and follow-up (intervention/control)	58 individuals in the intervention group and 74 individuals in the control group at baseline and at follow-up
	Age	6-9 years at baseline and 9-12 years at follow-up
	Sex	Both boys and girls
	Other characteristics	/
Intervention	Description	The PE time was expanded from one or two lessons a week (one lesson- 40 min including change and shower) to four lessons, with every lesson being guaranteed to last for 40 min. Time for change and shower was not included in the 40 min. The four lessons were scheduled on 4 days. On the 5th day, classes had outdoor physical activities with their classroom teacher for about 1 h. Obese children had the possibility to have one extra voluntary lesson a week, with special attention paid to motor skills and self-esteem
	Duration of intervention	36-months
	Frequency of PA	5 times/week
	Duration of PA	220 min/week
	Intensity of PA	Not specified
	Type of PA	Not specified

	Parent involvement	No
	Setting	School
	Who delivered the intervention	PE teachers (half-time) and partly by ordinary classroom teachers who were not specially trained for physical education teaching
	Theoretical framework	Not specified
	Control	Regular school activities
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; BMI ratio (compared to IOTF cut-off); WC (measured); actual physical performance (11 physical tests that comprised the physical index); aerobic fitness, muscular strength in the upper body, hands, abdomen and legs, flexibility, balance and motor skills (most of the tests are from the EUROFIT test battery); Endurance performance (running test for 6 min); learned motor skills (rope skipping and ball bouncing)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Spruijt-Metz et al. 2008
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	4 schools in the intervention group and 3 schools in the control group
	Follow-up	3 months post-intervention
	Country	US
	Period	Five to seven consecutive school days at each school early in the Spring Semester
Participants	Number of participants at baseline and follow-up (intervention/control)	136 girls in the intervention group and 110 girls in the control group at baseline and follow-up
	Age	12.5 years
	Sex	Girls only
	Other characteristics	Ethnicity - Asian/Asian American (15.7%), Latino (72.8%), Other (3.9%), White (7.6%)
Intervention	Description	A media-based physical activity intervention was delivered to students during five to seven in-class sessions for five to seven

		consecutive school days for two hours each day. Students received information about physical activity and sedentary behaviour, participated in learning activities ("teachable moments") that supported engagement in physical activity and reduction of time spent watching TV, sitting in front of the computer, or 'just sitting around'.
	Duration of intervention	5 – 7 days (1 week)
	Frequency of PA	/
	Duration of PA	/
	Intensity of PA	/
	Type of PA	/
	Parent involvement	No.
	Setting	School.
	Who delivered the intervention	Teachers.
	Theoretical framework	Self Determination Theory and the Theory of Meanings of Behavior.
	Control	Not specified.
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; BMI percentile (CDC); body fat (BIA); A modified previous day physical activity recall (PDPAR) instrument was used to assess physical activity and sedentary behaviour in blocks of 30-minute bouts throughout the day; Meanings of physical activity (Meanings of Physical Activity Scale (MPAS)); Motivation for physical activity (Exercise Self-Regulation Questionnaire (SRQ-E))
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Stock et al. 2007
Methods and setting	Study design	CBA
	Unit of allocation	School
	Number of clusters	1 school in the intervention group and 1 school in the control group
	Follow-up	Post-intervention
	Country	Canada
	Period	NR

Participants	Number of participants at baseline and follow-up (intervention/control)	235 individuals in the intervention group and 151 individuals in the control group at baseline; 228 individuals in the intervention group and 132 individuals in the control group at follow-up
	Age	1st -3rd grade and 4th -7th grade
	Sex	Both boys and girls
	Other characteristics	Ethnicity- predominantly white; Socio-economic status-slightly lower than the average for British Columbia
Intervention	Description	The program's content is based on 3 main components of healthy living: being physically active, eating healthy foods, and having a healthy body image. The program's slogan ("Go Move!", "Go Fuel!", and "Go Feel Good!") emphasizes these 3 themes. At the beginning of the school year, students in 4th through 7th grade were paired with kindergarten through 3rd-grade buddies. Each week, students in 4th through 7th grade at the intervention school received a 45-minute healthy-living lesson through direct instruction from the intervention teacher. Students in 4th through 7th grade then acted as peer educators, teaching a 30-minute lesson to their kindergarten through 3rdgrade buddy. The buddy pairs spent 2 sessions per week doing 30- minute structured aerobic fitness sessions, called fitness loops. Each fitness loop incorporated a circuit, with a series of stations, designed around a theme (e.g., transportation fitness loop). Students were encouraged during the fitness loops to exercise vigorously, using self-measured parameters of physical exertion (e.g., sweating, red in the face, etc.). The intervention school also participated in a school-wide healthy-living theme day, midway through the year. Each classroom prepared an activity and buddy pairs rotated through the different activities.
	Duration of intervention	21-weeks
	Frequency of PA	2 times/week
	Duration of PA	60 min/week
	Intensity of PA	VPA
	Type of PA	Structured aerobic fitness sessions, called fitness loops. Each fitness loop incorporated a circuit, with a series of stations, designed around a theme (e.g., transportation fitness loop)
	Parent involvement	Not specified

	Setting	School
	Who delivered the intervention	Teacher; Students (from 4th to 7th grade) acted as educators, teaching their kindergarten to 3rd grade friends.
	Theoretical framework	Not specified; Peer-teaching model
	Control	Regular school activities
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time,	BMI; fitness- measured by 9-minute run; knowledge about healthy living- questionnaire; self-competence-28-item self-report instrument; body image perception- modified version of Figure Rating Scale; eating attitudes- The Children's Eating Attitude Test (ChEAT)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Story et al. 2003
Methods and setting	Study design	RCT
	Unit of allocation	Child
	Number of clusters	/
	Follow-up	Only post-intervention
	Country	US
	Period	NR
Participants	Number of participants at baseline and follow-up (intervention/control)	26 individuals in the intervention group and 28 individuals in the control group
	Age	9 years
	Sex	Girls only
	Other characteristics	Ethnicity - "Approximately 83% of parents were African-American only, 6% were biracial, and 11% were Caucasian." Socio-economic status - "The majority of households were low-income, with 54% of parents reporting incomes of less than $30,000 per year. Approximately 44% of homes were female-headed households. The average BMI for parents was 32.8 kg/m2. The majority (92%) of parents were overweight (BMI 25–29.9) or obese (BMI > 30)."

Intervention	Description	The after-school intervention was conducted twice a week for 12 weeks, and focused on increasing physical activity and healthy eating. A major component of the afterschool intervention was increasing physical activity levels with a variety and choice of activities, such as dancing (ethnic, hip hop, aerobic), double-dutch jump rope, relay races, active African-American games, tag, and step aerobics.
	Duration of intervention	12-weeks
	Frequency of PA	2 times/week.
	Duration of PA	120 min/week.
	Intensity of PA	MVPA.
	Type of PA	Dancing (ethnic, hip hop, aerobic), double-dutch jump rope, relay races, active African- American games, tag, and step aerobics.
	Parent involvement	The after-school intervention messages were reinforced by family activities, including weekly family packets sent home to the parents; family night events; phone calls by GEMS staff to parents, to encourage them, and to check their progress on their family goals they set; and organized neighbourhood walks.
	Setting	School.
	Who delivered the intervention	Trained African-American GEMS staff.
	Theoretical framework	Social Cognitive Theory.
	Control	Participants attended monthly Saturday morning meetings (3 meetings during the 12-week period), which included arts and crafts, self-esteem activities, creating memory books, and a workshop on African percussion instruments.
	Intervention fidelity	Girls in the intervention group attended a mean of 21 of 24 sessions
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; WC (measured); %body fat (DEXA); physical activity (The Computer Science Application(CSA) accelerometer); The GEMS Activity Questionnaire(GAQ), developed by the GEMS research group, was used as a self-reported measure of physical activity; Dietary Intake (24-hour recalls (the first one face-to-face, the second by telephone) on non-consecutive days (one weekday and one weekend day, when possible)); A 12-item measure assessing behaviour intentions for choosing healthy food items

		was included; Self-efficacy for Healthy Eating (9-item self-efficacy measure was developed); diet Knowledge (6-item measure); Fruit and Vegetable Snack Accessibility (2-item measure); parent encouragement for Healthy Eating (5-item measure); Physical activity (PA) psychosocial variables (measured); Body image/weight concern (question); Parent-reported diet variables; Parent-reported activity variables
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Story et al. 2012
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	6 schools in the intervention group and 8 schools in the control group
	Follow-up	3 weeks; 27 weeks
	Country	USA
	Period	2006-2007
Participants	Number of participants at baseline and follow-up (intervention/control)	267 individuals in the intervention group and 187 individuals in the control group at baseline; 91.85% at follow-up
	Age	5.8 +- 0.5 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity-American Indian; 32% of boys and 25% of girls were overweight/obese baseline
Intervention	Description	The goals of the intervention were to: Increase physical activity at school to at least 60min/day. This was accomplished through a variety of approaches, including school PE, class walks outdoors, in-class action breaks, and active recess. The in-class "action breaks" were teacher-led, fun, active movements and dancing accompanied by American Indian music, counting, reciting the alphabet, using Lakota words, etc. Class walks of 20min were scheduled at least twice a week. Active daily recess to provide moderate-to-vigorous physical activity was promoted, and playground equipment, such as balls and jump ropes

		were provided to intervention schools. PE teachers were trained by a CATCH PE expert to incorporate CATCH PE. Food-service staff at the intervention schools were trained during each of the two years on specific goals, including to: offer 1% white milk instead of 2% or whole milk, eliminate chocolate or other flavoured milks, serve recommended portion sizes, purchase and use lower-calorie/fat foods, offer low-fat salad dressing in a portion-controlled container, provide more fruits and vegetables, and offer second helpings only on fruits and vegetables.
	Duration of intervention	12-months
	Frequency of PA	5 times/week
	Duration of PA	300 min/week
	Intensity of PA	MPA or VPA
	Type of PA	Walking, active play, dancing.
	Parent involvement	Yes, attending Family Nights setting specific behavioural goals with trained Bright Start research staff regarding changes that could be made in the home environment to foster healthy eating and physical activity
	Setting	School
	Who delivered the intervention	Teachers
	Theoretical framework	Not specified
	Control	Regular school activities
	Intervention fidelity	The means for total physical activity (min/day) in intervention schools were 64.2 (SD = 9.7) in kindergarten and 64.3 (SD = 12.3) in first grade, with school-specific means ranging from 51.4 to 89.6min/day. The mean physical activity from class walks was 12.9min/day (SD = 8.9) in kindergarten and 8.5min/day (SD = 3.9) in first grade. Corresponding means for action breaks were 9.6min/day (SD = 9.6) and 5.7min/day (SD= 3.3) for kindergarten and first grade, respectively. Across the intervention schools, the mean number of days per week that school was held during the intervention period was 4.0 (SD = 0.3) in kindergarten and 4.3 (SD = 0.3) in first grade.

Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time,	BMI; BMI z score (CDC); body fat % (BIA); prevalence of overweight and obesity (measured)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Taylor et al. 2008
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	4 schools in the intervention group and 3 schools in the control group
	Follow-up	After 1 year at the half time of the intervention, after 2 years immediately post-intervention and 2 years after the end of the intervention (4 years after baseline)
	Country	New Zealand
	Period	2003-2005
Participants	Number of participants at baseline and follow-up (intervention/control)	727 individuals at baseline; 280 (73.5%) in the intervention group and 274 (79.2%) in the control group at follow-up
	Age	7.5 ± 1.6 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity-82.6% white, 16.5% Maori, and 1% Pacific Islanders
Intervention	Description	APPLE was a multifaceted intervention with the aim of increasing physical activity, increasing the intake of fruit and vegetables, and reducing the intake of sugary drinks. Community Activity Coordinators were employed to increase noncurricular activity at recess, lunchtime, and after school; curricular-based activities. Development of resources facilitating short bursts of activity in class and the increased availability of sports equipment in an effort to encourage “free play.”
	Duration of intervention	24-months
	Frequency of PA	Not reported
	Duration of PA	Not reported

	Intensity of PA	Not reported
	Type of PA	Not reported
	Parent involvement	Yes
	Setting	School and community
	Who delivered the intervention	PE teachers, Activity coordinators, community volunteers
	Theoretical framework	Not specified
	Control	Regular school activities
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI z score (2000 CDC); prevalence of overweight (2000 CDC)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Treu et al. 2017
Methods and setting	Study design	CBA
	Unit of allocation	School
	Number of clusters	8 schools in the standard intervention group; 9 schools in the enhanced intervention group and 9 schools in the control group
	Follow-up	Only post-intervention
	Country	USA
	Period	2010-2011
Participants	Number of participants at baseline and follow-up (intervention/control)	416 individuals in the standard intervention group, 512 individuals in the enhanced intervention group and 559 individuals in the control group at baseline and at follow-up
	Age	8.7+-0.4 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity-significant differences in distribution of ethnicity among all three groups; 65-70% white, 10% black in the intervention groups; 46%black, 38% white in control group
Intervention	Description	This study used a quasi-experimental design with three treatment groups: a low-dose ‘‘standard intervention’’ (SI) group that received

		a nutrition education program and a classroom-based physical activity program for students; a higher-dose ‘‘enhanced intervention’’ (EI) group that received these two programs for students along with additional nutrition and physical activity components for these students and their parents; and a control group that offered its usual programming to its students. ABC for Fitness offers brief ‘‘bursts’’ of physical activity in the classroom, each of a few minutes in length, spread over the school day. Classroom teachers offered 30 daily minutes of activity bursts throughout the school year.
	Duration of intervention	10-months (1 school year)
	Frequency of PA	5 times/week
	Duration of PA	150 min/week
	Intensity of PA	Not specified
	Type of PA	Warm-up, cool-down, hopping, running in place, jumping jacks, or dancing to music.
	Parent involvement	Additional nutrition and physical activity components for these students and their parents
	Setting	School, (family for EI group)
	Who delivered the intervention	Classroom teachers
	Theoretical framework	Not specified
	Control	Regular school activities
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; BMI z-score (CDC); Aerobic capacity (VO2max) – (Progressive Aerobic Cardiovascular Endurance Run protocol)); abdominal strength (measured by Curl-ups, upper body strength by the 90-degree Push-ups, back extensor strength by the Trunk Lift), and flexibility (by the Back Saver Sit & Reach); Knowledge of Healthful Food Choices (Children’s ability to choose ‘‘better for you’’ foods was assessed by using a standardized test instrument based on nutrition labels of food items developed specifically for the ND program); Classroom Behaviour (classroom teachers recorded the number of incidents); Data on the number of children using medication for asthma and/or ADHD were collected by school nurses; Academic Performance (AIMSweb standardized tests)

Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Foster et al., 2010
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	21 schools in the intervention group and 21 schools in the control group
	Follow-up	Only post-intervention
	Country	USA
	Period	2006-2009
Participants	Number of participants at baseline and follow-up (intervention/control)	6358 individuals at baseline and 4603 at follow-up
	Age	11.3±0.6 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity-54.2% Hispanic,18.0% black, 19,3% white, 8,5% other; BMI>85th percentile 58,4% Hispanic, 18,4% black, 15,5% white, 7% other in the intervention group and 53,5% Hispanic, 15,7% black, 21,6% white and 9,2% in the control group at the baseline
Intervention	Description	The intervention had 4 components: nutrition, physical activity, behavioural knowledge and skills, communications and social marketing. The physical-education component was designed to increase the amount of time students spent in moderate-to-vigorous physical activity, defined as activity sufficient to raise the heart rate to 130 beats or more per minute. The core activities consisted of basketball, soccer (speedball embedded) and team handball. In total, the majority of the lessons had the potential to achieve 30 −40 min of MVPA in a 45- min class.
	Duration of intervention	36-months
	Frequency of PA	3 times/week
	Duration of PA	90 min/week
	Intensity of PA	Moderate or vigorous PA, heart rate > 130 bpm
	Type of PA	MVPA

	Parent involvement	Yes, but not specified
	Setting	School
	Who delivered the intervention	PE teachers
	Theoretical framework	Not specified
	Control	Regular school activities
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI z score (CDC 2000); WC (measured); fasting measurements of weight, height, waist circumference, blood pressure, glucose level, and insulin level (measured)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Thivel et al. 2011
Methods and setting	Study design	RCT
	Unit of allocation	School
	Number of clusters	14 schools in the intervention group and 5 schools in the control group
	Follow-up	Only post-intervention
	Country	France
	Period	January – June 2003
Participants	Number of participants at baseline and follow-up (intervention/control)	229 individuals in the intervention group and 228 individuals in the control group
	Age	6-10 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity – French
Intervention	Description	In the intervention schools, a physical activity program was organized for 6 months and consisted of 120 min of supervised physical exercise in addition to 2 h of Physical Education classes per week. The sessions consisted of a 10-min warm-up followed by psychometric activities and exercises to improve coordination, flexibility, strength, speed, and endurance. The main objective of the sessions was to increase the time spent in PA and minimize inactivity.

	Duration of intervention	6-months
	Frequency of PA	2 times/week.
	Duration of PA	120 min/week.
	Intensity of PA	Not specified.
	Type of PA	Exercises to improve coordination, flexibility, strength, speed, and endurance.
	Parent involvement	No.
	Setting	School.
	Who delivered the intervention	Sports science students as part of their training; they were themselves supervised by a member of the investigation staff.
	Theoretical framework	Not specified.
	Control	Regular school activities
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	Obesity (French reference curves for BMI); The sum of the four skinfolds and fat free mass were determined. Ground tests were used to assess aerobic (20-m shuttle run test) and anaerobic (cycling peak power) fitness
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Vandongen et al. 1995
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	5 schools in the control group, 5 schools in the physical fitness group, 5 schools in the school nutrition group, 5 schools in school nutrition + physical fitness group, 5 schools in home nutrition group and 5 schools in school nutrition + home nutrition group
	Follow-up	Only post-intervention
	Country	Australia
	Period	1990
Participants	Number of participants at baseline and follow-up (intervention/control)	1147 at baseline; 158 in physical fitness group, 162 in physical fitness + school nutrition group; 199 in school nutrition group, 126 in school

		+ home nutrition group, 181 in home nutrition group and 145 in control group at follow-up
	Age	10-12 years
	Sex	Both boys and girls
	Other characteristics	NR
Intervention	Description	The study consisted of six groups: 1) physical fitness, 2) physical fitness + school nutrition, 3) school nutrition, 4) school nutrition + home nutrition, 5) home nutrition, 6) control. 15 minutes of fitness activities that incorporated the principles of interval training and gradual progression were offered daily. In addition, 6 x 30 min classroom sessions aimed at providing the children with the rational basis for their activity programs and exercise in general were delivered during the first term. The school-based nutrition program consisted of 10 1-hr lessons, which aimed to improve knowledge, attitudes and eating habits. The home-based nutrition program presented 5 nutrition messages using comics delivered through the school.
	Duration of intervention	9-months
	Frequency of PA	5 times/week
	Duration of PA	75 min/week
	Intensity of PA	MVPA
	Type of PA	Physical fitness programs: Running, relays, skipping and “health hustles”
	Parent involvement	Only in the home-nutrition group (Parents were involved in child nutrition education by assisting with homework exercises and helping to prepare healthy recipes)
	Setting	School
	Who delivered the intervention	Researchers, classroom teachers and specialists in health and PE
	Theoretical framework	Not specified
	Control	Regular school activities.
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; body fat (skinfolds (triceps and subscapular)); blood pressure, cholesterol (measured)

Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Vilchis-Gil et al. 2016
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	2 schools in the intervention group and 2 schools in the control group
	Follow-up	After 6 months during intervention and post-intervention
	Country	Mexico
	Period	2013-2014
Participants	Number of participants at baseline and follow-up (intervention/control)	226 individuals in the intervention group and 181 in the control group at baseline; 193 in the intervention group and 154 in the control group at follow-up
	Age	7.9+-1.2 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity-Hispanic; Socio-economic status-low 26%; medium 33%, high 41%
Intervention	Description	Three educational in-person parents and children sessions were held at 2-month intervals to promote healthy eating habits and exercise. To reinforce the information, a website provided extensive discussion on a new topic every 2 weeks, including school snack menus and tools to calculate body mass index in children and adults. Text messages were sent to parents' mobile phones reinforcing the information provided
	Duration of intervention	12-months
	Frequency of PA	/
	Duration of PA	/
	Intensity of PA	/
	Type of PA	/
	Parent involvement	Parents were involved by in-person sessions and via SMS. Guidelines for parents were developed with information on how to prepare a healthy school lunch, including numerous examples.
	Setting	School

	Who delivered the intervention	Two Nutritionists and a Physical Educator
	Theoretical framework	Not specified
	Control	Not specified
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI z score (WHO); WC (measured)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Wadalovska et al. 2019
Methods and setting	Study design	Non-RCT
	Unit of allocation	Classroom
	Number of clusters	32 classes in the intervention group and 16 classes in the control group
	Follow-up	33 weeks
	Country	Poland
	Period	2015-2016
Participants	Number of participants at baseline and follow-up (intervention/control)	319 students in the intervention group and 145 in the control group at baseline and at follow-up
	Age	11-12 years
	Sex	Both boys and girls
	Other characteristics	Socio-economic status-The Family Affluence Scale (FAS), mean (95%CI)= 5.3 (5.1, 5.5)
Intervention	Description	The education program covered five topics about diet and lifestyle lasting three weeks (total of 15 h). Program was provided as talks and workshops focused on activating participants. Each topic lasted 4 h of school lessons (approximately 180 min) and included various forms of education from fun to “scientific” cognition .
	Duration of intervention	3-weeks
	Frequency of PA	/

	Duration of PA	/
	Intensity of PA	/
	Type of PA	Regular school
	Parent involvement	No
	Setting	School
	Who delivered the intervention	Academic researchers
	Theoretical framework	Not specified
	Control	Regular school activities
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time,	BMI; waist-to-height ratios –WHtR (measured); Screen time ("How much time do you spend watching TV or on the computer or in front of a computer on an average day of the week?"); Physical activity (2 questions > one of three answers describing their PA at school (low, moderate, vigorous) and during leisure time (low, moderate, vigorous))
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Wang et al. 2018
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	16 vs. 16 primary schools and 8 vs. 8 junior high schools within intervention vs. control group in this study
	Follow-up	Only post-intervention
	Country	China
	Period	From September 2013 to June 2014 (one academic school year)
Participants	Number of participants at baseline and follow-up (intervention/control)	10447 eligible participants, 10091 students were successfully recruited (response rate=96.6%) at baseline, and 9858 (97.7%) of them completed the follow-up survey immediately after the intervention
	Age	9.0+-0.1 years (4th grade) and 12.0+-0.01 years (7th grade)
	Sex	Both boys and girls
	Other characteristics	/

Intervention	Description	Intervention consisted of four components: 1) Classroom curricula: knowledge of obesity and its hazards to health, the benefits of sufficient PA for body weight control, and skills to maintain sufficient PA, reduce screen time and take physically active transportation in daily lives. 45 min for each classroom curriculum was delivered monthly 2) School environment: posters and slogans, easily-accessed measuring instruments, news leaflets regarding program progress, sent quarterly. 3) Family involvement: health classes for parents each semester, homeworks, three one-week activites in second semester (Physical housework week, Walk-to-school week, No-TV week). 4) Fun programs/events: composition writing with a focus on obesity and its hazards to health, PA and its impact on body weight control in the first semester, painting class with the theme of PA events in daily life in second semester.
	Duration of intervention	10-months (one school year).
	Frequency of PA	/
	Duration of PA	/
	Intensity of PA	/
	Type of PA	/
	Parent involvement	Families (parents) were involved in this study via three ways. First, one health class was prepared for parents in each semester. Second, parents were assigned homework and asked to complete it with their children Third, with assistance from parents, three special 1- week activities were developed for all intervention students in the second semester, including: Physical housework week; Walk-to- school week; No-TV week:
	Setting	School + home.
	Who delivered the intervention	Teachers.
	Theoretical framework	Not specified.
	Control	Control group continued standard education provision
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	Students' demographic characteristics, PA, obesity and healthy lifestyle-related knowledge and dietary behaviours (questionnaires); A validated item-specific PA questionnaire, Children Physical

		Activity Item Questionnaire (CPAIQ), was used to collect information on students' PA over the past seven days, including the name of each PA, frequency and duration; Consumption of red meat, vegetables, fast food and soft-drinks in the past seven days were assessed using items selected from a validated food frequency questionnaire (FFQ); BMI; BMI-Z score: the deviation of the value for an individual from the mean value divided by the standard deviation based on the recommendation for Chinese children; Weight status - overweight and obesity (specifically recommended age- and gender-specific references for Chinese children)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Waters et al. 2017
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	12 schools in the intervention group and 10 schools in the control group
	Follow-up	Only post-intervention
	Country	Australia
	Period	January 2006 - June 2009
Participants	Number of participants at baseline and follow-up (intervention/control)	1594 individuals at the intervention group and 1628 individuals in the control group at baseline; 1426 individuals in the intervention group and 1539 in the control group at follow-up
	Age	5-12 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity-Australian; socio-economic status- Of the 31 Melbourne municipalities, this area ranked seventh in social disadvantage at the time of the study. This municipality also has one of the highest levels of residents who belong to the Catholic and Islamic faiths (36% and 10%, respectively, compared to 30% and 4% across Melbourne). However, there is marked variation in demographic and economic background cross the municipality, and it has shifted over time

		towards a higher socio-economic profile as housing demand and inner-urban location has resulted in families with higher median incomes moving into the area.
Intervention	Description	Schools were supported to develop fun ‘n healthy pro- grams according to the fixed requirement of a whole school combined focus on increasing fruit, vegetable and water consumption, increasing physical activity and encouraging positive self-esteem in children. Three full time CDWs provided support to 4 schools each in the first 2 years. This then reduced to 2 full time CDWs providing targeted support to schools based on need. This support ensured that the strategies followed health promotion principles in creating a supportive and sustainable environment, customised for the school community to achieve changes in relation to the school system, policy, curriculum, environment, and child behaviour and health outcomes. PA strategies implemented in more than 4 schools: Changed playground New sports equipment Class/school exercise sessions After school sports class Active Transport Policy–Bike sheds/racks PE teacher Ride/walk to school Soccer club clinics
	Duration of intervention	42-months
	Frequency of PA	Not specified.
	Duration of PA	Not specified.
	Intensity of PA	Not specified.
	Type of PA	Not specified.
	Parent involvement	.
	Setting	School, home.
	Who delivered the intervention	Intervention staff were employed by Merri Community Health Services.
	Theoretical framework	Health Promoting Schools Framework.
	Control	Regular school activities

	Intervention fidelity	Not specified .
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI-z-score (WHO); Fruit and vegetable intake and sweet drink consumption (parental report and child report using questionnaire, direct assessment of school foods and 24 hour food record); Participation in sedentary activity, physical activity and activity intensity (parental and child report); Child experience (child report and child focus groups); Impacts on the school, home and community environments (School report, Principal exit interviews, Teacher-reported school- and class-based nutrition and physical activity initiatives and level of support, Observational measure: SOPLAY (System for Observing Play and Leisure Activity in Youth), Parental report through parent questionnaire)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Webber et al. 2008
Methods and setting	Study design	RCT
	Unit of allocation	Children in 6 schools at each of the 6 field centres
	Number of clusters	/
	Follow-up	spring 2003, 2005 and 2006
	Country	USA
	Period	2003-2006
Participants	Number of participants at baseline and follow-up (intervention/control)	During 2003 spring, a total of 1721 (79.7%) consented and participated in the measurement. During 2005 spring, 3504 (85.0%) consented and participated in the measurements. During 2006 spring, 3502 (89.5%) consented and participated in the measurements.
	Age	6th graders in 2003 and 8th graders in 2005
	Sex	Only girls
	Other characteristics	Ethnicity-The study population was diverse with the largest percentage of African-American girls in Louisiana and South Carolina and the largest percentage of Hispanic girls in California and Arizona. Socio-economic status-not stated

Intervention	Description	The intervention was designed to establish more opportunities, improve social support and norms, and increase self-efficacy, outcome expectations, and behavioural skills to foster greater MVPA. Intervention linked school and community agencies to develop and promote physical activity programs for girls. These programs were delivered both on and off school property, in most cases either before or after school. Community partners included the YMCA or YWCA, local health clubs, and community recreation centres. Examples of programs include lunch-time Dance Revolution, after-school step-aerobics class, before-school open gym, basketball camp, touch football, and weekend canoe programs. Programs did not replace physical education class. TAAG physical education class promoted MVPA for at least 50% of class time and encouraged teachers to promote physical activity outside of class. Physical education teachers were trained by TAAG interventionists on class management strategies, skill-building activities, the importance of engaging girls in MVPA during class, and the provision of appropriate equipment and choices of physical activity. TAAG promotions used a social marketing approach to promote awareness of and participation in activities through media and promotional events. TAAG promotions also provided schoolwide messages designed to increase the acceptance and support for physical activity for all girls. TAAG health education included six lessons designed to enhance behavioural skills known to influence physical activity participation.
	Duration of intervention	36-months
	Frequency of PA	Not specified.
	Duration of PA	Not specified.
	Intensity of PA	TAAG physical education class promoted MVPA for at least 50% of class time.
	Type of PA	Lunch-time Dance Revolution, after-school step-aerobics class, before-school open gym, basketball camp, touch football, and weekend canoe programs.

	Parent involvement	Not specified.
	Setting	School and community
	Who delivered the intervention	TAAG staff and teachers.
	Theoretical framework	operant learning theory, social cognitive theory, organizational change theory, and the diffusion of innovation model in a social-ecologic framework
	Control	Regular school activities
	Intervention fidelity	Across schools and sites, 93% and 89% of health education lessons were taught in Years 1 and 2, respectively, with 91% and77% of 7th- and 8th-grade girls, respectively, receiving the lessons. the average number of programs created from linking schools with community agencies was 4.7, 7.6, 6.3, and5.9 programs per school. Average program attendance per session by semester was 18.1, 11.5, 16.1, and 13.9 attendees/session.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	Physical activity (Actigraph accelerometers (MTI model 7164)); BMI (measured); triceps skinfold (measured); Percent body fat (was estimated from anthropometric measures using an equation); Class-level physical activity in physical education class (was measured by the system for observing fitness instruction time (SOFIT))
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Weber et al. 2017
Methods and setting	Study design	Non-RCT
	Unit of allocation	Class
	Number of clusters	4 classes in the intervention group and 6 classes in the control group
	Follow-up	Only post-intervention
	Country	Germany
	Period	School year 09/2012–06/2013
Participants	Number of participants at baseline and follow-up (intervention/control)	90 individuals in the intervention group and 134 individuals in the control group at baseline for body composition and fitness; 70 in the intervention group and 125 in the control group at follow-up for body composition; 70 in the intervention group and 122 in the control at

		follow-up for fitness; 20 in the intervention and 17 in the control group for accelerometer monitoring; 71 in the intervention group and 114 in the control group for dietary intake and knowledge
	Age	3rd and 4th grade children
	Sex	Both boys and girls
	Other characteristics	/
Intervention	Type	Extra PE hours, Lifestyle curriculum.
	Description	The children of the intervention group participated in the sport lessons for 2 additional school hours weekly, with each school hour lasting 45 min and offered a very diverse exercise program with extensive motor training and a high amount of moderate-intensity exercise time. The children additionally received 10 school lessons of nutritional education, i.e., about one school lesson monthly, per school year. Extra-curricular PA, which formed the third part of the intervention program and were conducted once per school year, included a soccer training session in the youth academy centre of a German soccer league team, an aqua fitness training session, a visit of an interactive musical on human health, and a visit of a bakery where the children baked their own bread. The intention of these activities were, first, to involve the parents within the otherwise mainly school-focused intervention and, second, to additionally get the children enthusiastic about physical activity and balanced nutrition.
	Sedentary time, physical activity or both	PA
	Duration of intervention	10-months.
	Frequency of PA	2 times/week.
	Duration of PA	90 min/week.
	Intensity of PA	MPA
	Type of PA	Psycho-motoric activity games, activity stories, and dances with the aim to improve strength, endurance, and coordination skills.
	Parent involvement	Yes in extracurricular out-of-school activities.
	Setting	School.
	Who delivered the intervention	The sport lessons were conducted by qualified trainers
	Theoretical framework	Not specified.

	Control	Control group underwent a test on physical fitness and motor skills but received no intervention.
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; body fat (BIA); Physical fitness and motor abilities (assessed by trained personnel using the 'CHECK!' test); dietary knowledge and behaviour (questionnaires); physical activity (accelerometer)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Williamson et al. 2012
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	5 primary schools only, 6 primary & secondary together and 6 control schools
	Follow-up	Only post-intervention
	Country	USA
	Period	2006-2009
Participants	Number of participants at baseline and follow-up (intervention/control)	2060 (713 in the primary intervention group, 760 in the primary & secondary intervention group and 587 in the control group) at baseline; 1429 at follow-up
	Age	10.5+-1.2 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity-70% African American, 30% White
Intervention	Description	The study had two programs: The primary prevention program consisted only of providing campaign materials in the classroom, hallways, and other locations within the school via media (e.g., posters). The primary prevention program has three components: 1) healthy diet promotion, 2) physical activity promotion, and 3) a program for families. Healthy Diet Promotion—Several changes in the food environment compatible with conventional nutrition recommendations Physical Activity promotion program is designed to increase physical activity and decrease sedentary behaviour in three school settings:

		the classroom, recess, and physical education (PE). In the classroom, these goals will be met by incorporating regular 5 minute physical activity breaks after 30 minutes of instruction (30 minute rule), providing suitable indoor physical activity equipment (Physical Activity Centres – "PACs"), by engaging in educational activities that increase physical activity, and by placing LA Health posters in the classroom that are designed to promote decreased sedentary behaviour and increased physical activity. Teachers are encouraged to increase physical activity during recess by provision of outdoor equipment supplied in PACs. The Sports, Play and Active Recreation for Kids (SPARK) curriculum will be provided to support PE teachers Primary Prevention Program for Families- Bi-monthly newsletters will be sent home with the student providing campaign-specific information, suggestions on how to alter the home environment, and specific activities that children are to complete at home with their parents. The secondary prevention program incorporates all three components of the primary prevention plus the secondary prevention program, which has two components: 1) classroom curriculum and 2) internet counselling and education. (synchronous (online) internet counselling and asynchronous e-mail) communications for children and their parents)
	Duration of intervention (months or weeks)	28-months
	Frequency of PA	5 times/week
	Duration of PA	multiple bouts of 5 min activity/day
	Intensity of PA	MVPA
	Type of PA	Not specified
	Parent involvement	Yes. via newsletters
	Setting	School
	Who delivered the intervention	Not specified
	Theoretical framework	Social Learning Theory
	Control	Not specified
	Intervention fidelity	Not reported.

Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI z score (NHANES 2013); body fat % (BIA); Behavior Related to Energy Balance (digital photography method); PA (self-Administered Physical Activity Checklist (SAPAC))
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Wooten et al. 2018
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	24 schools (16 2-days/week intervention+ 8 3-days/week intervention)
	Follow-up	Only post-intervention
	Country	USA
	Period	2015-2016
Participants	Number of participants at baseline and follow-up (intervention/control)	442 individuals in 2-days/week intervention group, 217 individuals in 3-days/week intervention group and 396 in the control group at baseline; 274 in 2-days/week intervention group, 151 in 3-days/week intervention group and 282 in the control group at follow-up
	Age	8.5+-1.3 years and 9.4+-1.3 years; range 5-12
	Sex	Both boys and girls
	Other characteristics	Ethnicity- 30% racial/ethnic minorities; Socio-economic status- "30% economically disadvantaged"; 35% and 30% and 30% OW+OB at baseline
Intervention	Description	Build Our Kids Success (BOKS) is a before school physical activity program. The 60-minute, 12-week program includes a core curriculum delivered by trained volunteers. Curriculum provides a day to day lesson plan to get kids moving for 40-45 minutes before and after the school day. All BOKS classes focus on a functional fitness skill of the week (ex. squat, push up, plank) and follow the same format including team oriented games. The lesson ends with

		short nutritional talk to provide kids with the tools to make smart healthy food choices.
	Duration of intervention	12-weeks
	Frequency of PA	2 or 3 times/week.
	Duration of PA	120 or 180 min/week.
	Intensity of PA	Not specified.
	Type of PA	Mostly endurance and coordination exercise
	Parent involvement	No.
	Setting	School.
	Who delivered the intervention	Trained volunteers.
	Theoretical framework	Social Contextual Theory of Behavior Change.
	Control	Did not participate in intervention activities.
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI z-score (CDC); overweight and obesity categories (CDC)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Xu et al. 2015
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	4 schools in the intervention group and 4 schools in the control group
	Follow-up	Only post-intervention
	Country	China
	Period	2010-2011
Participants	Number of participants at baseline and follow-up (intervention/control)	638 individuals in the intervention group 544 individuals in the control group at baseline; 605 individuals in the intervention group and 503 in the control group at follow-up
	Age	4th grade
	Sex	Both boys and girls

	Other characteristics	Ethnicity-Asian
Intervention	Description	CLICK-Obesity Study - Both control and intervention schools conducted their routine health education classes, while intervention schools additionally implemented the specially developed intervention components, comprising: a) classroom curriculum (including education on healthy eating and sufficient physical activity), b) school environment support, c) family involvement (including parents/guardians health classes), and d) fun programs/events.
	Duration of intervention	12-months
	Frequency of PA	Not specified
	Duration of PA	Not specified
	Intensity of PA	Not specified
	Type of PA	Not specified
	Parent involvement	Through a specifically developed health education class program, parents/guardians were educated to adopt healthy lifestyles and behaviours at home and asked to encourage their children to follow healthy lifestyle and behaviour guidelines at home. The specific interactive events/activities were designed to ask students and parents to complete home assignments regarding healthy lifestyle and obesity prevention together. For example, students and parents were asked to measure body weight and height and then calculate the BMI for each other at home.
	Setting	School
	Who delivered the intervention	Not specified
	Theoretical framework	Theory of Triadic Influence, Comprehensive School Health Program Model
	Control	Regular school activities
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; prevalence of overweight and obesity (Group of China Obesity Task Force); knowledge about health related factors (questionnaire); frequencies of physical activity (Chinese version of the International PA Questionnaire(CHN-IPAQ)); dietary intake (food frequency questionnaire (FFQ))
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Yang et al. 2017
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	2 elementary schools and 1 middle school in the intervention group; 1 elementary school and 1 middle school in the control group
	Follow-up	Only post-intervention
	Country	Korea
	Period	May 2014 until follow-up measurements in April 2015.
Participants	Number of participants at baseline and follow-up (intervention/control)	820 individuals at baseline; the final number of total participants was 768 (control - 350, intervention - 418)
	Age	4^{th} graders in the elementary schools (aged 9-10 years) and 7^{th} graders in the middle schools (aged 12-13 years)
	Sex	Both boys and girls
	Other characteristics	Korean
Intervention	Description	The participants in the intervention group received environmental intervention in addition to the usual school curriculum. In each classroom, educational dietary and exercise videos and the daily lunch menu were presented 5-10 minutes a day by IPTV service for 1 academic year. Various design materials were also painted along the school staircase and hallway to encourage physical activities by the students. For students who are already overweight or obese (BMI ≥ 85th percentile), a once-weekly obesity care program was held during the 12-week summer vacation. Intensive exercise was not mandatory, but the program was intended to provide an extension of the school environment to continue learning and provide a place to exercise during vacation.
	Duration of intervention	12-months.
	Frequency of PA	daily for classroom PA; 1 x week for vacation program
	Duration of PA	10 min/week (classroom PA). 50 min/week (Vacation obesity program).
	Intensity of PA	Not specified.

	Type of PA	Aerobic activity, stretching, and correction of posture (active breaks). Circuit training, interval training, or traditional Korean martial art (Vacation obesity program).
	Parent involvement	Parents twice underwent an education program about how to manage children with obesity. (Vacation obesity care program).
	Setting	School.
	Who delivered the intervention	IPTV service – internet protocol television. Not specified by whom.
	Theoretical framework	Not specified.
	Control	Regular school curriculum
	Intervention fidelity	Among the 113 overweight and obese students in the intervention group, only 30 (26.5%) participated in this program at least once. Among these, only 12 students (10.6%) completed the vacation program according to the completion criterion of over 70% attendance.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; BMI z-score and percentile (2007 Korean standard growth table); Body fat (BIA); The waist circumference (WC) measurement was performed with the participant standing erect with his/her arms at the side and feet together; The blood pressure (BP) (mercury sphygmomanometer (Model CL4114, Youngpoong Medical, Seoul, Korea) using an appropriate cuff); standard methods of PAPS to evaluate cardiovascular endurance, flexibility, muscular/endurance strength, and agility. All of the evaluation processes were performed by a specialized organization (Welltizen, Seoul, Korea)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Yin et al. 2012
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	9 schools in the intervention group and 9 schools in the control group
	Follow-up	Measurements at 1, 9, 13, 21, 25, and 33 months
	Country	US
	Period	Recruitment at 2003 – for three years

Participants	Number of participants at baseline and follow-up (intervention/control)	312 individuals in the intervention group and 289 individuals in the control group at baseline; 255 in the intervention group and 259 in the control group at y-1-post-test; 219 in the intervention group and 226 in the control group at y-2-post-test; 195 in the intervention group and 205 in the control group at 3-y-post-test
	Age	2^{nd}-3^{rd} grade students
	Sex	Both boys and girls
	Other characteristics	Ethnicity- 66% African-American; Socio-economic status- 65% qualified for reduced price or free school lunches
Intervention	Description	An 80-minute period that provided 20 minutes of warm-up and skills instruction, 40 minutes of continuous MVPA, and 10 minutes of calisthenics and cool-down.
	Duration of intervention	8-months
	Frequency of PA	5 times/week
	Duration of PA	400 min/week
	Intensity of PA	HR > 150 bpm for 40min/session,
	Type of PA	Different activity theme (fitness, basketball, soccer, etc.)
	Parent involvement	No
	Setting	School
	Who delivered the intervention	FitKid instructors who were mostly certified school teachers and professional staff from the intervention schools.
	Theoretical framework	Not specified
	Control	Regular free “health screenings,”, and diet/PA information to all participants
	Intervention fidelity	Attendance rate was under 50%
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	% body fat (measured by dual-energy X-ray absorptiometry); cardiorespiratory fitness (measured by heart rate in response to a submaximal step test); non fasting total and high-density lipoprotein cholesterol (HDL-C) and resting blood pressure (BP) (measured)
Adverse outcomes	State the outcome and the method of aG266 ssessment	Adverse events: year 1 – 20 mild, 3 moderate, 1 severe year 2 - 4 mild, 6 moderate, 2 severe year 3 – 5 mild, 2 severe

Characteristics of studies excluded from the quantitative synthesis

Authors and year		Akdemir et al. 2017
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	1 school in the intervention group and 1 school in the control group
	Follow-up	Only post-intervention
	Country	Turkey
	Period	2008-2009
Participants	Number of participants at baseline and follow-up (intervention/control)	674 individuals in the intervention group and 675 individuals in the control group at baseline; 647 individuals in the intervention group and 641 individuals in the control group at follow-up
	Age	10.4+-2.3 years
	Sex	Both boys and girls
	Other characteristics	Socio-economic status-region with higher than average SES
Intervention	Description	In intervention school educational activities focusing on "healthy nutrition and active lifestyle" as well as the "causes of and preventive strategies for obesity" were provided to students and their families. Education was provided in a total of five sessions for the students, three times before and two times after the semester break. The sessions were provided with one month intervals and lasted for 40 minutes. During the educational activities, "Specific Nutritional Guidelines for Turkey" was used as the reference. Also the book entitled "Nutritional Education and Counselling" was used as an additional Resource.
	Duration of intervention	three education sessions before and two times after the semester break
	Frequency of PA	/
	Duration of PA	/
	Intensity of PA	/
	Type of PA	/

	Parent involvement	Yes, via brochure and 2h education program of "healthy nutrition and active lifestyle"
	Setting	School
	Who delivered the intervention	Researchers
	Theoretical framework	Not specified
	Control	Not specified
	Intervention fidelity	not reported
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time,	BMI; overweight and obesity prevalence (WHO); systolic and diastolic blood pressure (measured)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Alexander et al. 2014
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	2 schools in the intervention group and 2 schools in the control group
	Follow-up	Only post-intervention
	Country	USA
	Period	2011
Participants	Number of participants at baseline and follow-up (intervention/control)	749 individuals at baseline; 272 in the intervention group and 289 in the control group at follow-up
	Age	1st and 2nd grade children
	Sex	Both boys and girls
	Other characteristics	Ethnicity- >80% Hispanic; Socio-economic status- >95% subsidised meals
Intervention	Description	Daily recess time (which was previously free time) was structured into organized play two days per week; One additional physical education class organised daily; Weekly cooking classes, a structured nutritional curriculum, and parental counselling..
	Duration of intervention	6-months
	Frequency of PA	5 times/week

	Duration of PA	150 min/week
	Intensity of PA	Not specified
	Type of PA	Relay races and obstacle course games
	Parent involvement	Yes, monthly group activities regarding nutrition, obesity, and physical activity.
	Setting	School
	Who delivered the intervention	PE Specialist teachers
	Theoretical framework	Not specified
	Control	Not specified
	Intervention fidelity	Not reported.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time,	BMI
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Bilinska et al. 2017
Methods and setting	Study design	CBA
	Unit of allocation	Schools
	Number of clusters	68 schools
	Follow-up	Only post intervention
	Country	Poland
	Period	2010-2011
Participants	Number of participants at baseline and follow-up (intervention/control)	5,293 children (2,679 girls and 2,614 boys)
	Age	7-11 years
	Sex	Both boys and girls
	Other characteristics	/
Intervention	Description	The aim of the educational program was to establish the habit of a healthy lifestyle and change inappropriate behaviours. Extensive educational program (including promoting physical activity, healthy diet and other health behaviours), directed to the students but also to

		their parents and teaching staff. Children from the research group also participated in extra physical activities. These were group physical activities carried out at school, including, among others, general development exercises, corrective exercises, dance, and classes at a swimming pool under advice by physiotherapists. It was an additional method to activate the children and educate them about the possibility of active leisure time.
	Duration of intervention	12-months
	Frequency of PA	Not specified.
	Duration of PA	Not specified.
	Intensity of PA	Not specified.
	Type of PA	Group physical activities carried out at school, including, among others, general development exercises, corrective exercises, dance, and classes at a swimming pool
	Parent involvement	Yes via educational activities
	Setting	School.
	Who delivered the intervention	Not specified.
	Theoretical framework	Not specified.
	Control	Control group received education on pro health- related behaviours.
	Intervention fidelity	
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; prevalence of overweight and obesity (IOTF)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Bogart et al. 2016
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	5 schools in the intervention group and 5 schools in the control group
	Follow-up	2 years post-intervention
	Country	USA

	Period	2009-2013
Participants	Number of participants at baseline and follow-up (intervention/control)	1354 individuals in the intervention group and 1919 individuals in the control group at baseline; 829 individuals in the intervention group and 539 individuals in the control group at follow-up
	Age	12.2+-0.7 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity - 75% Latino; Socio-economic status - 89% national school lunch program (a proxy for low income); 18.2% overweight + 30.0% obese at baseline
Intervention	Description	Lifestyle curriculum consisted of a 5-week, middle school– based obesity prevention intervention combining school-wide environmental changes, and encouragement to eat healthy school cafeteria foods, and peer-led education and marketing. Specifically, using role-plays, seventh-grade student peer leaders were taught skills for approaching other students during lunchtime activities, as well as family members at home, to promote SNaX messages (regarding cafeteria food, water, sugar-sweetened beverages, fruits/ vegetables, and physical activity/inactivity) with a motivational interviewing (no confrontational and encouraging) style. Each peer leader was asked to recruit a partner (another student) to assist with lunchtime activities, which directly exposed more students to intervention messages. The social marketing aspect also included taste tests of cafeteria foods, delivered by peer leaders, and a short film shown to the entire seventh-grade class that encouraged physical activity (e.g., through a dance video) and healthy eating. The environmental changes included offering a greater variety of sliced/bite-sized food and freely available chilled filtered water at lunch; posters promoting physical activity, cafeteria food, and healthy eating; and nutritional postings about cafeteria food.
	Duration of intervention	5-weeks
	Frequency of PA	/
	Duration of PA	/
	Intensity of PA	/
	Type of PA	/

	Parent involvement	Take home activities with their children (like worksheet about healthy nutrition)
	Setting	School and home
	Who delivered the intervention	Not specified
	Theoretical framework	Not specified
	Control	Wait list control
	Intervention fidelity	Not reported.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI percentile (CDC)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Carlin et al. 2018
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	3 schools in the intervention group and 3 schools in the control group
	Follow-up	Post-intervention and 12 weeks after
	Country	Northern Ireland
	Period	2014
Participants	Number of participants at baseline and follow-up (intervention/control)	101 individuals in the intervention group and 98 in the control group at baseline; 100 individuals in the intervention group and 97 individuals in the control group at follow-up
	Age	12.4 ± 0.6 years
	Sex	Both boys and girls
	Other characteristics	/
Intervention	Description	Participants were provided with the opportunity to attend a number of structured 10–15-min walks spread across the school week before the first bell, at mid-morning break and at lunch time.
	Duration of intervention	12-weeks
	Frequency of PA	5 times/week

	Duration of PA	50-75 min/week
	Intensity of PA	MPA
	Type of PA	Walk
	Parent involvement	No
	Setting	School
	Who delivered the intervention	Pupils (aged 15–17 years) trained as walk leaders
	Theoretical framework	Not specified
	Control	Normal PA habits
	Intervention fidelity	Not reported.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; WC (measured); physical activity (Actigraph GT3 accelerometer); cardiorespiratory fitness (Queens College Step Test); self-efficacy for PA (questionnaire); Social support for PA and walking from male and female parents/guardians as well as friends (five-item Likert scale)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Cecchetto et al. 2017
Methods and setting	Study design	Cluster RCT
	Unit of allocation	Class
	Number of clusters	2 classes in the intervention group and 2 classes in the control group
	Follow-up	Post-intervention and 12 weeks post-intervention
	Country	Brazil
	Period	March to November 2012
Participants	Number of participants at baseline and follow-up (intervention/control)	40 individuals in the intervention group and 39 individuals in the control group at baseline and at follow-up
	Age	7-11 years; 10.0 ± 1.1 years
	Sex (B&G;G only; B only)	Both boys and girls
	Other characteristics	Brazilian; Caucasian 75%, African 25%; socio-economic status - low socio-economic conditions
Intervention	Description	Intervention consisted of eight weekly Playful workshops lasting for 30-60 min. The workshops included collage, painting, games creation, physical activity, music and dance, and simulations of real

		life situations, all involving the importance of healthy habits for heart health, especially relating to healthy foods and physical activity.
	Duration of intervention	2-months
	Frequency of PA	/.
	Duration of PA	/
	Intensity of PA	/
	Type of PA	/
	Parent involvement	No.
	Setting	School
	Who delivered the intervention	Investigator
	Theoretical framework	Not specified.
	Control	Usual curriculum.
	Intervention fidelity	All other children attended to all sessions and completed the study. For those children that could not attend in a specific day, another day was scheduled.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	Knowledge about healthy habits and risk factors for cardiovascular disease (CARDIOKIDS questionnaire); BMI; Physical activity and food intake (Typical Day of Physical Activities and Food Intake questionnaire)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Chesham et al. 2018
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	1 school in the intervention and 1 school in the control group
	Follow-up	Only post-intervention
	Country	Scotland
	Period	October 2015-June 2016
Participants	Number of participants at baseline and follow-up (intervention/control)	259 individuals in the intervention group and 132 individuals in the control group at baseline; 236 individuals in the intervention group and 118 in the control at follow-up
	Age	4-12 years

	Sex	Both boys and girls
	Other characteristics	Ethnicity – Caucasian; Socio-economic status- Both schools had a range of levels of deprivation, although the majority of pupils were from higher socioeconomic quintiles.
Intervention	Description	The Daily Mile is a school-based physical activity intervention. It involves children going outside, at a time of the classroom teacher's choosing, for ~ 15 min of exercise at a pace self-selected by each individual child. This is done during normal classroom time and is in addition to time spent in physical education or scheduled breaks. Children often talk as they go and perform a mixture of walking and running
	Duration of intervention	Not specified.
	Frequency of PA	5 days/week.
	Duration of PA	75 min/week.
	Intensity of PA	Self-selected.
	Type of PA	Mixture of walking and running.
	Parent involvement	No.
	Setting	School.
	Who delivered the intervention	Classroom teachers.
	Theoretical framework	Not specified.
	Control	Regular school activities
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	MVPA and sedentary time (ActiGraph accelerometer); fitness (20-m shuttle run); body composition (skinfolds); BMI z scores relative for age (were calculated using UK 1990 reference dana)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Coleman et al. 2005
Methods and setting	Study design	CBA
	Unit of allocation	School
	Number of clusters	4 schools in the intervention group and 4 schools in the control group

	Follow-up	Post-intervention
	Country	US
	Period	CATCH was implemented in the fall of the 1998-1999 school year in 18 Title I elementary schools in El Paso and Las Cruces. In the second year (1999-2000), 22 Title I schools were added, and in the third year (2000-2001), 30 Title I schools were added.
Participants	Number of participants at baseline and follow-up (intervention/control)	423 individuals in the intervention group and 473 individuals in the control group; 152 individuals from intervention lost at follow-up
	Age	8-9 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity - Schools that participated in the evaluation ranged from 95% to 99% Hispanic Socio-economic status - Schools also had 82% to 92% of their children eligible for free or reduced-cost meals or some other form of public assistance, and 33% to 72% of their children had limited English proficiency.; participating children were mostly Title I status (most were low-income students)
Intervention	Description	The intervention had 3 of the national CATCH programme components (Home component was not implemented): (1) CATCH PE was designed to increase the amount of time students spent in enjoyable moderate-to-vigorous physical activity (MVPA) at school during PE, as well as to teach students appropriate activities for other times of the day that could be maintained throughout life (2) Eat Smart is designed to provide tasty low-fat and low-sodium meals at school (3) classroom curriculum includes 15 lessons about healthy food choices an exercise choices Schools were allowed to implement each component of El Paso CATCH in a way that suited the school environment.
	Duration of intervention	24-months
	Frequency of PA	3x/week
	Duration of PA	90 min/week
	Intensity of PA	at least 40% MVPA

	Type of PA	Not specified
	Parent involvement	No
	Setting	School
	Who delivered the intervention	Classroom teachers
	Theoretical framework	Social cognitive theory
	Control	Regular school activities
	Intervention fidelity	Emphasis was on adaptation rather than fidelity (using materials exactly as they were designed) of the CATCH intervention trial. Additionally, schools were allowed to implement each component of El Paso CATCH in a way that suited the school environment.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	Fitness (9-minute timed run during PE classes in temperatures below 80°F); height, weight, waist and hip circumference (measured); triceps skinfold (measured); BMI; risk of overweight were defined as equal to or exceeding the 85th and 95th percentiles of body mass index (BMI) (calculated as weight in kilograms divided by the square of height in meters), respectively, for sex and age using the newest Centres for Disease Control and Prevention growth charts
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Dallolio et al. 2016
Methods and setting	Study design	Non-RCT
	Unit of allocation	Classroom
	Number of clusters	4 classes in the intervention group and 6 classes in the control group
	Follow-up	Only post-intervention
	Country	Italy
	Period	2013-2014
Participants	Number of participants at baseline and follow-up (intervention/control)	97 in the intervention group and 135 in the control group baseline and follow-up
	Age	8-10 years
	Sex	Both boys and girls
	Other characteristics	/

Intervention	Description	The intervention aimed to increase children's activity levels through PE lessons given by specialist PE teachers specifically trained for the purpose. The children of the intervention group followed four weekly sessions of MVPA of one hour each, held during the last hour of the school day in the facilities of the school, throughout the whole school year. This activity was carried out as an augmentation to the standard program of physical education, consisting of two lessons of around 50 minutes a week, taught by the ordinary classroom teacher.
	Sedentary time, physical activity or both	PA
	Duration of intervention	8-months
	Frequency of PA	4 times/week
	Duration of PA	240 min/week
	Intensity of PA	MVPA
	Type of PA	Not specified
	Parent involvement	No
	Setting	School
	Who delivered the intervention	Specialist PE teachers specifically trained for the purpose
	Theoretical framework	Not specified
	Control	Regular school activities(PE 2 sessions of 50 minutes/week)
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time,	WHtR (measured); prevalence of overweight and obesity (IOTF); motor abilities and physical fitness (sit and reach test, standing long jump test, Harre circuit test, Yo-Yo Intermittent Recovery Level 1Test, Handgrip strength test); physical self-efficacy (Perceived Physical Ability Scale for Children (PPAS-C))
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		de Greef et al. 2016
Methods and setting	Study design	Cluster RCT
	Unit of allocation	Classroom
	Number of clusters	6 second-grade classes and 6 third-grade classes in the intervention group; 6 second-grade and 6 third-grade classes in the control group

	Follow-up	Only post-intervention
	Country	Netherlands
	Period	NR
Participants	Number of participants at baseline and follow-up (intervention/control)	181 individuals in the intervention group and 195 individuals in the control group at baseline and at follow-up
	Age	8.1±0.7 years
	Sex	Both boys and girls
	Other characteristics	/
Intervention	Description	During each lesson, 10-15 minutes were spent on solving math problems followed by 10- 15 minutes on solving language problems. For example, the children had to solve a mathematical problem by giving the answer with the correct number of jumps (2 times 3 is 6 jumps). Learning activities were matched with the regular learning activities, resulting in a different program for second- and third-grade children.
	Duration of intervention	22-weeks
	Frequency of PA	3 times/week
	Duration of PA	30 min
	Intensity of PA	MVPA 64% time of PA
	Type of PA	Jumps other activities not specified
	Parent involvement	No
	Setting	School
	Who delivered the intervention	Six substitute teachers, who were hired and trained
	Theoretical framework	Not specified
	Control	Not specified
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; Physical fitness (Eurofit physical fitness test battery)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		de Heer et al. 2008
Methods and setting	Study design	RCT
	Unit of allocation	Classroom
	Number of clusters	In the 6 schools, there were 85 randomized classrooms (intervention, n=44; control, n= 41)
	Follow-up	Only post-intervention
	Country	US
	Period	2008
Participants	Number of participants at baseline and follow-up (intervention/control)	At baseline n=901 (intervention n=292; spill over n=251; control n=354); at follow up n=804 (intervention n=242; spill over n=236; control n=326). Allocation was unknown for 4 participants.
	Age	9.2+-0.9 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity-Hispanic; socio-economic status-The average percentage of children with low socioeconomic status was 72%, similar to the school district's average (70%).
Intervention	Description	The after-school program ran twice weekly for 12 weeks. Each session took place in the schoolyard or in the multipurpose room and comprised a 20-to 30-minute health education component followed by 45 to 60 minutes of physical activity. The physical activity component of the after-school program from the CATCH physical activity curriculum was adapted. The activities for the program emphasized cardiovascular activity and aerobic recreational games. Health education curriculum, includes modules on healthy eating, exercise, diabetes, and self-esteem.
	Duration of intervention	12-weeks
	Frequency of PA	2 times/week.
	Duration of PA	90 - 120 min/week.
	Intensity of PA	Not specified.
	Type of PA	The activities for the program emphasized cardiovascular activity and aerobic recreational games.
	Parent involvement	No.
	Setting	School.

	Who delivered the intervention	Senior-level student teachers from the University of Texas at El Paso Physical Education.
	Theoretical framework	Social Cognitive Theory.
	Control	Control group received fourth-grade health workbooks and incentives at pre-test and follow-up measurements
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; aerobic capacity (with the Progressive Aerobic Cardiovascular Endurance Run (PACER) test, which requires participants to run up and down a 20-meter court); The study adapted nutrition indicators (which consisted of self-reported dietary intentions (8 items) and dietary knowledge (10 items) from the previously validated After School Student Questionnaire, derived from the Health Behavior Questionnaire and the School-Based Nutrition Monitoring Student Questionnaire)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Elinder et al. 2012
Methods and setting	Study design	CBA
	Unit of allocation	18 schools
	Number of clusters	9 schools in the intervention group and 9 schools in the control group
	Follow-up	Only post-intervention
	Country	Sweden
	Period	2009-2011
Participants	Number of participants at baseline and follow-up (intervention/control)	478 individuals in the intervention group and 328 individuals in the control group at baseline; 418 individuals in the intervention group and 310 individuals in the control group at follow-up
	Age	aged 6–12 year; 2nd, 4th and 7th
	Sex	Both boys and girls
	Other characteristics	At baseline: Overweight 15.1%, and obesity 3.2% (for all participants) NOTE! This includes 2,4 and 7 graders-there is separate analysis; Socio-economic status- socioeconomic status of

		inhabitants is slightly above the Swedish average
Intervention	Description	The programme is based on the social-ecological model of health targeting the individual student, the social and physical school environment and parents. The primary aim of the programme was to improve students' diet, physical activity and self-esteem and promote the development of healthy body weight. Each school formed local health teams consisting of 4–11 staff. Schools were asked to implement policies on nutrition, physical activity and mental health. Intervention activities related to physical activity: schoolyard and playground modification (3 schools); structured outdoor physical activities during school time (2 schools)); walking school bus lead by parents (1 school); collaboration with local sports clubs (1 school).
	Duration of intervention	24-months.
	Frequency of PA	Not specified.
	Duration of PA	Not specified.
	Intensity of PA	Not specified.
	Type of PA	Not specified.
	Parent involvement	Yes
	Setting	School.
	Who delivered the intervention	School staff (coached by the research team).
	Theoretical framework	Social Ecological Model.
	Control	Regular school activities. Children in the other nine schools that did not sign up to the programme served as the comparison group. Control schools reported that physical activity had been promoted during the period through improvements made in school yards and outdoor facilities and encouraging children to be active during leisure time.
	Intervention fidelity	The interviews with health teams showed that 27 of 56 measures (48%) were fully implemented after two years. One school did not succeed in implementing any measure fully.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI (measured); BMI sds (IOTF, Sweden standards and percentile curves); health behaviours (questionnaire); The physical activity assessment (included five items which were likely targets for the intervention, accelerometer (Actigraph GT1M) worn for 7 days in 48

		fourth grade and 38 seventh grade students); Leisure time sports participation, time spent outdoor, active commuting, recess activity, and membership of a club; TV-viewing (was assessed as hours in front of TV on school days and weekend days, respectively using four answering alternatives); Self-esteem (was evaluated in grade 4 and 7 with the global self-worth subscale of Harter's Self-Perception Profile for Adolescents)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Feng et al. 2015
Methods and setting	Study design	Non-RCT
	Unit of allocation	School and kindergarten
	Number of clusters	In Lubbock - 1 school in the intervention group and 1 school in the control group for baseline data; in San Elizario 41 intervention kindergarteners and 28 control kindergarteners provided baseline data, along with first and second grade students from one intervention elementary school and one control school.
	Follow-up	4, 10, 16 and 22 months after baseline
	Country	USA
	Period	January 2007 - November 2008 (18 months long intervention)
Participants	Number of participants at baseline and follow-up (intervention/control)	292 individuals in the intervention group and 221 in the control group at baseline; some students dropped out because of transfer, whereas new participants who gave consent were added at follow-up
	Age	6.7 ± 1.0 years; 5-9 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity-Hispanic
Intervention	Description	Martial arts PE curriculum; Junior Master Gardeners curriculum was integrated in science classes
	Duration of intervention	18-months
	Frequency of PA	Not specified
	Duration of PA	Not reported for PA
	Intensity of PA	Not specified

	Type of PA	Martial arts curriculum
	Parent involvement	Yes
	Setting	School + home visit to parents of children with overweight
	Who delivered the intervention	PA part was delivered by PE teachers
	Theoretical framework	Not specified
	Control	Regular school activities
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI percentile (CDC); Body fat (Tanita body composition analyser (v. TBF300A, Tokyo, Japan)); WC (measured); Sugar Sweetened Beverage (parents report)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Franckle et al. 2017
Methods and setting	Study design	CBA
	Unit of allocation	Community
	Number of clusters	2 communities in the intervention group (28 schools) and 9 communities in the control group
	Follow-up	4 years pre baseline; at 12th month during intervention; at 6th month post-intervention
	Country	USA
	Period	2012-2014
Participants	Number of participants at baseline and follow-up (intervention/control)	2456 students in the intervention group at baseline and 2506 students in the intervention group at follow-up
	Age	4^{th} and 7^{th} grade
	Sex	Both boys and girls
	Other characteristics	Ethnicity- white 45%, Hispanic 35%; Socio-economic status-Approximately two-thirds of the student body in both intervention communities were defined as low-income
Intervention	Description	The Childhood Obesity Research Demonstration (CORD) project is a multilevel, multisector community intervention. This program promoted four main topics in school:

		1. healthy food and drinks 2. to reduce screen time per day (no more than 2 hours per day) 3. get at least 1 hour of PA a day 4. to get enough sleep (10 hours per day 6-12 old). Intervention components in schools included evidence-based health education curricula (Eat Well, Keep Moving in grades 4–5 and Planet Health in grades 6–7). Food and Fun curriculum was delivered in afterschool programmes. Activities in other sectors most likely to affect the school-aged population included those implemented in health centres, afterschool programs, and the broader community
	Duration of intervention	24-months
	Frequency of PA	Not specified
	Duration of PA	Not specified
	Intensity of PA	Not specified
	Type of PA	Not specified
	Parent involvement	Yes
	Setting	School, Home and Community
	Who delivered the intervention	Teachers
	Theoretical framework	Childhood Obesity Research Demonstration (CORD) framework
	Control	Regular school programme
	Intervention fidelity	Not reported
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	Obesity prevalence (CDC); BMI; Dietary behaviours (4-point response scale); physical activity (Children were asked about the number of days in the past week that they participated in at least 30 minutes of moderate-to-vigorous PA); Screen time (Children's screen time was assessed using two questions); Sleep duration (Children recalled the times they went to bed and woke up the next morning on a usual weekday)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Fung et al. 2012

Methods and setting	Study design	CBA
	Unit of allocation	School
	Number of clusters	8 of the 10 APPLE Schools implemented a nutrition policy and all 10 APPLE Schools adopted policies ensuring all their students receive a minimum of 30 minutes of physical activity per school day
	Follow-up	Only post 2 year intervention
	Country	Canada
	Period	2008-2010
Participants	Number of participants at baseline and follow-up (intervention/control)	306 individuals at baseline and 293 individuals at follow-up
	Age	5th grade students
	Sex	Both boys and girls
	Other characteristics	Canadian
Intervention	Description	School policy change; Full-time School Health Facilitators are responsible for implementing healthy eating and active living strategies while addressing the unique needs and barriers to health promotion in the school environment by engaging all stakeholders, including parents, staff and the community. School Health Facilitators contributed to the schools 'health curriculum, engaged in developing cross curriculum links and taught across the curriculum. They facilitated professional development days for teachers and school staff, organized parent information nights, nutrition pro-grams such as cooking clubs, after school physical activity programs, weekend events and celebrations, and circulated newsletters. 8/10 APPLE Schools implemented a nutrition policy and all 10 APPLE Schools adopted policies ensuring all their students receive a minimum of 30 minutes of physical activity per school day.
	Duration of intervention	24-months
	Frequency of PA	5 times/week
	Duration of PA	150 min/week
	Intensity of PA	Not specified
	Type of PA	Not specified

	Parent involvement	Yes. Via newsletters. Also, they visited information nights, nutrition programs (cooking clubs), after school physical activity programs.
	Setting	School + community
	Who delivered the intervention	Teachers
	Theoretical framework	Comprehensive school health framework
	Control	No intervention
	Intervention fidelity	8/10 APPLE Schools implemented a nutrition policy and all 10 APPLE Schools adopted policies ensuring all their students receive a minimum of 30 minutes of physical activity per school day.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; BMI cut-points (IOTF); Dietary intake (Harvard Youth/Adolescent Food Frequency Questionnaire (FFQ)); Physical activity levels (Physical Activity Questionnaire for older Children (PAQ-C))
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Gatto et al. 2016
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	2 schools in the intervention group and 2 schools in the control group
	Follow-up	Only post-intervention
	Country	USA
	Period	2012-2014
Participants	Number of participants at baseline and follow-up (intervention/control)	204 individuals in the intervention school and 171 individuals in the control school at baseline; 172 individuals in the intervention group and 147 in the control at follow-up
	Age	9.3 +-0.9 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity- 89%Hispanic/Latino; Socio-economic status- ~90% eligible for free lunch at school
Intervention	Description	LA Sprouts was taught in school gardens constructed on campus (16). Raised bed planter boxes were placed on unpaved, grassy areas of the school yard or on areas where asphalt was removed; gardening

		tools were provided. An outdoor modular kitchen was outfitted with cooking supplies. Classes were held once a week for 12 weeks during either the fall or winter/spring school semester. Separate classes were offered to each grade level. The classes consisted of a 45-min interactive cooking/nutrition lesson and a 45-min gardening lesson.
	Duration of intervention	12-weeks
	Frequency of PA	1/week
	Duration of PA	45min/week
	Intensity of PA	Low
	Type of PA	Gardening
	Parent involvement	Parallel classes were offered to parents bimonthly on mornings, evenings and weekends.
	Setting	School
	Who delivered the intervention	Educator with a nutrition or gardening background
	Theoretical framework	Bandura's 'self-efficacy'
	Control	Students at two control schools did not receive any nutrition, cooking or gardening information from investigators between pre-testing and post-testing, and schools were asked to refrain from augmenting their curriculum with similar lessons during the study period. Following post-testing, control schools received a delayed LA Sprouts intervention, including a school garden.
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI-z-score (CDC); body fat % (BIA); WC (measured); fasting blood samples (analysed); glucose (Yellow Springs Instruments analyser); Total cholesterol, high-density lipoprotein cholesterol {HDL} and triglyceride levels (were measured using enzymatic methods on a Stanbio Sirrus analyser); Low-density lipoprotein {LDL} (was calculated using the Friedewald equation); Homeostatic model assessment (HOMA-IR) (was calculated as a measure of insulin resistance); Metabolic Syndrome (was identified using the definition of Cook et al. which was adapted in adolescents using the National Cholesterol Education Programme's criteria for adults)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Gentile et al. 2009
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	5 schools in the intervention group and 5 schools in the control group
	Follow-up	Post-intervention and 6 months post-intervention
	Country	US
	Period	October 2005-November 2006 (13 months)
Participants	Number of participants at baseline and follow-up (intervention/control)	1,196 (93%) provided data at baseline, 1,156 (90%) at post-intervention, and 1,110 (86%) children at 6 months post-intervention. Data were provided by 1,076 children (84%) at both baseline and post-intervention, 1,029 (80%) at both baseline and 6-months post-intervention, and 992 (77%) at all three time points.
	Age	9.6 +-0.9 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity- most (90%) were White, which is representative of their communities.
Intervention	Description	Family-, school- , and community-based intervention aimed at changing key behaviours (PA, television viewing/screen time, and nutrition) related to childhood obesity. The primary objectives were to: (1) increase the amount of PA; (2) reduce the amount television and video game time; and (3) increase fruit and vegetable consumption. The school component was designed to facilitate the family component of the intervention. Teachers were provided with a monthly teacher's packet which included: posters for the classroom; bulletin board ideas; activity/puzzle handouts for children to do during free time in classroom; a copy of the monthly calendar sent to families. The family component was designed to provide parents (and children) with materials and resources to facilitate the adoption of the healthy target behaviours. Monthly packets were provided containing: a printed brochure describing the project and

		highlighting the timeline; a printed calendar for the month to help motivate and remind parents about their progress on screen time, activity and nutrition goals designed to easily track each goal; a packet of screen time tickets for the child/parent to track screen time; an activity jar with tips for increasing physical activity; a screen time box with tickets to track the amount of screen time; a meal planner which the families could plan meals and make a grocery list; and recipes that primarily focused on increasing fruits and vegetables in creative and enticing ways that interested children were also provided. The community component included paid advertising (for example, bill-boards) and unpaid media emphasizing the key messages, community events and education workshops.
	Duration of intervention	8-months
	Frequency of PA	/
	Duration of PA	/
	Intensity of PA	/
	Type of PA	/
	Parent involvement	Yes, via family component
	Setting	School, family and community.
	Who delivered the intervention	Teachers.
	Theoretical framework	Social Ecological Model.
	Control	Exposed to the community intervention
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	Habitual PA (pedometer (Digiwalker 200-SW)); BMI; Time spent viewing TV and playing video games (was assessed (independently) by both parents and children); Fruit and vegetable consumption (National Youth Risk Behavior Survey)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Greening et al. 2011
Methods and setting	Study design	Cluster RCT

	Unit of allocation	School
	Number of clusters	1 school in the intervention group and 1 school in the control group
	Follow-up	Only post-intervention
	Country	USA
	Period	NR
Participants	Number of participants at baseline and follow-up (intervention/control)	507 at baseline; 204 individuals in the intervention group and 246 individuals in the control group at follow-up
	Age	8.34+-1.30 years (range 6-10)
	Sex	Both boys and girls
	Other characteristics	Ethnicity-63% black, 37% white
Intervention	Description	Health education: Nutritional content of foods addressed in monthly nutritional events. Portion sizes and eating in moderation addressed. Health benefits of the monthly physical activity events were provided during the activity. Nutrition: Family- and school-based nutritional events on alternating months including: (i) healthy tailgating recipe contest, (ii) supermarket sweep requiring parent and student to locate healthy, low-non-fat food ingredients for recipes, (iii) healthy snack selection contest, and (iv) parent–child healthy holiday eating and activity log. PA: Family- and school-based physical activity events on alternating months including: (i) parent–child football toss contest, (ii) parent–child holiday activity log, (iii) parent–child softball throw contest, and (iv) field day of various activities including rope jumping, hula hoops, baseball throws, foot races.
	Duration of intervention	8-months
	Frequency of PA	Not specified
	Duration of PA	Not specified
	Intensity of PA	Not specified
	Type of PA	Not specified
	Parent involvement	The schoolchildren and parents prepared healthy recipes for the event. Parent–child softball throw contest at the beginning of the baseball season; parent–child football toss contest.
	Setting	School and community

	Who delivered the intervention	Trained professionals from the Department of Education and from local academic institutions (universities)
	Theoretical framework	Social Learning Theory
	Control	The control school followed the state's standard health curriculum, which included didactic nutrition education, health information incorporated into academic lessons, and weekly physical education classes.
	Intervention fidelity	Not Specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	Body fat (BIA); WC (measured); prevalence of overweight and obesity (CDC); nutrition knowledge (Know Your Body Questionnaire); Fitness (Shuttle run, curl-ups and V sit; physical activity-21-item checklist); dietary habits (17-item Child Dietary Fat Questionnaire)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Hendy et al. 2011
Methods and setting	Study design	Cluster RCT
	Unit of allocation	Child
	Number of clusters	/
	Follow-up	6 months post-intervention
	Country	US
	Period	NR
Participants	Number of participants at baseline and follow-up (intervention/control)	457 children attended the 1st–4th grades at some time during the KCP application, data from 382 (83.6%) children were included in statistical analyses of the present report
	Age	1st, 2nd, 3rd and 4th grade
	Sex	Both boys and girls
	Other characteristics	Ethnicity- over 95% Caucasian; 112 children overweight
Intervention	Description	Kid's Choice Program (KCP) was designed to increase children's weight management behaviours, by awarding token rewards for three ''Good Health Behaviours'' including eating fruits or

		vegetables first at meals choosing low- fat and low-sugar healthy drinks and showing 5000 exercise steps recorded on pedometers
	Duration of intervention	3-months
	Frequency of PA	/
	Duration of PA	/
	Intensity of PA	/
	Type of PA	/
	Parent involvement	Optional. Parents could use weekly Parent Record to report children's weight management behaviours in the home environment
	Setting	School.
	Who delivered the intervention	school staff.
	Theoretical framework	Social Cognitive Theory, Self Determination Theory, Group Socialization Theory.
	Control	The control group (called the ''TIGERS'') received stars punched into their nametags for each of three ''Good Citizenship Behaviours'' that included talking quietly during meals, keeping their meal area clean, and respecting others by not touching them or their things
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI percentile (CDC); exercise steps (pedometers); including eating fruits or vegetables first at meals (FVFIRST), choosing low fat and low-sugar healthy drinks (HDRINK) (observer record)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Hoelscher et al. 2010
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	15 schools > CATCH basic plus (BP); 15 schools > CATCH basic plus + community (BPC)
	Follow-up	Only post-intervention
	Country	USA
	Period	2007-2008

Participants	Number of participants at baseline and follow-up (intervention/control)	554 individuals in BP group and 553 individuals in BPC group at baseline
	Age	9.9+-0.5 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity- 66% Hispanic, 20% white, 14% black; Socio-economic status- 89% economically disadvantaged; 42% OW And OB at baseline
Intervention	Description	CATCH Community Action teams were asked to: (i) conduct a self-assessment using the CDC School Health Index to identify priority areas of action (n= 15 schools); (ii) attend three "Best Practices" workshops per year with all CATCH BPC schools (n = 15 attended ≥2 workshops; n = 13 attended all workshops); and (iii) select an activity each semester from a "CATCH Community Café" menu of evidence-based strategies for promoting PA and healthy eating in the school setting (n = 15 implemented ≥1 activities). Examples of specific activities implemented by schools included: providing opportunities for students to have a taste of healthful foods (n = 7 schools); implementation of school gardening programs (n = 6 schools); implementation of PA breaks during class time (n = 5 schools); and implementation of after-school PA programs (n = 7 schools).
	Duration of intervention	48-months
	Frequency of PA	not reported
	Duration of PA	not reported
	Intensity of PA	not reported
	Type of PA	Not specified
	Parent involvement	Yes
	Setting	School
	Who delivered the intervention	Teachers
	Theoretical framework	Social Ecological Model and Social Cognitive Theory
	Control	CATCH programme. The four core include: K-5 classroom curricula, a PE program, a child nutrition services component, and family involvement. Teacher-led activity breaks, which consisted of structured time during the week for PA and health education, with activities adapted from the CATCH Kids Club were provided.

		The PE programme had four main objectives: 1. involvement of students in at least 30 min of daily physical activity; 2. involvement of students in MVPA for at least 40% of daily physical activity time; 3. providing students with many opportunities to participate and practise skills in physical activities that could be carried over into other times of the day and maintained later in life; and 4. providing students with a variety of enjoyable physical activities.
	Intervention fidelity	Not reported
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	Overweight and obesity prevalence (CDC); physical activity and dietary intake patterns (SPAN questionnaire); Moderate-to-vigorous PA during PE class: Student engagement in moderate-to-vigorous PA during PE class (was assessed using the System for Observing Fitness Instruction Time (SOFIT) method); Measures to assess the implementation of the CATCH program included a structured interview with the CATCH Champion and a self-administered questionnaire with 4th grade classroom teachers
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Honer et al. 2014
Methods and setting	Study design	Non-RCT
	Unit of allocation	Class
	Number of clusters	3 schools (10 classes) in the intervention group and 4 schools (8 classes) in the control group; Six classes contained boys and girls (four IG, two CG), seven classes contained only girls (three IG, four CG) and five contained only boys (three IG, two CG).
	Follow-up	Post-intervention and 3 months post-intervention
	Country	Germany
	Period	2010/2011 school year
Participants	Number of participants at baseline and follow-up (intervention/control)	297 individuals in the intervention group and 219 individuals in the control group at baseline and at follow-up

	Age	11.90 ±0.76 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity - Caucasian (German)
Intervention	Description	The intervention was carried out within a timeframe of eight weeks and consisted of eight health-promotion PE lessons, each of which lasted 90 minutes and were held during regular PE time. In contrast to the regular PE lessons, health and fitness was the central pedagogical perspective for the IG lessons, which mainly consisted of strength and endurance training taught via numerous games and exercises. The lessons combined age-appropriate practical training, theoretical elements and some additional components (e.g. homework and bonus points for various assignments). The students were given the opportunity to experience the effects of regular training and to raise their awareness of the relationship between regular PA and health. After the intervention, teachers in the IG were instructed to carry out the shuttle-run test two more times. The aim of the shuttle-run test and of the documentation of the results by the students in their booklets was to foster their motivation to continue training beyond the intervention timeframe.
	Duration of intervention	8-weeks
	Frequency of PA	1 time/week.
	Duration of PA	90 min/week.
	Intensity of PA	Not specified.
	Type of PA	Lessons mainly consisted of strength and endurance training taught via numerous games and exercises.
	Parent involvement	No.
	Setting	School
	Who delivered the intervention	Teachers.
	Theoretical framework	behaviour change techniques categorised by Abraham and Michie
	Control	Regular school activities
	Intervention fidelity	„Lesson observations showed that teachers implemented the lessons to a satisfactory extent.“
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	Physical activity - MVPA (measured using two questions to examine whether young people meet the current recommendation for an hour or more of MVPA on most days); Students’ motor

		performance (measured using the German motor performance testDMT6-18); BMI; The generic German questionnaire KINDL-R measures children's HRQOL in terms of subjective perception of physical, mental, social, psychological and functional aspects of well-being and health
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Ickovics et al. 2019
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	12 schools
	Follow-up	Only post-intervention
	Country	US
	Period	2011-2015
Participants	Number of participants at baseline and follow-up (intervention/control)	Of 756 students enrolled in study schools, 698 completed baseline surveys and physical assessments (92.3% participation rate). 595 students at follow-up (85.2% retention)
	Age	10.9+-0.6 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity- Racial/ethnic categorization generally reflected distribution of students in the district: 47.2% Hispanic, 35.0% black, and 17.8% white/other. Socio-economic status-no notable school-level differences in size or relevant socioeconomic characteristics. Free lunch is available to all students in the district because eligibility is high overall, exceeding 60% in all schools (mean=71.4%).
Intervention	Description	Policy interventions related to nutrition and physical activity were implemented and evaluated, leading to four conditions: nutrition only, physical activity only, nutrition and physical activity (dual), or control. Physical activity interventions included promotion of active transport (walk/bike) to school, integrating physical activity into classroom lessons, and fitness challenges. Additionally,

		nutrition interventions included cafeteria-based nutrition promotion to encourage healthy food choices, taste-testing new foods, and providing alternatives for use of food during celebrations.
	Duration of intervention	36 months
	Frequency of PA	Not specified.
	Duration of PA	Not specified.
	Intensity of PA	Not specified.
	Type of PA	Not specified.
	Parent involvement	Yes, via newsletters.
	Setting	School.
	Who delivered the intervention	Teachers.
	Theoretical framework	Not specified.
	Control	Health-focused messages not related to obesity prevention were implemented, with obesity prevention delivered at the end of the trial.
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	Physical measurements (obtained by trained research assistants according to WHO Expanded STEPS protocol); BMI (measured); BMI-percentile (CDC); Nutritional habits (Youth Risk Behavior Survey and School-Based Nutrition Monitoring Questionnaire); Physical activity behaviours (CDC)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Jurak et al. 2013
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	9 primary schools
	Follow-up	Seven years post intervention
	Country	Slovenia
	Period	NR

Participants	Number of participants at baseline and follow-up (intervention/control)	216 individuals in the intervention group and 229 individuals in the control group at baseline; 160 individuals in the intervention group and 164 in the control group at follow-up
	Age	Intervention 7.76+-0.33; control 7.71+-0.32
	Sex	Both boys and girls
	Other characteristics	Ethnicity - Caucasian (Slovenian)
Intervention	Description	The programme is delivered in the first four years of schooling, and includes three standard PE lessons (45 minutes per lesson) delivered by general teachers and two extra lessons of PE per week, delivered with the joint teaching of a specialist PE teacher and a generalist teacher. The lesson content and structure are determined by the specialist teachers. In addition, the enhanced programme includes a wider selection of PE content (e.g. other sports), which can also be conducted outside of school.
	Duration of intervention	48-months
	Frequency of PA	2 times/week.
	Duration of PA	90 min/week.
	Intensity of PA	Not specified.
	Type of PA	Not specified.
	Parent involvement	No.
	Setting	School.
	Who delivered the intervention	Specialist PE teacher jointly with teacher generalist.
	Theoretical framework	Not specified.
	Control	Regular school activities
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	SLOFIT test battery- 8 motor tests (arm plate tapping, standing long jump, polygon backwards, sit-ups, standing reach touch, bent arm hang, 60-meter run, 600-meter run) and 3 anthropometric measurements (body height, body weight and triceps skinfold)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Karczewski et al. 2016
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	2 schools in the intervention group and 2 schools in the control group
	Follow-up	Only post-intervention
	Country	USA
	Period	2009-2010
Participants	Number of participants at baseline and follow-up (intervention/control)	107 participants with complete baseline data on all study variables were used in the study; 76 in the follow-up
	Age	8.5+-1.0 years (7-11)
	Sex	Both boys and girls
	Other characteristics	Ethnicity- 58% black, 42% Latino; socio-economic status- >95% free or reduced lunch
Intervention	Description	Participants in the intervention program received 3 intervention sessions per week throughout the course of the year. Each session included nutrition and health instruction, as well as 60 minutes of soccer practice, and a character building discussion.
	Duration of intervention	24-weeks
	Frequency of PA	3 times/week
	Duration of PA	180 min/week
	Intensity of PA	Not specified
	Type of PA	Soccer practice
	Parent involvement	No
	Setting	School
	Who delivered the intervention	Teachers
	Theoretical framework	community-based participatory research (CBPR) model
	Control	Not specified
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI percentile (CDC)

Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Kocken et al. 2016
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	23 schools in the intervention group and 22 schools in the control group
	Follow-up	First follow-up after 6 months period during intervention and second follow-up post-intervention
	Country	Netherlands
	Period	2009-2011
Participants	Number of participants at baseline and follow-up (intervention/control)	615 individuals in the intervention group and 497 in the control group baseline; 568 in the intervention group and 496 in the control group at T1; 367 in the intervention group and 496 in the control group at T2
	Age	9.2+-0.6 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity-15% from non-Western countries; overweight prevalence-22.2% in the control group and 19.1% in the intervention group at baseline
Intervention	Description	The program consisted of seven lessons in the first school year and nine in the second year. Methods that were used included theory lessons, practical lessons, homework assignments, and involvement of parents in homework. Examples of themes that were addressed were physical activity, computer use, nutrition, and energy balance by using experiments, assignments, videos and classroom discussions. The intervention was focused on the main behavioural changes: decreasing consumption of high-energy or high-fat foods and sugar-sweetened drinks; promoting a healthy breakfast; increasing consumption of fruits and vegetables; reducing television viewing and computer gaming/browsing; and increasing physical activities at school and outside school hours. The behavioural determinants

		of the TPB that were targeted were: knowledge (theory lessons and practical assignments), attitude (group discussions, food diaries), social norm (group discussions and homework assignments) and perceived behavioural control (modelling through assignments e.g., preparing a healthy meal and physical activity games).
	Duration of intervention	20-months (2 school years)
	Frequency of PA	Not reported
	Duration of PA	Not reported
	Intensity of PA	Not reported
	Type of PA	Classroom and PA activities
	Parent involvement	via joint homework assignments
	Setting	School
	Who delivered the intervention	School teachers
	Theoretical framework	The Intervention Mapping (IM) procedure; Theory of Planned Behavior; Framework of the effective US intervention programs "Planet Health" and "Eat Well and Keep Moving"
	Control	Regular school activities; total time spent on education about healthy nutrition and physical activity per year was on average 3.3 h (SD = 3.9).
	Intervention fidelity	The average total duration of the EF! lessons per year was 7.6 h (SD = 2.8) during 16 weeks per school in the intervention group. In the control schools,); most children completed their homework without parents
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI z-score (IOTF); WC (measured); prevalence of overweight and obesity (IOTF); physical activity (one-dimensional accelerometer-the ActiGraph)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Madsen et al. 2013
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	4 schools in the intervention group and 3 schools in the control group

	Follow-up	Post-intervention
	Country	US
	Period	Study measures were collected in the fall (baseline), winter (midpoint), and spring (end point) of the 2009-2010 school year
Participants	Number of participants at baseline and follow-up (intervention/control)	82 individuals in the intervention group and 74 individuals in the control group at baseline; 79 individuals in the intervention group and 71 individuals in the control group
	Age	4th and 5th grade students
	Sex	Both boys and girls
	Other characteristics	42% Latino, 32% Asian and 12% African American
Intervention	Description	SCORES uses soccer as a "hook" to engage youth, with a primary goal of building competencies and skills that will support students' overall development, including teamwork, leadership, and academic commitment. The after-school program offers soccer, creative writing and service learning experiences to youth that would otherwise have limited access to extracurricular activities. spend 2–3 days per week in soccer drills or games. The 2 non-soccer days each week are dedicated to creative writing and performance in the 12-week fall session, and to community service projects in the 12-week spring session.
	Duration of intervention	2 x 12 weeks (fall and spring).
	Frequency of PA	3 times/week.
	Duration of PA	3 h/week.
	Intensity of PA	Not specified.
	Type of PA	Soccer drills and play.
	Parent involvement	Not specified.
	Setting	School.
	Who delivered the intervention	Trained after-school staff.
	Theoretical framework	Not specified.
	Control	Usual curriculum.
	Intervention fidelity	Participation was optional and overall attendance was 48% (range, 0%-100%), with overweight and obese students attending more than normal weight students (60% vs 39%); in the spring, only 7 weeks of SCORES were offered on average.

Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	Physical activity (GT1M or GT3X accelerometer (Actigraph LLC), which yield equivalent activity counts when programmed in uniaxial mode); BMI; BMI z-score (2000 CDC); Cardiorespiratory fitness (20-m shuttle test)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Manager et al. 2012
Methods and setting	Study design	CBA
	Unit of allocation	School
	Number of clusters	14 schools in the intervention group and 15 schools in the control group
	Follow-up	2 years post-intervention
	Country	USA
	Period	2005
Participants	Number of participants at baseline and follow-up (intervention/control)	396 individuals in the intervention group and 301 individuals in the control group at baseline; 125 of whom had two and 572 of whom had three assessments of BMI over the 2-year period
	Age	median (IQR)= 5.68 (5.40-5.98) years
	Sex	Both boys and girls
	Other characteristics	Prevalence of obesity -About 14% of the students in each group were obese based on an age- and sex-specific BMI percentile of 95 of greater
Intervention	Description	The VITAL curriculum consists of 8 different weekly lessons that teach young children healthy eating and appropriate physical activity. Each lesson last approximately 30 minutes (15 minutes devoted to teaching and 15 minutes to physical activity). Using plastic food models and games, children learn healthy nutrition and appropriate physical activity. VITAL provides simple exercise equipment, and children participate in games that increase physical activity. They receive pedometers to encourage physical activity.
	Duration of intervention	24-months

	Frequency of PA	1 times/week
	Duration of PA	15 min/week
	Intensity of PA	Not specified
	Type of PA	Hula hoops and skip ropes; classroom physical activities (e.g., hopscotch, musical chairs, London Bridge is falling down, bunny hop, crab walk, etc.)
	Parent involvement	Yes through parent-teacher meetings
	Setting	School
	Who delivered the intervention	Teachers
	Theoretical framework	Not specified
	Control	Regular school programme
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI percentile (CDC)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Manley et al. 2014
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	1 school in the intervention group and 1 school in the control group
	Follow-up	1 week
	Country	USA
	Period	2007
Participants	Number of participants at baseline and follow-up (intervention/control)	55 individuals in the intervention group and 61 individuals in the control group at baseline; 29 in the intervention group and 9 in the control group at follow-up
	Age	11.6+-0.7 years
	Sex	Both boys and girls
	Other characteristics	Socio-economic status-Discounted or free lunch eligibility rates 30 to 55%; Ethnicity-99% Caucasian; 13.8% of the student participants were overweight and 29.3% obese
Intervention	Description	Teachers provided encouragement to the

		students at the beginning of each day and education regarding the benefits of physical activity was provided in the health class. Students were provided with pedometers in the morning and encouraged to accumulate as many steps as possible, but specifically, girls were encouraged to achieve at least 12,000 steps and boys 15,000 steps each day at school. At the end of the day, teachers provided praise regarding the step counts that students received and continued to encourage increasing the number of steps During the health class, students participated in 10 minutes of physical activity. This activity was in addition to physical education class or any other structured physical activity. The 10-minute physical activity was provided in a group setting and was led by the teacher.
	Duration of intervention	12-weeks
	Frequency of PA	5 times/week
	Duration of PA	50 min/week
	Intensity of PA	MVPA
	Type of PA	Not specified
	Parent involvement	No
	Setting	School
	Who delivered the intervention	Teacher
	Theoretical framework	Social Cognitive Theory
	Control	Regular school activities
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time,	BMI relative (BMI/50th centile CDC); Physical activity (Yamax Digiwalker 200 pedometer); aerobic fitness (1-mile walk test); Self-efficacy (Physical Activity Self-Efficacy scale)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Marcus et al. 2009
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School

	Number of clusters	5 schools in the intervention group and 5 schools in the control group
	Follow-up	Only post-intervention
	Country	Sweden
	Period	Between August 2001 and June 2005 (4 years)
Participants	Number of participants at baseline and follow-up (intervention/control)	719 in the intervention group and 671 individuals in the control group at baseline; 591 individuals in the intervention group and 430 individuals in the control group at follow-up
	Age	6–10 years
	Sex	Both boys and girls
	Other characteristics	Socio-economic status - Participating schools had a mixed pupil population with children from middle and working class families living both in blocks of flats and in detached houses. The proportion of children with an immigrant background, defined as children requiring native-language teaching did not exceed 15%
Intervention	Description	The main focus of the intervention was to change the school environment rather than on healthy lifestyle education, although the school and after school care centre staff were encouraged to emphasize the importance of healthy eating and PA. An additional 30 min of daily PA was integrated into the regular school curriculum and facilitated by the class teachers. To reduce sedentary behaviour, children were not allowed to bring toys that might increase this behaviour, such as hand held computer games, to schools and after school care centres. The maximum time spent playing computer games at the after school care centres was restricted to 30 min per child per day. All intervention schools had agreed to offer a variety of vegetables, and the food was arranged so that the children first served themselves vegetables and thereafter the main course. White bread was substituted with whole-grain bread or similar products including a high amount of dietary fibres. The sugar content in the school lunches and in the afternoon snacks was reduced by strategies such as replacing fruit yogurt with plain yogurt and eliminating fruit juices, soft drinks, lemonades and desserts.

	Duration of intervention	12-48 months.
	Frequency of PA	5 days/week.
	Duration of PA	150 min/week.
	Intensity of PA	Not specified.
	Type of PA	Not specified.
	Parent involvement	STOPP newsletter was distributed to parents and school staff of intervention schools twice annually aimed to increase the awareness of the intervention.
	Setting	School.
	Who delivered the intervention	Class teachers.
	Theoretical framework	Not specified.
	Control	All control schools continued their normal curriculum
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	Overweight and obesity (IOTF); Physical activity (accelerometer, Actiwatch (AW) (model 4, Cambridge Neurotechnology Ltd, Cambridge, UK)); eating habits (questionnaire consisted of 14 multiple choice questions); BMI sds
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		McKay et al. 2005
Methods and setting	Study design	Prospective cohort study
	Unit of allocation	Child
	Number of clusters	/
	Follow-up	Only post-intervention
	Country	Canada
	Period	Participants were measured at baseline (start of the school year, September) and after 8 months (end of the school year, June)
Participants	Number of participants at baseline and follow-up (intervention/control)	51 individuals in the intervention group and 73 individuals in the control group at baseline and at follow-up
	Age	10.1 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity - approximately 34% Hong Kong Chinese, 57%

		North American/Western European Caucasian, 5% Southeast Asian, and 4% other ethnic origin or mixed ethnicity
Intervention	Description	Teachers instructed the children to perform 10 counter movement jumps (two foot take off, clutch knees, two foot landing), three times each school day (once at morning bell, once at noon bell, and once at home time bell).
	Duration of intervention	8-months
	Frequency of PA	3 times/day (15 times/week).
	Duration of PA	15 min /week.
	Intensity of PA	Not specified.
	Type of PA	Counter movement jumps.
	Parent involvement	No.
	Setting	School.
	Who delivered the intervention	Classroom teachers.
	Theoretical framework	Not specified.
	Control	Regular school activities
	Intervention fidelity	Compliance ranged from 10 jumps three times per day,2 days per week, to 10 jumps three times per day 5 days per week with a mean uptake of 90±34 jumps per week. Average school attendance of the intervention children was 96.8% ranging from 0 to 25 days absent (excluding statutory and school holidays)
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	Dietary calcium (The calcium food frequency questionnaire (FFQ)); physical activity (Physical Activity Questionnaire for Children (PAQ-C)); Bone mineral content (BMC) and bone area at the lumbar spine, total body, and proximal femur (measured Hologic QDR 4500 W bone densitometer (DXA)); Proximal femur scans (analysed for bone geometry and structural strength using the hip structural analysis program); Lean and fat mass (calculated); anthropometry (measured)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Nyberg et al. 2015
Methods and setting	Study design	Cluster RCT
	Unit of allocation	Classroom
	Number of clusters	7 classes in the intervention group and 7 classes in the control group
	Follow-up	Post-intervention and 6 months after intervention
	Country	Sweden
	Period	2010-2011
Participants	Number of participants at baseline and follow-up (intervention/control)	243 at baseline; 129 individuals in the intervention group and 112 individuals in the control group at follow-up
	Age	6.2+-0.3 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity-70% of the parents were born in Sweden, 7% in Europe and 23% were born outside of Europe; socio-economic status - 33% (n = 41) of the parents in the intervention group and 40% (n = 40) in the control group had a low level of education
Intervention	Description	The intervention included: 1)Teacher-led classroom activities with children. The activities were related to the different areas, for example discussing the importance of eating fruit and vegetables and thereafter trying a new fruit or vegetable. The children were exposed to ten 30-minute teacher-led sessions. After most sessions the children were given homework in their workbooks with the aim to discuss the session and perform related activities at home with their parents/guardians. 2) Health information for parents and 2 sessions of motivational interviewing
	Duration of intervention	6-months
	Frequency of PA	Not specified
	Duration of PA	Not specified
	Intensity of PA	Not specified
	Type of PA	Not specified
	Parent involvement	Information on diet and PA provided by brochure; Motivational interviewing
	Setting	School
	Who delivered the intervention	Teachers (trained by research team), parents

	Theoretical framework	Social Cognitive Theory
	Control	Regular school activities. Control classes were offered the whole programme directly after the 6-months follow up measurements.
	Intervention fidelity	The implementation of the programme has been evaluated qualitatively. This evaluation showed that the programme was appreciated by teachers and parents and perceived as flexible and easy to implement.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI z-score (Swedish reference standard); prevalence of overweight and obesity (IOTF); physical activity (accelerometry (GT3 XP, Actigraph; LCC; Pensacola, USA)); Indicator foods, PA habits, sedentary behaviour and sleep (parent-proxy questionnaire, the Eating and Physical Activity Questionnaire (EPAQ), parental self-efficacy-questionnaire)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Nyberg et al. 2016
Methods and setting	Study design	Cluster RCT
	Unit of allocation	Class
	Number of clusters	16 classes in the intervention group and 15 classes in the control group
	Follow-up	Post-intervention and 5 months post-intervention
	Country	Sweden
	Period	2012-2013 for 6 months
Participants	Number of participants at baseline and follow-up (intervention/control)	185 individuals in the intervention group and 193 individuals in the control group at baseline; 181 in the intervention group and 187 in the control at follow-up
	Age	6 years
	Sex	Both boys and girls
	Other characteristics	Swedish; socio-economic status - low to medium socioeconomic status; Families classified as having low parental education comprised 47.1 % of the total sample. Of all the parents, 80.4 % were born outside of the Nordic region with Iraq, Eritrea, Somalia, Iran and Turkey as the most common countries of birth."

Intervention	Description	The intervention components were: 1) A brochure with health information targeting parental knowledge; 2) Motivational interviewing targeting parental self-efficacy, willingness to change and care and control (two times for 45 minutes); and 3) Classroom activities targeting children's knowledge, attitudes and preferences and indirectly parental role modelling (ten 30-min teacher-led sessions. The brochure contains facts and advice for parents within seven areas: 1) parental feeding practices; 2) healthy food and family meal times; 3) physical activity; 4) sweets, snacks, ice-cream and soft drinks; 5) fruit and vegetables; 6) physical inactivity, screen time, and commercials; 7) sleep. The children were exposed to ten 30-min teacher-led sessions. The teachers were provided with a tool-box containing culturally appropriate images of common food, and used the teaching manual for each session. After most sessions, the children were given homework to discuss and complete together with their parents. Back in the classroom, the teachers and children summarised the homework, so that each theme was repeated
	Duration of intervention	7-months.
	Frequency of PA	/
	Duration of PA	/
	Intensity of PA	/
	Type of PA	/
	Parent involvement	Engaged in Motivational interviewing, and children's homeworks.
	Setting	School, home.
	Who delivered the intervention	Motivational interviewing counsellors, teachers, parents.
	Theoretical framework	social cognitive theory
	Control	Control classes were offered the entire programme after the follow-up measurements were completed.
	Intervention fidelity	The first MI session was performed with 146 parents (79 %). In the second session,86 of the initial 146 parents participated. In the 13 classes which reported their work with the classroom component, teachers spent on average 33 min on each lesson, ranging from 20 to 150 min. Eleven classes performed all 10 lessons, 4 classes performed 9 lessons, and 1 class performed 8

		lessons. Regarding the home assignments in the work book, 12 of the 16 intervention classes completed all 9 of the assignments, 1 class completed 8 assignments and 3 classes completed 1to“a few “of the home assignments.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	Physical activity (accelerometry (GT3X+, Actigraph, LCC, Pensacola, USA)); Dietary indicators (fruit, vegetables and energy-dense products), physical activity habits, sedentary behaviour and sleep (measured through a validated parent proxy questionnaire, the Eating and Physical Activity Questionnaire (EPAQ)); Height, weight and waist circumference measurements were performed in schools by two trained research assistants according to standardised procedures; BMI; overweight and obesity (IOTF); BMI standard deviation score (Swedish reference Standard)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Paradis et al. 2005
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	2 schools in the intervention group and 1 schools in the control group
	Follow-up	At the half time during intervention, post-intervention, 2, 3 and 6 years after intervention in the intervention group and at half time during intervention and post- intervention in the control group
	Country	Canada
	Period	1994-1996
Participants	Number of participants at baseline and follow-up (intervention/control)	394 individuals in the intervention group and 140 individuals in the control group at baseline; 330 in the intervention group and 119 in the control group at follow-up
	Age	6-11 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity- Aboriginal (Mohawk)
Intervention	Description	The KSDPP intervention program components include a health education curriculum delivered in grades 1 through 6 in the

		community's 2 elementary schools (ten 45-minute lessons per year for each grade). The curriculum includes topics on type 2 diabetes, healthy nutrition (including traditional foods), physical activity and fitness, and other healthy lifestyles. Community activities include regular use of the local newspaper and radio for advertisement, press coverage of events and reporting of results back to the community, promotional events such as contests and family activities (treasure hunts, snow sculpture contests, harvest fair, food tasting, cyclothons, walking clubs, line-dancing clubs, figure skating, etc.). Finally, the program supports the development of capacity (training of native staff and volunteers as well as community members) and promotes healthier environments and stronger social norms for healthy behaviours, especially nutritional choices and physical activity
	Duration of intervention	36-months
	Frequency of PA	/
	Duration of PA	/
	Intensity of PA	/
	Type of PA	/
	Parent involvement	Not specified
	Setting	School, Community
	Who delivered the intervention	Community health nurses and dietitian (1st and 2nd year), teachers (3rd year)
	Theoretical framework	Social Learning Theory, the Precede-Proceed model, the Ottawa Charter for Health Promotion, and traditional learning styles of native children
	Control	Not specified
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; body fat (triceps and subscapular skinfolds); lifestyle (questionnaire); physical activity (7-day recall adapted from an instrument developed by Sallis); sedentary behaviours (questions on the frequency of television watching and video playing); physical fitness (run/walk test); nutrition (7-day food-frequency questionnaire)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Parsons et al. 2014
Methods and setting	Study design	Non-RCT
	Unit of allocation	School
	Number of clusters	All schools in Anchorage, Alaska; control 1999-2004, intervention 2004-2010
	Follow-up	1 year post-intervention
	Country	USA
	Period	2006-2011
Participants	Number of participants at baseline and follow-up (intervention/control)	3716 individuals in the intervention group and 3506 individuals in the control group at follow-up, numbers at baseline not reported
	Age	1st grade
	Sex	Both boys and girls
	Other characteristics	Socio-economic status-34% in title I schools (is given to schools that have around 40% or more students whose families qualify under the U.S. Census's definitions as 'low income'); ethnicity-55% white, 45% minority (includes Alaska Native/American Indian, Asian, Hispanic, Black, Pacific Islander, and multiracial)
Intervention	Description	The program included nutritional guidelines and provisions for eliminating the sales of high-carbohydrate snacks and beverages in all schools. Stricter standards were adopted for the nutritional value of foods offered in the breakfast and lunch menus, and more fruits and vegetables were offered. In addition, a curriculum (Great body shop) which included topics about healthy lifestyle choices, nutrition, and physical activity (2 modules out of 10; others are not related to obesity behaviours), had been taught by Health/Social and Emotional Learning Specialist (previously taught occasionally by classroom teachers). After 2 years, an additional 30 min of weekly physical education (PE) classes for elementary-aged students was added.
	Duration of intervention	60-months; 36-monthd for PE
	Frequency of PA	1xweek

	Duration of PA	30 min/week
	Intensity of PA	/
	Type of PA	/
	Parent involvement	No
	Setting	School
	Who delivered the intervention	Classroom teachers and Health/Social and Emotional Learning Specialist
	Theoretical framework	Social Cognitive Theory
	Control	/
	Intervention fidelity	Not reported
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	Odds of staying becoming overweight (85th centile CDC)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Puma et al. 2013
Methods and setting	Study design	Non-RCT
	Unit of allocation	School-cohorts
	Number of clusters	1 school- intervention and comparison cohorts
	Follow-up	4 years
	Country	USA
	Period	2000-2002
Participants	Number of participants at baseline and follow-up (intervention/control)	173 individuals in the intervention group and 190 in the control group at baseline; 131 individuals in the intervention group and 177 individuals in the control group at follow-up
	Age	2nd grade
	Sex	Both boys and girls
	Other characteristics	Ethnicity- 55.6% Hispanic; Socio-economic status- 55.4% of students in the federal free-or reduced-cost lunch program
Intervention	Description	The Integrated Nutrition and Physical Activity Program (INPAP) is aimed to increase fruit and vegetable consumption and intensify physical activity levels by targeting simple and consistent messages and reinforcing them in multiple ways. Students received 28 lessons

		(18 focused on nutrition and 10 focused on physical activity) in each grade. The lessons included: (1) hands-on food preparation and classroom cooking, (2) tasting activities, (3) cooperative learning, and (4) integration of science, math, and literacy core content standards into the lessons. In addition, a secondary targeted behaviour related to physical activity was reducing the amount of time spent engaging in watching television (TV).
	Duration of intervention	20-months (2 school years)
	Frequency of PA	/
	Duration of PA	/
	Intensity of PA	/
	Type of PA	/
	Parent involvement	via take-home messages and parent night events
	Setting	School
	Who delivered the intervention	Resource teacher, classroom teacher
	Theoretical framework	Social Cognitive Theory and Piaget's Cognitive Development Theory
	Control	Not specified
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	Overweight and obesity prevalence (CDC); Nutrition and physical activity knowledge, self-efficacy, attitudes and behaviours and BMI
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Reed et al. 2013
Methods and setting	Study design	CBA
	Unit of allocation	School
	Number of clusters	1 school in the intervention group and 2 schools in the control groups
	Follow-up	Only post-intervention
	Country	USA
	Period	2009-2010

Participants	Number of participants at baseline and follow-up (intervention/control)	165 individuals in the intervention group and 308 individuals in the control group at baseline and follow-up
	Age	10.2+-2.3 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity-African American; Socio-economic status- low socio-economic status (title I school)
Intervention	Description	The experimental school implemented a comprehensive, multifaceted approach to education based on the premise that a 'sound body nurtures a sound mind.' Two certified physical education teachers were hired to provide 45 minutes of daily physical education, 5 days a week to all children in all grades.
	Duration of intervention	9-months
	Frequency of PA	5 times/week
	Duration of PA	225 min/week
	Intensity of PA	Not specified
	Type of PA	Not specified
	Parent involvement	No
	Setting	School
	Who delivered the intervention	PE teachers
	Theoretical framework	Not specified
	Control	Regular school activities; Control middle school students in grades 6th–8th received 50 minutes of daily physical education daily for the fall semester only. Elementary control school students in grades 2nd–5th received only 45 minutes of PE 1 day per week for the entire school year
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI percentile (CDC); Fluid Intelligence (The Standard Progressive Matrices (SPM) Test designed by Raven); Perceptual Speed (The Perceptual Speed Test developed by Salthouse); physical fitness (Fitnessgram)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Sahota et al. 2001
Methods and setting	Study design	Group RCT
	Unit of allocation	School
	Number of clusters	5 schools in the intervention group and 5 schools in the control group
	Follow-up	Only post-intervention
	Country	UK
	Period	September 1996 - July 1997
Participants	Number of participants at baseline and follow-up (intervention/control)	314 individuals in the intervention group and 322 individuals in the control group at baseline; 292 individuals in the intervention group and 303 individuals in the control group at follow-up
	Age	8.4 +- 0.63 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity- Caucasian mostly (British); Socio-economic status-The schools had 1-42% children from ethnic minorities and 7-29% entitled to free school meals compared with 11% and 25% respectively for Leeds children as a whole.
Intervention	Description	The programme consisted of teacher training, modifications of school meals, and the development and implementation of school action plans designed to promote healthy eating and physical activity over one academic year. It was designed to take place over one academic year and was based on the concept of school action plans, which were to be developed by the individual schools on the basis of their perceived needs. The programme was intended to influence dietary and physical activity behaviour and not simply knowledge in the school children. All schools elected to incorporate nutrition education into the curriculum, with additional sessions supplied by the project manager. They also included a “fit is fun” programme in physical education lessons and undertook to improve their health resources.
	Duration of intervention	12-months
	Frequency of PA	Not specified.

	Duration of PA	Not specified.
	Intensity of PA	Not specified.
	Type of PA	Not specified.
	Parent involvement	?
	Setting	School.
	Who delivered the intervention	The programme's team included a dietitian (project manager), a community paediatrician, a health promotion specialist, a psychologist, an obesity physician, and a nutritional epidemiologist.
	Theoretical framework	Not specified.
	Control	Regular school activities
	Intervention fidelity	All 10 schools participated throughout the study. 76 (89%) of the action points determined by schools in their school action plans were achieved, along with positive changes in school meals.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; Dietary information (assessed by both 24 hour recall and three day food diaries); the frequency of physical activity and sedentary behaviour (questionnaire); Psychological measures (36-item questionnaire)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Shamah et al. 2012
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	30 schools in the intervention group and 30 in the control group
	Follow-up	Only post-intervention
	Country	Mexico
	Period	2010-2011
Participants	Number of participants at baseline and follow-up (intervention/control)	509 children in intervention group and 510 children in the control group at baseline evaluation; 498 in the intervention group and 499 in the control group at follow-up
	Age	5th grade children
	Sex	Both boys and girls

	Other characteristics	Socio-economic status- Low interv 34.9 (30.8,39.0) contr 34.1 (30.1, 38.3), Medium interv 33.7 (29.6, 37.8) contr 39.3 (35.0, 43.5), High interv 31.4 (27.3, 35.4) contr 26.5 (22.7, 30.4); Ethnicity- Mexican
Intervention	Description	The strategy consisted of 4 components: 1. A gradual decrease of the energy content of school breakfasts 2. The gradual regulation of food offered within the school, through the technical council of the State of Mexico. 3. Gradual adherence to the physical activity program, according to the requirements of the Ministry of Public Education 4. Implementation of an educational campaign, called "Healthy Break, "for healthy eating and physical activity. The objectives of this program are to promote consuming one fruit and one vegetable, drinking pure water and performing physical activity (organized games and calisthenics) during break. The ongoing activities in schools in the IG were: a) Nutrition and physical activity workshops. b) Puppet Theatre, based on the theory of peer learning c) Two-day workshops with teachers in each school to raise awareness about healthy eating and physical activity. d) Sale of fruits, vegetables and pure water in the school's store cooperative e) To promote the consumption of pure water, spots were broadcast using the schools 'PA systems, and water bottles were delivered to children and teachers to encourage water consumption. f) Physical activation. Organized activities involving motion were conducted twice per week. Activities performed each day before the start of classes included warm-ups, activation and relaxation. Weekly activation sessions gradually increased from 2 to 5 days. g) Broadcasting of audio spots on the schools 'PA systems. Spots were broadcast 3 times per week during the break. The central messages were aimed at promoting the consumption of fruits, vegetables and pure water during break and to promote physical activity in children, with an average length of 1 min and 15 seconds per spot.

		h) Organized games during break (once per week). To this end, the schools were provided with balls, ropes and hoops, i) Placement of banners at the entrance of the school. In order to highlight the campaign in the school com-munity, a banner was hung that read, “This school pro-motes healthy breaks.
	Duration of intervention	6-months
	Frequency of PA	2-5 times/week.
	Duration of PA	not specified; >30min week.
	Intensity of PA	Not specified.
	Type of PA	Active play.
	Parent involvement	Yes, via educational material
	Setting	School.
	Who delivered the intervention	Standardized and trained promoters, nutrition and health professionals.
	Theoretical framework	Not specified.
	Control	Regular school curriculum
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI, overweight or obese, considering the distribution and cut off points (IOTF); food intake (A Food Frequency Questionnaire (FFQ)); physical activity (semi-quantitative questionnaire was used to record the physical activity of students, based on the Youth Activity Questionnaire developed and validated by Hernández et al. 1999); knowledge about diet and physical activity (questionnaire); Self-efficacy (dichotomous scale with 12 items)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Slusser et al. 2013
Methods and setting	Study design	CBA
	Unit of allocation	Study site
	Number of clusters	4 study sites in the intervention group and 4 study sites in the control group
	Follow-up	Only post-intervention
	Country	US

	Period	2008-2009
Participants	Number of participants at baseline and follow-up (intervention/control)	73 individuals in the intervention group and 48 individuals in the control group at baseline and at follow-up
	Age	3rd -5th graders, 73% 8 to 9 years old
	Sex	Both boys and girls
	Other characteristics	Ethnicity – 60% Asian
Intervention	Description	Catch Kids Club is an evidence- based program that is designed to teach students nutrition and the skills to make healthy dietary and physical activity choices at school, in the community and at home. It is a 32- lesson after school enrichment program designed for the early prevention of cardiovascular disease. It includes a nutrition education manual, an activity box, and hands-on snack preparation activities. After school Youth Specialists were coached to increase the students' opportunities to participate in moderate to vigorous physical activity. The curriculum consisted of physical activity cards that gave the after school Youth Specialists and Program Leaders creative ideas to get the students active. The physical activity cards provided the staff with ideas of activities that they could implement that required minimal or no equipment and were inclusive of children regardless of their physical activity talents, or abilities. The cards included instructions and illustrations, and identified the skills learned from each physical activity. The physical activity component had four main objectives: 1. involvement of students in at least 30 min of daily physical activity; 2. involvement of students in MVPA for at least 40% of daily physical activity time; 3. providing students with many opportunities to participate and practise skills in physical activities that could be carried over into other times of the day and maintained later in life; and 4. providing students with a variety of enjoyable physical activities
	Duration of intervention	10-months
	Frequency of PA	5 x /week
	Duration of PA	150 min/week
	Intensity of PA	/

	Type of PA	physical activities underscored simple generalizable skills such as gross motor movement (throwing, catching and kicking) and large muscle movement
	Parent involvement	No
	Setting	School.
	Who delivered the intervention	Youth Specialists.
	Theoretical framework	Social Cognitive Theory
	Control	Regular school activities
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI – z score (CDC); Physical activity knowledge, perception and behaviours (The Catch Kids Club questionnaire); The Day in the Life Questionnaire was used to measure fruit, vegetable, and snack foods intake and the Previous Day Physical Activity Recall (PDPAR) was used to measure physical activity behaviour
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Speroni et al. 2007
Methods and setting	Study design	CBA
	Unit of allocation	School
	Number of clusters	Four public elementary schools in the community served by the hospital were selected based on the school principals' willingness to accommodate an after-school program offering the KLF intervention
	Follow-up	Post-intervention and 12 weeks after intervention
	Country	USA
	Period	2006
Participants	Number of participants at baseline and follow-up (intervention/control)	86 individuals in the intervention group and 108 individuals in the control group at baseline; 80 individuals in the intervention group and 105 individuals in the control group at follow-up
	Age	2^{nd} to 5^{th} grade
	Sex	Both boys and girls
	Other characteristics	Ethnicity-80%white, 20%hispanic

Intervention	Description	Intervention included a weekly fitness program and monthly dietitian presentations. A physical fitness trainer led the participants in performing various types of physical fitness activities, such as aerobic dance, light strength training, stretching, balancing techniques, heart rate monitoring, yoga, and relaxation techniques. Best lifestyle choices were reinforced, encouraging participants to make best choices in selecting active behaviours such as running or cycling compared with being sedentary by viewing television or playing video games. The objective of the four 30- minute dietary education presentations given by registered dietitians was to encourage children to select foods best for them when making meal and snack selections.
	Duration of intervention	12-weeks
	Frequency of PA	1 time/week
	Duration of PA	30 min – 60 min/week
	Intensity of PA	Not specified
	Type of PA	Various types of physical fitness activities, such as aerobic dance, light strength training, stretching, balancing techniques, and heart rate monitoring, yoga, and relaxation techniques.
	Parent involvement	Parents were encouraged to attend each of the four dietary presentations.
	Setting	School
	Who delivered the intervention	Physical fitness trainer, registered dietitians
	Theoretical framework	Social Learning Theory
	Control	Not specified
	Intervention fidelity	The average attendance rate of participants was 82%.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI percentile (CDC); WC (measured); food, activity and satisfaction (questionnaire)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Spiegel et al. 2006

Methods and setting	Study design	Cluster RCT
	Unit of allocation	Class
	Number of clusters	35 classes in the intervention group and 34 classes in the control group
	Follow-up	Only post-intervention
	Country	USA
	Period	2003-2004
Participants	Number of participants at baseline and follow-up (intervention/control)	534 individuals in the intervention group and 479 individuals in the control group at baseline
	Age	4 and 5 grade
	Sex	Both boys and girls
	Other characteristics	Socio-economic status-0.1% to 58% free or reduced lunch (depending on school); 39.4% controls and 36.4% interventions were OW or OB at baseline
Intervention	Description	The WAY program engages students in multidisciplinary activities in language arts, mathematics, science, and health content, building their academic skills while developing their health attitudes, behavioural intent, and, ultimately, behaviour. Among other, students learn about the F.I.T.T. (Frequency, Intensity, Time, and Technique) principles, how to design a basic workout routine, and how to incorporate physical activity into their daily routine. Students apply this knowledge in social contexts, examining their attitudes and beliefs and projecting these on intended behaviour through role-play, journaling, and other techniques. Another module addresses nutrition and provides information about nutrients, eating balanced meals, balancing energy input with energy output, the food pyramid, nutrient density, and serving size Intervention classes followed a 10-minute aerobic exercise routine each day during class time. The video provided a common baseline exercise routine for all intervention classes. The routine (designed and choreographed by a PE specialist) builds up in intensity to moderate to vigorous physical activity and provides a cool down period.
	Duration of intervention	10 months (1 academic year)

	Frequency of PA	5 time/week
	Duration of PA	50 min/week
	Intensity of PA	MVPA
	Type of PA	Aerobic exercise
	Parent involvement	Yes. students were required to interview family members to learn about their family health history, discuss meal and activity planning with their parents or guardians,
	Setting	School
	Who delivered the intervention	PE Teachers
	Theoretical framework	Theory of Reasoned Action
	Control	Usual school programme
	Intervention fidelity	Not reported
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; overweight or obesity prevalence (CDC)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Stephens et al. 1998
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	1 schools in the intervention group and 1 schools in the control group
	Follow-up	Only post-intervention
	Country	US
	Period	NR
Participants	Number of participants at baseline and follow-up (intervention/control)	45 individuals in the intervention group and 44 individuals in the control group at baseline and at follow-up
	Age	8-10 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity - The student body of each school was predominantly black; Socio-economic status - from low-income families.

Intervention	Description	Students in experimental group received a 15-week fitness intervention program in addition to their usual schedule of PE (45 minutes weekly). Each class received three activity sessions in the classroom per week. The fitness intervention consisted of 5 minutes of warm-up activities and stretching, followed by 20 minutes of continuous aerobic activity. These activities were selected from a standard roster, defined by the Centres for Disease Control and Prevention to include repetitive movements of large muscle groups, designed to elevate the pulse rate 40–60 beats over the resting level. The sessions concluded with a 5–10 minute cool-down period, during which the medical student teams presented educational material about nutrition, exercise, and disease prevention.
	Duration of intervention	15-weeks.
	Frequency of PA	3 times/week
	Duration of PA	90 – 115 min/week.
	Intensity of PA	Moderate; Pulse rate 40–60 beats over the resting level.
	Type of PA	Aerobic activity
	Parent involvement	No.
	Setting	School
	Who delivered the intervention	Medical students volunteers.
	Theoretical framework	Not specified.
	Control	Regular school activities
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	Low-back and hamstring flexibility (-Weber sit and reach test); % body fat (the sum of skinfolds for triceps and calf); Heart rate response to submaximal exercise (modified step test)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Toledo-Domínguez et. al. 2017
Methods and setting	Study design	CBA
	Unit of allocation	School
	Number of clusters	4 primary schools

	Follow-up	Only post-intervention
	Country	Mexico
	Period	NR
Participants	Number of participants at baseline and follow-up	545 individuals at baseline; 287 individuals in the intervention group and 215 individuals in the control group at follow-up (total 502)
	Age	8-13 years: mean age=10.2 controls and 10.5 intervention
	Sex	Both boys and girls
	Other characteristics	/
Intervention	Description	The National School Physical Activation Program (PNAFE) consisted of daily 30 min sessions of physical activity. The first physical activity session consisted of three phases (warm-up, middle phase and relaxation) at the beginning of the school day. The second session was applied after recess.
	Duration of intervention	6-months
	Frequency of PA	5 x/week
	Duration of PA	30 min/day (15 min + 15 min)
	Intensity of PA	Moderate intensity
	Type of PA	Different activities
	Parent involvement	No
	Setting	School
	Who delivered the intervention	Researchers
	Theoretical framework	Not specified
	Control	Regular school physical activity
	Intervention fidelity	Not reported
Outcomes		BMI; BMI – z-score; overweight and obesity prevalence (CDC 2000); aerobic endurance (600 m run); strength of the legs (long jump without run-up)
Adverse outcomes		NR

Authors and year		Trevinoet al. 2004
Methods and setting	Study design	Cluster RCT

	Unit of allocation	School
	Number of clusters	13 schools in the intervention group and 14 schools in the control group
	Follow-up	Only post-intervention
	Country	US
	Period	October 1, 2001, to April 26, 2002
Participants	Number of participants at baseline and follow-up (intervention/control)	969 children in the intervention group and 1024 children in the control group. 713 (74%) children in the intervention group measured at baseline and 619 (87% of baseline) were included in analysis; 706 (69%) control children measured at baseline and 602 (85% of baseline) were included in analysis.
	Age	Intervention 9.79±0.53 years; Control students 9.77±0.49 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity- Intervention- Asian 5.5%, African American 7.0%, Mexican American 82.5%, Other 5.0%; Control Asian 6.2%, African American 13.1%, Mexican American 76.7%, Other 4.0%; Socio-economic status- The annual household income averaged $11 000 for intervention schools and $12 000 for control schools. The average number of persons living in a household was 5 for intervention and control schools. Twenty-one percent of intervention schools and 18% of control schools had households with single parents. Mother's level of education was similar for both groups. For each group, 82% of mothers had a high school education or less and 18% had some college education or more. Fifty-five percent of questionnaire respondents from intervention schools and 60% from control schools reported having a fair to poor health status. Family members responding to the questionnaire reported that 55% of children from intervention schools and 60% from control schools had a first- or second-degree relative with diabetes mellitus.
Intervention	Description	The objective of the Bienestar Health Program is to provide children with 50 sessions of health programming distributed throughout 7 months. The health sessions were used to transmit to children 3 health behaviour messages shown to be associated with diabetes mellitus control (decrease dietary saturated fat intake,

		increase dietary fiber intake, and increase physical activity in children). These behaviours were taught and reinforced through classroom, home, school cafeteria, and after-school care educational activities. Bienestar health and physical education class was held 45 min/d, 5 d/wk.; 1d is health education and 4 d are physical activities
	Duration of intervention	7-months
	Frequency of PA	4x/week
	Duration of PA	180 min/week.
	Intensity of PA	Not specified.
	Type of PA	Not specified.
	Parent involvement	Yes, via bimonthly school parent meetings
	Setting	School, home.
	Who delivered the intervention	Physical education teachers, parents, school cafeteria staff, and after-school caretakers.
	Theoretical framework	Social Cognitive Theory and Social Ecological Theory and Cultural Appropriateness.
	Control	Not specified.
	Intervention fidelity	Bienestar and school staff delivered 652 sessions of Bienestar programming to the 13 elementary schools (average of 50 sessions per school): 87 school cafeteria sessions, 26 parent activities, 222 health club sessions, 118 lunch visits, and 199health and physical education classes). On average, during the 7-month intervention period, a student attended 32 Bienestar sessions
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	Physical fitness (modified Harvard step test); body fat (BIA); dietary fiber and intake and energy intake from saturated fat (24-hour dietary recall protocol)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Tucker et al. 2011
Methods and setting	Study design	CBA
	Unit of allocation	Classroom

	Number of clusters	Ninety-nine children of varying heights and weights were recruited from two elementary schools – classrooms
	Follow-up	3 months post-intervention
	Country	US
	Period	October 2008 – May 2009
Participants	Number of participants at baseline and follow-up (intervention/control)	99 individuals at baseline - 66 individuals in the intervention group and 33 in the control group at baseline; 97 individuals at follow-up
	Age	9-10 yeras
	Sex	Both boys and girls
	Other characteristics	/
Intervention	Description	All children received classroom Let's Go 5-2-1-0 Program curriculum by the public health nurse. Intervention children also received 1:1 student nurse coaching, parent evening offerings, and reinforcement incentives. In one school coaching sessions were held after school hours at the location preferred by parent, or by telephone. The total number of sessions ranged from 1-12.5 sessions (15–75 min). In another school weekly sessions (range 10-14) were held at the school during the lunch hour; 2 parent evening offerings were held during this project period.
	Duration of intervention	7-months
	Frequency of PA	/
	Duration of PA	/
	Intensity of PA	/
	Type of PA	/
	Parent involvement	Yes via parent evenings
	Setting	School and location preferred by parent, or by telephone.
	Who delivered the intervention	Nursing students
	Theoretical framework	Not specified
	Control	Received classroom delivery of the Let's Go 5-2-1-0 Program curriculum by the public health nurse.
	Intervention fidelity	

Outcomes		BMI; BMI percentile (CDC); Health habits (Healthy Habits Survey, developed by the Maine Youth Overweight Collaborative); Physical activity (StepWatchActivity Monitor)
Adverse outcomes		NR

Authors and year		Warren et al. 2003
Methods and setting	Study design	RCT
	Unit of allocation	Child
	Number of clusters	/
	Follow-up	Post-intervention
	Country	UK
	Period	2000 start of a 14-16 months intervention
Participants	Number of participants at baseline and follow-up (intervention/control)	51 individuals in the control group (Be smart) at baseline and 42 at follow-up; 56 in the intervention group (Eat smart) at baseline and 40 at follow-up; 53 individuals in the intervention (Play smart) at baseline and 45 at follow-up; 53 individuals in the intervention (Eat/Play smart) at baseline and 42 at follow-up
	Age	5-7 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity - Most of the children were of Caucasian origin (89%); Thirty-nine per cent of their parents had obtained either a degree or a postgraduate qualification
Intervention	Description	Children were randomly allocated to one of four groups: three intervention (nutrition, physical activity, combined nutrition and physical activity group) or control group. Intervention group lesson was designed to last for a 25-min. The intervention program incorporated: 1. Raising the value of the desired behaviour, including the short-term benefits, which are most likely to appeal to children competitive physical activity. 2. Providing incentives to reinforce messages, for example verbal praise and small prizes.

		3. Developing practical skills and thus self-confidence in the desired behaviour. The physical activity programme was designed to promote activity in daily life rather than the promotion of specific leisure pursuits, which would not be accessible to everyone. Using insects as a theme, the concepts of energy and activity were explored in the first term. The promotion of activity in the playground and a reduction in television viewing were specifically addressed in the second and third terms, using team games, fun physical activities and quizzes. The US recommendations for physical activity in children have been translated into an 'activity pyramid' which formed the basis of the fourth term's lessons.
	Duration of intervention	20 weeks over 14 months
	Frequency of PA	1 times/week
	Duration of PA	25 min/week
	Intensity of PA	Not specified
	Type of PA	Team games, fun physical activities.
	Parent involvement	Yes, through newsletters and homeworks
	Setting	School and home
	Who delivered the intervention	Investigators
	Theoretical framework	Social Learning Theory
	Control	Educational programme (not specified about PA)
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI; body fat - Skinfold measurements were taken at five sites (biceps, triceps, subscapular, supra-iliac and calf); Circumferences were taken at four sites (waist, hip, mid-upper arm and head) using a standard tape measure (0.1 mm intervals); nutrition knowledge (questionnaire); physical activity (parent questionnaire); Children's diets were assessed using a combination of two questionnaires completed by parents on their behalf, a 24-h recall questionnaire and a food frequency questionnaire (FFQ)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Wendel et al. 2016
Methods and setting	Study design	RCT
	Unit of allocation	24 teachers in 3 Texas schools (8 in each school) approached
	Number of clusters	/
	Follow-up	Only post-intervention
	Country	US
	Period	At the beginning of school year 2011/2012 - at the end of school year 2012/2013
Participants	Number of participants at baseline and follow-up (intervention/control)	62 students at T-T group 49 students at C-C group, 23 students at C-T group and 59 students at T-C group; the final sample size for analyses was 193
	Age	Mean 8.8 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity- The majority of participating students were White (75%); approximately 8% were Hispanic, 7% were African American, and roughly 10% were of Asian or Native American descent; 12% were overweight, and 9% were obese at baseline
Intervention	Description	Altering classroom environments from traditional to stand-biased environments. Students' regular desks were replaced with standing-desks.
	Duration of intervention (	24-months
	Frequency of PA	/
	Duration of PA	/
	Intensity of PA	/
	Type of PA	/
	Parent involvement	No.
	Setting	School.
	Who delivered the intervention	/
	Theoretical framework	Not specified.
	Control	Regular school activities.
	Intervention fidelity	Not specified.
Outcomes	State the outcome and the method of assessment	BMI percentile (CDC)

	weight related outcomes, PA, fitness, sedentary time	
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Widhalm et al. 2018
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	2 schools in the intervention group and 2 schools in the control group
	Follow-up	6 months post-intervention
	Country	Austria
	Period	NR
Participants	Number of participants at baseline and follow-up (intervention/control)	82 individuals in the intervention group and 59 individuals in the control group at baseline; Due to illness or absence at the times of measurements, not all data from the subjects were collected at all points of time. This led to small variations in the sample between the different test parameters.
	Age	11.7+-0.7 years (11-14)
	Sex	Both boys and girls
	Other characteristics	/
Intervention	Description	The intervention group received 20 h of nutritional training, five lessons about physiology and the impact of a healthy lifestyle, and 20-hour sports and exercise intervention. The pupils received a 10-hour sports and movement intervention per semester during their normal physical education lessons. The sports interventions served to stimulate the subjects to integrate movement into their everyday life through movement and coordination games. In addition, the exercises were constructed to improve the endurance and physical strength of the adolescents.
	Duration of intervention	12-months
	Frequency of PA	Not specified
	Duration of PA	20 hours/year
	Intensity of PA	Not specified

	Type of PA	Movement and coordination games (to improve the endurance and physical strength)
	Parent involvement	No
	Setting	School
	Who delivered the intervention	All interventions were conducted by experts from the EDDY study team. The lifestyle intervention was held by physicians
	Theoretical framework	Not specified
	Control	Not specified
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	% body fat (BIA); BMI (standard deviation score were calculated according to Must and Anderson); nutritional knowledge (specially designed quiz); Food preferences (Food Frequency Questionnaire for children and adolescents); Physical fitness ('Deutsche Motorik Test 6–18'); Psychological Measurements (The interdisciplinary test system 'AD-EVA')
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Williamson et al. 2007
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	2 schools in the intervention group and 2 schools in the control group
	Follow-up	18 months after the start of the intervention
	Country	USA
	Period	NR
Participants	Number of participants at baseline and follow-up (intervention/control)	670 individuals at baseline; 586 individuals at follow-up
	Age	9.2+-4.1 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity- 627 white (94.9%), 16 were black (2.4%) and 18 were classified as other ethnic group (2.7%) at baseline
Intervention	Description	Changes to school environment were made in health promotion program (add more fruits, vegetables, milk products, and grains.),

		physical activity promotion (posters were positioned to promote decreased sedentary behaviour and increased physical activity during the school day and after school), classroom health promotion (equipment to promote physical activity, pedometers for each child, jump ropes, and balls). Teachers were instructed to allow children 10 to 15 minutes of play-time for every hour of instruction
	Duration of intervention	20-months (2 academic years)
	Frequency of PA	Not specified
	Duration of PA	Not specified
	Intensity of PA	Not specified
	Type of PA	Active play (with balls, jump ropes)
	Parent involvement	Yes via newsletters and assembly meetings.
	Setting	School and home
	Who delivered the intervention	Teachers
	Theoretical framework	Not specified
	Control	Regular school activities
	Intervention fidelity	Not reported.
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time	BMI z-score (from the 2003 National Health and Nutrition Education Survey database); body fat (BIA); food selections (Digital photography); Physical Activity (The Self-Administered Physical Activity Checklist (SAPAC), a 29-item self-report, Godin-Shephard Leisure Time Physical Activity Questionnaire); Psychosocial Variables (questionnaire)
Adverse outcomes	State the outcome and the method of assessment	NR

Authors and year		Zonderland et al. 1994
Methods and setting	Study design	Cluster RCT
	Unit of allocation	School
	Number of clusters	6 schools in the intervention group and 6 schools in the control group
	Follow-up	Only post-intervention
	Country	Netherlands

	Period	NR
Participants	Number of participants at baseline and follow-up (intervention/control)	156 individuals in the intervention group and 111 individuals in the control group at baseline; 115 individuals in the intervention group and 68 individuals in the control group at follow-up
	Age	10 years
	Sex	Both boys and girls
	Other characteristics	Ethnicity- 40% girls in the intervention group were non-Caucasian and other groups about 18% non-Caucasian
Intervention	Description	The intervention consisted of 1.5 additional classes of physical education (PE) per week (one PE class = 45 minutes) and one afternoon of out-of-school sport activities every 6 weeks, all led by qualified PE teachers.
	Duration of intervention	36-months
	Frequency of PA	1,5 times/week
	Duration of PA	67,5 min/week
	Intensity of PA	Not specified
	Type of PA	Different sports (swimming, skating, korfball, basketball, little league baseball, hockey, soccer, tag games, modem dancing, exercises on mats and use of climbing apparatus, track and field (high jump, relay race, endurance, and interval training), and circuit training with aerobic, strength, and flexibility exercises)
	Parent involvement	No
	Setting	School
	Who delivered the intervention	PE teachers
	Theoretical framework	Not specified
	Control	Regular school activities (3 PE classes per week in the sixth grade and 2 in the seventh and eighth grade)
	Intervention fidelity	Not specified
Outcomes	State the outcome and the method of assessment weight related outcomes, PA, fitness, sedentary time,	% body fat (sum of 4 skinfolds)
Adverse outcomes	State the outcome and the method of assessment	NR

Appendix A4

Table S2. Risk of bias summary across individual randomised controlled studies (Cochrane "Risk of bias" assessment tool for randomised studies, Higgins et al., 2011)

Authors	random sequence generation	allocation concealment	blinding of outcome assessment	incomplete outcome data	selective outcome reporting	other sources of bias	recruitment bias	baseline imbalance between groups	loss to follow-up of clusters	adequate analysis methods for C-RCT
Adab et al. 2018	+	+	+	+	+	x	+	x	+	+
Alvirde-García et al. 2013	x	x	+	x	+	-	x	x	x	x
Anderson et al. 2016	+	+	+	+	+	x	+	+	+	+
Angelopoulos et al. 2009	+	+	+	+	+	-	+	+	+	+
Annesi et al. 2015	-	-	+	+	+	+	-	+	+	x
Annesi et al. 2016	+	-	+	+	+	-	-	+	+	+
Bacardi-Gascon et al. 2012	+	-	+	+	+	-	-	+	+	+
Barbeau et al. 2007	-	+	+	x	+	x				
Borrestad et al. 2012	+	+	+	+	+	x				
Brandstetter et al. 2012	-	+	+	+	+	x	+	+	+	+
Caballero et al. 2003	+	+	+	+	+	x	+	+	+	+
Cao et al. 2015	-	-	+	x	+	-	-	+	-	x
da Cruz et al. 2017	-	+	+	+	+	x	+	+	+	x
Donnelly et al. 2009	-	-	+	+	+	+	-	+	+	+
Drummy et al. 2016	-	-	+	+	+	-	-	+	+	x
Dzewaltowski et al. 2010	+	+	+	+	+	-	+	+	+	+
Eather et al. 2013	+	+	+	+	+	-	+	+	+	+
Fairclough et al. 2013	+	x	+	x	+	-	x	+	x	+
Farmer et al. 2017	+	x	+	+	+	+	x	+	+	+
Ford et al. 2013	+	+	-	+	+	+				
Foster et al. 2008	-	-	+	x	+	+	-	+	+	+
Foster et al. 2010	+	+	+	+	+	+	+	+	+	+
Gallota et al. 2016	x	+	+	+	+	+	+	+	+	X
Grydeland et al. 2014	+	+	+	+	+	x	+	+	+	+
Habib Mourad 2013	+	+	+	+	+	+	+	+	+	+
Have et al. 2018	+	+	+	+	+	-	+	+	+	+
Herazo-Beltran et al. 2018	-	+	+	+	+	-				
Herscovici et al. 2013	-	-	+	+	+	+	-	x	+	X
Ho et al. 2017	+	+	+	+	+	+				
Hollis et al. 2016	+	+	+	+	+	+	+	+	+	+
Jago et al. 2019	+	+	+	+	+	x	+	+	x	+
Jansen et al. 2011	+	x	+	+	+	-	x	x	+	+
Jiang et al. 2007	-	+	+	+	+	x	+	+	+	X
Kain et al. 2014	-	-	+	+	+	+	-	-	+	X
Katz et al. 2010	-	-	+	+	+	-	-	x	+	X
Kesztyus et al. 2017	-	-	+	+	+	-	-	+	+	+
Kipping et al. 2008	-	-	+	+	+	x	-	+	+	+
Laazar et al. 2007	+	-	+	+	+	+	-	+	+	X
Lau et al. 2016	-	+	+	+	+	-				

Li et al. 2010	?	+	+	+	+	?	+	+	+	+
Liu et al. 2019	+	+	+	+	+	x	+	+	+	+
Llaurado et al. 2014	x	+	+	+	+	?	+	+	+	x
Llaurado et al. 2018	x	x	+	+	+	?	x	x	+	x
Lloyd et al. 2012	+	+	+	+	+	?	+	+	+	+
Lloyd et al. 2018	+	+	+	+	+	+	+	+	+	+
Lucertini et al. 2013	x	?	?	+	+	+	+	x	+	x
Lynch et al. 2016	+	?	+	x	+	+	?	x	+	x
MacKelvie et al. 2003	+	+	+	x	+	+	+	x	x	x
Madsen et al. 2015	x	x	+	+	+	?	x	+	x	+
Magnusson et al. 2012	?	x	+	x	+	x	x	x	+	+
Martinez-Vizcaino et al. 2014	+	x	+	+	+	+	x	+	+	+
McKay et al. 2000	?	?	+	+	+	+	?	+	+	x
McMannus et al. 2008	x	x	+	+	+	+	x	+	+	x
Meinhardt et al. 2013	+	+	+	+	+	?				
Meiring et al. 2014	x	?	+	x	+	+	?	+	+	x
Meng et al. 2013	?	+	+	+	+	?	+	x	+	+
Meyer et al. 2014	+	+	+	x	+	+	+	+	+	+
Muller et al. 2019	+	?	+	x	+	x	?	+	+	+
Muros et al. 2015	x	?	+	+	+	+	?	x	+	x
Nader et al. 1999	?	+	+	+	+	+	+	+	+	+
Nogueira et al. 2017	x	+	+	+	+	+	+	+	+	x
Orntoft et al. 2016	?	+	+	+	+	?	+	+	+	x
Pablos et al. 2018	+	+	+	+	+	?	+	+	+	x
Recasens et al. 2019	?	?	+	x	+	?	?	x	+	+
Reed et al. 2008	+	+	+	+	+	+	+	+	+	+
Robinson 1999	x	?	+	+	+	+	?	+	+	+
Rosario et al. 2012	?	+	+	x	+	+	+	+	+	+
Rush et al. 2012	+	?	+	x	+	+	?	?	?	+
Sacchetti et al. 2013	?	?	+	+	+	?	?	+	+	x
Safdie et al. 2013	?	+	+	+	+	+	+	+	+	x
Salcedo Aguilar et al. 2010	+	x	+	+	+	+	x	+	+	+
Salmon et al. 2008	+	+	+	+	+	x	+	x	+	+
Santos et al. 2014	+	+	+	+	+	?	+	x	x	+
Scherr et al. 2017	+	x	+	+	+	x	x	x	+	+
Serbescu et al. 2006	?	?	+	+	+	+				
Sevinc et al. 2011	?	+	+	+	+	?	+	+	+	x
Siegrist et al. 2013	?	?	+	+	+	?	?	+	+	x
Siegrist et al. 2018	+	?	+	x	x	?	?	+	+	+
Simon et al. 2014	?	+	+	+	+	x	+	x	+	+
Skoradal et al. 2018	?	x	+	x	+	?	x	+	+	x
Spruijt-Metz et al. 2008	?	x	+	+	+	+	x	+	x	+
Story et al. 2003	?	?	+	+	+	?				
Story et al. 2012	?	+	+	?	+	x	+	+	+	+
Thivel et al. 2011	?	?	+	+	+	?	?	+	+	x
Vandongen et al. 1995	?	?	+	+	+	+	?	x	+	x
Wang et al. 2018	+	+	+	+	+	?	+	+	+	+
Waters et al. 2017	+	+	+	+	+	x	+	x	x	+
Webber et al. 2008	?	+	?	+	+	+	+	+	+	+
Williamson et al. 2012	+	+	+	+	+	+	+	+	+	+
Xu et al. 2015	+	+	+	+	+	+	+	+	+	+
Yin et al. 2012	+	x	+	+	+	x	x	+	+	+

Appendix A5

Table S3. Risk of bias summary across individual non-randomised studies (modified Newcastle-Ottawa scale, Wells et al., 2008)

Authors	representativeness of the exposed cohort	selection of the non-exposed cohort	ascertainment of exposure (fidelity)	demonstration that outcome of interest was not present at start of	comparability of cohorts	assessment of outcome	was follow-up long enough for outcomes to occur (>6m)	adequacy of follow-up of cohorts	total stars
Adab et al. 2014	★	★	★	/	★★	★	★	★	★★★★★★★★
Agurto et al. 2018		★	★	/		★		★	★★★★
Aparco et al. 2017		★		/	★	★	★	★	★★★★★
Ayala et al. 2016		★		/	★	★	★	★	★★★★★
Azevedo et al. 2014				/	★★	★	★		★★★★
Balas-Nakash et al. 2010		★		/		★			★★
Benjamin Neelon et al. 2015	★			/	★★	★	★		★★★★★
Bhave et al. 2016				/	★	★	★	★	★★★★
Breslin et al. 2012	★	★		/		★			★★★
Bumaryoum 2015		★		/	★	★		★	★★★★
Centis et al. 2012		★		/		★	★	★	★★★★
da Silva et al. 2013				/			★	★	★★
de Henauw et al. 2015		★		/	★	★	★		★★★★
de Meij et al. 2011				/	★★	★	★		★★★★
Donnelly et al. 1996		★		/		★	★		★★★
Erfle et al. 2015		★		/		★	★		★★★
Ermetici et al. 2016		★		/	★★	★	★	★	★★★★★★
Eyre et al. 2016		★		/		★			★★
Farias et al. 2009		★		/	★	★	★		★★★★
Fritz et al. 2016		★		/	★★	★	★	★	★★★★★★
Gorely et al. 2011			★	/	★		★		★★★
Graf et al. 2008	★	★		/	★★	★	★		★★★★★★
Hamelink-Baksteen et al. 2008				/		★		★	★★
Harrison et al. 2006		★	★	/	★★	★		★	★★★★★★
Hatzis et al. 2010	★			/	★★		★		★★★★
Heelan et al. 2009		★		/			★		★★
Herrick et al. 2012		★		/	★	★		★	★★★★
Hollar et al. 2010		★		/		★	★		★★★
Jordan et al. 2008		★	★	/		★	★		★★★★
Kain et al. 2004			★	/	★★	★	★	★	★★★★★★
Kain et al. 2009				/	★★	★	★		★★★★
Klakk et al. 2013		★	★	/	★	★	★	★	★★★★★★
Knox et al. 2012		★		/		★		★	★★★
Li et al. 2014		★	★	/	★	★		★	★★★★★
Liu et al. 2008		★	★	/		★	★		★★★★
Mandigout et al. 2001		★		/		★		★	★★★
Meszaros et al. 2009		★		/			★		★★
Morris et al. 2013				/	★	★	★		★★★
Neumark-Sztainer et al. 2009		★		/	★★	★	★	★	★★★★★★

Perez Solis et al. 2015				/		★	★	★	★★★
Plachta-Danielz et al. 2011	★	★		/	★★	★	★		★★★★★★
Resaland et al. 2011		★	★	/		★	★	★	★★★★★
Robbins et al. 2012		★		/	★★	★	★	★	★★★★★★
Ronsley et al. 2013		★		/		★		★	★★★
Sallis et al. 1997		★		/	★★	★	★		★★★★★
Shofan et al. 2011		★		/		★	★	★	★★★★
Sollerhed & Ejlertsson 2008		★		/	★	★	★	★	★★★★★
Stock et al. 2007		★		/	★	★	★	★	★★★★★
Taylor et al. 2008	★		★	/	★★	★	★		★★★★★★
Treu et al. 2017				/	★★	★	★		★★★★
Vilchis-Gil et al. 2016		★		/	★★	★	★	★	★★★★★★
Wadalovska et al. 2019		★		/	★	★	★		★★★★
Weber et al. 2017		★		/	★	★	★		★★★★
Whooten et al. 2018		★		/	★	★			★★★
Yang et al. 2017		★		/	★	★	★	★	★★★★★

Appendix A6

Table S4. Comparison of standardised mean differences in change in BMI and percentage body fat (%BF) and mean differences in change in BMI z-score between the intervention group and the control group according to the characteristics and the contents of interventions

Outcome	BMI		BMI z-score		%BF	
	PA+SB	Fitness+SB	PA+SB	Fitness+SB	PA+SB	Fitness+SB
PA duration						
1-120 vs. 0 min/week	0.00 (-0.22, 0.22)	/	/	/	0.06 (-2.07, 2.18)	/
>120 vs. 0 min/week	0.00 (-0.36, 0.37)	/	/	/	/	/
>120 vs. 1-120 min/week	-0.03 (-0.91, 0.85)	-3.80 (-6.42, -1.14)	-0.19 (-0.20, 0.58)	/	/	/
PA intensity						
Moderate-to-vigorous vs. Low-to-moderate	-2.90 (-6.12, 0.27)	/	-0.63 (-1.04, -0.21)	/	-0.63 (-1.04, -0.21)	/
Diet component						
Yes vs. No	-0.01 (-0.20, 0.18)	0.05 (-0.17, 0.26)	-0.00 (-0.38, 0.37)	/	-1.16 (-6.46, 4.14)	/
Parent involvement						
Yes vs. No	-0.13 (-0.32, 0.06)	0.19 (-4.45, 4.83)	-0.00 (-0.38, 0.37)	/	-0.21 (-2.19, 1.76)	/
Intervention duration						
>=9 months vs. <9 months	-0.00 (-0.13, 0.12)	0.05 (-0.17, 0.26)	-0.24 (-0.68, 0.19)	/	-0.21 (-2.19, 1.76)	/
Follow-up duration						
>=3 months vs. <3 months	-0.07 (-0.23, 0.09)	/	0.05 (-0.35, 0.45)	/	0.02 (-0.13, 0.16)	/
	PA	**Fitness**	**PA**	**Fitness**	**PA**	**Fitness**
PA duration						
1-120 vs. 0 min/week	-0.36 (-1.96, 1.21)	/	0.07 (0.01, 0.13)	/	0.10 (-9.30, 9.51)	/
>120 vs. 0 min/week	-0.34 (-1.25, 1.93)	/	0.01 (-0.07, 0.09)	/	0.04 (-9.38, 9.44)	/
>120 vs. 1-120 min/week	0.02 (-0.15, 0.11)	-0.12 (-0.21, -0.03)	-0.06 (-0.15, 0.03)	-0.08 (-0.24, 0.09)	-0.07 (-0.41, 0.27)	-0.07 (-0.53, 0.39)
PA intensity						
Moderate-to-vigorous vs. Low-to-moderate	0.03 (-0.17, 0.10)	-0.15 (-0.30, -0.00)	-0.01 (-0.06, 0.05)	-0.18 (-0.30, -0.05)	/	0.37 (-0.21, 0.95)
Diet component						
Yes vs. No	-0.00 (-0.11, 0.11)	0.00 (-0.09, 0.10)	-0.06 (-0.12, -0.01)	0.11 (-0.02, 0.24)	0.11 (-0.13, 0.35)	0.21 (-0.16, 0.57)
Parent involvement						
Yes vs. No	-0.03 (-0.15, 0.10)	0.00 (-0.08, 0.09)	-0.04 (-0.18, 0.10)	-0.04 (-0.18, 0.10)	-0.14 (-0.40, 0.13)	-0.37 (-0.71, -0.03)
Intervention duration						
>=9 months vs. <9 months	0.04 (-0.20, 0.27)	-0.08 (-0.29, 0.15)	0.06 (-0.02, 0.14)	-0.07 (-0.20, 0.06)	-0.11 (-0.34, 0.12)	-0.50 (-0.90, -0.10)
Follow-up duration						
>=3 months vs. <3 months	-0.05 (-0.16, 0.07)	0.03 (-0.06, 0.12)	0.08 (0.02, 0.13)	-0.11 (-0.38, 0.15)	-0.02 (-0.24, 0.20)	-0.21 (-0.19, 0.62)

/ = too few observations; PA=physical activity; SB=sedentary behaviour

Appendix A7

Table S5. Standardised mean differences in change in BMI and percentage body fat (%BF) and mean differences in change in BMI z-score between the intervention group and the control group in boys and girls

Outcome	BMI		BMI z-score		%BF	
	Girls	Boys	Girls	Boys	Girls	Boys
PA	-0.09 (-0.21 to 0.03)	-0.04 (-0.18 to 0.09)	-0.04 (-0.12 to 0.04)	-0.02 (-0.08 to 0.04)	-0.25 (-0.62 to 0.11)	0.00 (-0.40 to 0.40)
Fitness	-0.04 (-0.13 to 0.04)	0.00 (-0.07 to 0.07)	0.20 (-1.23 to 1.63)	-0.11 (-1.60 to 1.40)	-0.13 (-0.49 to 0.23)	-1.80 (-3.66 to 0.05)
PA + SB	-0.23 (-0.64 to 0.18)	0.61 (0.19 to 1.02)	-0.18 (-0.41 to 0.05)	0.02 (-0.06 to 0.09)	-0.43 (-0.95 to 0.08)	-0.53 (-1.43 to 0.37)
Fitness + SB	-2.39 (-6.47 to 1.70)	-0.01 (-0.09 to 0.07)	/	/	/	/

PA=physical activity; SB=sedentary behaviour

Appendix A8

Table S6. Comparison of standardised mean differences in change in BMI and percentage body fat (%BF) and mean differences in change in BMI z-score between the intervention group and the control group according to study design (RCT vs. other), study period (before vs. after 2009), risk of bias and mean age of the participants (6-9 yrs vs. 10-12 yrs)

Outcome	BMI		BMI z-score		%BF	
	PA + SB interventions	Fitness + SB interventions	PA + SB interventions	Fitness + SB interventions	PA + SB interventions	Fitness + SB interventions
Study design (RCT vs. other designs)	-0.05 (-0.19, 0.10)	0.05 (-0.17, 0.26)	0.05 (-0.03, 0.13)	/	-0.21 (-0.99, 0.58)	/
Study period (Before 2009 vs. after 2009)	-0.08 (-0.22, 0.05)	0.02 (-0.16, 0.20)	-0.06 (-0.13, 0.01)	/	-0.01 (-0.16, 0.14)	/
Risk of bias (Low risk vs. moderate&high risk)	-0.03 (-0.15, 0.10)	-0.03 (-0.27, 0.22)	0.04 (-0.02, 0.10)	/	0.02 (-0.12, 0.17)	/
Age (6-9 yrs vs. 10-12 yrs)	0.01 (-0.13, 0.14)	0.05 (-0.17, 0.26)	0.01 (-0.06, 0.07)	/	0.29 (-0.52, 1.11)	/
	PA	Fitness	PA	Fitness	PA	Fitness
Study design (RCT vs. other designs)	0.15 (0.01, 0.30)	0.00 (-0.08, 0.08)	-0.13 (-0.18, -0.09)	-0.06 (-0.20, 0.08)	-0.05 (-0.30, 0.19)	0.10 (-0.27, 0.48)
Study period (Before 2009 vs. after 2009)	0.04 (-0.08, 0.17)	-0.05 (-0.17, 0.06)	-0.08 (-0.13, -0.02)	-0.08 (-0.26, 0.09)	-0.05 (-0.30, 0.19)	0.10 (-0.27, 0.48)
Risk of bias (Low risk vs. moderate&high risk)	-0.03 (-0.17, 0.10)	-0.03 (-0.12, 0.06)	0.16 (0.12, 0.20)	0.22 (0.05, 0.39)	-0.12 (-0.35, 0.10)	-0.28 (-0.59, 0.02)
Age (6-9 yrs vs. 10-12 yrs)	0.05 (-0.13, 0.22)	-0.26 (-0.52, -0.01)	-0.02 (-0.13, 0.09)	-0.04 (-1.06, 0.98)	-0.02 (-0.26, 0.22)	1.47 (-1.75, 4.70)

/ = too few observations; PA=physical activity; SB=sedentary behaviour

APPENDIX B

SUPPORTING INFORMATION FOR PUBLICATION 2

Appendix B1

Table S1: Characteristics of girls from the intervention group who continued or discontinued their participation in individual year of intervention.

Participation	Age	Height percentile	BMI percentile	Triceps skinfold percentile	School-level obesity
Discontinued after year 1	10.56 (2.38)**	53.16 (29.01)	52.64 (29.49)	55.69 (28.35)	7.30 (2.86)**
Continued after year 1	9.42 (1.91)**	53.94 (28.64)	53.28 (29.20)	55.76 (28.28)	7.98 (3.30)**
Discontinued after year 2	10.81 (2.10)**	53.52 (28.87)*	53.66 (29.44)	55.64 (28.90)	7.68 (3.14)**
Continued after year 2	10.09 (1.65)**	55.44 (28.29)*	53.40 (29.17)	56.23 (28.88)	8.25 (3.41)**
Discontinued after year 3	11.38 (1.78)**	55.87 (28.49)	53.25 (29.44)	56.09 (28.69)	8.06 (3.25)**
Continued after year 3	10.77 (1.43)**	55.64 (27.83)	53.16 (29.52)	55.52 (28.36)	8.46 (3.55)**
Discontinued after year 4	12.03 (1.61)**	57.19 (27.87)	52.62 (29.82)	54.38 (29.51)	8.36 (3.44)
Continued after year 4	11.51 (1.17)**	55.08 (27.86)	53.16 (29.53)	55.98 (28.65)	8.55 (3.66)
Discontinued after year 5	12.79 (1.30)**	54.79 (28.35)	55.04 (29.05)	56.86 (28.67)	8.21 (3.44)*
Continued after year 5	12.25 (0.96)**	55.70 (27.92)	52.57 (30.00)	57.42 (28.14)	8.89 (3.84)*

Values presented are mean (SD); School-level obesity - baseline obesity prevalence in individual school in %; *significant difference between groups, $p < .05$; ** significant difference between groups, $p < .005$

Appendix B2

Table S2: Characteristics of boys from the intervention group who continued or discontinued their participation in individual year of intervention.

Participation	Age	Height percentile	BMI percentile	Triceps skinfold percentile	School-level obesity
Discontinued after year 1	10.67 (2.44)**	54.41 (28.59)	52.81 (29.71)	55.18 (28.53)	7.25 (2.87)**
Continued after year 1	9.66 (1.99)**	54.13 (28.37)	53.38 (29.42)	55.32 (28.39)	7.99 (3.27)**
Discontinued after year 2	11.22 (2.18)**	55.22 (28.00)	54.56 (29.59)	55.73 (28.53)	7.70 (3.20)**
Continued after year 2	10.26 (1.73)**	55.16 (28.48)	53.41 (29.50)	55.44 (28.88)	8.20 (3.31)**
Discontinued after year 3	11.65 (1.92)**	56.28 (28.43)*	53.84 (29.53)	55.30 (28.97)	7.97 (3.18)**
Continued after year 3	10.92 (1.47)**	54.68 (28.60)*	53.48 (29.33)	55.69 (28.39)	8.39 (3.41)**
Discontinued after year 4	12.24 (1.68)**	55.53 (28.65)	51.70 (29.94)	53.53 (28.48)*	8.33 (3.30)
Continued after year 4	11.65 (1.21)**	55.84 (28.39)	52.65 (29.66)	55.77 (29.16)*	8.45 (3.50)
Discontinued after year 5	13.02 (1.32)**	56.55 (27.48)	52.72 (28.83)	54.11 (30.12)	8.24 (3.47)*
Continued after year 5	12.28 (0.96)**	56.54 (28.67)	53.08 (30.12)	55.79 (29.65)	8.65 (3.52)*

Values presented are mean (SD); School-level obesity - baseline obesity prevalence in individual school in %; *significant difference between groups, $p < .05$; ** significant difference between groups, $p < .005$

APPENDIX C

CANDIDATE'S BACKGROUND

Petra Jurić was born on 23 April 1995 in Zagreb, the capital of Croatia. At an early age, she was oriented toward sport and physical activity. When she was 3 years old, she started artistic gymnastics, and at the age of seven, swimming and figure skating. She focused exclusively on figure skating from the age of 10. She was a 2007 novice national champion and 2008, 2009, 2010 junior national champion. She placed third at 2011 and 2012 senior national championships and second at 2013 senior national championships. She was the 2009 and 2010 European criterium champion in her age category and placed second at the same competition in the 2011 junior category. She was a Croatian representative at the 2011 and 2013 Golden spin, ISU competition of „A" category. Further, she represented Croatia at the European Youth Olympic Winter Festival in 2011 in Liberec, Czech Republic. She was a member of the Development Program from the Croatian Olympic Committee for „A" users and a member of the Program for Supporting Athletes from younger age categories, also from the Croatian Olympic Committee. She represented Croatia at the 2011 ISU Junior Grand Prix in Innsbruck, Austria.

Professional scientific development

She currently works as an assistant at the Center for Scientific Research, Physical Activity Measurement and Surveillance Laboratory, Faculty of Kinesiology, University of Zagreb, for the Horizon 2020 Project *Science and Technology in Childhood Obesity Policy - 'STOP*'. She is also an associate at the physical activity and health course, Faculty of Kinesiology, University of Zagreb. She spent one full academic year at Macquarie University, Sydney, Australia as part of her doctoral research which was conducted under the cotutelle program agreed between University of Zagreb and Macquarie University. During her doctoral research, she was a casual research assistant at Deakin University's School of Exercise and Nutrition Sciences, Melbourne, Australia. She has a Master of Kinesiology in Education and Kinesiotherapy attained at the Faculty of Kinesiology, University of Zagreb. She is a DE-PASS member which focuses on identifying, understanding, and measuring the determinants that promote, maintain, or inhibit physical activity behaviours across the lifespan and in different settings and translating this knowledge to assist policymakers to achieve greater health impact. She is also a member of The European Network for the Support of Development of Systems for Monitoring Physical Fitness of Children and Adolescents (FitBack).

Publications

1. **Jurić P**, Dudley DA, Petocz P. Does incorporating high intensity interval training in physical education classes improve fitness outcomes of students? A cluster randomized controlled trial. Prev Med Rep. 2023 Feb 4;32:102127. doi: 10.1016/j.pmedr.2023.102127. PMID: 36816767; PMCID: PMC9932703.
2. **Jurić P**, Jurak G, Morrison SA, Starc G, Sorić M. Effectiveness of a population-scaled, school-based physical activity intervention for the prevention of childhood obesity. Obesity (Silver Spring). 2023 Mar;31(3):811-822. doi: 10.1002/oby.23695. PMID: 36811242.
3. **Jurić P**, Karuc J, Martinko A, Mišigoj-Duraković M, Sorić M. Does time of the day matter? Temporal associations between physical activity and quality and quantity of subsequent sleep in adolescents. Sleep Med. 2022 Apr;92:41-49. doi: 10.1016/j.sleep.2022.02.020. Epub 2022 Mar 7. PMID: 35325768.
4. Podnar H, **Jurić P**, Karuc J, Saez M, Barceló MA, Radman I, Starc G, Jurak G, Đurić S, Potočnik ŽL, Sorić M. Comparative effectiveness of school-based interventions targeting physical activity, physical fitness or sedentary behaviour on obesity prevention in 6- to 12-year-old children: A systematic review and meta-analysis. Obes Rev. 2021 Feb;22(2):e13160. doi: 10.1111/obr.13160. PMID: 33462934.
5. Martinko A, Karuc J, **Jurić P**, Podnar H, Sorić M. Accuracy and Precision of Consumer-Grade Wearable Activity Monitors for Assessing Time Spent in Sedentary Behavior in Children and Adolescents: Systematic Review. JMIR Mhealth Uhealth. 2022 Aug 9;10(8):e37547. doi: 10.2196/37547. PMID: 35943763; PMCID: PMC9399884.
6. Khudair M, Marcuzzi A, Ng K, Tempest GD, Bartoš F, Peric R, Maier M, Beccia F, Boccia S, Brandes M, Cardon G, Carlin A, Castagna C, Chaabene H, Chalkley A, Ciaccioni S, Cieślińska-Świder J, Čingienė V, Cortis C, Corvino C, de Geus EJ, Di Baldassarre A, Di Credico A, Drid P, Fernández Tarazaga RM, Gallè F, García Sánchez E, Gebremariam M, Ghinassi B, Goudas M, Hayes G, Honorio S, Izzicupo P, Jahre H, Jelsma J, **Juric P**, Kolovelonis A, Kongsvold A, Kouidi E, Mansergh F, Masanovic B, Mekonnen T, Mork PJ, Murphy M, O'Hara K, Torun AO, Palumbo F, Popovic S, Prieske O, Puharic Z, Ribeiro JC, Rumbold PLS, Sandu P, Sorić M, Stavnsbo M, Syrmpas I, van der Ploeg HP, Van Hoye A, Vilela S, Woods C, Wunsch K, Caprinica L, MacDonncha C, Ling FCM; DE-PASS. DE-PASS Best Evidence Statement (BESt): modifiable determinants of physical activity and sedentary behaviour in children and adolescents aged 5-19 years-a protocol for systematic

review and meta-analysis. BMJ Open. 2022 Sep 20;12(9):e059202. doi: 10.1136/bmjopen-2021-059202. PMID: 36127107; PMCID: PMC9490573.

Conferences and congresses

5. 2ND ASIA-PACIFIC SOCIETY FOR PHYSICAL ACTIVITY (ASPA) CONFERENCE, Melbourne, Australia, November 28-29th 2022.
   Winner of the Oral Presentation Award – *Does high intensity interval training within physical education improve health-related fitness and adiposity?*
6. 36TH WORLD CONGRESS OF SPORTS MEDICINE, Athens, Greece, September 23-26, 2021.
   Presentation - *Association of evening physical activity with quality and quantity of sleep in adolescents: moderating effect of sport participation*
7. 9th INTERNATIONAL SCIENTIFIC CONFERENCE ON KINESIOLOGY, Opatija, Croatia, September 12-19, 2021.
   Presentation - *Associations of sleep quality with cardiovascular disease risk factors in adolescents*
8. Croatian Longitudinal Study of Physical Activity in Adolescents – Symposium Faculty of Kinesiology, University of Zagreb, November 20, 2020.
   Presentation - *Associations between sleep, physical activity and weight status in adolescents*
9. 12th INTERNATIONAL CONFERENCE ON KINANTHROPOLOGY "Sport and Quality of Life", Brno, Czech Republic, November 7-9, 2019.
   Presentation - *Associations between performing time of physical activity during the day with quantity and quality of sleep in adolescents*
10. 30th FIEP WORLD CONGRESS and the 14th EUROPEAN CONGRESS (Federation Internationale D'education Phisique), FIEP 2019, Barcelona, Spain, June 27-29, 2019.
    Presentation - *Associations between sleep, physical activity and weight status in adolescents* at the

Prizes and Awards (Faculty of Kinesiology, University of Zagreb)

1. 2015 DEAN'S AWARD for the best 1st year student of the integrated undergraduate and graduate university study.
2. 2016 DEAN'S AWARD for the best 2nd year student of the integrated undergraduate and graduate university study.

3. 2017 DEAN'S AWARD for the best 3rd year student of the integrated undergraduate and graduate university study.
4. 2018 DEAN'S AWARD for the best 4th year student of the integrated undergraduate and graduate university study.
5. DEAN'S AWARD for the Best Graduate Student in 2019.
6. RECOGNITION for demonstrating excellence in modules Kinesiology in education at the 28th Summer School of Kinesiologists, Zadar 2019.
7. ORAL PRESENTATION AWARD at the ASPA 2022 Conference

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APPENDIX D

SUPERVISOR INFORMATION

Associate Professor Maroje Sorić, PhD

Maroje Sorić was born in 1979 in Zagreb (Croatia). He currently serves as an Associate Professor in Physical Activity and Health, and the Head of the Physical Activity Measurement and Surveillance Laboratory at the University of Zagreb, the Faculty of Kinesiology. At the same time, he acts as a Research Associate at the University of Ljubljana as a member of the SLOfit research group where he participates in monitoring and evaluating fitness of school-children. He qualified as a medical doctor at the Zagreb School of Medicine (Croatia) in 2003 and earned his PhD in Biomedicine at the same institution in 2010. His main scientific interests relate to the objective measurement of physical activity, sleep and physical fitness and the relationships of physical activity and inactivity with health and disease. Dr. Sorić's work is highly focused on school children and adolescents. His global perspective is reflected in his work in the NCD Risk Factor Collaboration (NCD-RisC), a global network of health scientists funded by the Wellcome Trust that provides rigorous and timely data on major risk factors for noncommunicable diseases for all of the world's countries. From 2016 when he became one of the central members of the NCD-RisC, he has been monitoring global prevalence and trends in obesity and high blood pressure in both adults and children. As one of the central members of the NCD-RisC, he was invited to a small group of authors of several articles published in the world's most prestigious journals. Among them, 3 papers stand out: an article published in the journal Nature that refutes the common paradigm that urbanization is the main driver of the current obesity epidemic, and two articles in the Lancet: one on global height and BMI trends in children between 1985 and 2019, and the other on global blood pressure trends over the last 40 years. He published more than 50 scientific papers in journals indexed in the Web of Science, one university textbook and authored chapters in two additional university textbooks. while his work received >8000 citations to date. He ranked among top 2% World's most influential scientist for 2021 according to the Stanford-Elsevier list. During his career dr. Sorić has participated in numerous large-scale scientific projects relating to the field of physical activity and health, including two projects funded under Horizon2020 scheme and several projects funded by the European Commission under other programmes. He was an invited speaker on several international scientific meetings, including the 16th World Congress of Public Health, and an active participant in more than 30 national and international scientific meetings. He serves as an evaluator for the Marie Skłodowska-Curie Actions, the European Union's flagship

funding programme for doctoral education and postdoctoral training of researchers. He has also acted as a reviewer in numerous international scientific journals. In 2020 he received a reward under “Ten best research achievements in 2020” programme from the University of Ljubljana. In 2007-2010 he formed a part of an expert panel formed by the Government of the Republic of Croatia that conceived the ‘National action plan for the prevention of obesity 2010-2012’. In his free time, dr. Sorić balances his passion for exquisite food and wine, with an active lifestyle through running, swimming and active transportation, in order to maintain his sports career as a competitive volleyball player in OK Sheeft (Zagreb, Croatia).

Associate Professor Dean Alan Dudley, PhD

Dean Dudley holds the position of Associate Professor (Health and Physical Education) in the Macquarie School of Education at Macquarie University. He is also an honorary associate professor in the School of Human Movement and Nutrition Sciences at the University of Queensland and in the Center of Educational Measurement and Assessment at the University of Sydney.

Dr Dudley is a 2012 Churchill Fellow and was an expert consultant for the United Nations Educational, Scientific, and Cultural Organization’s Quality Physical Education Guidelines for Policy Makers (2015) and the Kazan Action Plan ratified at MINEPS VI in 2017. In 2018, Dr Dudley was appointed as an independent specialist in health and physical education by UNESCO's International Bureau of Education.

Dr. Dudley has held numerous funded grants, totalling more than $3M in research grants and contracts as a principal investigator. He been an author in more than 80 peer-reviewed publications since 2010. Dr. Dudley has a multidisciplinary program of research but he is broadly interested in the association between health and education, with a specific interest in the role that learning plays in the health and quality of life of children. Internationally, he is recognised for his work in physical education, learning assessment, pedagogy, and physical literacy.