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The Impact of Typical School Provision of Physical Education, Physical Activity and Sports on Adolescent Physical Health: A Systematic Literature Review and Meta-Analysis

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Abstract

Typical school provision of physical education, physical activity and sports may impact adolescent physical health. However, systematic literature reviews and meta-analysis have not yet considered this impact. The Web of Science, SPORTDiscus, PsychINFO, ERIC and MEDLINE databases were searched for relevant literature (2000–2023) pertaining to adolescents aged 12–18 years in secondary schools. Twenty-nine studies met the inclusion criteria, including twenty-three interventions, four cross-sectional and two longitudinal studies. Included studies contributed 268 reported effects on indicators of adolescent obesity, physical fitness, blood pressure and bone health. Fifteen studies were included in the meta-analysis and reported significantly positive effects on indicators of adiposity in experimental groups with minor modifications to typical school provision ($g = -0.11$ [95% CI $-0.22, -0.01$], $p < 0.04$, $I^2 = 32.49\%$), in boys and girls. Subgroup analysis found significantly positive effects for body fat percentage ($g = -0.28$ [95% CI $-0.49, -0.06$], $p < 0.01$). Robust examples of best practice in schools include extended days dedicated to physical education weekly (≥ 4 days), integration of theoretical components to physical education, sports field/gymnasium availability and a range of training modalities. Studies without the integration of a minor modification to typical school provision were deemed to have a limited impact on adolescent physical health. Further research that examines the additive impact of school physical activity and sports to supplement physical education is warranted.

Keywords Physical education · Physical activity · Sport · Adolescence · Youth · School · Health

Introduction

The World Health Organization's (2020) physical activity guidelines advocate for an average of sixty minutes per day of moderate to vigorous physical activity, mostly aerobic, physical activity, across a week, for adolescent populations. However, the prevalence of physical inactivity is worsening with just one in five adolescents meeting these guidelines (Guthold et al., 2020; World Health Organization, 2022a). Furthermore, physical inactivity is considered a leading risk factor for obesity, non-communicable diseases and mental health disorders in adolescent populations that can lead to further complications in adulthood (Chiyanika et al., 2020; Schlack et al., 2021). Physical activity habits in adolescents are cited as powerful predictors of future physical activity patterns that track into adulthood and impact future health (Rollo et al., 2020; Telama et al., 2005). The global health

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cost of physical inactivity is estimated to reach in excess of $300 billion by 2030 (World Health Organization, 2022a). It has been emphasized by leading health enhancing organizations that physical activity promotion strategies are necessary to increase adolescent physical activity for health and reduce the cost of healthcare globally (Department of Health, 2016; ISPAH, 2020; World Health Organization, 2022a). This study addresses this research gap by systematically reviewing the literature that examines typical school provision of physical education, physical activity and sports as a strategy to impact adolescent physical health outcomes.

In recent years, international policymakers have increasingly recognized schools as institutions that offer the most effective means of promoting health among adolescents via physical activity opportunities such as the provision of physical education, physical activity and sports (Kriemler et al., 2011; Love et al., 2019; Morton et al., 2016; Sevil et al., 2019; World Health Organization, 2022b). A total of 90% of global adolescents are enrolled in secondary schools (World Health Organization, 2018). Therefore, a health promoting school, that "constantly strengthens its capacity as a healthy setting for living, learning and working" should not be undervalued (World Health Organization, 2022b, p. 1). An effective health promoting school, that impacts adolescents' health promoting behaviors (i.e., attitude, knowledge, values) and creates conditions that are conducive for health, can be considered "the most cost-effective investment a nation can make" to enhance adolescent health outcomes that track into adulthood and reduce the economic burden of ill health (World Health, 2018, p. 17). Additionally, it is estimated that four in five adolescents' primary source of physical activity is acquired within the school setting (Ding et al., 2016). Furthermore, adolescents who are not exposed to physical education, physical activity and sports in school are unlikely to be physically active through adulthood and thus, are more susceptible to health complications during this phase of life (Aljuhani & Sandercock, 2019; Comte et al., 2015; Dohle et al., 2013).

International policy now recognizes schools as primary vehicles to instill values of healthy living. The World Health Organization's (2018) global action plan advocates for a systems-based approach to promote physical activity for health with the concept of a health enhancing school considered a key pillar for success. The International Society for Physical Activity and Health's (ISPAH, 2020) eight investments that work for physical activity advocate for a whole school approach that weaves multiple opportunities for physical activity into the school day via the provision of physical education, physical activity and sports. In addition, over three quarters of schools worldwide now endorse physical education as a primary requirement (Hardman et al., 2014; SHAPE America, 2016). In the context of the current study, physical education is considered "teaching students a structured curriculum to help them acquire the skills, knowledge and disposition necessary to become "wise consumers" of physical activity" for health (Johnson & Turner, 2016, p. 3; Morton et al., 2016). In the context of the current study school sports are characterized by the preparation for or participation in competition, while school physical activity encompasses "any bodily movement produced by skeletal muscle that results in energy expenditure" that is not physical education or sports within the school setting e.g., active classroom breaks, recess or active transport to school (Casperson et al., 1985, p. 126). Global research in this field, indicates a paucity of empirical evidence that investigates the additive impact of typical school provision of physical education, physical activity and sports, rather empirical evidence to this point has investigated each exposure in isolation (ISPAH, 2020).

Although a significant body of evidence indicates the preventability of obesity in adolescents, over 340 million worldwide are considered overweight or obese (Chiyanika et al., 2020). Physical activity is considered a key enabler of physical health indicators such as obesity and health related fitness (Ruiz et al., 2009). Thus, worldwide investment in school physical education, physical activity and sports is substantial. In Europe, between 2014 and 2020, a total of €265 million was made available by the European Union Erasmus + program to boost employability, skill development and the provision of physical education, physical activity and sports in academic institutions such as secondary schools (European Parliament, 2016). In the United Kingdom, the national parliament announced that revenue yielded from the soft drinks industry would be utilized to "provide up to £285 million a year to give….increased opportunity to extend the school day to offer a wider range of activities for pupils, including more sport" (Barber & Sutherland, 2017, p. 6). In the USA, the provision of high-quality physical education, physical activity and sports is underpinned by national federal funding (Kohl & Cook, 2013) and in Australia the Department of Health's "Building the Education Revolution Initiative" has seen in excess of $16 billion invested into state-of-the-art educational facilities to support integral components of school life such as physical education, physical activity, and sports (Australian Department of Health, 2021).

Despite common consensus among international experts in the field, policy makers and government officials regarding the inherent value of schools in today's society, a gap in the literature exists that synthesizes the impact of typical school provision of physical education, physical activity and sports on adolescent physical health outcomes. Considering the worldwide adoption of policy and significant infusion of investment to enhance typical school provision of physical education, physical activity and sports for health, a review that evaluates its impact is required.

Current Study

Typical school physical education, physical activity and sports may have a considerable impact on the physical health of adolescents. In the context of the current study, "typical" refers to what occurs in the majority of schools with no significant departure from the norm and "provision" refers to the underpinning structures and activities involved in providing the physical education curriculum, and opportunities for physical activity and sports participation for adolescents in secondary schools. The extent and nature of the provision reflects the response to the national or state curricula, resource base and ethos of schools. Some evidence regarding the specific nature of typical school provision exists, however, no systematic literature review and meta-analysis of this evidence has been completed to date. Therefore, the current study addressed four research questions. How is typical school provision of physical education, physical activity and sports related to adolescent physical health (Research Question 1)? Is typical school provision of physical education, physical activity and sports impactful on adolescent physical health (Research Question 2)? Are there robust examples of best practices in schools to potentiate positive impact on adolescent physical health (Research Question 3)? Does typical school provision of physical education, physical activity and sports have a greater impact on girls or boys' physical health (Research question 4)? Accordingly, this systematic literature review and meta-analysis will apply both a narrative synthesis and meta-analytical lens on the current body of evidence looking at typical school provision of physical education, physical activity and sports, summarizing the key characteristics that appear to be the most pertinent to impacting adolescent physical health.

Methods

Reporting in this review was underpinned by the Preferred Reporting Items for Systematic Reviews and Meta-analyses (Page et al., 2021). The review was registered with the International Prospective Register of Systematic Reviews on July 17th, 2021 (ID number CRD42021197447) (Booth et al., 2012).

Study Eligibility Criteria

Eligible studies included (1) male and/or female participants with a mean age of between 12 and 18 years up to one standard deviation (SD) point (i.e., 68% of the population were required to be aged 12–18 years). If one SD was below 12 or above 18 years, a breakdown for the specific target population was required in the results section, (2) "typical" school provision of physical education, physical activity and sports as an exposure (see earlier definition) (studies that only defined/measured school physical activity and/or sports but not physical education were excluded), (3) objective measures of physical health and (4) one or more of the following outcome variables; indicators of adiposity, defined as "abnormal or excessive fat accumulation which may impair health" (Jenatabadi et al., 2021, p. 1) (i.e., body mass index, obesity, weight, body fat percentage, lean mass and skinfold thickness, note; an indicator of adiposity is considered a primary outcome in this study, therefore, studies that did not include an indicator of adiposity were excluded), indicators of physical fitness (i.e., flexibility, musculoskeletal fitness, cardiovascular fitness and speed/agility), blood pressure (i.e., systolic and diastolic blood pressure) and bone health (e.g., mineral density). Articles needed to be peer reviewed and published in English, between 2000 and 2023. Systematic literature reviews and meta-analysis were excluded. In intervention studies, the control and/or experimental group pre and post baseline results were utilized (provided they had not received an intervention that caused significant or deliberate change to usual practice). Articles that reported on studies including minor modifications to typical school provision of physical education, physical activity and sports were included e.g., additional time, emphasis on physical activity intensity or teacher support workshops. The setting for the physical education, physical activity and sports exposure had to be in secondary schools (i.e., post primary, high school), within school time and extended pre and post school physical activity and sports opportunities. The setting for the outcome measures was in and/or outside secondary schools.

Sources, Search Strategies and Selection Processes

A systematic search of five electronic databases was performed in July 2021: MEDLINE, PsychINFO, ERIC, SPORTDiscus and Web of Science. Search strategies were completed in collaboration with a university library technician from inception to December 2021. Keyword search terms included: "school", "provision", "physical education", "physical activity", "sport", "adolescents", "obesity", "blood pressure", "bone health", "physical fitness", "cardiovascular fitness", "aerobic capacity", "body mass index", "cardiovascular disease risk factors" and "coronary heart disease risk factors". A comprehensive copy of the search strategy is provided (Appendix B). Articles were imported to Rayyan Intelligent Systematic Review online platform where they were stored and curated throughout the screening process (Ouzzani et al., 2016). Duplicates were removed. Screening of titles and abstracts were independently assessed for eligibility by two review authors (PR, AB). Subsequently, full text articles were assessed for eligibility by two review authors (PR, AB). A 10% inter reviewer reliability was incorporated into stage 1 and stage 2 of the screening process which established agreement among reviewers. Disagreements were resolved by consensus. A supplementary search was conducted in May 2023 via (1) database updates (2) screening reference lists of eligible articles (3) contacting leading experts in the field.

Quality Assessment and Data Extraction

The tool used to assess the quality of the included articles was the Downs and Black checklist (Downs & Black, 1998). The Downs and Black checklist has been shown to be a valid, reliable tool for assessing experimental and non-experimental quantitative study designs in the physical health field (Eime et al., 2013; Nugent et al., 2021). The modified checklist included 22 items that were categorized into 5 subscales: reporting (10), external validity (1), internal validity—bias (4), internal validity—confounding (6) and power (1). Items were scored as 1 (compliance) or 0 (non-compliance). Study quality was assessed out of a total of 23 points (distribution of principal confounders were awarded 2 points). Aligning with the methodology outlined by Woods et al., (2021, p. 4) we "calculated the total percentage of criteria met per study based on the criteria applicable to the type of study design." Criteria that were not applicable were scored NA. Articles were assessed independently by two review authors (PR, EM) via Covidence software and disagreements were resolved through consensus.

Data were extracted through the use of a customized data extraction table via Covidence, by two review authors (PR, EM). A 10% inter reviewer reliability check was incorporated which established agreement among reviewers. Disagreements were resolved through consensus. The data extraction table included study descriptives, population demographics and data that reported the relationship between the exposure and outcome. Authors of articles were contacted to obtain omitted details where necessary.

Data Synthesis

Outcome data was tabulated to determine the impact of typical school provision of physical education, physical activity and sports on 4 parameters: indicators of adiposity, indicators of physical fitness, blood pressure and bone health. A detailed description of each outcome is provided in Table 1. The potential effects of typical school provision of physical education, physical activity and sports on each outcome investigated was established by two independent reviewers (PR, MA) using the method described by Panter et al. (2019). The main reported effects were assessed and coded for all specified outcomes within each article, based on four levels of effects; significantly positive; significantly negative; inconclusive/no effect or no significance test. Many articles tested a multitude of outcomes therefore, the overall evidence of effectiveness was expressed as a percentage of the four effects within each article (i.e., significantly positive; significantly negative; inconclusive/no effect or no significance test). An article was deemed significantly positive when 50% or more of the reported effects were significant and in positive direction, significantly negative when 50% or more of the reported effects were significant and in a negative direction and inconclusive/no effect when 50% of more of the reported effects were non-significant or when results were mixed (both positive and negative). An article was deemed to have no significance test when the reported effects were not supported with a test of significance. Where no test of significance was applied the direction of the effect was required i.e., positive/negative direction.

Statistical Analysis

A separate meta-analysis of (a) control groups and (b) experimental groups in intervention studies was conducted by two review authors (MATS, LGG) to analyze the effects of typical school provision of physical education, physical activity and sports on indicators of adiposity (i.e., body mass index (BMI) and body fat percentage). When the data reported

Table 1 Descriptions of the health outcomes synthesized in this review

Outcomes	Description
Adiposity	Abnormal or excessive fat accumulation which may impair health (Jenatabadi et al., 2021, p. 1). For the purpose of the current study, indicators of adiposity included body mass index, obesity, weight, body fat percentage, lean mass and skinfold thickness
Physical fitness	"Multifaceted construct integrating a wide set of bodily functions including morphological, muscular, motor, cardiorespiratory, and metabolic." For the purpose of the current indicators of physical fitness included cardiovascular fitness, musculoskeletal fitness, flexibility and speed/agility (O' Keeffe et al., 2020, p. 48)
Blood pressure	Pressure exerted by the circulating blood around the body against the walls of the blood vessels e.g., arteries
Bone health	The overall strength and wellbeing of the skeletal system including bones, joints and connective tissues

in the articles were insufficient, the corresponding authors were contacted for additional information. The remaining variables (i.e., indicators of physical fitness, blood pressure, and bone health) could not be meta-analyzed because a) the number of included studies was low due to heterogeneity in the measurement processes b) the required data could not be obtained or (c) the variables did not pertain to intervention studies (Appendix C). All analyses were performed using STATA software (v17; Stata Corp, College Station, TX, USA).

Effect sizes were analyzed using the DerSimonian-Laird inverse random-effects variance model because heterogeneity between studies was expected. Effect sizes for the control and experimental groups were obtained by calculating the standard mean differences between the post-test and baseline measures (Cooper, 2019). The control groups referred to typical school provision of physical education, physical activity and sports while the experimental groups referred to minor modifications of typical school provision. If an article had one or more experimental groups, its data were included in the meta-analysis of the experimental group. Hedges' g of effect size was used to represent the standard mean difference between the post-test and baseline means for the control group and the intervention group separately. According to Cooper (2019), effect sizes for Hedges' g are classified as $g \leq 0.5$ small, $0.5 < g \leq 0.8$ medium, $g \geq 0.8$ large. For the indicators of adiposity, positive effect sizes indicated higher adiposity after the intervention, while a negative effect size indicated lower adiposity after the intervention. Two subgroup analyses were performed to investigate whether heterogeneity could be explained by the adiposity variable used (i.e., BMI and body fat percentage).

A sensitivity analysis was also performed by eliminating studies one by one to assess the robustness of the summary estimates. This indicated whether an individual article accounted for a substantial proportion of the heterogeneity. Study heterogeneity was then assessed using Cochran's Q test (with alpha set at $p < 0.01$) and the I^2 statistic. The magnitude of heterogeneity was considered low if $I^2 < 50\%$, moderate if $I^2 = 50\%$—75%, and large if $I^2 > 75\%$ (Higgins & Green, 2011). If τ^2 was below 1 (Higgins & Thompson, 2002), it suggested that there was not substantial heterogeneity between studies. Publication bias was checked by visual inspection of the Funnel Plot on the outcome measures (an asymmetrical, rather than symmetrical, inverted funnel shape indicated publication bias). In addition, the asymmetry of the funnel plot was statistically assessed using Egger's (Higgins et al., 2011) linear regression test to quantify the bias captured by the funnel plot and to check whether it was significant ($p < 0.05$). Random effects meta-regression was performed to assess the relationship between gender and effect size on indicators of adiposity for the control and experimental groups separately.

Results

Article Identification

The search strategy yielded 10,493 peer reviewed articles (Web of Science = 5,137; SPORTDiscus = 1,817; PsychINFO = 886; ERIC = 781; MEDLINE = 1,872). A total of 6,928 articles remained after removing duplicates. Upon completing stage 1 screening of title and abstracts, 483 articles remained for full text review. Upon completion of stage 2 screening of full text articles, 21 articles were included for analysis. The most common reasons for excluding articles at stage 2 screening were non-targeted outcomes (n = 181), and population (n = 127). A supplementary search of the literature yielded an additional eight articles. Fifteen articles were included for quantitative synthesis. See Fig. 1 for the study flowchart.

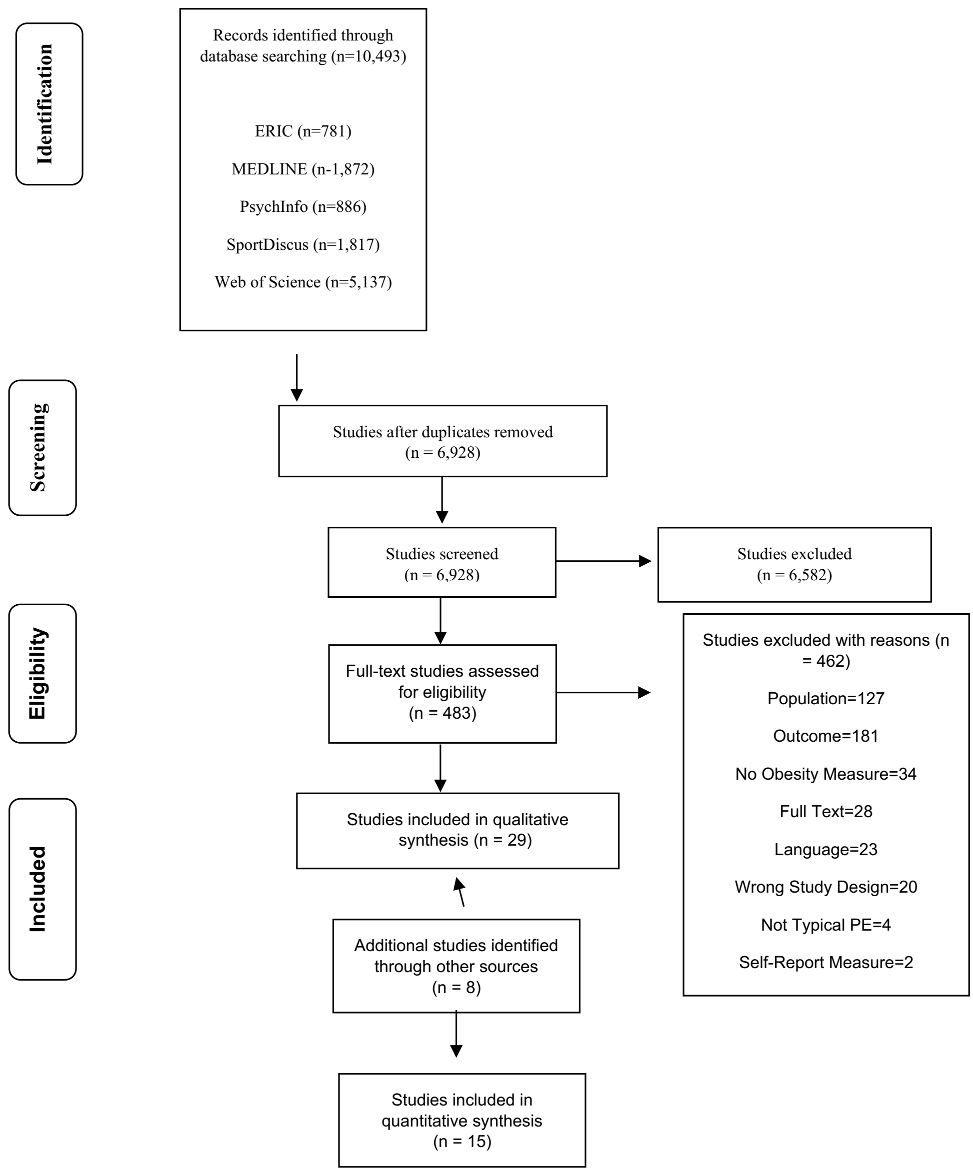
Study Design and Location

Of the 29 articles included in this review, 23 were interventions (Abdukic, 2015; Alonso-Fernandez et al., 2019; Ardoy et al., 2011; Baquet et al., 2001; Bielec, 2008; Bielec et al., 2013; Costigan et al., 2015a; De Souza Santos et al., 2015; Dorgo et al., 2009; Farias et al., 2013; Giannaki et al., 2016; Hollis et al., 2016; Kojic et al., 2022; Laparidis et al., 2010; Martinez-Lopez et al., 2012; McMurray et al., 2002; Muntaner & Palou, 2017; Neumark-Sztainer et al., 2003; Plevkova & Perackova, 2019; Trajkovic et al., 2018; Weeks & Beck, 2012; Weeks et al., 2008; Wong et al., 2008), five were cross-sectional (Aphamis et al., 2015; Hinojosa et al., 2018 Lo et al., 2017; Madsen et al., 2009; Perez et al., 2022) and one was longitudinal (Czarniecka et al., 2012). Fifteen studies were conducted in European countries (Abdukic, 2015; Aphamis et al., 2015; Alonso-Fernandez et al., 2019; Ardoy et al., 2011; Baquet et al., 2001; Bielec, 2008; Bielec et al., 2013; Czarniecka et al., 2012; Giannaki et al., 2016; Kojic et al., 2022; Laparidis et al., 2010; Martinez-Lopez et al., 2012; Muntaner & Palou, 2017; Trajkovic et al., 2020), five in the USA (Dorgo et al., 2009; Hinojosa et al., 2018; Madsen et al., 2009; McMurray et al., 2002; Neumark-Sztainer et al., 2003), four in Australia (Costigan et al., 2015a; Hollis et al., 2016; Weeks & Beck, 2012; Weeks et al., 2008), three in Brazil (De Souza Santos et al., 2015; Farias et al., 2013; Perez et al., 2022) and one in Taiwan (Lo et al., 2017) and Singapore (Wong et al., 2008). Twenty-six of twenty-nine articles were published in 2008 or later.

Population

The number of schools sampled in each article ranged from 1 to 6000, with a combined total of 6076 schools

Fig. 1 PRISMA Flowchart of the Study Selection Process



and a mean of 210 schools per article. Sample sizes ranged from 24 to 5,265,260 participants, with a combined total of 5,924,652 and a mean of 204,298 participants per article. The mean age of the included participants ranged from 12 to 17 years. Nineteen articles had a mixed gender sample.

Exposure

Articles typically reported on the physical education curriculum with 28 of the 29 articles reporting this as a primary exposure (Abdukic, 2015; Aphamis et al., 2015; Alonso-Fernandez et al., 2019; Ardoy et al., 2011; Baquet et al., 2001; Bielec, 2008; Bielec et al., 2013; Costigan et al., 2015a; Czarniecka et al., 2012; De Souza Santos et al., 2015; Dorgo et al., 2009; Farias et al., 2013; Giannaki et al., 2016; Hinojosa et al., 2018; Hollis et al., 2016; Kojic et al., 2022; Laparidis et al., 2010; Madsen et al., 2009; Martinez-Lopez et al., 2012; McMurray et al., 2002; Muntaner & Palou, 2017; Neumark-Sztainer et al., 2003; Perez et al., 2022; Plevkova & Perackova, 2019; Trajkovic et al., 2020; Weeks & Beck, 2012; Weeks et al., 2008; Wong et al., 2008). For the purpose of this study, physical education curriculum is described as a standard physical education class in accordance with the physical education curriculum of the specified country or state. Additional exposures included active recess (Costigan et al., 2015a; Dorgo et al., 2009), physical education and sports facilities (Lo et al., 2017), school sports programs (Hollis et al., 2016; Perez et al., 2022), active transport to/from school (Madsen et al., 2009) and extracurricular activities (Trajkovic et al., 2020). Interventions with minor modifications to typical school provision included the implementation of a program of volleyball, basketball, gymnastics and athletics (Abdukic, 2015), additional physical education class time (Ardoy et al., 2011; Wong et al., 2008), swimming (Bielec, 2008; Bielec et al., 2013), cardiovascular exercise and body weight program (Costigan et al., 2015a), calisthenic exercises (De Souza Santos et al., 2015), manual resistance and cardiovascular endurance program (Dorgo et al., 2009), heart rate monitoring program (Farias et al., 2013), high intensity interval training (HIIT) (Alonso-Fernandez et al., 2019), strength and circuit training (Kojic et al., 2022; Plevkova & Perackova, 2019), fitness, diet and health theory (Laparidis et al., 2010; Muntaner & Palou., 2017), aerobic activities (McMurray et al., 2002), recreational soccer (Trajkovic et al., 2020) and jumping activities (Weeks & Beck, 2012; Weeks et al., 2008). Of the 23 interventions, the experimental group exposure was deemed outside the realms of typical school provision in four (Baquet et al., 2001; Hollis et al., 2016; Martinez-Lopez et al., 2012; Neumark-Sztainer et al., 2003).

Outcomes

A description of the outcomes is reported in Table 1. Indicators of adiposity were present in all twenty nine articles (Abdukic, 2015; Aphamis et al., 2015; Alonso-Fernandez et al., 2019; Ardoy et al., 2011; Baquet et al., 2001; Bielec, 2008; Bielec et al., 2013; Costigan et al., 2015a; Czarniecka et al., 2012; De Souza Santos et al., 2015; Dorgo et al., 2009; Farias et al., 2013; Giannaki et al., 2016; Hinojosa et al., 2018; Hollis et al., 2016; Kojic et al., 2022; Laparidis et al., 2010; Lo et al., 2017; Madsen et al., 2009; Martinez-Lopez et al., 2012; McMurray et al., 2002; Muntaner & Palou, 2017; Neumark-Sztainer et al., 2003; Perez et al., 2022; Plevkova & Perackova, 2019; Trajkovic et al., 2020; Weeks & Beck, 2012; Weeks et al., 2008; Wong et al., 2008), indicators of physical fitness in twenty one articles (Abdukic, 2015; Aphamis et al., 2015; Alonso-Fernandez et al., 2019; Ardoy et al., 2011; Baquet et al., 2001; Bielec et al., 2008; Costigan et al., 2015a; Czarniecka et al., 2012; De Souza Santos et al., 2015; Dorgo et al., 2009; Giannaki et al., 2016; Kojic et al., 2022; Laparidis et al., 2010; Lo et al., 2017; Madsen et al., 2009; McMurray et al., 2002; Muntaner & Palou, 2017; Perez et al., 2022; Trajkovic et al., 2020; Weeks & Beck, 2012; Wong et al., 2008), blood pressure in four articles (Giannaki et al., 2016; Laparidis et al., 2010; McMurray et al., 2002; Wong et al., 2008) and bone health in one article (Weeks et al., 2008). Indicators of adiposity included body mass index, obesity, weight, body fat percentage, lean mass and skinfold thickness. A range of indicators of physical fitness were included e.g., V02 max, hand grip strength, sit and reach, vertical jump, shuttle run, sit up, cooper swim test, pushup, bent arm hang and standing broad jump. Blood pressure included systolic and diastolic blood pressure and a range of indicators of bone health were included e.g., lumbar spine and femoral neck bone mineral apparent density. All 29 articles used a range of objectively based outcome measures (e.g., stadiometer, measuring scale, bioelectric impedance analysis, skinfold calipers, sit and reach box, dynamometer and ultrasound densitometer).

Quality Assessment

All 29 articles were assessed for quality using a modified Downs and Black checklist for quantitative studies by two reviewers (PR, BOK) (Downs & Black, 1998; Nugent et al., 2021). Three articles were given a rating of 'excellent' (85–100%), six articles were given a rating of 'good' (70–84%), sixteen articles were given a rating of 'fair' (55–69%) and four articles were given a rating of 'poor' (< 55%). The mean quality assessment score was 66% (fair). Five articles demonstrated external validity by ensuring the sample was representative of the entire population from which they were recruited. Six articles provided a power calculation to demonstrate use an adequate sample size (see Table 2).

Summary of Findings

This section provides an overview of the main findings presented in Table 3. Included articles (n = 29) contributed a total of 268 reported effects between typical school provision of physical education, physical activity and sports and adolescent physical health. The evidence indicated that 38% of the overall reported effects were significantly positive (n = 101 effects), 45% were non-significant (n = 120 effects), 16% were significantly negative (n = 44 effects), and 1% had no significance test applied (n = 3 effects). Of the reported effects that indicated no significance test, all demonstrated a negative direction.

The impact summary of the reported effects within each article indicated that 24% were significantly positive (n = 7 articles) (Aphamis et al., 2015; Czarniecka et al., 2012; Dorgo et al., 2009; Faria et al., 2013; Kojic et al., 2022; Lo et al., 2017; Weeks et al., 2008), 62% were inconclusive/no effect (n = 18 articles) (Abdukic, 2015; Alonso-Fernandez et al., 2019; Ardoy et al., 2011; Bielec, 2008; Bielec et al., 2013; Costigan et al., 2015a, 2015b; De Souza Santos et al., 2015; Giannaki et al., 2016; Hinojosa et al., 2010; Laparidis et al., 2010; Madsen et al., 2009; McMurray et al., 2002; Muntaner & Palou, 2017; Perez et al., 2022; Plevkova & Perackova, 2019; Trajkovic et al., 2020; Weeks & Beck, 2012; Wong et al., 2008), 10% were significantly negative (n = 3 articles) (Baquet et al., 2001; Hollis et al., 2016; Martinez-Lopez et al., 2012) and 3% demonstrated a

Table 2 Summary of Downs and Black Checklist Quality Assessment Score

Study	Reporting (11 items)	External validity (1 item)	Internal validity (Bias) (4 items)	Internal validity (confounding) (6 items)	Power (1 item)	Total score	Quality rating
Abdukic (2015)	6	0	2	1	0	9/23 (39%)	Poor
Aphamis et al. (2015)	9	0	2	1	0	12/14 (86%)	Excellent
Ardoy et al., (2011)	10	1	4	4	1	20/23 (87%)	Excellent
Baquet et al., (2001)	9	0	3	1	0	14/23 (61%)	Fair
Bielec (2008)	9	0	3	1	0	13/23 (57%)	Fair
Bielec et al., (2013)	9	0	4	1	0	14/23 (61%)	Fair
Costigan et al., (2015a)	8	0	4	3	1	16/23 (70%)	Good
Czarniecka et al., (2012)	7	0	3	1	0	11/21 (52%)	Poor
De Souza Santos et al., (2015)	8	0	3	3	0	14/23 (61%)	Fair
Dorgo et al., (2009)	9	0	3	0	0	12/23 (52%)	Poor
Farias et al., (2013)	10	1	4	3	0	18/23 (78%)	Good
Alonso-Fernandez et al. (2019)	8	0	4	3	0	15/23 (65%)	Fair
Giannaki et al., (2016)	9	1	4	3	0	17/23 (74%)	Fair
Hinojosa et al. (2018)	6	0	2	1	0	9/14 (64%)	Fair
Hollis et al., (2016)	10	0	3	1	1	15/23 (65%)	Fair
Kojic et al., (2022)	9	0	4	1	1	15/23 (65%)	Fair
Laparidis et al., (2010)	8	0	4	1	0	13/23 (57%)	Fair
Lo et al., (2017)	7	1	2	1	0	11/14 (79%)	Good
Madsen et al., (2009)	9	0	2	1	0	12/14 (86%)	Excellent
Martinez-Lopez et al. (2012)	9	1	4	1	0	15/23 (65%)	Fair
McMurray et al., (2002)	9	0	4	3	0	16/23 (70%)	Good
Muntaner and Palou (2017)	9	0	2	1	0	12/23 (52%)	Poor
Neumark-Sztainer et al., (2003)	9	0	4	1	0	14/23 (61%)	Fair
Perez et al., (2022)	8	0	2	0	0	10/14 (61%)	Fair
Plevkova and Perackova (2019)	9	0	3	2	0	14/23 (61%)	Fair
Trajkovic et al. (2020)	9	0	4	1	0	14/23 (61%)	Fair
Weeks and Beck (2012)	9	0	4	3	1	17/23 (74%)	Good
Weeks et al., (2008)	10	0	4	3	1	18/23 (78%)	Good
Wong et al., (2008)	8	0	4	3	0	15/23 (65%)	Fair

Note Quality rating of 'excellent' (85–100%), 'good' (70–84%), 'fair' (55–69%) or 'poor' (<55%) (Woods et al., 2021)

negative direction but with no significance test (n = 1 article) (Neumark-Sztainer et al., 2003).

When analyzed by study design, the overall frequency of reported effects showed that 85% (n = 227 effects, n = 23 articles) occurred in intervention studies with a mean quality assessment score of 67% (fair) (Abdukic, 2015; Alonso-Fernandez et al., 2019; Ardoy et al., 2011; Baquet et al., 2001; Bielec, 2008; Bielec et al., 2013; Costigan et al., 2015a; De Souza Santos et al., 2015; Dorgo et al., 2009; Farias et al., 2013; Giannaki et al., 2016; Hollis et al., 2016; Kojic et al., 2022; Laparidis et al., 2010; Martinez-Lopez et al., 2012; McMurray et al., 2002; Muntaner & Palou, 2017; Neumark-Sztainer et al., 2003; Plevkova & Perackova, 2019; Trajkovic et al., 2020; Weeks & Beck, 2012; Weeks et al., 2008; Wong et al., 2008), 12% (n = 31 effects, n = 4 articles) in cross-sectional studies with a quality assessment score of 78% (good) (Aphamis et al., 2015; Lo et al., 2017; Madsen et al., 2009; Perez et al., 2022) and 4% (n = 10 effects, n = 2 articles) in longitudinal studies (some numbers add to 99/101% due to rounding) with a quality assessment score of 56% (fair) (Czarniecka et al., 2012; Hinojosa et al., 2018. The bulk of significantly positive (79% n = 80 effects), non-significant (89% n = 107 effects), significantly negative effects (82% n = 36 effects) were reported most frequently in intervention studies.

Table 3 Summary Findings of Included Studies

Reference, Country, Study Design, QR	School Level, Pupils Age, School Number, Total Students, Aim	PE, PA, Sport Exposure	Outcome Measure, Instrument, Study Duration	Summary Result	Main Reported Effects, Impact Summary	Conclusion/Nuance
Abdukic (2012) **Bosnia and Herzegovina** **Intervention** **QR: 39%**	Secondary School 14-16 (No SD) 1 School 106 Pupils/ 0 (Boys), 106 (Girls) Aim: To determine the effectiveness of different school-based PA interventions on body fat and BMI in female students.	**1.PE Curriculum** *Typical PE class with a program of volleyball (Intervention Condition 1)* *Typical PE class with a program of volleyball, basketball, gymnastics, and athletics (Intervention Condition 2)*	1.Weight 2.BMI 3.Skinfolds Skinfold Callipers Digital Scale and Stadiometer 1 Year.	No Sig difference between baseline and follow up for body weight (p=.72), BMI (p=.98), skinfold thickness subscapular (p=.91), skinfold thickness abdominal (p=.25) and skinfold thickness triceps (p=.70) in experimental group 1. * No Sig difference between baseline and follow up for body weight (p=.44), BMI (p=.34), skinfold thickness subscapular (p=.58), skinfold thickness abdominal (p=.36) and skinfold thickness triceps (p=.76) in experimental group 2. * No Sig difference between the control and experimental groups for body weight (p=.89), BMI (p=.79), skinfold thickness subscapular (p=.56), skinfold thickness abdominal (p=.31) and skinfold thickness triceps (p=.93) at follow up *	Non-Significant Non-Significant Non-Significant **Inconclusive / No Effect**	The choice of kinesiology operators, methodical work forms and application of PE content were insufficient factors to achieve success in reducing the level of BMI and adiposity.
Aphamis et al., (2014) **Cyprus** **Cross-Sectional** **QR:85.70%**	Secondary School 16.9 (± 0.8) 1 School 270 Pupils/ 110 (Boys), 160 (Girls) Aim: To investigate the association between adolescent obesity, body composition, and fitness levels.	**1. PE Curriculum** *Number of PE sessions weekly.*	1.Weight 2.BMI 3.Body Fat % 4.Flexibility 5.Hand Grip Strength 6.V02 Max 7.30m Sprint 8.Vertical Jump Portable Analogue Scale, Stadiometer, Bioelectric Impedance Analysis, 20m Shuttle Run, Digital Dynamometer, Opto Jump Electronic Device, Sit and Reach Box, Electronic Photocells. NA	Percentage body fat was sig inversely associated with the number of PE classes per week taken by the students (p=.001, r=.204). * BMI was not sig associated with the number of PE classes taken per week (Data not provided). * VO2 max score was sig positively associated with the number of PE sessions per week taken (p=.001, r=.504). ** 30m speed max was sig positively associated with the number of PE sessions per week taken (p=.001, r=.706). ** Hand grip (left hand, p=.012, r=.161) (right hand, p=.006, r=.173) was sig positively associated with the number of PE sessions per week taken. **	Significantly Negative Non-Significant Significantly Positive Significantly Positive Significantly Positive	

Table 3 (continued)

				Vertical jump was sig positively associated with the number of PE sessions per week taken (p=.001, r=.35). **	Significantly Positive	
				Flexibility was not sig associated with the number of PE sessions per week taken (no data provided). **	Non-Significant	
					Significantly Positive	
Ardoy et al., (2011) **Spain** **Intervention** **QR: 86.95%**	Secondary School 12-14 (No SD) 1 School 67 Pupils/ 43 (Boys), 24 (Girls) Aim: To analyze the effects of a school-based intervention program, focused on increasing the volume and intensity of physical education (PE) sessions, on adolescents' physical fitness.	**1.PE Curriculum** *Participation in typical PE class (X2 sessions weekly) (Control)* *Participation in typical PE class (X4 sessions weekly) (Intervention Condition 1)* *Participation in typical PE class (X4 sessions weekly with a focus on intensity) (Intervention Condition 2)*	1. Weight 2. BMI 3. Skinfold Thickness 4. % Body Fat 5. Fat Mass Index 6. Waist Circumference 7. Waist to Height Ratio 8. Fat Free Mass 9. Fat Free Mass Index 10. Aerobic Capacity 11. Muscular Strength 12. Speed/Agility 13. Flexibility Protocols utilized in the HELENA study. 16 weeks	No Sig differences between baseline and follow up for 1,2,3,4,5,6,7,8 and 9 for the control group, intervention condition 1 and intervention condition 2 (p>.05). *	Non-Significant	The results suggest that doubling the frequency of PE sessions is a sufficient stimulus to improve physical fitness, particularly aerobic fitness, which has been shown to be a powerful indicator of cardiovascular health in adolescents.
				Sig difference in favor of intervention condition 2 versus the control group for aerobic capacity using the course navette test (p<.001, Cohens D=1.68). **	Significantly Positive	
				No Sig difference between intervention condition 2 versus intervention condition 1 (p=.07, Cohens D=.67) for aerobic capacity using the course navette test. **	Non-Significant	
				No Sig difference between intervention condition 1 versus the control group (p=.008, Cohens D=1.00)) for aerobic capacity using the course navette test. **	Significantly Positive	
				Sig difference in favor of intervention condition 2 versus the control group (p<.001, Cohens D=1.69) and in favor of intervention condition 1 versus the control group (p=.005, Cohens D=1.04) for aerobic capacity using the max oxygen consumption test. **	Significantly Positive	
				No Sig difference between the intervention condition 1 and intervention condition 2 for aerobic capacity using the course navette test (p=.08, Cohens D=.64). **	Non-Significant	
				No Sig difference between the intervention condition 1 versus control (p=.73, Cohens D=.37), intervention condition 2 versus the control (p=1.00, Cohens D=.31) and intervention 1 versus intervention 2 (p=1.00, Cohens D=.08) for muscular strength. **	Non-Significant	
				No Sig difference between the intervention condition 1 versus control (p=.09, Cohens D=.71) and intervention 1 versus intervention 2 (p=.39, Cohens D=.45) for speed/agility. **	Non-Significant	
					Significantly Positive	

Table 3 (continued)

				Sig difference in favor of intervention condition 2 versus the control group for speed/agility (p=.001, Cohens D=1.17). **		
				Sig difference in favor of intervention condition 2 versus the control group (p=.002, Cohens D=1.16) and in favor of intervention condition 1 versus the control group (p=.04, Cohens D=1.82) for flexibility. **	Significantly Positive	
				No Sig difference between intervention condition 1 and intervention condition 2 for flexibility (p=.75, Cohens D=.33). **	Non-Significant _____ **Inconclusive / No Effect**	
Baquet et al., (2001) **France** **Intervention** **QR: 61%**	Secondary School 11-16 (No SD) NA 48 Pupils/ 27 (Boys), 21 (Girls) Aim: To analyze the effects of a high intensity aerobic training program on different components of physical fitness in adolescents aged 11 to 16 years.	**1.PE Curriculum** *Typical PE class with a program of games (Control).*	1.Weight 2.BMI 3.% Body Fat 4.Standing Broad Jump 5.5m Shuttle Run 6.Sit Ups 7.Maximal Speed 8.7 Minute Running Test Wall Stadiometer, Skinfold Callipers, Repetitions, Distance. EUROFIT Testing Battery 10 Weeks	Sig difference between baseline and follow up for 1 (p<.001), 2 (p<.001) and 3 (p<.01) in the control group for boys. * Sig difference between baseline and follow up for 1 (p<.001), 2 (p<.001) and 3 (p<.01) in the control group for girls. * No Sig difference between baseline and follow up for 4,5,7,8 and 9 for girls and boys combined (p>.01).**	Significantly Negative Significantly Negative Non-Significant ___ **Significantly Negative**	Typical physical education provision has only a limited influence on motor development and indicators of obesity. Intervention groups are not considered as the mean age and SD fall outside the inclusion criteria.
Bielec (2008) **Poland** **Intervention** **QR:56.50%**	Secondary School No Mean Age/SD 2 Schools 162 Pupils/ 79 (Boys), 83 (Girls) Aim: To investigate the effect of regularly attended swimming classes on BMI values in secondary school pupils.	**1. PE Curriculum** *Participation in typical PE class (Control)* *Participation in typical PE class with a focus on swimming (Intervention)*	1.Weight 2.BMI 3.12 Minute Cooper Swim Test Seca 214 Stadiometer, Seca 711 Scale, Distance. 10 Weeks	Sig difference between baseline and follow up for BMI in the experimental group for girls (p=.013). * Sig difference between baseline and follow up for BMI in the control group for girls (p<.001). * Sig difference between baseline and follow up for BMI in the experimental group for boys (p=.015). * Sig difference between baseline and follow up for BMI in the control group for boys (p<.001). * No Sig difference between the control and experimental groups for body weight at follow up for the girls (p=.064). *	Significantly Negative Significantly Negative Significantly Negative Significantly Negative Non-Significant	Secondary school students, regularly taking part in swimming classes, have less values of BMI and distinctly less body mass than their non-swimming contemporaries.

Table 3 (continued)

				No Sig difference between the control and experimental groups for BMI at follow up for the girls (p=.085). *	Non-Significant	
				Sig difference in favor of the experimental group versus the control group for body weight at follow up for the boys (p=.016). *	Significantly Positive	
				No Sig difference between the control and experimental groups for BMI at follow up for the boys (p=.079). *	Non-Significant	
				Boys achieved Sig higher results in the 12-minute cooper swim test compared to girls at follow up (p<.05). **	Significantly Positive (B)/Non-Significant (G)	
				No Sig differences between boys and girls for BMI at follow up (p>.05). *	Non-Significant _____ **Inconclusive / No Effect**	
Bielec et al., (2013) **Poland** **Non RCT** **QR:60.80%**	Secondary School 13.4 (± 0.3) 1 School 230 Pupils/ 124 (Boys), 106 (Girls) Aim: To evaluate the influence of regular participation in school swimming lessons on anthropometric variables and postural defect occurrence in junior high school students.	**1. PE Curriculum** *Participation in typical PE class (Control)* *Participation in typical PE class with a focus on swimming (Intervention)*	1.Weight 2.BMI Calibrated Standard Scale, Stadiometer. 2 Years.	No Sig difference between the control and experimental groups for body weight after 1 and 2 years for girls (p>.05). *	Non-Significant	Students from the intervention group had lower body mass than their peers in the control group at the end of the course. However, the differences in body mass index between the groups were insignificant.
				Sig difference in favor of the experimental group versus the control group for body weight after 1 year for boys (p<.05). *	Significantly Positive	
				Throughout the experiment changes in body weight of adolescents in the control and experimental groups were Sig (p=.027). *	Significantly Positive	
				No sig difference between the control and experimental groups for BMI after 1 year for girls (p=.084). *	Non-Significant	
				No sig difference between the control and experimental groups for BMI after 1 year for the boys (p=.079). *	Non-Significant	
				Throughout the experiment changes in BMI of adolescents in the control and experimental groups were not significant (p=.087). *	Non-Significant ____ **Inconclusive / No Effect**	
Costigan et al., (2015a) **Australia** **RCT**	Secondary School 15.8 (± 0.6) 1 School 65 Pupils/ 45 (Boys), 20 (Girls)	**1. PE Curriculum/Active Recess** *Typical PE and lunchtime activities (Control).*	1.Weight 2.Waist Circumference 3.BMI 4.BMI Z Score 5.Cardiorespiratory Fitness	Sig difference in favor of the experimental group (condition 1) versus the control group for 4 at follow up (p=.037, Cohens D= -0.6). *	Significantly Positive	
					Non-Significant	

Table 3 (continued)

QR:69.60%	Aim: To assess the effectiveness and feasibility of embedding HIIT into the school day.	**2. PE Curriculum/Active Recess** *Cardiorespiratory Exercise Program (Intervention Condition 1 (AEP)* *Cardiorespiratory Exercise and Body Weight Resistance Exercise Program (Intervention Condition 2 (RAP)*	6.Push Ups 7.Standing Long Jump Shuttle Run Test, Distance, Repetitions, Portable Digital Scale, Portable Stadiometer, Steel Tape. 8 Weeks.	No Sig difference between control and experimental group (condition 1) for 2 (p=.113, Cohens D= -0.50) and 3 (p=.086, Cohens D= -0.50). * No Sig difference between control and experimental group (condition 1) for 5 (p=.605, Cohens D= 0.1) ,6 (p=.731, Cohens D= 0.1) and 7 (p=.789, Cohens D= 0.1). ** Sig difference in favor of the experimental group (condition 2) versus the control group for 2 at follow up (p=.024, Cohens D= -0.7). * No Sig difference between control and experimental group (condition 2) for 3 (p=.067, Cohens D= -0.5) and 4 (p=.093, Cohens D= -0.5). * No Sig difference between control and experimental group (condition 2) for 5 (p=.571, Cohens D=0.4) ,6 (p=.668, Cohens D= -0.1) and 7 (p=.492, Cohens D= -0.2). **	Non-Significant Non-Significant Significantly Positive Non-Significant Non-Significant **Inconclusive / No Effect**	
Czarniecka et al., (2012) **Poland** **Longitudinal** **QR:47.80%**	Secondary School 13.3 (± 0.35) 1 School 141 Pupils/ 0 (Boys), 141 (Girls) Aim: To evaluate changes in strength abilities of adolescent girls that underwent a 3-year physical education curriculum.	**1. PE Curriculum** *Participation in typical PE class.*	1.Weight 2.BMI 3.Standing Broad Jump 4.Handgrip Strength 5.Sit Ups 6.Bent Arm Hang Dynamometer, Horizontal Bar, Digital Scale and Stadiometer, Distance, Repetitions, Time. 3 Years. EUROFIT Testing Battery	Sig difference between baseline and follow up for weight (p<.001). * Sig difference between baseline and follow up for BMI (p<.001). * Sig difference between baseline and follow up for standing broad jump (p<.001). ** Sig difference between baseline and follow up for handgrip strength (p<.001). ** Sig difference between baseline and follow up for sit ups (p<.001). ** Sig difference between baseline and follow up for bent arm hang (p<.05). **	Significantly Negative Significantly Negative Significantly Positive Significantly Positive Significantly Positive Significantly Positive **Significantly Positive**	The effects of the 3-year PEC show that the development of motor abilities in adolescent girls can be effectively shaped by physical education lessons at school.
De Souza Santos et al., (2015) **Brazil** **Intervention**	Secondary School 12.8 (± 0.6) 1 School 39 Pupils/ 19 (Boys), 20 (Girls)	**1. PE Curriculum** *Participation in typical PE class (Control).*	1.Weight 2.BMI 3.Push Ups 4.Abdominal Strength 5.Horizontal Jump 6.Speed	No Sig % change between experimental and control groups (p>.01) for 1 (n^2 =-.02) and 2 (n^2 =-.05). * Sig % change in favor of the experimental group versus the control group (p>.01) for 3 (n^2 = .73), 4 (n^2 = 2.06), 5 (n^2 = .13), 6 (n^2 = .69). **	Non-Significant Significantly Positive	The addition of calisthenics strength exercises into typical PE class improved the strength levels of adolescents. Similar

Table 3 (continued)

QR:60.80%	Aim: To investigate the effects of calisthenic strength exercises in Physical Education classes on morphological and functional adaptations in school children.	*Participation in typical PE class with a focus on calisthenic exercises (Intervention).*	Anthropometer, Pan Scale, Max Repetitions, Contact Mat, 50m Sprint. 12 Weeks.	No Sig interaction effect between the control and experimental groups for 1 and 2 (p>.05). * No Sig interaction effect between the control and experimental groups for 5 and 6 (p>.05). ** Sig interaction effect in favor of the experimental group versus the control group for 3 and 4 (p<.05). **	Non-Significant Non-Significant Significantly Positive **Inconclusive / No Effect**	findings were reported for girls and boys separately with the exception of speed which was found to be statistically significant in favor of the experiment group for girls and boys.
Dorgo et al., (2009) **USA** **Intervention** **QR:52.30%**	Secondary School 15.9 (± 1.2) 2 Schools 222 Pupils/ 122 (Boys), 100 (Girls) Aim: To document the physical changes in adolescents using manual resistance training in school-based PE settings.	**1. PE Curriculum/Active Recess** *Participation in typical PE class (Control).* *Manual Resistance Training Program (Intervention Condition 1)* *Manual Resistance Training Program and cardiovascular endurance training (Intervention Condition 2)*	1.BMI 2 One Mile Run 3.Curl Up 4.Trunk Lift 5.Push Up 6.Flexed Arm Hang 7.Modified Pull Up 8.Skinfold Repetitions, Distance, Time, Skinfold Callipers. 18 Weeks.	No Sig difference between baseline and midterm for BMI in the control and intervention condition 1 and 2 (p>.05). * No Sig difference between baseline and follow up for BMI in the control and intervention condition 1 and 2 (p>.05). * Sig difference between baseline and midterm for skinfold in the control and intervention condition 1 (p<.05). * Sig difference between baseline and follow up for skinfold in the control and intervention condition 1 (p<.05). * Sig difference between baseline and midterm for 3,4,5,6 and 7 in the control and intervention condition 1 (p<.05). ** Sig difference between baseline and follow up for 3,4,5,6 and 7 in the control group (p<.05). ** No Sig difference between baseline and midterm for one mile run in the control and intervention group 1 (p>.05). ** Sig difference between baseline and follow up for one mile run in the control group (p<.05). ** No Sig difference between baseline and follow up for one mile run in intervention condition 1 (p>.05). ** No Sig difference between baseline and midterm for skinfold in intervention condition 2 (p>.05). *	Non-Significant Non-Significant Non-Significant Non-Significant Non-Significant Non-Significant Significantly Negative Significantly Negative Significantly Negative Significantly Negative Significantly Positive Significantly Positive Significantly Positive Significantly Positive Non-Significant Non-Significant Significantly Negative Non-Significant Non-Significant	An 18-week combined MRT and cardiovascular endurance training program effectively improved cardiovascular and muscular fitness but was ineffective in improving adolescent body composition.

Table 3 (continued)

No Sig difference between baseline and follow up for skinfold in intervention condition 2 (p>.05). *	Non-Significant
Sig difference between baseline and midterm for 3,4 and 5 in intervention condition 2 (p<.05). **	Significantly Positive
Sig difference between baseline and follow up for 2, 3,4 and 5 in intervention condition 2 (p<.05). **	Significantly Positive
No Sig difference between baseline and midterm for 2,6 and 7 in intervention condition 2 (p>.05). **	Non-Significant
No Sig difference between baseline and follow up for 6 in intervention condition 2 (p>.05). **	Non-Significant
Sig difference between baseline and follow up for modified pull up in intervention condition 2 (p<.05). **	Significantly Positive
No Sig difference between midterm and follow up for 3,4,5,6 and 7 in the control and intervention 1 and 2 (p>.05). **	Non-Significant
No Sig difference between midterm and follow up for 1 and 8 in the control and intervention 1 and 2 (p>.05). **	Non-Significant
No Sig difference between midterm and follow up for 2 in intervention condition 1 and 2 (p<.05). **	Non-Significant
Sig difference between midterm and follow up for 2 in the control group (p<.05). **	Significantly Negative
No Sig difference between the control versus intervention condition 1 and 2 for 1,6 and 8 at midterm and follow up (p>.05). *	Non-Significant Non-Significant
Sig difference in favor of intervention condition 1 and 2 versus the control group for 2,3 and 5 at midterm and follow up (p<.05). **	Significantly Positive Significantly Positive
Sig difference in favor of intervention condition 1 and 2 versus the control group for 4 and 7 at midterm (p<.05). **	Significantly Positive Significantly Positive
No Sig difference between intervention condition 1 and 2 versus the control group for 4 and 7 at follow up (p>.05). **	Non-Significant Non-Significant
	Significantly Positive

Table 3 (continued)

Farias et al., (2013) **Brazil** **Intervention** **QR:78.30%**	Secondary School 15.95 (± 0.8) 1 School 386 Pupils/ 200 (Boys), 186 (Girls) Aim: To investigate the changes in body composition in post-pubertal schoolchildren after a programmed physical activity intervention implemented in physical education classes during one school year.	**1. PE Curriculum** *Participation in typical PE class including recreational games learning, fundamentals of sport and sports activities (Control).* *Participation in typical PE class including physical activity with HR monitoring consisting of aerobic activity, sports games and stretching (Intervention).*	1.% Body Fat 2.Lean Mass 3.Fat Mass 4.Waist Portable Stadiometer, Medical Scale, Skinfold Callipers, WHO Recommendations.	Sig group x time interaction effect for % body fat in boys and girls in favor of the experimental group (p<.001). * Sig group x time interaction effect for lean mass in boys and girls in favor of the experimental group (p<.001). * Sig group x time interaction effect for fat mass in boys and girls in favor of the experimental group (p<.001). * Sig group x time interaction effect for waist in boys and girls in favor of the experimental group (p<.001). * Significant reduction of excess weight participants and increase of non-obese participants post-intervention in the experimental group (p<.001). *	Significantly Positive Significantly Positive Significantly Positive Significantly Positive Significantly Positive ___ **Significantly Positive**	The programmed physical activity (consisting of aerobic activity, sports games and stretching) in the intervention group led to changes in the variables of body composition not observed in the control group.
Alonso-Fernandez et al., (2019) **Spain** **Intervention** **QR:65.21%**	Secondary School 15-16 (No SD) 1 School 26 Pupils/ 13 (Boys), 13 (Girls) Aim: To analyze the effect of high-intensity interval training based on functional exercises on body fat percentage and cardiorespiratory capacity in a group of adolescents	**1. PE Curriculum** *Participation in typical PE class with regular warm up (Control)* *Participation in typical PE class with HIIT warm up (Intervention)*	1.Weight 2.BMI 3.Body Fat 4.Fat Mass 5.Fat Free Mass 6.Aerobic Capacity Bioelectric Impedance Analysis, Tanita MC 980 MA, 20m Cardiorespiratory Endurance Test. 9 Weeks.	No Sig difference between baseline and follow up for body weight, BMI, body fat, fat mass and fat free mass in the control group (p>.001). * No Sig difference between baseline and follow up for aerobic capacity in the control group (p>.001). ** No Sig difference between baseline and follow up for body weight (n^2= .02) and BMI (n^2= .03) in the experimental group (p>.001). * Sig difference between baseline and follow up for body fat (n^2= .58), fat mass (n^2= .02) and fat free mass (n^2= .15) in the experimental group (p<.001). * Sig difference between baseline and follow up for aerobic capacity (n^2= .32) in the experimental group (p<.001). **	Non-Significant Non-Significant Non-Significant Significantly Positive Significantly Positive _____ **Inconclusive / No Effect**	Functional HIIT shows potential to become a reliable strategy for countering obesity in the young population, given its impact on the reduction of body fat in the individuals involved.
Giannaki et al., (2016) **Cyprus** **Intervention** **QR : 73.91%**	Secondary School 16 (No SD) 1 School 39 Pupils/ 39 (Boys), 0 (Girls) Aim: To examine the effects of an eight-week circuit training on physical	**1. PE Curriculum** *Participation in typical PE class (Control)* *Participation in typical PE class with a focus on circuit training (Intervention)*	1.Weight 2.BMI 3. % Body Fat 4.Handgrip R Arm 5. Handgrip L Arm 6. Vertical Jump 7. Systolic Blood Pressure	Sig difference between baseline and follow up for weight and BMI in the control group (p<.05). * No Sig difference between baseline and follow up for weight and BMI in the experimental group (p>.05). * Sig difference in favor of the experimental group versus the control group for weight and BMI (p<05). *	Significantly Negative Non-Significant Significantly Positive	Eight weeks of circuit training during PE class appears to be effective in improving various physical fitness parameters and reducing fatness in male adolescents.

Table 3 (continued)

fitness and body fat in male adolescents.	8.Diastolic Blood Pressure	Sig difference between baseline and follow up for % body fat in the control group ($p<.05$). *	Significantly Negative
	Portable Analogue Scale, Stadiometer, Bioelectric Impedance Analysis, 20m Shuttle Run, Dynamometer, Height, Omron M6.	Sig difference between baseline and follow up for % body fat in the experimental group ($p<.05$). *	Significantly Positive
		Sig difference in favor of the experimental group versus the control group for % body fat ($p<.05$). *	Significantly Positive
	8 Weeks.	No Sig difference between baseline and follow up for hand grip r arm, l arm and vertical jump in the control group ($p>05$). **	Non-Significant
		Sig difference between baseline and follow up for handgrip r arm, l arm and vertical jump in the experimental group ($p<.05$). **	Significantly Positive
		No Sig difference between the control versus the experimental group for handgrip r arm and l arm and vertical jump ($p>.05$). **	Non-Significant
		No Sig difference between baseline and follow up for systolic blood pressure in the control group ($p>.05$). ***	Non-Significant
		Sig difference between baseline and follow up for systolic blood pressure in the experimental group ($p<.05$). ***	Significantly Positive
		Sig difference in favor of the experimental group versus the control group for systolic blood pressure ($p<.05$). ***	Significantly Positive
		No Sig difference between baseline and follow up for diastolic blood pressure in the control group ($p>.05$). ***	Non-Significant
		No Sig difference between baseline and follow up for diastolic blood pressure in the experimental group ($p>.05$). ***	Non-Significant
		No Sig difference between the control group versus the experimental group for diastolic blood pressure ($p>.05$). ***	Non-Significant
			Inconclusive / No Effect

Table 3 (continued)

Hinojosa et al., (2010) **USA** **Longitudinal** **QR:64.30%**	Secondary School 14-15 (No SD) 6,000 Schools (Total) 5,265,265 Pupils (Total) Aim: To conduct a state-wide examination of public schools and the school neighborhood as potential targets for environmental public health tracking to address childhood obesity.	**1. PE Curriculum** *Participation in typical PE class, Number of PE teachers per student.*	1.Obesity Calliper Test or Bioelectric Impedance or Portable Stadiometer and Medical Scale. 4 Years.	PE participation had sig effect on obesity in 9^{th} grade adolescents (p<.05). * Number of PE teachers per student had a sig effect on obesity in 9^{th} grade adolescents (p<.05). * PE participation had no sig effect on obesity in 7^{th} grade adolescents (p>.05). * Number of PE teachers per student had no sig effect on obesity in 7^{th} grade adolescents (p>.05). *	Significantly Negative Significantly Positive Non-Significant Non-Significant ______ **Inconclusive / No Effect**	
Hollis et al., (2016) **Australia** **RCT** **QR:65.20%**	Secondary School 13 (± 0.8) 10 Schools 956 Pupils/ 465 (Boys), 491 (Girls) Aim: To conduct a state-wide examination of public schools and the school neighborhood as potential targets for environmental public health tracking to address childhood obesity.	**1. PE Curriculum & Sports** *Participation in typical PE and sports program (Control).*	1. Weight 2. BMI 3.BMI Z Score Portable Digital Scale, Portable Stadiometer, WHO BMI Growth reference, 24 Months.	Sig difference between baseline and follow up for weight (p<.001), BMI (p<.001) and BMI Z Score (p<.0001) in the control group*	Significantly Negative ___ **Significantly Negative**	Intervention groups are not considered 'typical' PE in this study; therefore, they are excluded.
Kojic et al., (2022) **Serbia** **Intervention** **QR: 65%**	Secondary School 14.20 (± 0.50) 4 Schools 220 Pupils/ 108 (Boys), 112 (Girls) Aim: To investigate whether the implementation of an unstable surface strength exercise program in physical education would contribute to the improvement of physical fitness in 14-years students.	**1. PE Curriculum** *Participation in typical PE class, prescribed PE strength program (Control)* *Participation in typical PE class, strength training under unstable condition (Intervention)*	1.Subscapular Skinfold Thickness (ST) 2.Abdominal ST 3.Pectoral ST 4.Total ST 5.Push-Up 6.Sit Up 7.Dynamic Trunk 8.Trunk Lift Harpenden Skinfold Caliper, Repetitions. 12 Weeks.	No Sig difference between baseline and follow up for 3 in the control (p>.05) and experimental group. * Sig difference between baseline and follow up for 1 (p<.001, n^2 = .84), 2 (p=.010, n^2 = .26) and 4 (p=.001, n^2 = .34) in the control group. * Sig difference between baseline and follow up for 5 (p=.026, n^2 = 1.43), 6 (p<.001, n^2 = 1.57), 7 (p<.001, n^2 = 1.49), and 8 (p<.001, n^2 = 1.17) in the control group. **	Non-Significant Significantly Positive Significantly Positive Significantly Positive	The present results promote the use of unstable surface calisthenic exercises in trunk and upper-body movements to improve strength performance in adolescent boys and girls. From a morphological perspective, an unstable program does not appear to have additional effects in reducing risk factors for obesity (i.e., skinfold thickness).

Table 3 (continued)

				Sig difference between baseline and follow up for 1 (p<.001, n^2 = .85) and 4 (p=.001, n^2 = .31) in the experimental group. *	Significantly Positive	
				Sig difference between baseline and follow up for 2 (p=.026, n^2 = .20) in the experimental group. *	Significantly Positive	
				Sig difference between baseline and follow up for 5 (p<.001, n^2 = 1.35), 6 (p<.001, n^2 = 1.74), 7 (p<.001, n^2 = 1.26) and 8 (p<.001, n^2 = 1.20), in the experimental group. **	Non-Significant	
				No Sig group x time interaction effect for 1 (n^2 = .03), 2 (n^2 = .05) ,3 (n^2 = .01) and 4 (n^2 = .04) (p>.05). *	Significantly Positive	
				Sig group x time interaction effect for 5 (n^2 = .45), 6 (n^2 = .39), 7 (n^2 = .32), 8 (n^2 = .21) in favor of the experimental group (p<.01). **	**Significantly Positive**	
Laparidis et al., (2010) **Greece** **Intervention** **QR:56.50%**	Secondary School 13.47 (± 1.19) 7 Schools 317 Pupils/ 160 (Boys), 183 (Girls) Aim: To evaluate the effectiveness of a school-based program designed to reduce specific modifiable risk factors for preventing cardiovascular disease.	**1. PE Curriculum** *Participation in typical PE class (Control).* *Participation in typical PE class with a classroom theoretical component (Intervention)*	1.Weight 2.BMI 3.Systolic Blood Pressure 4.Diastolic Blood Pressure 5.One Mile Run 6.Curl Up 7.90° Push Up 8.Sit and Reach Test 9. Vo2 Max 10.Trunk Lift Automatic Digital Oscillometer, Repetitions Distance. 35 Weeks.	No Sig difference between baseline and follow up for 7, 8, 9 and 10 in the control group (p>.05). **	Non-Significant	The intervention appears to be effective in improving some risk factors for cardiovascular disease.
				No Sig difference between baseline and follow up for 2 in the control group (p>.05). *	Non-Significant	
				Sig difference between baseline and follow up for 1 in the control group (p<.05). *	Significantly Negative	
				Sig difference between baseline and follow up for 5 in the control group (p<.05). **	Significantly Negative	
				No Sig difference between intermediate and follow up for 8 and 9 in the control group (p<.05). **	Non-Significant	
				Sig difference between intermediate and follow up for 1 and 2 in the control group (p<.05). *	Significantly Negative	
				Sig difference between intermediate and follow up for 5, 7 and 10 in the control group (p<.05). **	Significantly Negative	
				Sig difference between baseline and follow up for 1 in the experimental group (P<.05). *	Significantly Negative	
					Significantly Positive	

Table 3 (continued)

				Sig difference between baseline and follow up for 2 in the experimental group (P<.05). *	Significantly Positive	
				Sig difference between baseline and follow up for 5,7,8,9 and 10 in the experimental group (P<.05). **	Significantly Negative	
				Sig difference between intermediate and follow up for 1 and 2 in the experimental group (P<.05). *	Significantly Negative	
				Sig difference between intermediate and follow up for 5 in the experimental group (P<.05). **	Significantly Positive	
				Sig difference between intermediate and follow up for 8 in the experimental group (P<.05). **	Non-Significant	
				No Sig difference between intermediate and follow up for 7,9 and 10 (p>.05). **	Non-Significant	
				No Sig differences between the control and experiment group for 1 and 2 at the intermediate and follow up measure (p>.05). *	Non-Significant	
				No Sig differences between the control and experiment group for 3 and 4 at the intermediate and follow up measure (p>.05). ***	Non-Significant	
				No Sig differences between the control and experiment group for 8 and 9 at the intermediate and follow up measure (p>.05). **	Non-Significant	
				Sig differences in favor of the experimental group versus the control group for 5,7 and 10 at the intermediate and follow up measure (p<.05). **	Significantly Positive	
				No Sig differences between the control and experiment group for 6 at the intermediate measure (p>.05). **	Non-Significant	
				Sig differences in favor of the experimental group versus the control group for 6 at follow up (p>.05). **	Significantly Positive	
					Inconclusive / No Effect	
Lo et al., (2017) **Taiwanese** **Cross-Sectional**	Secondary School 13-15 (No SD) NA 649,442 Pupils/ 337,077 (Boys), 312,365 (Girls)	**1. PE and Sport Facilities** *Sport field and gymnasium.*	1.BMI 2.Sit Ups 3.Standing Long Jump 4. Sit and Reach 5.800m-1,600m Run	Boys in schools with access to sports fields had sig lower BMI (p<.05). *	Significantly Positive	Findings demonstrated that school facility provision help shape adolescents' physical fitness in Taiwan. However, these
				Boys in schools with access to sports fields had sig better performance in 2,3 and 5 (p<.05). **	Significantly Positive	

Table 3 (continued)

QR:79%				Boys in schools with access to sports fields did not have sig lower/higher scores for the sit and reach test (p>.05). **	Non-Significant	association patterns differed by gender.
	Aim: To investigate the association of school environment with health-related physical fitness in Taiwanese adolescents.		Stadiometer, Balance Beam Scale, Repetitions, Distance, Measuring Scale.	Girls in schools with access to sports fields did not have sig lower/higher scores for BMI (p>.05). *	Non-Significant	
			NA	Girls in schools with access to sports fields had sig better performance in 2, 3 and 5 (p<.05). **	Significantly Positive	
				Girls in schools with access to sports fields had sig worse performance for the sit and reach test (p<.05). **	Significantly Negative	
				Boys in schools with gymnasiums had sig lower BMI (p<.05). *	Significantly Positive	
				Boys in schools with gymnasiums had sig better performance in 2,3 and 5 (p<.05). **	Significantly Positive	
				Boys in schools with a gymnasium did not have sig lower/higher scores for the sit and reach test (p>.05). **	Non-Significant	
				Girls in schools with gymnasiums did not have sig higher/lower BMI (p>.05). *	Non-Significant	
				Girls in schools with gymnasiums had sig better performance in 2,3 and 5 (p<.05). **	Significantly Positive	
				Girls in schools with gymnasiums had sig worse performance for the sit and reach test (p<.05). **	Significantly Negative	
					—— **Significantly Positive**	
Madsen et al., (2009) **USA** **Cross-Sectional** **QR:85.70%**	Secondary School NA 19 Schools 5357 Pupils/ 2564 (7th grade) 1282 (Boys), 1282 (Girls)/ 2793 (9th grade) 1424 (Boys), 1369 (Girls)	**1. PE Curriculum** *Participation in typical PE class, >20 min of PA in PE.*	1.BMI z-scores 2.1-mile run	Student groups reporting higher rates of active transport (to or from school) had higher average BMI z scores. *	Significantly Positive	PE, active transport and the use of school grounds outside of school hours can improve students' health and fitness and reduce BMI.
				Students reporting at least 20 minutes of exercise during PE tended to have lower BMI z scores (p=.13). *	Non-Significant	
	Aim: To identify physical activity opportunities linked to fitness and weight status among adolescents in low-income communities.	**2. PA** *Active transport to school, active transport from school, PA in school grounds but not during school hours.*	Portable Stadiometer, Digital Healthcare Scale	Using school grounds outside school hours was significantly associated with greater cardiovascular fitness (p=.02). **	Significantly Positive	
			NA	Walking to school did not have a sig association with greater cardiovascular fitness in the adjusted model (p=.07). **	Non-Significant	
					Significantly Negative	

Table 3 (continued)

				Stronger associations with cardiovascular fitness for seventh graders than for ninth graders. **	____ **Inconclusive / No Effect**	
Martinez-Lopez et al., (2012) **Spain** **Intervention** **QR:65.20%**	Secondary School 13.88 (± 1.44) 5 Schools 112 Pupils/ 49 (Boys), 63 (Girls) Aim: To determine the effect of a pedometer intervention on body fat and BMI levels in overweight teenagers.	**1. PE Curriculum** *Participation in typical PE class (Control).*	1.BMI 2.Body Fat % Multifrequency Tetrapolar Body Analyzer Dual System 12 Weeks.	No Sig difference between baseline and 6 week follow up for BMI in the control group (p>.05). * Sig difference between baseline and 12 week follow up for BMI in the control group (p<.01). * Sig difference between baseline and 12 week follow up for Body Fat % in the control group (p<.05). *	Non-Significant Significantly Negative Significantly Negative ____ **Significantly Negative**	Intervention groups are not considered 'typical' PE in this study; therefore, they are excluded.
McMurray et al., (2002) **USA** **Intervention** **QR:70%**	Secondary School 12.20 (± 0.10) 5 Schools 80 Pupils/ NA (Boys), NA (Girls) Aim: To determine the effect of increasing the aerobic component of the school's physical activity program and improving the knowledge about weight control and blood pressure on the blood pressure and body fat of early adolescents.	**1. PE Curriculum** *Participation in typical PE class (Control)* *Participation in typical PE class, aerobic activities (Intervention)*	1. Weight 2.BMI 3.Skinfold Thickness 4.Systolic Blood Pressure 5.Diastolic Blood Pressure 6. V02 Max Stadiometer, Balance Bean Scale, Skinfold Callipers, Random-Zero Mercury Sphygmomanometer 8 Weeks.	No Sig difference between the control and experimental group for weight (p>.05). * No Sig difference between the control and experimental group for BMI (p>.05). * No Sig difference between the control and experimental group for V02 Max (p>.05). ** Sig difference in favor of the experimental group versus the control group for skinfolds thickness (p<.001). * Sig difference in favor of the experimental group versus the control group for systolic blood pressure (p<.001). *** Sig difference in favor of the experimental group versus the control group for diastolic blood pressure (p-.0001). ***	Non-Significant Non-Significant Non-Significant Significantly Positive Significantly Positive Significantly Positive ________ **Inconclusive / No Effect**	
Muntaner & Palou (2017) **Spain** **Intervention**	Secondary School 15.85 (± 0.59) 1 School 466 Pupils/ NA (Boys), NA (Girls)	**1. PE Curriculum** *Participation in typical PE class (Control).*	1. Weight 2.BMI 3.Waist Circumference 4.Body Fat % 5.Standing Broad Jump 6.Speed Agility	No Sig difference between control and experimental groups for 1 (p=.438), 2 (p=.531) 3 (p=.337) and 4 (p=.691) at follow up. *	Non-Significant Non-Significant ____	The results showed that the students analyzed improved their body composition and some components of the

Table 3 (continued)

QR:52.30%	Aim: To examine the effects of a 2-month high-intensity interval training program implemented during PE classes at the level of compulsory secondary education on physical fitness in adolescents between 15- 16 years.	*Participation in typical PE class with a focus on high intensity interval training (Intervention)*	7.Handgrip Strength Test (R & L) 8.Aerobic Capacity Tanita Model BC-601 Scale, Ergonomic Metric Tape Seca 201, Analog Dynamometer, 4X10 Run Test, Beep Test. 16 Weeks.	No Sig difference between control and experimental groups for 5 (p=.156), 6 (p=.595), 7 (p=.124; L: p=.712) and 8 (p=.716) at follow up. **	**Inconclusive / No Effect**	physical condition, in a non-significant manner.
Neumark-Sztainer et al., (2003) **USA** **Intervention** **QR:60.80%**	Secondary School 15.40 (± 1.1) 6 Schools 201 Pupils/ 0 (Boys), 221 (Girls) Aim: To investigate the feasibility of an innovative school-based program for obesity prevention in adolescent girls.	**1. PE Curriculum** *Participation in typical PE class (Control).*	1.BMI Stadiometer and Calibrated Scales.	Mean BMI increased from postintervention (26.65) to follow up (26.98).*	Negative Direction/No Significant Test — **Negative Direction/ No Significance Test**	Intervention groups are not considered 'typical' PE in this study; therefore, they are excluded.
Perez et al., (2022) **Brazil** **Cross-Sectional** **QR: 71.40%**	Secondary School 14.68 (± 0.49) 1 School 25 Pupils/ 25 (Boys), 0 (Girls) Aim: To compare the cardiorespiratory response to exercise, by analyzing the maximum oxygen consumption (VO2 max), the ventilatory anaerobic threshold (VAT) and the respiratory compensation point (RCP) parameters, of adolescent boys participating only in PE or in PE and school sports (SS).	**1. PE Curriculum** *Participation in typical PE class.* **2. PE Curriculum & Sport** Participation in typical PE and school sports.	1.Weight 2.BMI 3.Fat % 4.V02 (mL.kg-1.min-1) 5.V02 (L.min-1) 6.% V02 Max 7. Respiratory Exchange Rate 8.Speed Electronic Scale, Skinfold Measurements, 12 Lead Electrocardiogram, Treadmill Ergometer, Cortex Metalyzer 3B Gas Analyzer	No Sig difference between the PE group and the PE + Sports group for 1 (p=.152), 2 (p=.255) and 3 (p=557). * No Sig difference between the PE group and the PE + Sports group for 5 (p=.466) and 7 (p=.948) in the maximum oxygen consumption parameter. ** Sig difference in favor of the PE + Sports group versus the PE group for 4 (p=.002) and 8 (p=.001) in the maximum oxygen consumption parameter. ** No Sig difference between the PE group and the PE + Sports group for 7 in the ventilatory anaerobic threshold parameter (p=.440) ** Sig difference in favor of the PE + Sports group versus the PE group for 4 (p=.001), 5 (p=.03) and 8 (p=.001) in the ventilatory anaerobic threshold parameter **	Non-Significant Non-Significant Significantly Positive Non-Significant Significantly Positive	

Table 3 (continued)

				No Sig difference between the PE group and the PE + Sports group for 6 (p=.182) and 7 (p=.499) in the respiratory compensation point parameter. **	Non-Significant
				Sig difference in favor of the PE + Sports group versus the PE group for 4 (p=.003) and 8 (p=.001) in the respiratory compensation point parameter. **	Significantly Positive
					Inconclusive / No Effect
Plevkova & Perackova (2019) **Slovakia** **Intervention** **QR:60.90%**	Secondary School 17.05 (± 0.32) 1 School 35 Pupils/ 0 (Boys), 35 (Girls) Aim: To extend the knowledge about the influence of strength and endurance circuit training intervention on body image of female high school students.	**1. PE Curriculum** *Participation in typical PE class (Control).* *Participation in typical PE class with a focus on strength and endurance circuit training (Intervention)*	1.BMI Digital Scale, Wall Height Measure.	Sig difference between baseline and follow up for BMI in the experimental group (p=.003). *	Significantly Positive
				No sig difference between baseline and follow up for BMI in the control group (p=.187). *	Non-Significant
					Inconclusive / No Effect
Trajkovic et al., (2020) **Serbia** **Intervention** **QR:61%**	Secondary School 15.70 (± 0.60) NA 54 Pupils/ 40 (Boys), 14 (Girls) Aim: To determine the effects of a school-based soccer program on physical fitness and aggression in adolescent students.	**1. PE Curriculum** *Participation in typical PE class (Control)* **2. PE Curriculum & Extracurricular Activities** *Participation in typical PE class in addition to X2 recreational soccer sessions after school (Intervention)*	1.Body Weight 2.BMI 3.Medicine Ball Throw 4.Vertical Jump 5.Cardiovascular Fitness Height, YoYo Test, Anthropometric Measurements. 32 Weeks.	Body weight increased from 65.1 (± 6.9) to 66.3 (± 6.6) from baseline to follow up in the control group. *	Negative Direction / No Significance Test
				Body weight increased from 66.4 (± 7.5) to 65.2 (± 5.8) from baseline to follow up in the experimental group. *	Negative Direction / No Significance Test
				Sig difference between baseline and follow up for vertical jump, medicine ball throw and cardiovascular fitness in the experimental group (p<.05). **	Significantly Positive
				No Sig difference between baseline and follow up for vertical jump and cardiovascular fitness in the control group (p>.05). **	Non-Significant
				Sig difference between baseline and follow up for medicine ball throw in the control group (p<.05). **	Significantly Negative
				No Sig group x time interaction effect for vertical jump (p=.067, n^2 = .032). **	Non-Significant
					Significantly Positive

Table 3 (continued)

				Sig group x time interaction effect for medicine ball throw (P<.0005, n^2 =.308) and cardiovascular fitness (P<.0005, n^2=.15) in favor of the experimental group. **	_____ **Inconclusive / No Effect**	
Weeks & Beck (2012) **Australia** **RCT** **QR:73.90%**	Secondary School 13.80 (± 0.40) 1 School 99 Pupils/ 46 (Boys), 53 (Girls) Aim: To determine the effect of twice weekly school based, 10-minute jumping regime on muscle and fat tissue in health adolescent boys and girls.	**1. PE Curriculum** *Participation in typical PE class (Control).* *Participation in typical PE class with a focus on jumping activities (Intervention)*	1.Weight 2.BMI 3.Lean Mass (g) 4.Fat Mass % 5.Fat Mass (g) 6.Grip Strength 7.Vertical Jump Digital Scales and Stadiometer, Densitometer, Yardstick. 8 Months.	**Girls and Boys** Sig difference between baseline and follow up for 1 and 2 in the control group and experimental groups (p<.01).* Sig difference between baseline and follow up for 3 and 4 in the control group and experimental groups (p<.05).* No Sig difference between baseline and follow up for 5 in the control group and experimental groups (p<.05). * No Sig difference between the control and experimental groups for 1, 2,4 and 5 at follow up (p>.05). * Sig difference in favor of the experimental group versus the control group for 3 at follow up (p<.01). * **Boys** Sig difference between baseline and follow up for 1 in the control and experimental groups for boys (p<.01). * Sig difference between baseline and follow up for 3 in the control group for boys (p<.05). * Sig difference between baseline and follow up for 6 and 7 in the control group for boys (p<.01). ** No Sig difference between baseline and follow up for 2 and 5 in the control group for boys (p>.05). * Sig difference between baseline and follow up for 3 and 5 in the experimental group for boys (p<.01). * Sig difference between baseline and follow up for 6 and 7 in the experimental group for boys (p<.01). ** No Sig difference between baseline and follow up for 2 in the experimental group for boys (p>.05). *	 Significantly Negative Significantly Negative Significantly Positive Significantly Positive Non-Significant Non-Significant Non-Significant Significantly Positive Significantly Negative Significantly Negative Significantly Positive Significantly Positive Non-Significant Significantly Positive Significantly Positive Non-Significant	Regular, short duration, jumping activity during adolescence increased lean tissue mass and boys additionally lost fat mass. Sex-specific and/or maturation-specific factors may explain the disparity in effect.

Table 3 (continued)

				No Sig difference between the control and experimental groups for 1,2,4 and 5 at follow up for boys (p>.05). *	Non-Significant	
				No Sig difference between the control and experimental groups for 6 and 7 at follow up for boys (p>.05). **	Non-Significant	
				Sig difference in favor of the experimental group versus the control group for 3 at follow up for boys (p<.05). *	Significantly Positive	
				Girls		
				Sig difference between baseline and follow up for 1 and 2 in the control and experimental groups for girls (p<.01). *	Significantly Negative Significantly Negative	
				Sig difference between baseline and follow up for 3 in the control and experimental groups for girls (p<.01). *	Significantly Positive Significantly Positive	
				Sig difference between baseline and follow up for 6 in the control and experimental groups for girls (p<.01). **	Significantly Positive Significantly Positive	
				No Sig difference between baseline and follow up for 5 in the control and experimental groups for girls (p>.05). *	Non-Significant Non-Significant	
				No Sig difference between baseline and follow up for 7 in the control and experimental groups for girls (p>.05). **	Non-Significant Non-Significant	
				No Sig difference between the control and experimental groups for 1,2,3,4 and 5 at follow up for girls (p>.05). *	Non-Significant	
				No Sig difference between the control and experimental groups for 6 and 7 at follow up for girls (p>.05). **	Non-Significant	
					Inconclusive / No Effect	
Weeks et al., (2008) **Australia** **RCT** **QR: 78.26%**	Secondary School 13.80 (± 0.40) 1 School 99 Pupils/ 46 (Boys), 53 (Girls) Aim: To determine the effect of twice weekly school based, 10-minute jumping regime on muscle	**1. PE Curriculum** *Participation in typical PE class (Control).* *Participation in typical PE class with a focus on jumping activities (Intervention)*	**Bone Health** 1.Broadbank Ultrasoud Attenuation 2.Femoral Neck BMC 3.Femoral Neck Area 4.Femoral Neck Bone Mineral Apparent Density	**Girls and Boys** Sig difference in favor of the experimental group versus the control group for 1,2,6,10 and 11 at follow up (p<.05). **** No Sig difference between the control and experimental groups for 3,4,5,7,8 and 9 at follow up (p>.05).****	Significantly Positive Non-Significant Significantly Positive	Ten minutes of jumping activity twice a week for 8 months during adolescence seems to improve bone accrual in a sex-specific manner.

Table 3 (continued)

and fat tissue in health adolescent boys and girls. ,	5.Femoral Neck Cross-Sectional Moment of Inertia 6.Trochanter BMC 7.Lumbar Spine BMC 8.Lumbar Spine Area 9.Lumbar Spine Bone Mineral Apparent Density 10.Lumber Spine Index of Bone Structural Strength 11.Whole Body BMC 12. Weight 13. BMI 14. Lean Mass 15. Fat Mass 16. Vertical Jump QUS-2 Ultrasound Densitometer, XR-36 Quickscan Densitometer, Stadiometer, Digital Scales, Yardstick. 8 Months.	Sig difference in favor of the experimental group versus the control group for 14 at follow up (p=.001). * No Sig difference between the control and experimental groups for 15 at follow up (p>.05). *	Non-Significant
		Boys Sig difference between baseline and follow up for 2,5,t6,7,8,9,10,11 in the control boys (p<.05).****	Significantly Positive
		No Sig difference between baseline and follow up for 1,3 and 4 in the control group for boys (p>.05).****	Non-Significant
		Sig difference between baseline and follow up for 12 in the control group for boys (p=.001). *	Significantly Negative
		No Sig difference between baseline and follow up for 13 and 15 in the control group for boys (p>.05). *	Non-Significant
		Sig difference between baseline and follow up for 14 in the control group for boys (p=.001). *	Significantly Positive
		Sig difference between baseline and follow up for 16 in the control group for boys (p=.01). **	Significantly Positive
		Sig difference between baseline and follow up for 1,2,3,5,6,7,8,9,10,11 in the experimental group for boys (p<.05).****	Significantly Positive
		No Sig difference between baseline and follow up for 4 in the experimental group for boys (p>.05).****	Non-Significant
		Sig difference between baseline and follow up for 12 in the experimental group for boys (p=.001). *	Significantly Negative
		No Sig difference between baseline and follow up for 13 in the experimental group for boys (p>.05). *	Non-Significant
		Sig difference between baseline and follow up for 14 (p=.001) and 15 (p=.02) in the experimental group for boys. *	Significantly Positive
		Sig difference between baseline and follow up for 16 in the experimental group for boys (p=.01). **	Significantly Positive
		Girls	

Table 3 (continued)

Sig difference between baseline and follow up for 7,8,10 and 11 in the control group for girls (p<.05).****	Significantly Positive
No Sig difference between baseline and follow up for 1,2,3,4,5,6 and 9 in the control group for girls (p>.05).****	Non-Significant
Sig difference between baseline and follow up for 12 (p=.001) and 13 (p=.002) in the control group for girls. *	Significantly Negative
Sig difference between baseline and follow up for 14 in the control group for girls (p=.001). *	Significantly Positive
No Sig difference between baseline and follow up for 15 in the control group for girls (p>.05). *	Non-Significant
No Sig difference between baseline and follow up for 16 in the control group for girls (p>.05). **	Non-Significant
Sig difference between baseline and follow up for 2,7,9,10 and 11 in the experimental group for girls (p<.05).****	Significantly Positive
No Sig difference between baseline and follow up for 1,3,4,5,6 and 8 in the experimental group for girls (p>.05).****	Non-Significant
Sig difference between baseline and follow up for 12 (p=.001) and 13 (p=.001) in the experimental group for girls. *	Significantly Negative
No Sig difference between baseline and follow up for 16 in the experimental group for girls (p>.05). **	Non-Significant
Sig difference between baseline and follow up for 14 in the experimental group for girls (p=.001). *	Significantly Positive
No Sig difference between baseline and follow up for 15 in the control group for girls (p>.05). *	Non-Significant
	Significantly Positive

Table 3 (continued)

Wong et al., (2008) **Singapore Intervention QR:65.20%**	Secondary School 14.00 (± 1.3) 1 School 24 Pupils/ 24 (Boys), 0 (Girls) Aim: The aim of this study to examine the effects of a 12-week twice weekly exercise training program which combined various forms of aerobic activities, resistance training, sports and games, and stair-climbing exercises, on aerobic fitness, body composition, serum C-reactive protein (CRP) and lipid profile in 13-to 14-year-old obese boys compared with a control group.	**1. PE Curriculum** *Participation in typical PE class (Control).* *Participation in typical PE class in addition to X2 exercise training sessions (Intervention).*	1.Weight 2.BMI 3.Fat % 4.Fat Mass 5.Systolic Blood Pressure 6.Diastolic Blood Pressure 7.Aerobic Fitness 8.Lean Mass Platform Bean Balance and Stadiometer, Dual Energy X-Ray Absorptiometry, Bicycle Ergometer. 12 Weeks.	Sig difference between baseline and follow up for 1 in the control group for (p<.05). *	Significantly Negative
				No Sig difference between baseline and follow up for 2, 3, 4 and 8 in the control group (p>.05). *	Non-Significant
				No Sig difference between baseline and follow up for 5 and 6 in the control group (p>.05). ***	Non-Significant
				No Sig difference between baseline and follow up for 7 in the control group (p>.05).**	Non-Significant
				No Sig difference between baseline and follow up for 1,3 and 4 in the experimental group (p>.05). *	Non-Significant
				Sig difference between baseline and follow up for 2 and 8 in the experimental group (p<.05). *	Significantly Positive
				No Sig difference between baseline and follow up for 6 in the experimental group (p>.05). ***	Non-Significant
				Sig difference between baseline and follow up for 5 in the experimental group (p<.05). ***	Significantly Positive
				No Sig difference between control and experimental groups for 4 and 8 at follow up (p>.05). *	Non-Significant
				Sig difference in favor of the experimental group versus the control for 1,2 and 3 at follow up (p<.05). *	Significantly Positive ____ **Inconclusive / No Effect**

Notes *Indicators of Adiposity, **Indicators of Physical Fitness, ***Blood Pressure****Bone Health

QR Quality Rating, *PE* Physical Education, *PA* Physical Activity, *G* Girls, *B* Boys, *WHO* World Health Organization

Significantly Positive = when 50% or more of the reported effects are significant and in positive direction, Significantly Negative = when 50% or more of the reported effects are significant and in a negative direction, Inconclusive/No Effect = when 50% of more of the reported effects were non-significant or when results were mixed (both positive and negative), No Significance Test = when the reported effects were not supported with a test of significance the direction of the effect whether positive or negative is indicated

Of the 23 intervention studies included, the impact summary indicated that 17% (n = 4 articles) were significantly positive (Dorgo et al., 2009; Faria et al., 2013; Kojic et al., 2022; Weeks et al., 2008), 65% (n = 15 articles) were inconclusive/no effect (Abdukic, 2015; Alonso-Fernandez et al., 2019; Ardoy et al., 2011; Bielec, 2008; Bielec et al., 2013; Costigan et al., 2015a; De Souza Santos et al., 2015; Giannaki et al., 2016; Laparidis et al., 2010; McMurray et al., 2002; Muntaner & Palou, 2017; Plevkova & Perackova, 2019; Trajkovic et al., 2020; Weeks & Beck, 2012; Wong et al., 2008), 13% (n = 3 articles) was significantly negative (Baquet et al., 2001; Hollis et al., 2016; Martinez-Lopez et al., 2012) and 4% (n = 1 article) demonstrated a negative direction but with no significance test (Neumark-Sztainer et al., 2003). Of the five cross-sectional studies, 66% (n = 3 articles) were significantly positive (Aphamis et al., 2015; Lo et al., 2017), while 33% (n = 1 article) was inconclusive/no effect (Madsen et al., 2009). Of the two longitudinal studies, 50% (n = 1 article) was significantly positive (Czarniecka et al., 2012) while 50% (n = 1 article) was inconclusive/no effect (Hinojosa et al., 2018). Table 3 provides an in-depth analysis of each outcome.

Indicators of Adiposity

Indicators of adiposity were identified in 100% of articles (n = 29), representing 51% (n = 137) of the total reported effects. Of this, 28% (n = 39 effects) were significantly positive, 45% (n = 62 effects) were non-significant, 24% (n = 33 effects) were significantly negative and 2% (n = 3 effects) indicated a negative direction but with no significance test. The bulk of the evidence was most prevalent in intervention studies (79%, n = 23 articles) (Abdukic, 2015; Alonso-Fernandez et al., 2019; Ardoy et al., 2011; Baquet et al., 2001; Bielec, 2008; Bielec et al., 2013; Costigan et al., 2015a; De Souza Santos et al., 2015; Dorgo et al., 2009; Farias et al., 2013; Giannaki et al., 2016; Hollis et al., 2016; Kojic et al., 2022; Laparidis et al., 2010; Martinez-Lopez et al., 2012; McMurray et al., 2002; Muntaner & Palou, 2017; Neumark-Sztainer et al., 2003; Plevkova & Perackova, 2019; Trajkovic et al., 2020; Weeks & Beck, 2012; Weeks et al., 2008; Wong et al., 2008), then cross-sectional studies (14%, n = 4 articles) (Aphamis et al., 2015; Lo et al., 2017; Madsen et al., 2009; Perez et al., 2022) and longitudinal studies (7%, n = 2 articles) (Czarniecka et al., 2012; Hinojosa et al., 2018). When analyzed by study design, the frequency of reported effects indicated that 89% (n = 122 effects) occurred in intervention studies, 6.5% (n = 9 effects) in cross-sectional studies and 4% (n = 6 effects) in longitudinal studies. Of the intervention studies, the reported effects indicated that 29% (n = 35 effects) were significantly positive, 45% (n = 55 effects) were non-significant and 24% (n = 29 effects) were significantly negative and 2% (n = 3 effects) indicated a negative direction but with no significance test. Of the cross-sectional studies, the reported effects indicated that 33.3% (n = 3 effects) were significantly positive, 55.5% (n = 5 effects) were non-significant and 11% (n = 1 effects) were significantly negative. Of the longitudinal studies, the reported effects indicated that 17% (n = 1 effects) were significantly positive and 33% (n = 2 effects) were non-significant and 50% (n = 3 effects) were significantly negative.

Indicators of Physical Fitness

Indicators of physical fitness were identified in 72% of articles (n = 21), representing 40% (n = 108) of the total reported effects with a quality assessment score of 67% (fair). Of this, 35% (n = 38 effects) were significantly positive, 56% (n = 61 effects) were non-significant and 8% (n = 9 effects) were significantly negative. The bulk of the evidence was most prevalent in intervention studies (76%, n = 16 articles) (Alonso-Fernandez et al., 2019; Ardoy et al., 2011; Baquet et al., 2001; Bielec, 2008; Costigan et al., 2015a; De Souza Santos et al., 2015; Dorgo et al., 2009; Giannaki et al., 2016; Kojic et al., 2022; Laparidis et al., 2010; McMurray et al., 2002; Muntaner & Palou, 2017; Trajkovic et al., 2020; Weeks & Beck, 2012; Weeks et al., 2008; Wong et al., 2008), then cross-sectional studies (19%, n = 4 articles) (Aphamis et al., 2015; Lo et al., 2017; Madsen et al., 2009; Perez et al., 2022) and longitudinal studies (5%, n = 1 article) (Czarniecka et al., 2012). When analyzed by study design, the frequency of reported effects indicated that 76% (n = 82 effects) occurred in intervention studies, 20% (n = 22 effects) in cross-sectional studies and 4% (n = 4 effects) in longitudinal studies. Of the intervention studies, the reported effects indicated that 49% (n = 40 effects) were significantly positive, 39% (n = 32 effects) were non-significant and 12% (n = 10 effects) were significantly negative. Of the cross-sectional studies, the reported effects indicated that 54.5% (n = 12 effects) were significantly positive, 32% (n = 7 effects) were non-significant and 14% (n = 3 effects) were significantly negative. Of the longitudinal studies, the reported effects indicated that 100% (n = 4 effects) were significantly positive.

Blood Pressure

Blood pressure was identified in 14% of articles (n = 4), representing 5% (n = 13) of the total reported effects with a mean quality assessment score of 66.5% (fair). Of this, 38% (n = 5 effects) were significantly positive and 62% (n = 8 effects) were non-significant. There were zero significantly negative effects when examining the impact of typical school provision of physical education, physical activity and sports on adolescent blood pressure. The evidence was most prevalent in intervention studies (100%, n = 4 articles) (Giannaki

Fig. 2 Frequency of Reported Effects by Outcome

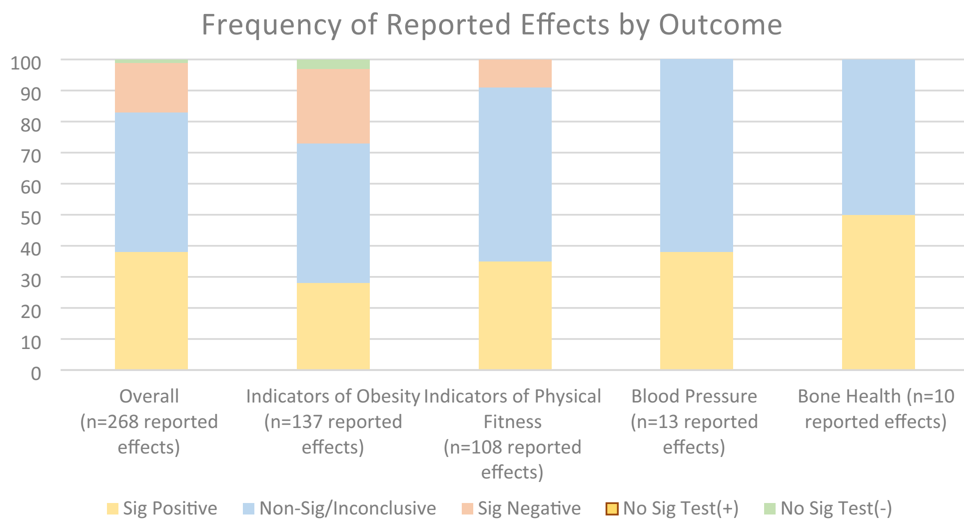


Fig. 3 Frequency of Reported Effects by Study Design

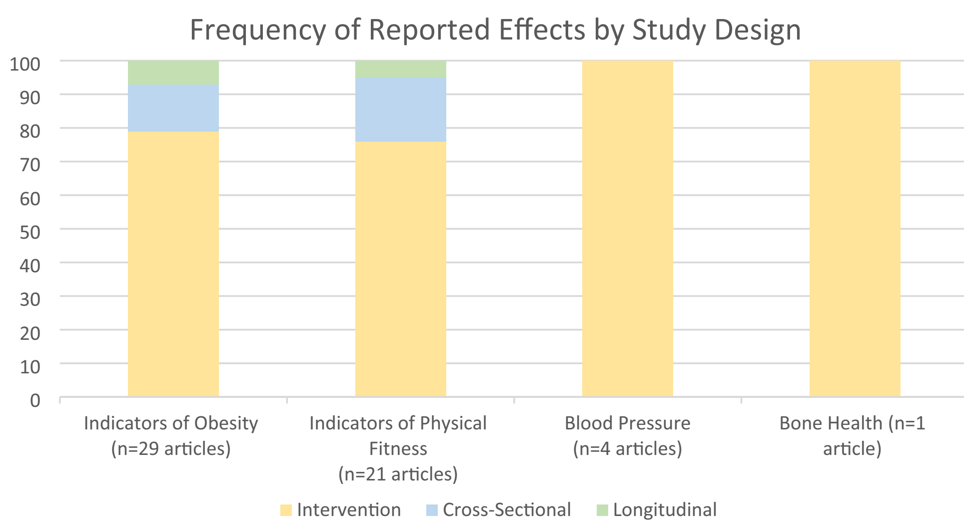
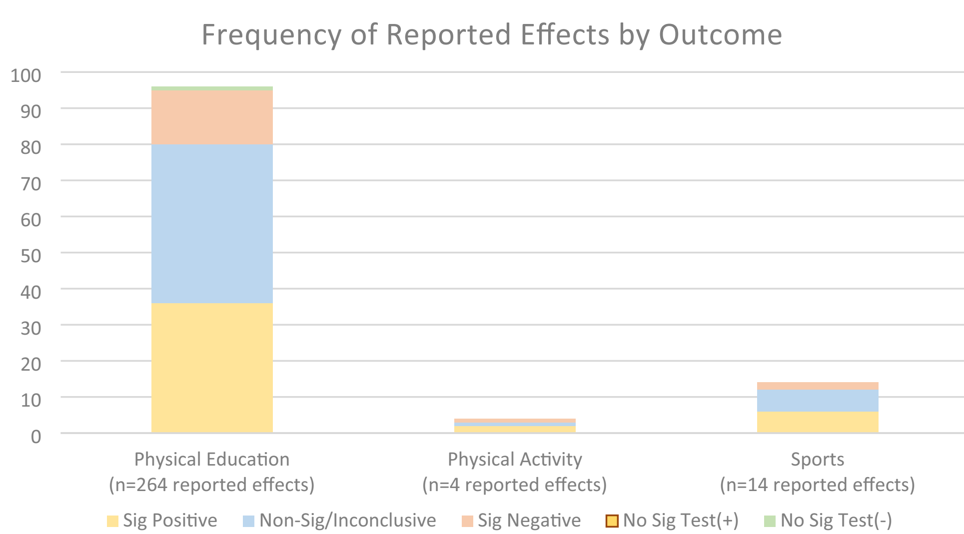


Fig. 4 Frequency of Reported Effects by School Exposure



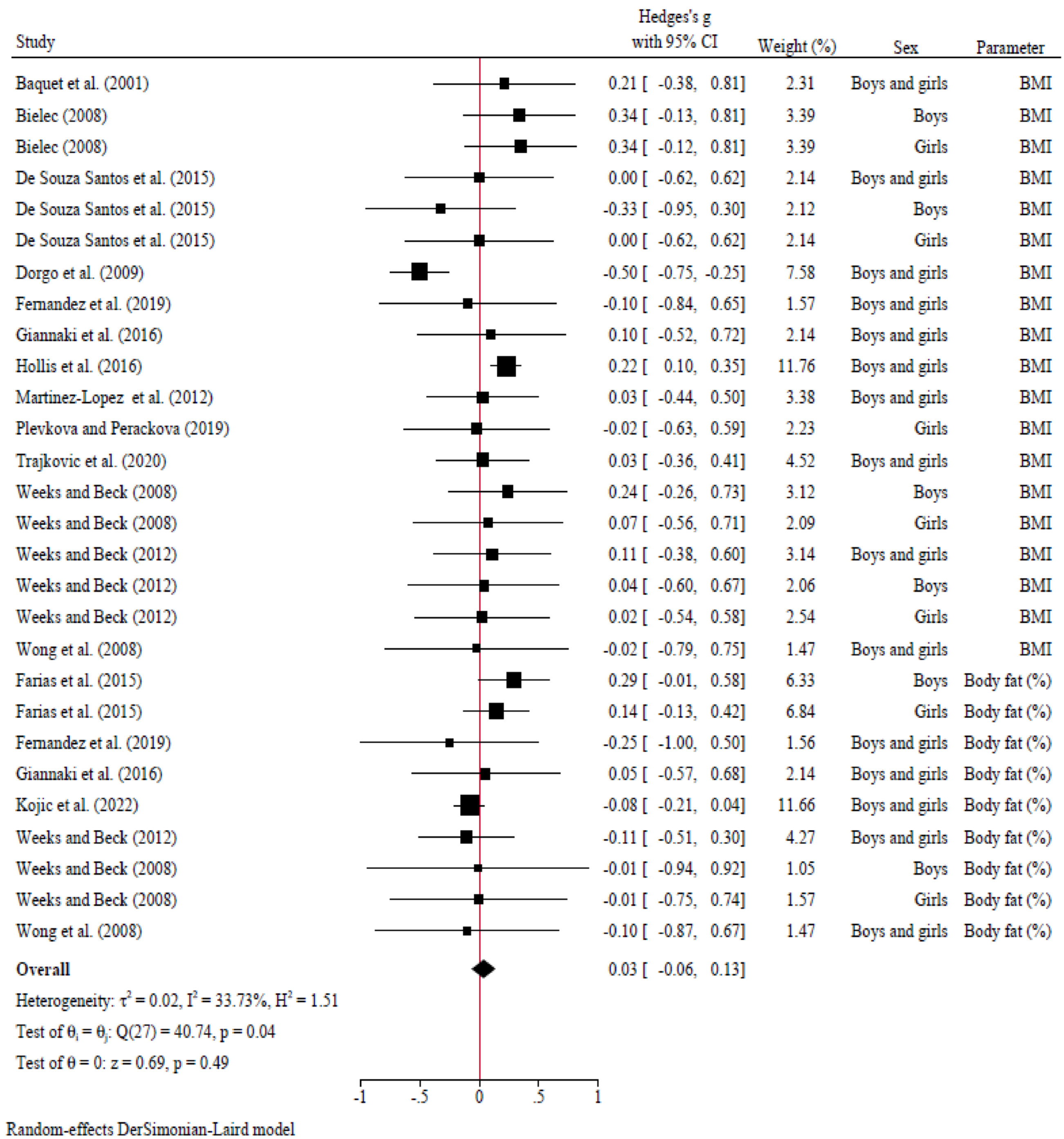


Fig. 5 Forest plot showing the effects sizes (Hedges's *g*) of typical school physical education, physical activity and sports on indicators of adiposity in the control groups

et al., 2016; Laparidis et al., 2010; McMurray et al., 2002; Wong et al., 2008). There were no cross-sectional or longitudinal study designs for this outcome.

Bone Health

Bone health was identified in 3% of articles (n = 1), representing 4% (n = 10) of the total reported effects with a quality assessment score of 78% (good). Of this, 50% (n = 5 effects) were significantly positive and 50% (n = 5 effects)

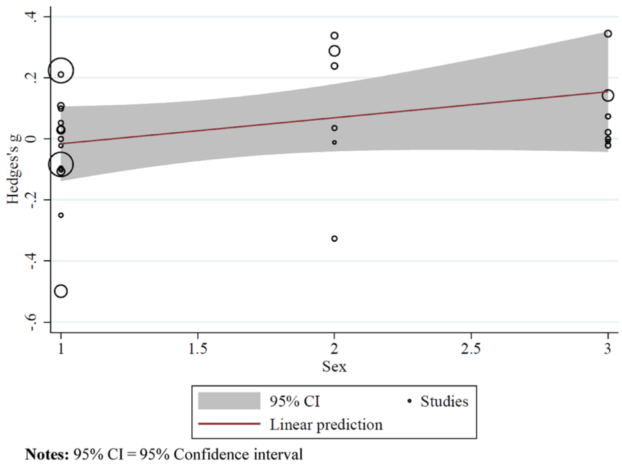


Fig. 6 Association between the effect on the control groups and the gender of the participants. Notes: 95% CI 95% Confidence interval

Table 4 Indicators of Adiposity subgroup analyses in the control groups

Variables	*n*	Hedges's *g* with 95% CI	*p* for subgroup analyses
Body mass index	13	0.04 (−0.10, 0.18)	0.610
Body fat (%)	7	−0.01 (−0.11, 0.09)	0.830

95% CI 95% Confidence interval; $p = < .05$

were non-significant. There were zero significantly negative effects when examining the impact of typical school provision of physical education, physical activity and sports on adolescent bone health. The evidence was underpinned by a randomized control trial study design (Weeks et al., 2008). There were no cross-sectional or longitudinal study designs for this outcome. Figures 2, 3 and 4 illustrate the frequency of reported effects by outcome, study design and exposure.

Meta-Analysis

Control Groups

Figure 5 reports the effect sizes of typical school provision of physical education, physical activity, and sports on indicators of adiposity in the control groups. The effect sizes in the control groups for the indicators of adiposity were ($g = 0.03$ (95% CI [−0.06, 0.13], $p = 0.49$, $I^2 = 33.73\%$), indicating a low non-significant effect. Sensitivity analysis revealed that there were no outlier studies of influential power (Appendix D). Neither the funnel plot nor the Egger's test showed a significant publication bias for adiposity ($Z = -0.43$, $p = 0.670$) (Appendix E). Random effects meta-regression analysis found that gender for the control groups was not associated with significant changes in adiposity ($\beta = 0.09$; $p = 0.169$) (Fig. 6). Table 4 reports the subgroup analysis for BMI and body fat percentage and illuminated no significant results.

Experimental Groups

Figure 7 reports the effect sizes of typical school provision of physical education, physical activity and sports on indicators of adiposity in the experimental groups with minor modifications to typical school provision. The effect sizes of the experimental groups for the indicators of adiposity were ($g = -0.11$ [95% CI −0.22, −0.01], $p = 0.04$, $I^2 = 32.49\%$), indicating a significant decrease in indicators of adiposity. Sensitivity analysis found no outlier studies of influential power (Appendix D). Regarding publication bias for adiposity, although the funnel plot demonstrated an asymmetric distribution, the Egger's test found this not to be significant ($Z = 0.88$, $p = 0.337$) (Appendix E). Random effects meta-regression analysis found that gender for the experimental groups was not associated with significant changes in adiposity ($\beta = 0.06$; $p = 0.233$) (Fig. 8). Subgroup analyses found no significant changes in BMI, however, for body fat percentage significant changes were found ($g = -0.28$ [95% CI −0.49, −0.06], $p < 0.01$) (Table 5).

Discussion

Adolescent physical activity for health is a public health priority. Policy development and financial investment advocate for typical school provision of physical education, physical activity and sports as a primary vehicle to effect change in the status of adolescent health and decrease global health costs (Australian Department of Health, 2021; ISPAH, 2020; World Health Organization, 2018). Much of the extant literature addresses the impact of physical activity outside of school on adolescent health (Biddle & Asare, 2011; Sirico et al., 2018), however further strategies are required to supplement this. By systematically analyzing, categorizing, assessing and meta-analyzing the impact of typical school provision of physical education, physical activity and sports, the authors aimed to address this gap in the literature. Twenty-nine articles of fair quality were examined. The overarching evidence indicates that minor modifications to typical school provision of physical education, physical activity and sports may have a significant impact on adolescent physical health outcomes. Literature advocates for a whole school approach to physical activity, including physical education, physical activity and sports. However, the current review suggests that there are gaps between policy and practice, as the additive impact of physical education,

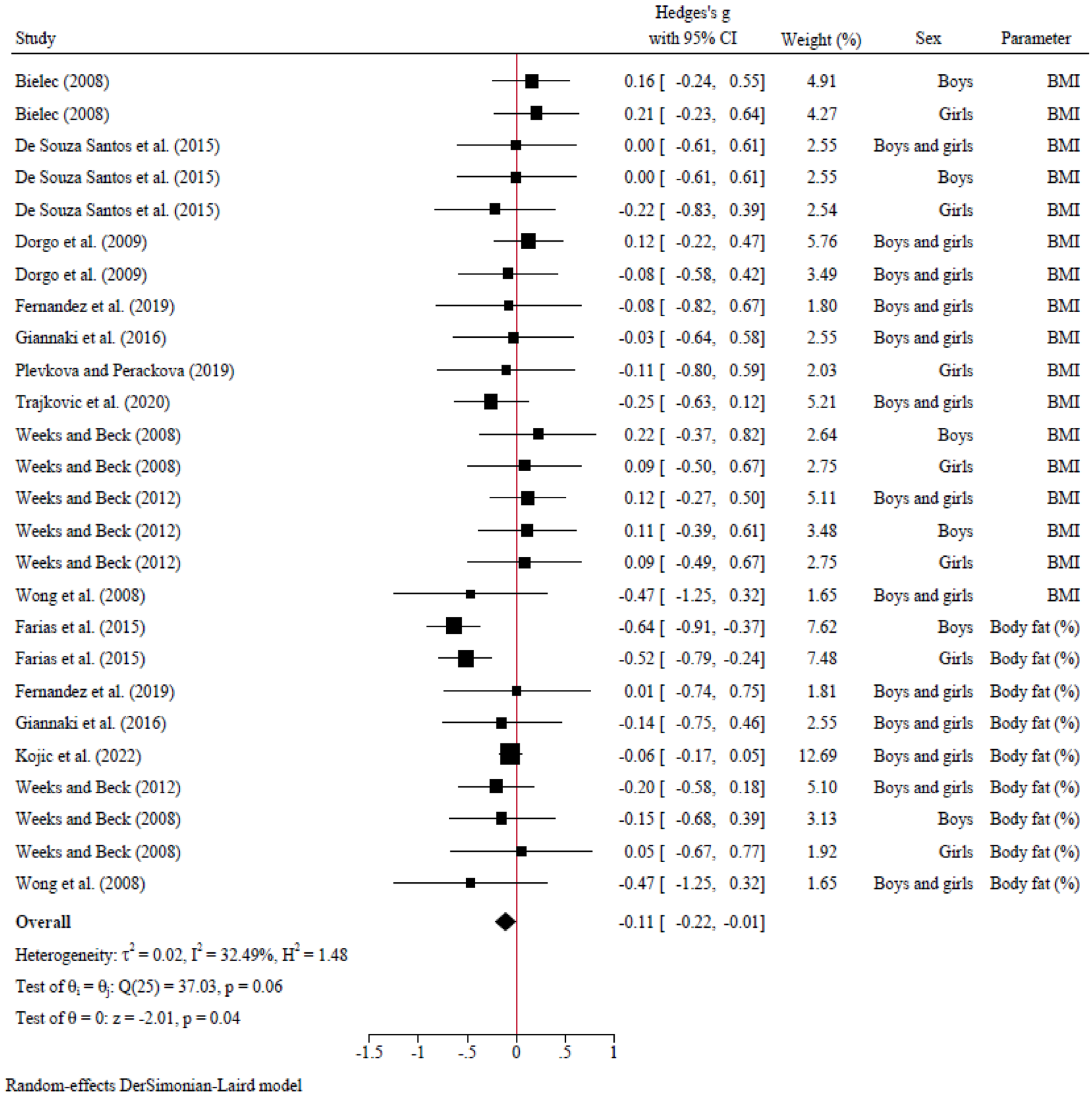


Fig. 7 Forest plot showing the effects sizes (Hedges's *g*) of typical school provision of physical education, physical activity and sports with minor modifications on indicators of adiposity for experimental groups

physical activity and sports was seldom examined. Accordingly, future research may consider this additive impact. A considerable bulk of the evidence illuminating the impact of typical school provision of physical education, physical activity and sports on adolescent physical health outcomes were deemed significantly positive or non-significant. There were few significantly negative effects. A notable proportion of the significantly positive effects pertained to intervention studies with minor modifications to typical school provision. Of the non-significant effects with minor modifications to existing provision, these were often found to slow the decline in indicators of physical fitness and bone health and slow the increase in indicators of indicators adiposity and blood pressure. Therefore, it may be hypothesized that modifications to typical school provision, even relatively minor modifications, may have a significant impact on adolescent physical health. Robust examples of best practices are illuminated below.

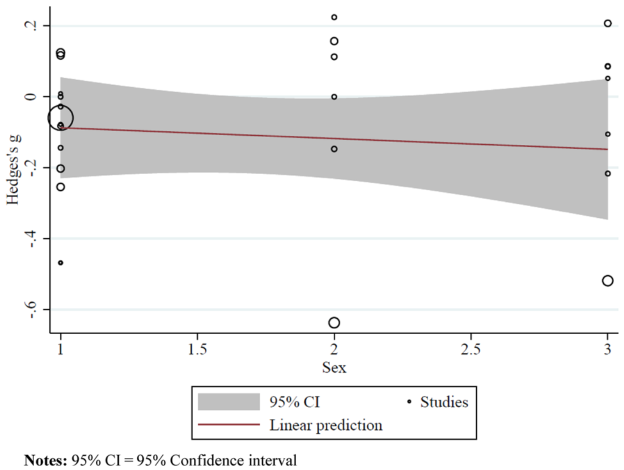


Fig. 8 Association between the effect on the experimental groups and the gender of the participants. Notes: 95% CI 95% Confidence interval

Table 5 Indicators Adiposity subgroup analyses in the experimental groups

Variables	*n*	Hedges's *g* with 95% CI	*p* for subgroup analyses
Body mass index	10	0.02 (−0.10, 0.15)	0.650
Body fat (%)	7	−0.27 (−0.48, −0.06)	< 0.01

95% CI 95% Confidence interval; $p = <.05$

Impacts on Indicators of Adiposity

Examining indicators of adiposity is pertinent as they are often negatively correlated with an array of components of health (Montague & Rahilly, 2000). The extant evidence indicated a mix of non-significant, significantly positive and significantly negative effects when examining the impact of typical school provision of physical education, physical activity and sports on indicators of adiposity. Data pertaining to a host of variables (e.g., body mass index, obesity, weight, body fat %, lean mass and skinfold thickness) were found in each of the 29 included articles. There is accumulated evidence suggesting that individual components of typical school provision of physical education, physical activity and sports does not sufficiently impact indicators of adiposity in adolescents, with 70% of the significantly negative effects found in non-intervention studies or control groups in intervention studies without minor modifications to typical school provision. The significantly negative effects in this context emphasize the failure of typical physical education, physical activity and sports provision, without minor modifications, to impact or even slow the grade related increase of indicators of adiposity. Comparatively, a total of 72% of the significantly positive effects were yielded from experimental groups with minor modifications to typical school provision (e.g., swimming classes, cardiorespiratory exercise program, physical activity with heart rate monitoring and circuit training), confirmed by the meta-analytical findings. This is consistent with a systematic review and meta-analysis by Liu and colleagues (2019) among a plethora of recent, relevant literature (Bleich et al., 2018; Katz et al., 2008; Xu et al., 2015) that illuminates the effective properties associated with school-based interventions that solicit modifications to typical school provision to positively impact indicators of adiposity.

While it is acknowledged that some of the interventions in Lie et al. (2019) are considered outside the realms of minor modifications to typical school provision, the evidence highlights the opportunities to potentiate positive impact in schools through the incorporation of subtle alterations to typical school provision as found in the meta-analytical subgroup findings on body fat percentage. Therefore, future research may consider examining a middle ground between interventions with minor modifications to typical school provision that do not pivot from the national curriculum, available resources and school ethos and major modifications to typical school provision that allow sufficient opportunities to potentiate positive impact. Comparatively, it is noteworthy that a meta-analysis conducted by Harris et al. (2009) yielded inconclusive results regarding the impact of school-based physical activity interventions on adolescent BMI, a finding that aligns with the outcomes observed in the meta-analytical subgroup findings on BMI. Experts in the field suggest that inconsistent findings concerning adolescent indicators of adiposity may be due to the use of a variety of alternative anthropometric methodological assessments and indices to determine levels of obesity in adolescent populations (Hills et al., 2011; Karnik & Kanekar, 2012; Reilly et al., 2006). In addition, this phase of life encompasses many physiological adaptations in adolescents pertaining to height and weight. Therefore, the maturation stage of the adolescent particularly where longitudinal studies are concerned, may play a pivotal role in some of these inconsistencies (Saha et al., 2011).

While it is acknowledged that many of the non-significant experimental groups slowed the grade related decline of indicators of adiposity in comparison to the control groups, further research is required to confirm these findings. Exposure to aerobic and/or resistance/strength training are often cited as primary vehicles to reduce adiposity in the literature (Alberga et al., 2016; Keating et al., 2017; Willis et al., 2012; Wewege et al., 2022). The nature of the exposures in the current study attest to this with outcome variables pertaining to high intensity interval training (HIIT), circuit training, cardiorespiratory exercise, jumping activities that are embedded into the typical physical education class and/or active transport to school, all yielding significantly positive effects on biomarkers of adiposity in adolescents. It is noteworthy, that there is a universal consensus regarding low engagement in active transport to schools (Brazo-Sayavera et al., 2023; Deakin University and Hesketh, 2022; Edwards et al., 2018; ParticipACTION, 2022) while the benefits of active transport to school are rarely promoted (Rocliffe et al., 2023a). Therefore, fostering a school ethos that both supports active transport to schools and embeds components of aerobic and/or resistance/strength training into the typical physical education class may be a viable strategy to impact indicators of adiposity in adolescents. Such effects would likely be even greater if combined (i.e., physical education, physical and sports), the additive impact of which is rarely examined in the current study.

When examining the impact of typical school provision of physical education, physical activity and sports on indicators of adiposity according to gender, the present study found no significant differences in boys and girls. In contrast, the intervention study by Weeks and Beck (2012) revealed notable losses in fat mass for boys when exposed to minor modifications to typical physical education provision that included jumping activities in comparison to girls. Moreover, it should be noted that the results for the control group, without the implementation of jumping activities, were non-significant, suggesting that minor modifications to typical school provision such as this may be pertinent to impacting biomarkers of adiposity, particularly in boys. Similarly, a randomized controlled trial that integrated swimming classes into typical school provision of physical education found significantly positive effects for reduced weight and body mass index in comparison to a typical physical education control group for adolescent boys (Bielec et al., 2013). This is consistent with an intervention study according to Knopfli (2008) consisting of a physical activity program (ball games, water games and hiking) that found a significantly more pronounced impact on weight loss in obese boys than girls. However, longitudinal studies are required to corroborate these findings as a suitable strategy to combat indicators of adiposity in the long-term. The aforementioned gender differences are hypothesized to occur due to overall greater compliance with physical activity by boys (Guthold et al., 2020; Woods et al., 2023) and a lower metabolic rate in adolescent girls (Yang et al., 2021). Therefore, although many of the interventions with a minor modification to typical school provision in the current study prescribed the same dose of physical activity to both girls and boys, future studies may take into consideration both differing metabolic rates in boys and girls and the use of heart rate monitors to measure perceived exertion (Lagally et al., 2016). Interestingly, a cross-sectional study in the current review, of over 600,000 participants, found that adolescent boys were more likely to report reduced body mass index in comparison to girls when exposed to schools with a sports field and/or a gymnasium (Lo et al., 2017). This is a consistent finding in the literature (Limstrand & Rehrer, 2008), hypothesized to occur due to girls favoring playground spaces and boys preferring facilities designed specifically for sport (Schmidt et al., 2004; Sallis et al., 2001). Therefore, public health policies aimed at ensuring that school facilities are attractive to both boys and girls may be beneficial. Despite this evidence, longitudinal studies are required to combat long-term indicators of adiposity.

Impacts on Indicators of Physical Fitness

Flexibility

Flexibility in adolescent populations may be linked to a variety of health outcomes (Institute of Medicine, 2013). The current study highlighted favorable patterns associated with sit and reach scores when exposed to a minor modification to typical physical education provision that saw the addition of a theoretical component (health and diet) in comparison to a non-theoretical component control group (Laparidis et al., 2010). Similar findings indicated significantly positive effects when adjusting physical education class time from two sessions weekly (control group) to four sessions weekly (intervention group) on adolescent flexibility (Ardoy et al., 2011). This is consistent with literature regarding the positive effects of additional physical education time on adolescent flexibility (Kain et al., 2004). However, contrasting, studies that included alternate exposures, such as additional active recess time and greater intensity in physical education classes, found non-significant differences (Baquet et al., 2001; Katz et al., 2010). Therefore, further research is warranted. There is a lack of research investigating differences in flexibility between boys and girls. Of the evidence that did, non-significant gender differences were found over a 10-week period (Baquet et al., 2001). It is noteworthy that the study in question examined the effects of games in physical education classes without the implementation of a minor modification to typical school provision. These findings are inconsistent with a meta-analysis of 15 studies that examined gender differences and found that girls scored higher than boys for sit and reach tests (Catley & Tomkinson, 2013) among other research findings (Tomkinson et al., 2018). While the current study previously revealed a positive relationship between school facilities (sports field and/or gymnasium) on adolescent indicators of adiposity, particularly in boys, this was not the case when examining the effects on adolescent flexibility, which were found to be non-significant in boys and significantly negative in girls (Lo et al., 2017). Thus, renewed strategies that consider minor modification to existing physical education provision or the additive impact of multiple components of school physical activity (e.g., active recess) and sports (e.g., team-based invasion games) may be impactful.

Musculoskeletal Fitness

Musculoskeletal fitness comprises muscular strength, endurance, and power (Institute of Medicine, 2013). Empirical evidence indicates the positive correlation between muscular strength, endurance and power and indicators of adolescent health (Garcia-Hermoso et al., 2019; Ortega et al., 2012; Smith et al., 2014; Yang et al., 2019). Furthermore, many positive indicators of adolescent health track from adolescence into adulthood illuminating the potential to reduce worldwide health costs (Hayes et al., 2019). Therefore, investigation into potential positive typical school provision of physical education, physical activity and sports exposures to impact adolescent muscular strength, endurance and power during this phase of life is a worthwhile endeavor. Muscular strength defines the "ability to exert force on an external object or resistance" (Suchomel et al., 2016, p. 1420), while muscular endurance is "the ability to sustain a given level of force over time" (Strand et al., 2014, p. 94). In the context of muscular strength/endurance, the current study indicated positive interactions when examining the impact associated with a number of exposures via physical education classes (e.g., games, cardiovascular endurance training, calisthenic/resistance exercises, circuit training, strength training, implementation of a theoretical component to physical education classes, jumping activities and availability of a sports field and/or gymnasium (Baquet et al, 2001; Czarniecka et al., 2012; Dorgo et al., 2009; Giannaki et al., 2016; Kojic et al., 2022; Laparidis et al., 2010; Lo et al., 2017; Weeks & Beck, 2017). Additional physical education classes were also considered (Aphamis et al., 2015; Ardoy et al., 2011).

Handgrip strength is considered one of the most valid measures of muscular strength (Artero et al., 2012; O' Keeffe et al., 2020). However, schools often have limited access to equipment that pertains to handgrip strength measures. Therefore, a broad range of outcome measures associated with both muscular strength and endurance were included in the current study (e.g., sit ups, push-ups, bent arm hangs, curl ups, trunk lifts etc.). Unlike many of the other variables in the current study, positive interactions with muscular strength/endurance were associated with both typical school provision of physical education with and without minor modifications. Similar to speed/agility (discussed below), the most marked effects occurred when adolescents were exposed to calisthenic exercises during physical education classes (e.g., push-ups, plank holds on stable and unstable surfaces) (Kojic et al., 2022). An intervention study that saw the implementation of calisthenic exercises on stable surfaces (control) and unstable surfaces (experiment) reported significantly positive effects for both control and intervention groups on components of muscular strength/endurance (push-ups, sit ups, trunk lift) (Kojic et al., 2022). Furthermore, an intervention consisting of resistance training (experiment) implemented into physical education class saw significantly positive effects for curl up, trunk lift, push-ups, flexed arm hang and modified pull up in both control and intervention groups (Dorgo et al., 2009). In addition, typical physical education provision in accordance with the Polish curriculum, over a three-year period, without a minor modification, was found to have significantly positive effects on handgrip strength, bent arm hand and sit ups (Czarniecka et al., 2012). The increase in muscular strength/endurance illuminated in these studies is considered an interesting adaptation as "high levels of neuromuscular fitness…present an inverse association with visceral adiposity, and cardiovascular and metabolic risk, in addition…to bone health and self-esteem" and therefore underpin physical education, in accordance with the curriculum, as a viable strategy to potentiate positive impact on adolescent muscular strength/endurance among other key indicators of physical health (Smith et al., 2014, p. 60). However, it must be noted that maturation rate for adolescents accelerates during this phase of life and may be accountable for some of the marked longitudinal effects (Baxter-Jones, 2013).

Unlike flexibility, the presence of a school sports field and gymnasium was found to have significantly positive effects on the number of bent leg sit ups in both boys and girls in comparison to schools without a sports field and/or gymnasium (Lo et al., 2017). Comparatively, sit up scores were found to be non-significant in both boys and girls when exposed to a typical program of games (e.g., handball, badminton) in physical education (Baquet et al., 2001). Some of the disparities pertaining toward muscular strength/endurance indicators may be due to the dearth of longitudinal study designs that measure cause and effect and should be considered in future research. Interestingly, of the non-significant effects, additional physical education time (X4 sessions weekly) were found to have non-significant effects on muscular strength/endurance (Ardoy et al., 2011). While there is limited evidence that focuses on the effects of additional physical education classes on muscular strength/endurance, this finding is consistent with an intervention study that increased the provision of physical education classes from two to four sessions weekly over a three-year period that observed no differences between control and intervention groups for muscular strength/endurance (Sollerhed & Ejlertsson, 2007). Contrastingly, a study that embedded physical activity during recess and in between classes were found to have significantly positive effects on muscular strength/endurance (Katz et al., 2010), further illuminating the potential effect of additive components of provision in schools to supplement physical education, such as active recess and active classroom breaks.

Muscular power is defined as peak force of the skeletal muscle by the velocity of the muscle contraction (Institute of Medicine, 2012). Standing long jump is considered one of the most valid field-based tests for muscular power (Artero et al., 2012). Similar to muscular strength and endurance, schools have varied access to equipment that pertains to muscular power measurements. Therefore, a plethora of outcome measures pertaining to muscular power were found in the current study (e.g., vertical jump, standing broad jump, standing long jump and medicine ball throw). While an abundance of evidence exists to support the positive impact of physical activity outside of school on muscular power (Georges et al., 2014; Ibrahim et al., 2018; Jager et al., 2016), further research is warranted within the school context. Once more, some of the evidence gleaned from the current study suggests that typical physical education provision alone, without a minor modification, often fails to impact adolescent muscular power. Participation in physical education classes that infused calisthenic exercises (de Souza et al., 2015) or circuit training (Giannaki et al., 2016) over 8–12 weeks were found to have significantly positive effects on horizontal and vertical jumps in comparison to typical school provision control groups without minor modifications. Although, it is understood that resistance exercises and HIIT training can induce muscular power (Alcaraz et al., 2011; Arazi & Asadi, 2012), the current study found non-significant effects for both resistance exercises and HIIT in school on muscular power (Costigan et al., 2015a; Muntaner & Palou, 2017). However, it is hypothesized that this may be explained due to limited power in the sample size. This is consistent with a systematic literature review and meta-analysis of 20 studies that found non-significant overall effects for HIIT on muscular fitness (e.g., vertical jump) (Costigan et al., 2015b). Interestingly, when comparing girls with boys, the current study found that a minor modification to typical school provision of physical education classes that included jumping activities (e.g., jumping jacks, star jumps, skipping) to have significantly positive effects on boys compared to girls (Weeks & Beck, 2012). However, the study considered that "as boys were closer to peak height velocity, and thus growing more rapidly than girls, this finding is not unexpected" (Weeks & Beck, 2012, p. 202). It is noteworthy that schools with a sports field and gymnasium had significantly positive effects on standing long jump in both adolescent boys and girls (Lo et al., 2017). Therefore, ensuring access to the aforementioned facilities even outside schools' hours, could be considered a viable strategy to impact adolescent muscular power and in turn adolescent physical health (Smith et al., 2014).

Cardiovascular Fitness

Cardiovascular fitness is the most researched variable within health-related physical fitness (Armstrong et al., 2011) and is commonly recognized as a predictor of future health (Harber et al., 2017; Hogstrom et al., 2015; Schmidt et al., 2016) and mitigating factor to reduce obesity (Ruiz et al., 2009) and metabolic diseases (Bailey et al., 2005), among a range of outcomes associated with the current study (e.g., bone health, blood pressure, musculoskeletal fitness) (Chen & Wang, 2008). Cardiovascular fitness is defined as "the capacity of the circulatory and respiratory systems to supply oxygen to skeletal muscle mitochondria for energy production needed during physical activity" (Raghuveer et al., 2020, p. 101) and is often referred to aerobic capacity/fitness or cardiorespiratory endurance (Armstrong et al., 2011). The extant evidence indicated a mix of significantly positive, non-significant and significantly negative effects on cardiovascular fitness via a range of outcome variables pertaining to V02 max, 12-min cooper swim test and various running tests such as the one-mile run, 7-min run and 800 m-1,600 m run. Once more, the evidence suggests that typical school provision of physical education, physical activity and sports without the supplementation of a minor modification does not sufficiently impact cardiovascular fitness. A total of 83% of the significantly negative effects pertaining to cardiovascular fitness did not include a relative minor modification to typical school provision illuminating several provision shortfalls with particular respect to physical education in which the bulk of the evidence is presented in this review. Furthermore, 58% of the significantly positive effects included a minor modification to typical school provision (e.g., participation in physical education class with a theoretical component, addition of recreational soccer sessions to physical education class and resistance training). Thus, it is considered, why are typical physical education classes failing to have a consistent impact on indicators of physical health, such as cardiovascular fitness? Qualified physical education teachers are trained to "design and deliver developmentally appropriate curriculum aligned" physical education classes that foster physically educated adolescents (Napper-Owen et al., 2008, p. 30). However, physical education classes are often taught by non-qualified physical education teaching personnel (Rocliffe et al., 2023a; Burnett et al., 2021). Therefore, it is considered that many physical education classes are not appropriately structured to impact levels of cardiovascular fitness. Thus, many adolescents are not developing into wise consumers of physical activity that track into adulthood (Belanger et al., 2015; Teixeira et al., 2012). Viable future strategies to ensure the effective provision of physical education classes that positively impacts indicators of adolescent physical health may include policy implementation that ensures that physical education classes are taught suitably qualified physical education teachers. Furthermore, physical education classes have traditionally been seen as a secondary subject in schools, with a higher focus placed on grade-related subjects, such as mathematics (Lee & Cho et al., 2014; Hayes et al., 2008). In 88.4% of secondary schools worldwide, physical education provision is a compulsory requirement (Hardman et al., 2014). However, the evidence base suggests gaps between policy and practice with 82% failing to meet the physical education recommendations in the Republic of Ireland (Rocliffe et al., 2023a). Furthermore, 74% of adolescents in the United Arab Emirates and 32% of adolescents in South Africa are failing to participate in physical education classes (Aubert et al., 2018). The literature points to goal priority (emphasizing one policy over the next) and protocols to monitor policy implementation as key variables that contribute to the gaps between policy and practice (Nathan et al., 2018). In the context of the current study, it is considered that physical education classes taught by non-specialist physical education personnel, priority of grade related subjects and gaps between policy and practice to ensure sufficient participation in physical education classes, may be key contributors to why physical education classes are failing to have the desired impact on indicators of physical health, such as cardiovascular fitness and should be strongly considered.

Many of the non-significant effects on adolescent cardiovascular fitness had positive interactions that did not reach statistical significance. It is considered that this may be due to inadequate sample sizes which should be considered in future research. The combined effects of physical education and the addition of another exposure (e.g., school sports and physical activity) to potentiate positive impact on indicators of adolescent physical health are also rarely considered in the current study. However, there is evidence to suggests that the supplementation of extracurricular recreational soccer to physical education classes over 32 weeks may yield desired outcomes in the context of adolescent cardiovascular fitness in comparison to a typical physical education class control group (Trajkovic et al., 2020). This is consistent with a recent systematic literature review and meta-analysis of 40 articles that found that physical education classes alone are not enough to significantly improve aerobic fitness in adolescents (Minatto et al., 2013). Furthermore, the current study found that the supplementation of school sports to typical physical education provision had significantly positive effects on V02 max in adolescents compared to a typical physical education class group (Perez et al., 2022) and is consistent with previous literature (Colantonio et al., 1999; Rodrigues et al., 2006). However, further research into alternative exposures to supplement physical education classes is required. It is noteworthy that access to school grounds outside of school hours was significantly associated with greater 1 mile run times (Madsen et al., 2009). This finding may reflect the impact of provision of after school programs which often demonstrate a promising effect on adolescent cardiovascular fitness and overall health (Beets et al., 2009; Carrel et al., 2011; Yang et al., 2019).

According to gender, similar to the indicators of adiposity, when examining the impact of typical school provision of physical education, physical activity and sports on cardiovascular fitness, a randomized controlled trial that integrated swimming classes into physical education classes found more favorable effects for boys than girls (Bielec, 2008). However, it must be noted that according to thresholds outlined by Pietrusik et al. (2005), both sets of results were poor indicating the need for further longitudinal studies in this research area. The current study also revealed notable improvements in 800 m–1600 m running time for both boys and girls when exposed to schools with a sports field and/or gymnasium (Lo et al., 2017). This demonstrates that potential impact of accessible school sports facilities before, in, or after school to optimize cardiovascular fitness in adolescents. Therefore, strategies that ensure access to school sports fields, gymnasiums and playgrounds may be of benefit.

Speed/Agility

Speed/agility in adolescents is a powerful marker of future health (Ortega et al., 2008). When analyzing the impact of typical school provision of physical education, physical activity and sports on adolescent speed/agility, a high proportion of the available research suggested a combination of significantly positive and non-significant findings. There were no notable negative effects recorded. The current study revealed favorable patterns associated with speed/agility when exposed to a minor modification to typical physical education provision that included calisthenic exercises, emphasized the frequency of physical education classes per week or saw the addition of extra physical education classes (e.g., four sessions weekly) (Aphamis et al., 2015; Ardoy et al., 2011; De Souza Santos et al., 2015). This was also noted by Bonhauser et al. (2005) who reported the positive effects associated with increasing the number of physical education classes weekly on adolescent speed/agility. Therefore, public health policies that consider prioritizing additional physical education classes should be considered. It is noteworthy, that the impact of additional physical education time on adolescent physical health indicators is a consistent trend among many recent, relevant systematic literature reviews in this research area (Rocliffe et al., 2023b, 2023c). Additional exposures, such as the additive impact of typical school physical education and sports combined, were also found to have significantly positive effects on adolescent speed/agility (Perez et al., 2022). While a paucity of empirical evidence exists that examines the additive impact of multiple components of provision on adolescent physical health indicators (e.g., active recess, active classroom breaks, extracurricular activities), there is a universal consensus regarding the advocation of a whole school, systems-based approach to physical activity provision in schools (Bowles et al., 2019; Department of Health, 2020; ISPAH, 2020; World Health Organization, 2018;. However, it is clear that further research is required to explore a whole school approach to physical activity and its subsequent impact on adolescent health. Of the non-significant effects, it's worth noting that there were no differences between a physical education class with a minor modification to include HIIT in comparison to a typical physical education class control group without a minor modification, when looking at the impact on adolescent speed/agility (Muntaner & Palou, 2017). Considering the HIIT consisted of just 10 min of physical education class time, further research that considers frequency and volume is warranted. When comparing boys with girls, similar to flexibility, limited evidence existed. Of the limited evidence, non-significant differences were found when exposed to physical education without a minor modification to typical school provision (Baquet et al., 2001). Once more, this emphasizes the limited effectiveness of typical school provision that has not been supplemented with a minor modification and the need for further investigation in this research area.

Impacts on Blood Pressure and Bone Health

The extant evidence that examined the impact of typical school provision of physical education, physical activity and sports on adolescent blood pressure and bone health was found to be significantly positive or non-significant. The relationship between typical school provision of physical education, physical activity and sports and blood pressure was examined in four articles (interventions), illuminating the paucity of evidence in this research area. Of the significantly positive effects, an 8-week intervention with a minor modification to typical school provision of physical education class that saw the implementation of aerobic exercises (e.g., aerobic tag) had a significant impact on systolic and diastolic blood pressure in adolescents in comparison to a non-aerobic exercise skill development control group (McMurray et al., 2002). These findings are consistent with a plethora of empirical studies that note a reduction in blood pressure via the prism of physical activity (Farpur-Lambert et al., 2009; Plavsic et al., 2020; Son et al., 2017). In addition, blood pressure is understood to be highly related to body fat while high blood pressure in adolescents is often correlated with hypertension in adulthood (Din-Dzietham et al., 2007; Sun et al., 2007). Therefore, providing physical activity opportunities in schools (e.g., aerobic exercise during physical education class, active classroom breaks or active recess) may be a strategic arm to reduce adolescent blood pressure that track into adulthood and inadvertently lowers body fat. While these findings are supplemented by further minor modifications to typical school provision, including circuit training and additional exercise training classes infused into physical education classes, that had significantly positive group and time effects on systolic blood pressure, many instances demonstrated non-significant effects for both control and intervention groups when measuring the impact on diastolic blood pressure (Giannaki et al., 2016; Laparidis et al., 2010; Wong et al., 2008). Although non-significant, it must be noted that a high proportion of the non-significant effects in the current study, such as when examining the impact of provision on diastolic blood pressure, were found to slow the grade related increase of negative physical health outcomes (e.g., high blood pressure and indicators of adiposity) and decrease in positive physical health outcomes (e.g., indicators of physical fitness and bone health). The concept of slowing the grade related increase/decrease of adolescent physical health outcomes is a recent phenomenon and requires further investigation to further conceptualize these findings. The current study illuminated a dearth of evidence examining the impact of typical school provision of physical education, physical activity and sports on adolescent blood pressure across gender which warrants further investigation.

In the context of bone health, although infrequent, typical school provision of physical education, physical activity and sports had the greatest impact on this outcome variable with 50% significantly positive effects. It must be noted however that the extant evidence pertains to just one article (RCT) illuminating the insufficient evidence in this research area (Weeks et al., 2008). The randomized controlled trial comprising a minor modification to typical school provision of physical education consisting of 8–10 min of jumping activities (jumping jacks, body weight exercises), implemented twice a week over an eight-month period, had significantly positive effects on a range of indicators for bone strength in adolescents (e.g., broadband ultrasound attenuation, lumber spine index of bone structural strength) in comparison to a typical physical education warm up. This is consistent with findings alluding to the positive effects of aerobic exercise outside of school on bone health that are noted by experts in the field (Chaplais et al., 2018; Fonseca et al., 2008; Troy et al., 2018). These findings also indicate the potential impact of school physical education, physical activity and sports as a supplementary strategy to impact adolescent bone health. However, further research is needed. When contrasting boys versus girls, the current study indicated significantly positive effects for both boys and girls in both the control and experimental groups. Although more significant in the experimental group with a minor modification to typical school provision, these findings suggest that even a typical physical education warm up, without a minor modification, may be impactful on indicators of bone strength in adolescents. It is noteworthy, that the randomized controlled trial had a bigger impact on indicators of bone strength in boys compared to girls. However, longitudinal studies are warranted to confirm these findings and are worth considering.

Strengths and Limitations

To our knowledge, the current study is the first to examine the impact of typical school provision of physical education, physical activity and sports on adolescent physical health. The methodological approach is underpinned by the Preferred Reporting Items for Systematic Reviews and Meta-analysis. An extensive search strategy was developed and utilized across a broad range of databases. A comprehensive review of the literature including a wide range of physical health indicators pertaining to adiposity, physical fitness, bone health and blood pressure were included. Multiple reviewers were included throughout each review stage to limit bias. Investigating the additive impact of typical school provision of physical education, physical activity and sports exposures allowed for a thorough examination of the literature. Outcome measures were measured objectively, strengthening the findings, while the use of a suitably recognized quality assessment tool ensured the included articles were of reasonable quality. Lastly, a rigorous meta-analysis was utilized to strengthen the findings gleaned from this review.

Heterogeneity in the article's measurement processes and analysis presented challenges in synthesizing the data in a logical fashion. Grey literature was excluded. Quality assessment revealed the articles to be of fair quality. A high proportion of the included participants were from high income countries, meaning the data is difficult to generalize to lower income countries (Hamadeh et al., 2022). In the context of data analysis, articles with higher/lower frequencies of reported effects were not accounted for. Lastly, the literature search was restricted to English articles only.

Conclusion

A systematic literature review and meta-analysis that examines typical school provision of physical education, physical activity and sports as a viable strategy to impact adolescent physical health indicators is imperative as global health costs associated with physical inactivity are increasing and a dearth of evidence exists in this research area. The evidence suggests that minor modifications to typical school provision of physical education, physical activity and sports may be required to have a desired effect on indicators of physical health in adolescents with results from the meta-analysis illuminating a significant impact on body fat percentage in both boys and girls concerning experimental groups with minor modifications to typical school provision. Similar to previous reviews in this research area (Rocliffe et al., 2023b, c), a high proportion of the evidence pertained to typical school physical education, with a paucity of evidence concerning the additive impact of typical school physical activity and sports. Robust examples of best practice gleaned from the current body of evidence illuminated the integration of swimming classes, supplementary heart rate monitoring, health and diet related theoretical classes, extended days dedicated to physical education weekly (≥ 4 days), active transport, sports field/gymnasium availability, cardiorespiratory, resistance, strength, calisthenic or jumping exercises and/or circuit training into the school day, as viable strategies to impact adolescent physical health. Overall, the analysis indicated that there was a limited number of significantly negative effects and while many of the outcomes were deemed non-significant, the concept of mitigating the rise in negative indicators of adolescent physical health (e.g., BMI) and reversing the decline in positive indicators of adolescent physical health (e.g., cardiovascular fitness) warrants further investigation.

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Authors' Contributions PR conceived of the study, participated in its design and coordination, performed the analysis and drafted the manuscript; MT participated in the analysis of the results and the drafting of the article; LGG participated in the design, interpretation and analysis of the data; MA participated in the design and the interpretation of the data and performed the analysis; LW participated in the design and interpretation of the data; AB participated in the design and interpretation of the data; EM participated in the design and the interpretation of the data; IS conceived of the study, participated in its design and coordination, performed the analysis and drafted the manuscript; BOK conceived of the study, participated in its design and coordination and interpretation of the data; PMM conceived of the study and participated in its design and coordination; CMD conceived of the study, participated in its design and coordination, performed the analysis and drafted the manuscript. All authors read and approved the final manuscript.

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Declarations

Conflict of interest The authors report no conflict of interest.

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