School-based health promotion: understanding the educational context to facilitate change

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Declaration

This thesis is the result of my own work and includes nothing which is the outcome of work done in collaboration except as declared in the Preface and specified in the text.

I further state that no substantial part of my thesis has already been submitted, or, is being concurrently submitted for any such degree, diploma or other qualification at the University of Cambridge or any other University or similar institution except as declared in the Preface and specified in the text.

It does not exceed the prescribed word limit for the relevant Degree Committee.

Mairead Ryan

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Abstract

The World Health Organisation recommends children and adolescents aged 5-18 years engage in an average of 60 minutes of at least moderate-intensity physical activity per day across the week. This helps them meet their multiple physical, mental and well-being needs. A substantial proportion (67-81%) of children and adolescents worldwide are not meeting these guidelines. Global intervention efforts, which largely focus on school settings, are reported to have failed and reasons for intervention outcomes remain poorly understood. To improve understanding of these outcomes, and the school context as a venue to facilitate change, I adopted an interdisciplinary approach, integrating theory and evidence from the fields of both Public Health and Educational research, to consider and address existing knowledge gaps in the field.

In the first part of this thesis, I examined how interventions have been implemented to date. Teachers are typically tasked with delivering interventions, but the effectiveness of the training they receive is poorly understood. I investigated programmes provided in research and real-world contexts. Study 1 involved a systematic review and meta-analysis of staff training programmes within 51 trials of school-based physical activity interventions. I identified characteristics (e.g., use of theory) and behaviour change techniques (e.g., feedback, action planning) positively associated with intervention fidelity and student outcomes. Most training programmes included few of these features, and were not designed based on Educational research about teacher professional development.

In study 2, I surveyed teachers (n=170) who participated in professional development programmes aimed at supporting the implementation of the UK government's largest policy targeting physical activity promotion in primary schools in England. I assessed the design features of programmes undertaken, and measured the use of 14 mechanisms hypothesised to facilitate four proposed purposes of professional development: 1) to learn knowledge, 2) to master skills, 3) to motivate action towards a goal, and 4) to facilitate implementation of acquired knowledge into practice. Most participants attended programmes that addressed just one or two of these functions. Teachers that

attended programmes addressing all four functions, comprising less than 25% of participants, reported experiencing greater impacts on their practice.

In the second part of this thesis, I aimed to improve understanding of the school context as a venue to facilitate change, exploring understudied school-level environmental and policy correlates of student physical activity. In study 3, I analysed data from primary school-age students in Australia (n=684). I examined students' use of school playground infrastructure and associations between infrastructure use, break time step cadence and cardio-respiratory fitness. Boys reported greater use of playground infrastructure than girls. Regular use of some items (e.g., playing fields) was associated with a higher break time step cadence and fitness test score. Gender differences were observed in the strength of some associations. For example, associations between playing field use and cardio-respiratory fitness were stronger in boys; associations between teacher-organised games and break time step cadence were stronger in girls.

In the final study, I examined associations between school uniforms and student physical activity, using population-level data from 135 countries. Across all age groups, compliance with physical activity guidelines was lower in countries with uniform practices compared to those without. Among primary school-aged students, uniformed countries showed a greater gender gap in meeting activity guidelines, favouring boys, compared to non-uniformed countries. Associations between school uniforms and population gender inequalities in physical activity were also greater in high-income countries than in countries with other income classifications.

This thesis contributes valuable insights into how interventions have been implemented to date and the school context as a setting to facilitate change. Studies 1 and 2 indicate that teachers tasked with implementing interventions are often provided with training that is unlikely to change their behaviour. Studies 3 and 4 identify novel school-level environmental and policy correlates of student physical activity. The interdisciplinary literature and studies presented in this thesis can contribute to the development of more effective and gender-equitable interventions to promote physical activity.

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List of abbreviations and acronyms

Chapter 1

AFLY5: Active for Life Year 5

CI: Confidence Internal

GRADE: Grading of Recommendations Assessment, Development and Evaluation

GSHS: Global School-based Student Health Survey

HBSC: Health Behaviour in School-aged Children

INSET: In-Service Education and Training

MET: Metabolic Equivalent of Task

PE: Physical Education

UK: United Kingdom of Great Britain and Northern Ireland

US: United States

WHO: World Health Organisation

Chapter 2

BCT: Behaviour Change Technique

EPHPP: Effective Public Health Practice Project

IQR: interquartile range

MRC: Medical Research Council

PRISMA: Preferred Reporting Items for Systematic reviews and Meta-Analyses

SD: standard deviation

SE: standard error

SMD: Standardised Mean Difference

TIDieR: Template for Intervention Description and Replication

Chapter 3

AfPE: Association for Physical Education

IP: Internet Protocol

OR: Odds Ratio

PE Premium: The Primary PE and Sport Premium

QTS: Qualified Teacher Status

REDCap: Research Electronic Data Capture

STROBE: STrengthening the Reporting of OBservational studies in Epidemiology

Chapter 4

ASGS: Australian Statistical Geography Standard

AWARE: Active WeAR Everyday

GLIMMIX: Generalised Linear Mixed Models

GPS: Global Positioning System

RSPL: residual pseudo-likelihood

SAS: Statistical Analysis System

SEIFA: Socio-Economic Indexes for Areas

VO_2: Volume of Oxygen

Chapter 5

Q-Q plots: quantile-quantile plots

Publications, evidence briefs, journal impacts, and presentations

The following publications, evidence briefs, journal impacts and conference presentations were generated from work presented in this thesis.

Publications

Chapter 2: The study presented in chapter 2 is published as:

Ryan, M., Alliott, O., Ikeda, E., Luan, J. A., Hofmann, R., & van Sluijs, E. (2022). Features of effective staff training programmes within school-based interventions targeting student activity behaviour: a systematic review and meta-analysis. *International Journal of Behavioral Nutrition and Physical Activity*, *19*(1), 1-23.

Chapter 6: The commentary discussed in chapter 6 is published as:

Ryan, M., Hoffmann, T., Hofmann, R., & van Sluijs, E. (2023). Incomplete reporting of complex interventions: a call to action for journal editors to review their submission guidelines. *Trials*, *24*(1), 176.

Publications submitted/in preparation

Chapter 5: The study presented in chapter 5 is currently under review at BMJ Public Health:

Ryan, M., Ricardo, L., Nathan, N., Hofmann, R., & van Sluijs, E. (2023). Are school uniforms associated with gender inequalities in physical activity? A pooled analysis of population-level data from 135 countries. *BMJ Public Health [Under review]*.

Chapter 4: The study presented in chapter 4 is currently in preparation for submission to Journal of Physical Activity and Health:

Ryan, M., Hall, A., Lecathelinais, C., McCarthy, N., Pollock, E., Wolfenden, L., Hofmann, R., van Sluijs, E., & Nathan., N. (2023) Primary school students' playground use, step cadence and cardio-respiratory fitness: a cross-sectional study in New South Wales, Australia. Journal of Physical Activity and Health

Evidence briefs

Chapter 2. The study presented in chapter 2 informed the development of an evidence brief for practitioners entitled 'Evidence-based guidance for impact: How to strengthen teacher professional development to promote children's health'.

Journal impacts

Chapter 6. The following journals changed their submission guidelines in response to the initiative described in chapter 6:

- American Journal of Preventive Medicine,
- British Journal of Sports Medicine,
- Evaluation and Program Planning,
- Journal of Experimental Social Psychology,
- Journal of Physical Activity & Health,
- Journal of Science & Medicine in Sport,
- Psychology of Sport & Exercise, and
- Sport, Exercise, and Performance Psychology.

Conference contributions

Chapter 2: Oral presentation (delivered by Esther van Sluijs), 'Features of effective staff training programmes within school-based interventions targeting student activity behaviour: a systematic review and meta-analysis', International Society of Behavioral Nutrition and Physical Activity, June 2023, Uppsala, Sweden.

Oral presentation, 'School-based health promotion: What went wrong and where to next?' Cambridge University Behavioural Insights Team, May 2022; Trinity Hall, Cambridge.

Oral presentation (preliminary findings), 'A systematic review of staff training in school-based interventions targeting student physical activity behaviour', 8th International Society for Physical Activity and Health (ISPAH) Congress, October 2021; online.

Chapter 6: Oral presentation, 'Incomplete reporting of activity behaviour interventions in school-based research: a systematic review of randomised controlled trials published 2015-2020', Sports Medicine Australia, November 2022, Gold Coast, Australia.

Chapter 1: Introduction

1.1 Benefits of physical activity among children and adolescents

Physical activity is defined as any bodily movement resulting in energy expenditure.[1] It can be accumulated through various aspects of daily life, including work, household chores, transportation, leisure time, sports, walking, active recreation, and play. A large body of evidence suggests that regular physical activity is advantageous for all young people aged 5-18 years, regardless of their gender, cultural background, or socioeconomic status.[2-4] For example, a comprehensive evaluation of recently published systematic reviews, using the GRADE (Grading of Recommendations Assessment, Development and Evaluation) framework,[5] finds moderate certainty evidence indicating that regular physical activity is positively associated with cardio-metabolic health, higher bone mass, improved bone structure, greater bone strength, and reduced risk of depression and depressive symptoms among young people.[6] The review also identified additional benefits for brain health, cognition, and academic outcomes (e.g., school performance, memory and executive function).[6] A moderate certainty GRADE rating indicates that the estimated effect likely closely represents the true effect.[7] In addition, other reviews find evidence to indicate that physical activity patterns established during childhood and adolescence also moderately track into early adulthood.[8] Given further benefits associated with regular physical activity during adulthood,[6] engaging in physical activity during childhood and adolescence may not only provide immediate advantages but also confer long-term benefits.

1.2 Amounts and types of beneficial physical activity

Existing evidence emphasises the benefits of specific amounts (frequency, duration, intensity) and types (aerobic, muscle-strengthening, and bone-strengthening activities) of physical activity for young people.[9] While the precise frequency and duration of physical activity required for young people to achieve associated benefits is uncertain, evidence suggests that more regular engagement and longer periods of physical activity confer the greatest benefits.[9] Physical activity intensity is also a key component, referring to the amount of energy that a young person expends when engaging in the activity, commonly measured using Metabolic Equivalent of Task (MET) values. Though recent research indicates some benefits from activities at the lower end of the intensity spectrum that require less energy expenditure (e.g., light-intensity physical activity),[10,11] the most consistent and significant benefits are observed from physical activities at the upper end of the intensity spectrum (e.g., vigorous-intensity physical activity).[9] Examples of physical activity behaviours across the intensity spectrum along with their associated MET range are outlined in Table 1.1.

Table 1.1. Physical activity behaviours across the intensity spectrum, including sedentary behaviour, associated MET range, and example activities

Intensity	**MET Range[a]**	**Example activities[b]**
Sedentary Behaviour	<1.5	Arts and crafts, reading, playing with toys
Light Intensity	1.5-2.9	Arcade games, drawing and colouring (standing),
Moderate Intensity	3.0-5.9	Active lessons, rollerblading, dancing
Vigorous Intensity	≥6.0	Playing tag, hiking, ball games, swimming, cycling

[a] *MET* Metabolic Equivalent; [b] based on calculations by Butte and colleagues[12] regarding the MET values associated with a range of activities among young people aged 6-18 years

Finally, evidence indicates that different types of physical activities (e.g., aerobic, muscle-strengthening and bone-strengthening activities) are important to undertake as they confer independent benefits.[9] For instance, bone-strengthening activities like jumping can promote bone growth and strength, while aerobic physical activities, like skipping, can enhance cardiorespiratory fitness.[6] Table 1.2 provides definitions of different types of physical activity and example behaviours.[13-15]

Table 1.2. Definitions of different types of physical activity and example behaviours

Type of physical activity	**Definition**	**Example behaviours**
Aerobic physical activity	"Activity in which the body's large muscles move in a rhythmic manner for a sustained period of time".[6]	Running, hopping, skipping, jumping rope, swimming, dancing, cycling
Muscle-strengthening activities	"Resistance training and weightlifting requiring muscular activation against an external object or bodyweight".[16]	Playing on playground equipment, climbing trees, playing tug-of-war, lifting weights, working with resistance bands
Bone-strengthening activities	"Weight-bearing activities producing a force against the body".[16]	Running, jumping rope, basketball, tennis, hopscotch

1.3 Physical activity guidelines and benefits of compliance

Based on comprehensive reviews of the evidence,[9] the World Health Organisation (WHO) currently recommends children and adolescents aged 5-18 years engage in an average of 60 minutes of moderate-to-vigorous intensity physical activity per day across the week.[6] They also recommend vigorous-intensity aerobic activities, as well as muscle- and bone-strengthening activities, are incorporated at least three days per week. Children and adolescents are advised to limit sedentary time, particularly if that time is spent watching screens for non-school or work purposes. See Figure 1.1.

Figure 1.1. WHO physical activity and sedentary behaviour guidelines for young people

These guidelines, last updated in 2020, are grounded in decades of research,[17] suggesting that compliance with these recommendations yields numerous benefits for children and adolescents.[9] In recognition of the evidence base underpinning these recommendations, and the reported benefits associated with compliance, governments worldwide largely endorse, support, and promote the WHO physical activity guidelines in their respective countries. While some countries have developed their own national guidelines (e.g., UK, Canada, US, Brazil, and Australia), these closely align with the WHO's recommendations. For example, the physical activity guidelines issued by the Chief Medical Officers of England, Scotland, Wales, and Northern Ireland, similarly advocate for young people aged 5-18 years in the UK to engage in an average of at least 60 minutes of moderate-to-vigorous intensity physical activity per day throughout the week, participate in various types and intensities of physical activity, and aim to minimise sedentary time.[18]

1.4 Measuring physical activity

In order to accurately measure the amount and type of physical activity young people are undertaking, and hence assess their compliance with these guidelines, considerable research efforts have been invested into developing valid and reliable measures.[19,20] Table 1.3 presents an overview of these measures, broadly grouped into i) self/proxy measures and ii) device-based measures.

Self and proxy report measures (e.g., surveys) have traditionally been employed to assess young people's physical activity. This usually involves a single-item question aimed at determining the quantity of physical activity a young person has engaged in over the previous week (e.g., 'During the past 7 days, on how many days were you physically active for a total of at least 60 minutes per day?'; response options: 0 days – 7 days). The GSHS (Global School-based Student Health Survey) and the HBSC (Health Behaviour in School-aged Children) studies are the largest global surveys of adolescent physical activity and they both use this approach.[21,22] Parent questionnaires are typically employed to assess physical activity among young people under 12 years of age. These questionnaires similarly tend to focus on the number of days in the previous week their child has engaged in physical activity for 60 or more minutes.[23,24]

While self- and proxy-report measures are often considered convenient and cost-effective methods of assessing physical activity among large groups of young people, studies suggest they may not provide accurate measurements and often lead to inflated estimates. For example, Basterfield and colleagues compared parent proxy reports of children's weekly physical activity against 7-day accelerometer data for the same period and found a significant discrepancy.[25] Parents reported, on average, that their child accumulated 146 minutes of moderate-to-vigorous intensity physical activity per day (95% Confidence Internal (CI): 124-169); the accelerometer data showed a significantly lower mean estimate of 24 min/day (95% CI: 22-26).[25] Similar findings have been observed in other studies, where parent proxy report measures have shown only weak to moderate correlations with device-based estimates.[26] A recently updated systematic review examining both proxy and self-report measures of young people's physical activity failed to identify any questionnaire with "conclusive evidence for both acceptable validity and reliability".[27] As a result of these findings, researchers have cautioned against the use of self and proxy-report measures "unless there is evidence of validity, reliability and cultural appropriateness".[19]

The use of device-based measures to assess young people's physical activity has increased in recent years due to the availability of affordable and user-friendly wearable technologies (e.g., pedometers, accelerometers).[28] These measures offer advantages by mitigating some of the biases associated with self/proxy reports and can objectively assess different intensities of physical activity. Still, they have limitations. Device-based measures are associated with additional financial costs, researcher and participant burden (e.g., device maintenance, distribution, and collection, participant compliance with wear time protocols), and they cannot reliably capture all types of physical activity (e.g., muscle-strengthening activities cannot be detected). It is also difficult to compare data derived from device-based measures between studies if researchers use different wear protocols, and cut-points, or adopt different methods to process the data.[20] Standardised (harmonised) methods have yet to be developed.[29]

Despite these challenges, surveillance initiatives worldwide have embraced the availability of these measures to assess population levels of physical activity among young people.[30,31] These surveillance studies, which typically focus on measuring young people's weekly moderate-to-vigorous intensity physical activity,[30,31] play a crucial role in evaluating guideline compliance and hence the health status of young people.

Table 1.3. Self-report and device-based methods used to monitor physical activity among children and adolescents: their advantages, disadvantages, and surveillance initiatives using this approach

Assessment methods	**Advantages**	**Disadvantages**	**Use in population-level surveillance initiatives**
Proxy/self-report measures (e.g., parent/ adolescent survey, diary, interview)	✓ Cost-effective ✓ Captures various activities ✓ Low researcher burden ✓ Low participant burden	× Subjective × Associated with various biases × Can lead to overestimation × Questions require age and cultural-specific testing	The Global School-based Student Health Survey (GSHS) HBSC study The Global Matrix on Physical Activity for Children and Adolescents
Device-based measures (e.g., accelerometers, pedometers)	✓ Objective ✓ Reduces forms of bias ✓ Captures intensity ✓ Captures duration	× Costly × Heterogeneity in methods × High researcher burden (drop off and collection) × High participant burden (requires device wear and adherence) × Cannot detect all physical activity types (e.g., muscle-strengthening activities) × Data lost if the device is not returned	International Children's Accelerometry Database (ICAD) The International Study of Childhood Obesity, Lifestyle and the Environment (ISCOLE) Determinants of diet and physical activity (DEDIPAC) The Global Matrix on Physical Activity for Children and Adolescents

1.5 Descriptive epidemiology of young people's physical activity

The findings from international surveillance studies indicate low levels of physical activity among children and adolescents worldwide.[31-34] For example, the most recent findings from the Global Matrix surveillance initiative, which analysed evidence from 54 countries, found that only 27-33% of young people aged 5-17 years were achieving the recommended 60 minutes of moderate-to-vigorous intensity physical activity on average per week.[35] These estimates remained consistent when the findings were stratified based on the Human Development Index classification and the geo-cultural region of the countries represented. Similarly, Guthold and colleagues' pooled analysis of data from 146 countries found that only 19% of adolescents aged 11-17 were meeting the recommended weekly amount of moderate-to-vigorous intensity physical activity.[33] Their analysis also revealed low levels of physical activity across low (15%), middle (16-21%) and high-income (21%) countries. While the majority of these estimates are based on self and proxy measures of physical activity,[33,35] surveillance initiatives reporting on device-based data similarly indicate low levels of physical activity among young people in many countries.[33] For instance, Jostein and colleagues harmonised device-measured physical activity data collected from over 47,000 young people aged 2-19 years across 18 European countries and reported that “a maximum” of 29% of children (2-9 years) and 29% of adolescents (10-19 years) were meeting the recommended 60 minutes of moderate-to-vigorous intensity physical activity.[36]

In addition to low levels of physical activity in the population, surveillance studies also consistently report gender inequalities in physical activity, whereby girls are less physically active than boys throughout childhood and adolescence.[31-33,37,38] For example, Guthold and colleagues reported that in 27 countries represented in their analysis (18.5%), 90% or more of girls aged 11-17 years were not engaging in the recommended amount of moderate-to-vigorous intensity physical activity. In contrast, this was observed in only two countries (1.4%) for boys.[33] While all children and adolescents appear to engage in less physical activity as they age, the rate of decline is shown to be greater among girls than boys. For example, Farooq and colleagues compared the year-to-year changes in physical activity between girls and boys aged 3-18 years.[39] They analysed data from 52 longitudinal studies conducted in 19 countries, reporting on young people’s device-measured moderate-to-vigorous intensity physical activity (boys=8,857; girls=13,234). They observed significant declines in physical activity among girls from the age of 6, and again at 9, 10, and 13 years of age. No significant year-to-year decline was observed among boys until the age of 9, and no other significant declines were identified in later years.[39]

The findings from these many surveillance studies collectively highlight an urgent need to increase population levels of physical activity among children and adolescents worldwide, and to address known inequalities in physical inactivity between population subgroups, including gender-based inequalities.[33,36,40-42] In response to the findings from surveillance studies, the WHO launched a global action plan in 2018, and set a global target of reducing the prevalence of physical inactivity by 15% by 2030, with a focus on addressing disparities and reducing inequalities.[43] Though evidence suggests that achieving this target would yield substantial benefits for young people in many countries,[43] effectively achieving and sustaining change to large numbers of young people's behaviour represents a considerable public health challenge.

1.6 Use of Behavioural Epidemiology Framework to guide intervention development

For researchers to help promote positive change to young people's health, the Behavioural Epidemiology Framework suggests that a systematic sequence of studies is required to identify evidence-based interventions that effectively target populations (see Figure 1.2).[44]

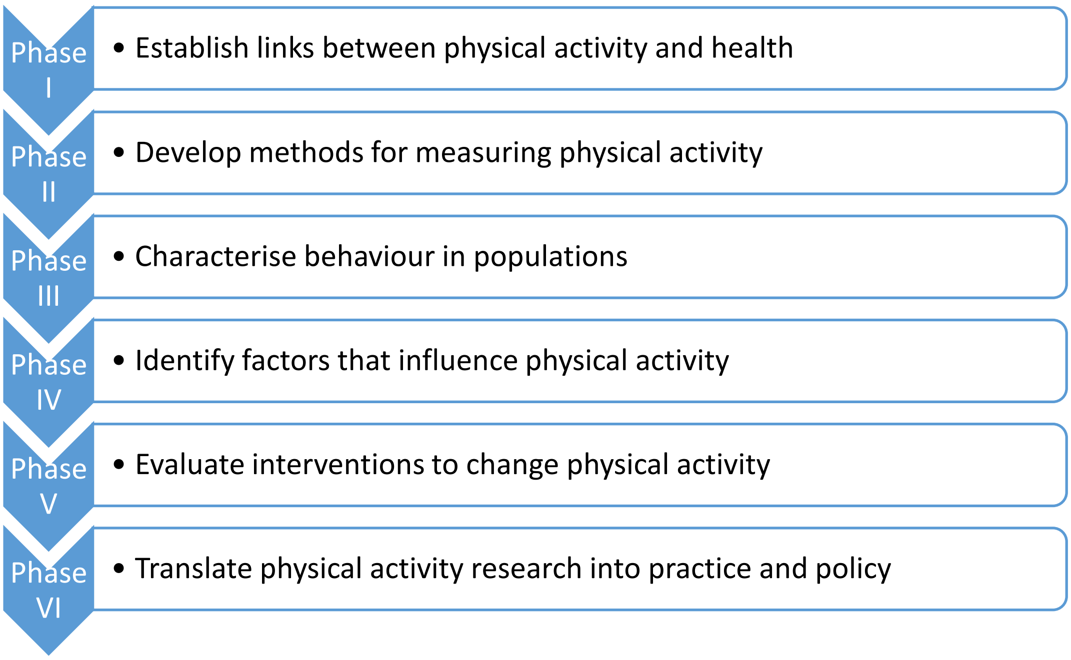

Figure 1.2. The Behavioural Epidemiology Framework. Figure adapted from Noonan[45]

Encouragingly, many efforts have already been invested into Phases I-VI of the Framework. Public Health researchers have collaborated with colleagues from adjacent fields (e.g., exercise science, kinesiology) to conduct extensive research addressing Phases I-III of the Framework, some of which has been cited in previous paragraphs.[2,3,46-49] A large body of research has also investigated the correlates and determinants of young people's physical activity (Phase IV of the Behavioural Epidemiology Framework),[50] with a growing consensus that multiple proximal (e.g., individual, interpersonal, organisational characteristics) and distal (e.g., supportive built environments and national policies) correlates and determinants influence child and adolescent physical activity behaviour. These factors are commonly conceptualised within a socio-ecological model[51] that is used to guide and interpret observational and experimental studies in the field.[51] In response to the recognised need for population-wide intervention efforts, multiple interventions have also been developed and tested in various contexts, including home, community, and school settings (Phase V).[52-54] Finally, researchers have also explored effective messaging strategies to facilitate research translation into policy and practice (Phase VI).[55,56]

1.7 Opportunities and challenges for school-based physical activity research

Public Health researchers focusing on young people's physical activity have identified schools as one of the well-placed settings for conducting studies addressing Phases IV and V of the Behavioural Epidemiology Framework (i.e., correlational and intervention studies).[57] Educational settings facilitate access to young people in a single setting, on a regular basis, and over a long period of time. A large proportion of children and adolescents aged 5-18 years also have access to formal education.[58,59] Hence, the factors that influence young people's physical activity could be studied across relatively large and diverse populations. The effects of interventions could similarly be tested and potentially experienced by many young people.[60] In conducting school-based studies, researchers can also leverage insights gained from research studies that addressed earlier phases of the Behavioural Epidemiology Framework (i.e., Phases I-III) (e.g., to employ the best available measures, to focus on known priority groups).

However, while acknowledging these opportunities, Public Health researchers have also reported many challenges in conducting school-based studies of young people's physical activity to date.[61] Schools are dynamic environments with a range of educational priorities, and are often burdened by high-stakes accountability pressures.[62] Researchers have therefore often found it challenging to secure time and stakeholder interest for data collection activities and/or intervention studies that do not directly alleviate these pressures. Observational and experimental studies may also disrupt or directly seek to alter regular classes and curricula. In addition, school-based research is also typically resource-intensive, and requires approval from and engagement with multiple parties, including school administrators, principals, teachers, parents and students. Hence, to ensure the collection of high-quality data and the delivery of compatible interventions, school-based studies require careful consideration, planning, and ongoing engagement with many stakeholders.

1.8 Limited success of numerous school-based physical activity interventions

In recognition of the potential benefits associated with school-based approaches in promoting population health, numerous government and research interventions have targeted educational settings to change young people's physical activity behaviour.[63,64] For instance, various countries (e.g., England, Ireland, Canada, Poland, Australia) have initiated national programmes like 'Let's Move! Active Schools' in the United States. [65] These initiatives provide schools with resources, training, and grants to implement various physical activity-promoting initiatives, related to Physical Education, active break times, and before/after-school activities. Public Health researchers have also designed their own interventions. One such example is the 'Active for Life Year 5 (AFLY5)' intervention.[66] This was developed by researchers in England and aims to improve physical activity among children by providing primary schools with staff training, materials, lesson plans, and interactive homework plans for students and their parents. The effects of these interventions are typically assessed by researchers using different experimental study designs. For example, the researchers who designed the AFLY5 intervention recruited 60 schools to evaluate the effectiveness of the programme using a cluster-randomised controlled trial design.[66] Many researchers in other countries have similarly developed their own interventions and tested their effects across different school settings, regions and student populations.

Despite substantial investments into the development and delivery of these interventions, data from population surveillance studies and intervention evaluation studies suggest that their impact on changing young people's physical activity behaviour has been limited.[67-70] Surveillance initiatives show that the proportion of children and adolescents meeting physical activity guidelines has not significantly increased since the launch of these nationwide programmes.[19,32] Systematic reviews and meta-analyses of researcher-led interventions similarly indicate that these interventions have also had limited success in achieving or maintaining positive change to young people's physical activity (see Table 1.4 below for a summary of review findings).[67-70] While some evaluations of research-led interventions have reported significant positive effects,[54] these have been primarily observed in trials with self-report measures, small sample sizes, and brief follow-up periods.[71-73] Crucially, reviews have shown that when attempts have been made to scale up and replicate these 'successful' interventions in other settings, the effects reported in scaled-up interventions have generally been at least 25% lower than the effects reported in initial efficacy trials.[74] This phenomenon, commonly referred to as 'voltage drop', has been identified in many scale-up efforts.[75,76] The overall approach taken so far has yet to demonstrate observable population benefits for young people's physical activity. All government and research-led interventions have also failed in eliminating known inequalities in physical inactivity by gender, age, or socio-economic position.[33,64,67,71] Furthermore, why these interventions have failed to achieve their desired outcomes also remains largely unknown. These findings collectively indicate that studies addressing Phase V of the Behavioural Epidemiology Framework require greater attention; subsequent efforts to 'Translate physical activity research into practice and policy' (Phase VI) are dependent on the insights gained from Phase V and its preceding phases.

Table 1.4. Summary of systematic reviews analysing the impact of school-based interventions reporting on device-based student outcome measures

Systematic review	Population	Intervention[a]	Studies included	Physical activity outcomes of interest	Summary of findings
Borde et al., 2017[69]	Students aged ≥10 years	Any school-based intervention aimed at increasing physical activity	13 RCTs	Total physical activity Moderate-to-vigorous intensity physical activity	Non-significant effects for both
Love et al., 2019[67]	Students aged 6-18 years	Any school-based physical activity intervention	17 cluster RCTs	Daily minutes of moderate-to-vigorous physical activity	Non-significant effects
Jones et al., 2020[68]	Students aged 5-11 years	Any school-based intervention that promoted physical activity and/or reduced sedentary time	57 studies (29 RCTs, 17 non-RCTs, 10 descriptive studies and one mixed-methods study)	Moderate-to-vigorous intensity physical activity Sedentary time	Non-significant effects for whole-day moderate-to-vigorous intensity physical activity Inconclusive evidence for effects on sedentary time
Neil-Sztramko et al., 2021[70]	Students aged 6-18 years	Any school-based intervention where the primary aim was to increase physical activity or fitness	61 RCTs	Proportion of participants meeting physical activity guidelines Duration of moderate-to-vigorous intensity physical activity and sedentary time	Non-significant effects for physical activity Small to no decrease in sedentary time

RCT randomised controlled trial; [a] All reviews excluded studies reporting on interventions delivered for a period of less than 4 weeks

1.9 Integrating Public Health and Educational research to advance knowledge

Understanding the reasons why these interventions have not achieved their desired outcomes is crucial to avoid further investment into ineffective approaches, and to accelerate progress towards improving child and adolescent health. Systematic reviews of the literature have identified specific areas that warrant increased attention to advance the study of school-based physical activity promotion among young people. These include:

(i) a greater examination of the teacher-targeted training programmes that have been provided to promote the delivery of these interventions (Phase V);[77] and

(ii) a more comprehensive understanding of the correlates of young people's physical activity within the school environment (Phase IV).[78-80]

Addressing these gaps in Phases IV and V of the Behavioural Epidemiology Framework may be most effectively achieved by considering and integrating expertise beyond the scope of what has previously guided experimental and observational studies to date. In doing so, Public Health researchers could gain a different perspective as to why interventions may be failing to change student behaviour and identify new approaches and strategies that may yield better results. The field of Educational research is explicitly concerned with the school setting, the correlates and determinants of its many actors, and the various influences that determine organisational change and outcomes. However, perhaps surprisingly, Educational theory and research appear largely absent from Public Health research studies and government policy documents concerning school-based physical activity promotion.[81,82] This thesis is therefore concerned with exploring how theory and evidence from both Public Health and Educational research could be leveraged to consider and address these gaps in the literature.

In this thesis, I will adopt an interdisciplinary approach that aims to integrate knowledge from both of these disciplines to inform and design my studies. While this approach is considered to be more resource-intensive than some other forms of collaborative research practices (distinctions outlined in Table 1.5), it is considered particularly valuable when addressing complex issues, such as interventions targeting population-level behaviour change. In the following sections, I will appraise Public Health and Educational research to consider how literature from these distinct disciplines could be integrated to enhance scientific understanding of teacher and student behaviour related to physical activity in educational settings.

Table 1.5. Forms of collaboration between disciplines

Term	**Definitions adopted**
Discipline	"A broadly accepted field of study that is institutionalised as a degree-granting department in a large number of colleges and universities".[83]
Multidisciplinarity	Multidisciplinarity refers to the most basic level of collaborative involvement between disciplines, in which researchers from different disciplines work on a problem in parallel or sequentially, without challenging their disciplinary boundaries.[84]

Interdisciplinarity	Interdisciplinarity fosters a reciprocal interaction between disciplines, requiring a blurring of disciplinary boundaries to generate new common methodologies, perspectives, knowledge, or even new disciplines.[84]
Transdisciplinarity	Transdisciplinary involves researchers from different disciplines working together as well as non-scientists to transcend disciplinary boundaries to look at the dynamics of systems in a holistic way.[84]

1.10 Examining teacher-targeted programmes in school-based interventions

Teacher reliance in school-based interventions

Public Health researchers have historically tasked teachers with delivering various health-promoting interventions before, during and after the school day to effect positive change to a range of student health behaviours,[85] including physical activity.[77] For example, a recent scoping review conducted by Brandes and colleagues examined the features of school-based physical activity interventions within studies published between 2010-2019 and found that 75% of these interventions were reliant upon a teacher for intervention delivery.[86] To facilitate this process, teachers are typically provided with some training and/or resources (e.g., lesson plans) that are intended to change their behaviour, which in turn, is intended to change their students' behaviour. Thus, in the explicit or implicit logic model of many of these interventions, the effectiveness of the student-targeted intervention is heavily reliant on the effectiveness of the teacher-targeted intervention (i.e., the training or resources provided).[86] See Figure 1.3.

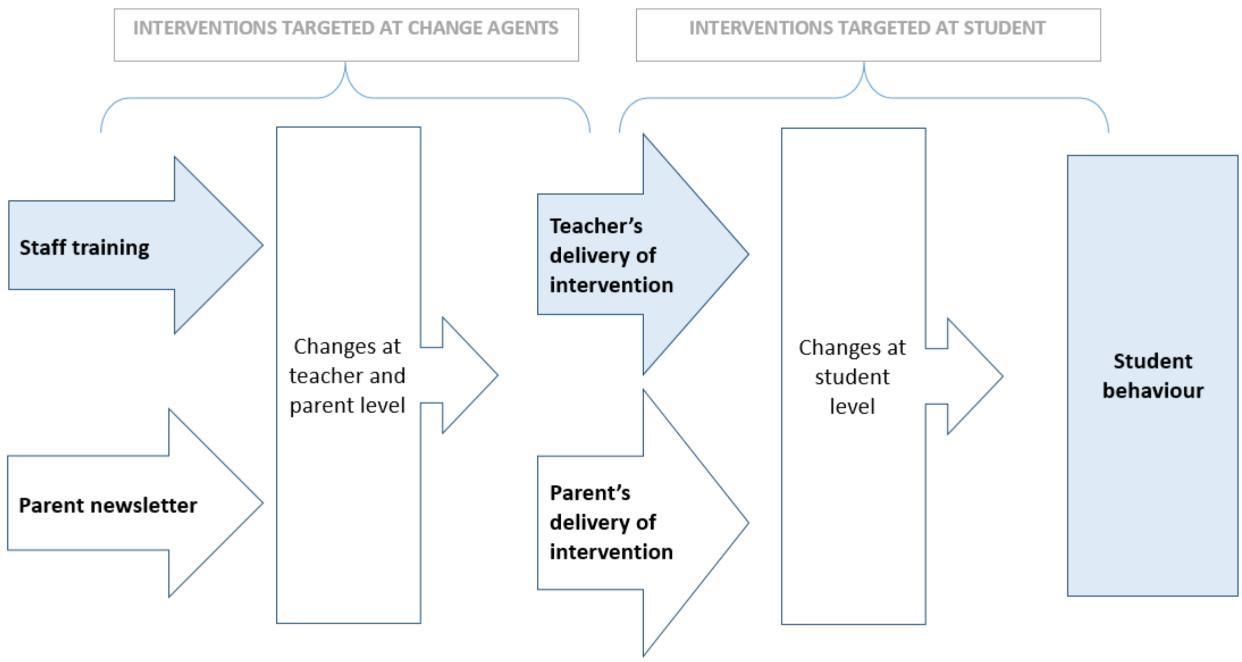

Figure 1.3. Logic model of teacher-led school-based physical activity interventions

Teacher-targeted programmes understudied and underreported

Despite this reliance, knowledge of how best to effect change to teachers' practice is poorly understood in Public Health research. A previous review aimed to address this question by exploring the features and effectiveness of the teacher-targeted programmes in previous physical activity interventions (published any time before March 2015).[77] The authors concluded that the teacher-targeted interventions were "not only under-reported but (also) under-studied". Since the publication of this review in 2017, it remains unclear "what role teacher [professional development] is having on (student) outcomes".[77] Most intervention evaluation efforts have instead stayed primarily focused on the student-targeted intervention. This is evidenced by the methods section and primary objective of most intervention studies, which typically focus on student-level exposure and outcome measures (e.g., change in students' step count). This focus on the student may be attributable to the significant resources required to design, deliver and evaluate a student-targeted physical activity intervention. As a result, limited resources may be available to consider or develop expertise concerning teacher-targeted interventions. Nevertheless, this narrow scope, which is common to most of these studies, may be hindering important scientific progress in understanding some of the potential causal mechanisms underlying (in)effective physical activity intervention efforts.

Educational literature on teacher professional development

Educational theory and research can play a vital role here, as teacher-targeted interventions are a primary area of study in the literature. Teacher professional development, which typically has an explicit focus on behaviour change, is thought to be a key mechanism for improving educational quality.[87] While this now 'global hyper-narrative', that - improving teaching quality will improve student outcomes - has been criticised by some,[88] it has led to numerous Educational research studies and reviews seeking to understand the links between professional development activities, and teaching and student impacts.[89-91] Multiple trials and reviews suggest that some teacher professional development programmes can have a significant positive impact on students.[92-95] For example, a recent trial of a teacher professional development programme in Australia reported significant student improvements in mathematics, equivalent to two months of additional progress.[95] However, these classroom effects are often not observed.[96,97] Reviews of the literature that apply strict inclusion criteria (e.g., randomised controlled trials) and outcome measures (e.g., students' standardised test scores) often find no student effect.[98] Scaled-up programmes of efficacy trials, shown to be effective in a limited number of schools, seem to encounter the same previously mentioned 'voltage drop' phenomenon.[99] This has raised questions about the value of professional development, particularly given the substantial resources typically associated with participation in these programmes.

Educational research efforts have therefore been dedicated to identifying the potential factors contributing to (in)effective teacher-targeted interventions. Public Health researchers can hence learn from these efforts.

Studies of teacher professional development design features

A large body of evidence indicates that professional learning and change is a complex process, and is associated with multiple internal (e.g., teachers' self-efficacy, reflective practices)[100,101] and external factors (e.g., peer learning, classroom norms, wider school and government priorities).[90,101-103] A large body of research also suggests that some programme/activity design features may be important to facilitate professional change among teachers.[87] For example, multiple systematic reviews and best evidence syntheses have identified design features common to the professional development programmes that have had an observable impact on teachers' students. These include:

i) sustained duration (i.e., programmes are not a one-off workshop),[90,101,104,105]

ii) collaboration (i.e., teachers learn together),[90,106,107]

iii) models and modelling (e.g., teachers are provided with demonstrations),[90,104,108] and

iv) active learning opportunities (e.g., programmes include rehearsal opportunities).[90,104,106,107]

Based on the findings from these and other studies, Educational researchers often consider the design features of professional development programmes in theoretical models describing the trajectory from teacher exposure to student impact (see Figure 1.4). As a result of the reviews listed above, which provide overlapping support for these design features, multiple policy documents in the UK, Europe, and the US, including professional development standards intended to guide practice, also endorse the use of these design features in teacher-targeted programmes/activities.[109]

Model author	Background/ context	Professional development design	Teacher learning (internal change)	Teacher practice (external change)	Student impacts	Teacher beliefs (internal change)
Desimone[110]		✓	✓	✓	✓	
Opfer[111]		✓		✓	✓	
Timperley et al[101]		✓	✓	✓	✓	
Loucks-Horsley & Matsumoto[112]		✓	✓		✓	
Supovitz and Turner[113]		✓		✓	✓	
Guskey[114]		✓		✓	✓	✓
Fishman[115]	✓	✓	✓	✓	✓	

Figure 1.4. McChesney and colleagues' summary of conceptual models theorising trajectories from teacher professional development to student impacts[116]

*Arrows (→ & ↔) represent uni- and bidirectional relationships, respectively, as theorised by the authors

Limited scope of teacher professional development research

This theory and research offer an informed lens through which the features of teacher-targeted interventions could be studied within the context of school-based physical activity promotion initiatives. However, some caution should be applied in directly applying this evidence base to all areas of teacher professional development. A majority of the literature on which this 'consensus' has built, relating to active design features, is based on studies of professional development for maths, literacy, and science.[89,117,118] Professional development for these subjects is already supported by wider factors beyond the programmes themselves. These factors include alignment with government and school priorities, as well as the enhanced capacity for teachers in these subjects to engage in reflective practices and observe changes in their students (e.g., through homework, test performance, more regular lessons). Research shows that these external and internal factors help to facilitate and sustain professional change among teachers.[100,101,119] Thus, it remains unknown whether the inclusion of these design features is sufficient to promote classroom change in the context of subjects/areas which typically lack wider supportive infrastructure. Given the public resources invested into professional development activities for all subjects and the intended generalisability of professional development standards that endorse the use of these design features, this is a significant knowledge gap.

Unknown function(s) of effective professional development design features

Educational researchers have also reported that the inclusion of these design features does not always yield the intended impact on student achievement.[120,121] As a result, many researchers have raised the question – what, if any, function do each of these features facilitate in promoting teacher behaviour change?[109] Addressing this question has important implications for designing both effective and efficient programmes. For example, if it is determined that time alone does not significantly contribute towards professional learning and change, this may result in substantial opportunity costs, not least because professional development undertaken beyond designated In-Service Education and Training (INSET) days (or their equivalent) incurs substantial costs for schools (to pay for both the programmes and the substitute teachers). It also has implications for teachers' workloads, as they are increasingly reporting a requirement to engage in professional development in their personal time.[122] There are also opportunity costs to consider for teachers' students in the form of lost learning opportunities.[123] Other commonly endorsed design features (e.g., teacher collaboration) are similarly resource-intensive. Hence, a greater understanding of the underlying role these features play in promoting change is important in the development of more effective and efficient teacher professional development.

Drawing on this theory and research from the field of Education can hence guide evaluations of teacher-targeted interventions in the context of physical activity initiatives. By addressing these knowledge gaps, Public Health researchers can also contribute to the field of Education, ensuring a more comprehensive evidence base that extends knowledge of teacher professional development beyond the core subjects.

1.11 Understanding the context in which school-based interventions are delivered

In addition to a greater understanding of how existing interventions have been implemented to date, researchers have argued there remains a poor understanding of context-specific drivers of young people's physical activity in educational settings.[78-80,124] Addressing this question could help identify whether interventions should be targeting other and/or additional components.

Use of the socio-ecological model

I previously mentioned that extensive research efforts have investigated the correlates and determinants of physical activity among young people (Phase IV of the Behavioural Epidemiology Framework).[50] These correlates and determinants are commonly viewed through a socio-ecological model,[51,125,126] which encompasses various factors: individual (e.g., psychological, biological), interpersonal (social norms and practices), environmental (e.g., built and natural environment), community and public policy factors (see Figure 1.5 below).[127,128] Public Health researchers have traditionally used this model to guide studies aimed at identifying correlates of young people's physical activity.[50]

Limitations of the socio-ecological model

From an Educational research perspective, a major limitation associated with using the socio-ecological model to study young people's physical activity in the school setting is that the school is represented as a 2D non-hierarchical structure in the model (see Figure 1.5 below). This representation suggests that single components of the school could be studied and/or targeted to understand and change students' physical activity. A large body of Educational research however shows that schools are dynamic complex ecosystems, with their own proximal (e.g., individual, interpersonal, organisational) and distal (e.g., school policies and built environments) factors, which interact to influence organisational behaviour (e.g., staff practices, student behaviour) and school 'outcomes' (e.g., student achievement).[129-133] Hence, consideration and examination of each of these school-level factors may be necessary to understand the 'chemistry' between the aims of an intervention (e.g., school-day physical activity promotion) and the behaviours that each of these school-level factors potentially elicits.

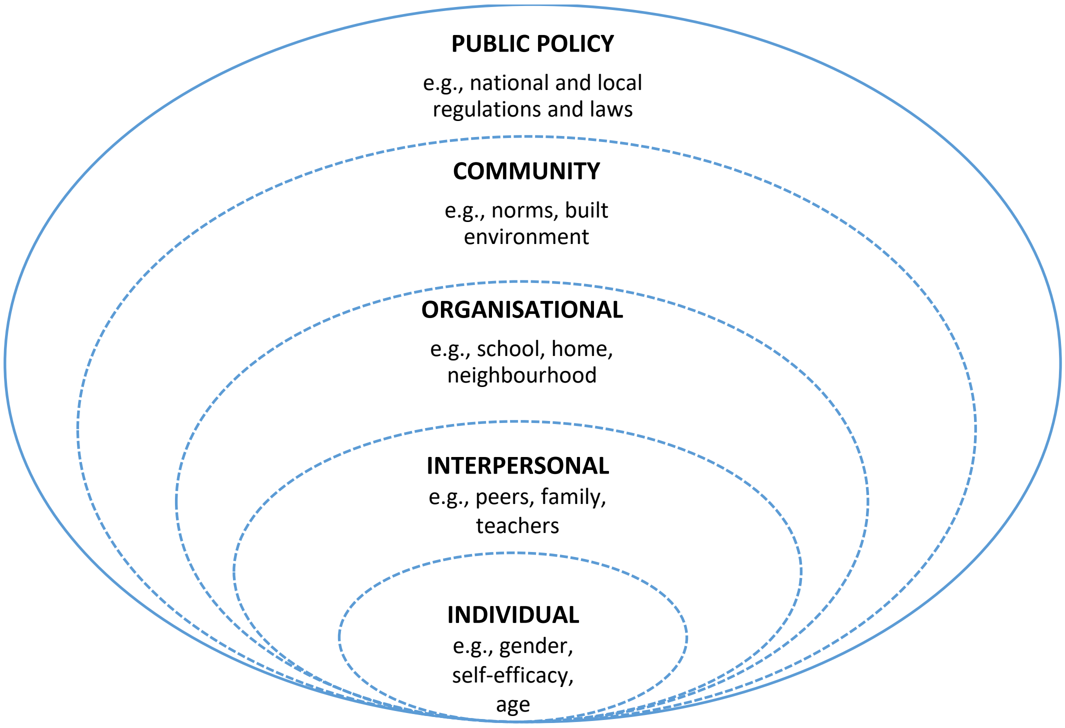

Figure 1.5. The socio-ecological model outlining the multi-level influences of physical activity behaviour in young people. Figure adapted from Mehtälä and colleagues[128]

Focus on individual and interpersonal factors

Many observational studies of young people's physical activity behaviour have previously examined individual and interpersonal school-level correlates of student physical activity (e.g., social norms, peer behaviour, teacher influence).[126,134-138] Most experimental studies have similarly focused on targeting these factors.[86] Public Health researchers however have paid less attention to school-level environmental and policy factors. While physical activity researchers have argued that environmental and policy factors "add explanatory value above that provided by individual and interpersonal factors",[139] context-specific environment and policy factors within schools remain relatively underexplored. Investigating these factors and their associations with individual and interpersonal factors could enhance our understanding of the potential breadth of factors associated with young people's physical activity at school.

School-level environmental correlates of student physical activity

The school-built environment refers to the physical surroundings and infrastructure of the school, including classrooms, playgrounds, sports facilities, and other amenities. Various components of the school-built environment may facilitate or restrict students' ability to engage in certain amounts (e.g., vigorous-intensity physical activity) and types (e.g., aerobic activity) of physical activity.[102,140] Review-level evidence suggests a positive association between some general features of the school-built environment (e.g., sports facilities, playgrounds, and recreational spaces) and student physical activity.[80,141] However, this evidence base could be strengthened by a deeper examination of whether specific features of the school-built environment are particularly important (e.g., fixed vs. loose equipment within a school playground). Addressing this question could offer valuable insights for schools with financial and/or spatial constraints. The evidence base could also be strengthened by a better understanding of whether specific features of the built environment (e.g., playing fields) support different amounts and types of physical activity (e.g., aerobic activity).[142] This could support the development of school-built environments that promote compliance with all physical activity guideline recommendations. Finally, how infrastructure is used by different student populations is poorly understood. Addressing this question could help provide important context to the findings from built environment intervention studies reporting that girls have benefitted less than boys from these interventions.[80,143] Further research in this area is hence necessary to improve understanding of school-level environmental correlates of student physical activity.

School-level policy correlates of student physical activity

School-level policies refer to "organisational statements or rules that are intended to influence behaviour".[139] They may also have intentional or unintentional effects on student physical activity. However, review-level evidence indicates that research to date has heavily focused on school policies related to only limited segments of the whole school day,[79,144] specifically Physical Education (PE) (e.g., policies related to minimum PE time requirements, PE curriculum adherence, PE specialist teacher training, and PE class size restrictions).[79] While these studies have advanced knowledge of effective PE-related policies, it is important to acknowledge that PE constitutes only a small portion of the school day. The physical activity students typically gain from a PE lesson represents a fraction of students' total recommended moderate-to-vigorous intensity physical activity.[145] Very few studies in comparison have examined school policies that cut across the whole school day.[79] Review-level evidence also highlights that the vast majority of known studies concerning school policies and student physical activity have focused on schools and students in high-income countries.[78] Given that physical inactivity is a widespread issue affecting many countries worldwide, there is an opportunity to address this gap through an ecological study, examining whole-day school policies (e.g., those related to uniforms) and student physical activity. By investigating the potential associations between school uniform policies and student physical activity, researchers can gain valuable insights into school-level policy factors that may be associated with physical activity at the population level. In doing so, researchers can advance understanding of the school environment and the role of whole-day policies in shaping physical activity behaviour across diverse student subgroups.

1.12 Thesis aims

In consideration of the literature presented in this chapter, the overall aim of this thesis is to integrate theory and evidence from Public Health and Educational research to enhance scientific understanding of teacher and student behaviour related to physical activity in educational settings.

To accomplish this overall aim, I developed five research objectives. These are:

1. To identify the features of teacher-targeted programmes that have been provided to support the delivery of school-based interventions targeting student physical activity;
2. To examine associations between features of teacher-targeted programmes and teacher and student-level outcomes;
3. To explore students' use of school playground infrastructure during break time, and study associations between infrastructure use, physical activity and cardio-respiratory fitness;
4. To assess associations between school uniforms and students' total weekly physical activity; and
5. To examine gender-based differences in associations between break time playground infrastructure use, school uniform policies, and student physical activity.

I address research objectives 1 and 2 in the first part of this thesis. In Chapters 2 and 3, I examine the professional development provided to teachers responsible for delivering school-based interventions targeting student physical activity in research and real-world contexts. These studies aim to advance understanding of the features of the training and professional development provided to teachers in recent years and the potential mechanisms of effect underlying their observed outcomes. The findings from these studies can provide insights into why interventions may be failing to affect student physical activity and guide the development of evidence-based teacher-targeted interventions.

I address research objectives 3, 4 and 5 in the second part of this thesis. In Chapters 4 and 5, I focus on the relationships between the school-built and policy environment and student physical activity. In Chapter 4, I examine if there are overall and gender-based associations between students' break time infrastructure use, their step cadence during break time, and their cardio-respiratory fitness. In Chapter 5, I examine if there are associations between school policies relating to uniforms and gender inequalities in total weekly physical activity. The findings from these studies may be used to inform the development of gender-equitable interventions targeting distal school-level factors.

More specific research objectives for each study are outlined in greater detail in Chapters 2-5. In the overall discussion chapter, Chapter 6, I consolidate the cross-cutting findings from these four studies, explore overarching methodological considerations, highlight contributions, and outline future directions for researchers and policy actors to consider.

Chapter 2: Features of effective staff training programmes within school-based interventions targeting student activity behaviour: a systematic review and meta-analysis

Contributions

I designed this study in collaboration my supervisors, Riikka Hofmann and Esther van Sluijs. Olivia Alliott, Esther van Sluijs and I screened all articles. I extracted all of the data, and Olivia Alliott and I conducted the BCT coding. Erika Ikeda and I conducted quality assessment ratings, and assessed and classified fidelity outcomes. I conducted the analyses, with input from Jian'an Luan and Esther van Sluijs. I led on data interpretation and wrote this chapter. Erika Ikeda, Olivia Alliott, Jian'an, Riikka Hofmann and Esther van Sluijs provided critical feedback.

2.1 Introduction

This chapter describes the first study of my thesis and aims to advance current understandings of the features of teacher-targeted interventions and their effectiveness in school-based physical activity research studies. To accomplish this, I conducted a systematic review and meta-analysis of staff training programmes delivered within randomised controlled trials. I extracted trial data to examine the features of staff training programmes delivered within school-based physical activity promotion interventions. I also investigated if specific features were associated with successful implementation and device-measured student physical activity.

2.2 Background

As outlined in Chapter 1, many school-based interventions have been delivered worldwide to promote physical activity and reduce sedentary behaviour among young people.[63,64] Review-level evidence shows that these interventions have mostly failed to change any device-measured activity behaviour across the intensity spectrum.[67,68,70] Research to date has commonly focused on assessing students' activity behaviour outcomes. Equal efforts have not been applied to determine how interventions have been implemented. Consequently, reasons for outcomes remain unknown and existing guidance for schools on how to promote physical activity or reduce sedentary behaviour is vague and underpinned by weak evidence.[e.g.,146]

Medical Research Council (MRC) guidance highlights the need to focus on the most important areas of uncertainty to interpret observed outcomes arising from interventions delivered within complex systems (e.g., educational systems).[147,148] Review-level evidence indicates that school-based interventions in the last decade have been largely implemented by teachers,[86] who, have been selected to deliver new instructional programmes (e.g., a new sports programme or 'active' lesson)[149-151] aimed at promoting physical activity among students. To facilitate this process, teachers are frequently enrolled in training programmes, the broad aim of which is to change their teaching practices. However, little is known about the training they receive,[77] and how this affects their professional practice and student physical activity outcomes.

The most recent review to examine staff training within school-based activity behaviour interventions was conducted in 2015.[77] Lander and colleagues evaluated features of training associated with significant changes in self-reported fundamental movement skills and/or physical activity within a physical education lesson. They found that training which is one day or more in length, delivered using multiple formats, and comprised of both subject and pedagogical content was associated with positive student outcomes. However, due to the prevalence of poor reporting across studies, the authors could not determine more specific training features that were causally related to desired outcomes. Hence, little is known on how to design training programmes to optimise intervention implementation (e.g., fidelity) and outcomes (e.g., activity behaviour).

To support the development of evidence-based teacher professional development, effective features of training programmes must be identified. This requires training features to be adequately described. 'Behaviour change techniques' (BCTs) offer a means of breaking down variable training programmes into observable, replicable, and irreducible features.[152] Specifying training programmes in terms of BCTs alongside features such as duration enables nuanced but rigorous evidence synthesis, and comparison with the wider professional development literature.[99,153,154]

Many school-based intervention studies have been published since Lander and colleagues conducted the search for their review in 2015.[77] The quality of reporting and underlying evidence may have improved since this time, given the greater availability of reporting guidelines[155] and use of device-based activity monitors.[156] I therefore aimed to build on their review, and, in line with Cochrane guidance[157] reconsidered all elements of the review questions and scope. I aimed to determine, more specifically, which teacher-targeted BCTs have been used within school-based activity behaviour interventions that included staff training, and how their use and other training features are associated with intervention fidelity and students' device-measured outcomes.

Review questions

1. What BCTs have been used in staff training programmes to change student activity behaviour?
2. Is there an association between staff training features, including BCTs, and intervention fidelity?
3. Is there an association between staff training features, including BCTs, and changes in students' device-measured activity behaviours?

2.3 Methods

This review is reported in accordance with the 2020 Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) checklist[158] (see Appendix 2.1). The review protocol was prospectively registered on PROSPERO (CRD42020180624) (see Appendix 2.2). Operational definitions adopted for the review are outlined in *Table 2.1*.

Table 2.1. Terms and definitions adopted for the review

Term	Definition
Behaviour change technique	"An observable, replicable, and irreducible component of an intervention designed to alter or redirect causal processes that regulate behaviour; that is, a technique that is proposed to be an 'active ingredient'".[152]
Fidelity	"The extent to which the intervention is delivered as intended".[148]
Staff training	Any set of activities aimed at changing teaching practice(s).
Activity behaviour	Any activity behaviour across the intensity spectrum, including physical activity and sedentary behaviour.[159]
Physical activity	"Any body movement generated by the contraction of skeletal muscles that raises energy expenditure above resting metabolic rate. It is characterised by its modality, frequency, intensity, duration, and context of practice".[1]
Sedentary behaviour	"Any waking behaviours characterised by an energy expenditure ≤ 1.5 metabolic equivalent of tasks, while in a sitting, reclining, or lying posture".[160]
An intervention	Single or multiple components (e.g., contents and/or design features) of a programme that aim to effect one or more changes in a defined group of participants (e.g., school staff, students, parents).
A study	"A defined group of participants and one or more interventions and outcomes". A study may have more than one output, peer-reviewed or otherwise, to report information about the protocol, analysis plan, process evaluation or observed outcomes.[161]

Literature search

The search strategy and terms were based on the inclusion and exclusion criteria (*Table 2.2*), and developed in collaboration with an experienced librarian. The sensitivity and specificity of combinations of free-text terms and database subject headings were tested using MEDLINE (via Ovid). Search terms and operators were subsequently translated and iteratively tested on additional databases identified as relevant (Education Resources Information Center, Applied Social Sciences Index and Abstracts, Embase (via Ovid), Scopus, Web of Science, SPORTDiscus). Searches were run on 15 May 2020 and limited to articles published since 1 January 2015 to avoid inclusion of studies assessed in the Lander review[77] and to focus resources on the highest quality data available to address the review's aims. No language or geographic limitations were applied. Appendix 2.3 outlines the search terms used and the number of records identified.

Table 2.2. Study inclusion and exclusion criteria for systematic review

	Inclusion	Exclusion
Population:	School staff participating in an intervention aimed at changing any student activity behaviour across the intensity spectrum	Interventions targeting pre-school and/or pre-service teachers Interventions targeting mostly special student populations
Intervention(s), exposure:	Any staff training (at least one behaviour change technique must have been identified)	Staff training aimed at extramural school staff behaviour (e.g., training for teacher-led after-school interventions)
Comparator(s)/ control:	Any control condition described	
Outcomes:	Staff fidelity (any quantitative measure), and/or any device-measured student activity behaviour assessed at both baseline and follow-up	Studies that do not report on outcomes after training was first introduced
Study design:	Any experimental design [a]Any randomised controlled design (determined by descriptions of the study design rather than its label)	[a]Feasibility, pilot, or small-scale studies, defined as studies with ≤100 students at baseline (determined based on the title, abstract and methods sections of study publications reporting on outcomes)

[a] denotes criteria was applied during second round of full-text screening,

Screening

Search results were imported into EndNote X7 for deduplication (Clarivate, Philadelphia, PA). Remaining records were then imported into Covidence (Veritas Health Innovation, Melbourne, Australia) for screening. Title and abstract screening was conducted by one reviewer. A random sample (10%) of excluded records was checked to minimise screening errors (Cohen's Kappa=0.48). All full texts were independently screened for eligibility by two reviewers (Cohen's Kappa=0.60). If eligibility could not be determined based on an article, I searched for other publications reporting on that same study to obtain further information. Eligibility disagreements were resolved by discussion. After the original criteria were applied, the number of eligible articles (n=166) was deemed too large for the review team's resources. A second round of full-text screening was conducted with updated inclusion and exclusion criteria; studies had to report on randomised controlled trials, and pilot, feasibility, and small-scale trials (≤100 students at baseline) were also excluded (Cohen's Kappa=0.98) (Table 2.2).[73] Following screening, I conducted forward and backward citation tracking using Google

Scholar, and searched through articles and their supplementary materials for peer-reviewed publications and other outputs relevant to studies eligible for inclusion.

Data extraction

All data extraction was performed by one reviewer using a pre-piloted form. Articles not published in English (n=2) were translated using DeepL Translator (available at www.deepl.com/translator). Details on staff training were extracted based on items in the Template for Intervention Description and Replication (TIDieR) checklist,[155] a reporting guideline outlining the minimum set of items considered essential for intervention description and replication (e.g., use of theory, duration, mode of delivery). Where multiple training programmes were delivered within a study (e.g., in the form of content, dose, material etc. beyond local adaptation or personalisation), and outcome data were reported for each arm, data was sought and extracted for each arm. Information reported across study publications and outputs was pooled for data extraction. Where discrepancies were identified between study publications/outputs and data were mutually exclusive (e.g., training duration), data reported in the most recent outcome paper were selected. Where data differed but were mutually inclusive (e.g., BCTs), data were treated as cumulative and extracted as such.

Most studies (50/51; 98.0%) failed to report all TIDieR items about the staff training. Lead authors of included articles were contacted. They were requested to check and complete a partially filled TIDieR-based form, and to add any relevant study publications not listed. Authors were given three weeks to respond with a reminder email. Most authors responded (41/50; 82.0%) and 85.1% (39/41) provided additional information.

Data coding, outcome classification and selection

BCT coding

All training content extracted from peer-reviewed publications was compiled for coding, including any information about interventions delivered to staff in control groups. Other study outputs (e.g., websites) were not coded as access was variable between studies. Content was independently coded in duplicate by two reviewers for the presence and absence of BCTs using the BCT Taxonomy Version 1 (BCTTv1).[152] Coders completed certified training in advance (available at www.bct-taxonomy.com). Only content that aimed to change staff behaviour within school hours and that specifically related to student activity behaviour was coded. Disagreements were resolved through discussion and by referring back to the BCTTv1 guidance (Cohen's kappa=0.70).

Assessing and classifying fidelity outcome(s)

To account for differences in fidelity measurement and reporting across studies, I established a structured process (see Appendix 2.4) to assess, calculate, and classify fidelity outcomes as high (80-100%), medium (50-79%), or low (0-49%) fidelity.[162] All fidelity data was classified by one reviewer. A second reviewer checked all fidelity classifications (low, moderate, high); conflicts were resolved by discussion.

Selecting activity behaviour outcomes

A single reviewer extracted one physical activity and one sedentary behaviour outcome per study. Where more than one of either outcome was reported, I applied a hierarchy (see Appendix 2.5) to focus on outcomes closest to the review's exposure of interest. Activity behaviours measured during periods in which teachers were present for the greatest proportion of that time were prioritised as follows: i) teacher period, ii) school hours, iii) weekdays, and iv) whole of week. Where multiple physical activity outcomes within one of these periods were reported, outcomes were prioritised as follows: i) time spent in moderate-to-vigorous physical activity, ii) total physical activity, iii) vigorous physical activity, iv) moderate physical activity, and v) light physical activity, based on evidence of their respective associations with health outcomes.[163,164] Where multiple sedentary behaviour outcomes within one of these periods were reported, I prioritised time spent in any sedentary behaviour above other outcomes (e.g., number of breaks in sedentary time). Where multiple follow-up measures were reported, outcomes measured closest to the end of the student-targeted intervention were extracted.

Quality assessment

Quality assessment ratings of fidelity and activity behaviour outcomes were conducted independently by two reviewers using the Effective Public Health Practice Project (EPHPP) tool and dictionary.[165,166] The EPHPP tool rates six individual domains; selection bias, study design, confounder bias, blinding, data collection methods, and withdrawals and dropout. Domain-specific ratings were used to calculate the global rating ('strong', 'moderate' or 'weak') according to the EPHPP dictionary. We piloted the EPHPP using a subsample of studies (n=11 studies) to ensure consistency in the interpretation of signalling questions between reviewers before starting the full set. Conflicts regarding global ratings were resolved through discussion (inter-rater agreement=76.2% and 80.6% for fidelity and activity behaviour outcomes, respectively).

Data synthesis

All statistical analyses were conducted using Stata (version 16.1). To assess the relative effectiveness of BCTs on fidelity, promise ratios were calculated as the frequency of a BCT appearing in a promising intervention (defined as high/moderate fidelity) divided by its frequency of appearance in a non-promising intervention (low fidelity).[167] BCTs had to be identified in at least two interventions reporting eligible fidelity data to be assessed. Where BCTs were only identified in promising interventions, the promise ratio was calculated as the frequency of a BCT appearing in a promising intervention divided by one.[167] BCTs were considered promising if their calculated promise ratio was ≥2. Chi-square and Wilcoxon rank-sum tests were performed to assess differences in other training features (total training time, use of theory, session number, training period, number of BCTs) between moderate/high and low fidelity studies. The level of statistical significance and confidence was set at 5% and 95%, respectively. Results are reported in accordance with the Synthesis Without Meta-analysis guidelines.[168]

Meta-analysis

Intervention effects on physical activity and sedentary behaviour outcomes were analysed separately. Standardised mean differences (SMDs) were used to estimate effect sizes, and calculated based on the number, mean, and standard deviations (SDs) of treatment and control groups at baseline and follow-up. Appendix 2.6 outlines all formulae used to calculate SMDs and their standard errors (SEs) to perform random-effects meta-analyses. Where means and SDs were reported at a subgroup level (e.g., by sex), formulae outlined in the Cochrane handbook[169] were used to estimate outcomes at the unit of interest. Missing SDs were calculated using SEs, 95% confidence intervals (CIs), and t-distributions using formulae.[169] Where both SDs and means were missing, these were calculated using medians and interquartile ranges (IQRs) using Wan's formulae.[170,171] Studies that did not report on the mean and SD values of the same sample size at baseline and follow-up were excluded from analyses. Cohen thresholds were used to interpret SMDs as trivial (<0.2), small (≥0.2 to <0.5), moderate (≥0.5 to <0.8), and large (≥0.8).[172] Random-effects meta-regressions were performed to explore variations in effect estimates for outcomes as a function of BCTs, total number of BCTs, total training time, number of training sessions, and training period. In line with previous reviews,[173] only BCTs unique to treatment groups and those identified in at least four interventions were included in analyses. Statistical heterogeneity was assessed using forest plots, the tau-squared (τ^2) value and its 95% prediction interval.[174] Publication bias was assessed by visual inspection of funnel plots and Egger's test.

2.4 Results

Overview of studies included

Figure 2.1 outlines the screening process, resulting in the inclusion of 51 individual studies. Further information about articles excluded during full-text screening is available in Appendix 2.7.

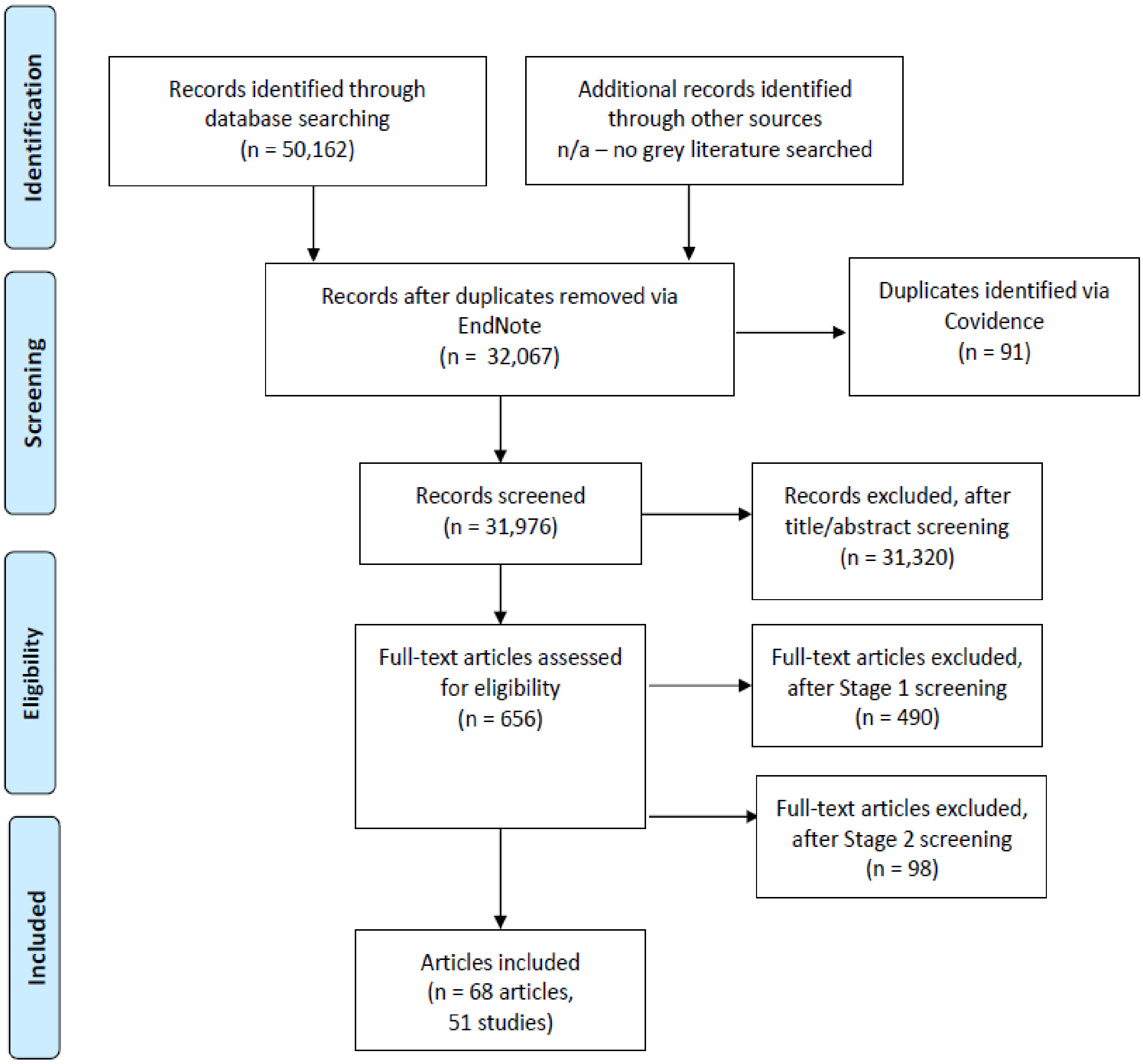

Figure 2.1. PRISMA flow diagram for study inclusion. n/a = not applicable

Studies originated from 19 countries, although 51% were from three countries (Australia: 19.6%,[175-191] the United States: 15.7%,[192-200] and the United Kingdom: 15.7%[201-212]). Most were conducted in primary school settings (n=32, 62.8%). At baseline, the median number of schools and students per study was 14 (IQR: 9-24) and 779 (IQR: 361-1397), respectively. Fifty-three eligible training programmes were identified across 51 studies. Based on the percentage of studies with data reported, most programmes were delivered face-to-face (88.2%), in a group setting (60.5%), by research team members (65.3%) and underpinned by some theory or rationale (74.4%). The median training time was 7 hours (IQR: 2-14 hours). The median session count was 2 (IQR: 1-3). Full study details, including any theory or rationale used to inform training, are outlined in Appendix 2.8.

Use of BCTs in training programmes

Thirty-seven out of 93 possible unique BCTs were identified across 53 training programmes (see Table 2.3). The mean number of BCTs identified per treatment group was 5.1 (SD=3.2; range=1 – 15). Two BCTs were identified in at least 50% of treatment groups; 'Instruction on how to perform the behaviour' (98.1%) and 'Social support (unspecified)' (50.9%). I also identified BCTs in two control staff training programmes;[198,213] 'Instruction on how to perform the behaviour' was coded in each of these. Appendix 2.9 provides a list of BCTs identified per training programme.

Table 2.3. Behaviour change techniques identified in treatment and control groups of training programmes (n=53)

Behaviour change techniques (n=37)		N[a]	%[b]
4.1	Instruction on how to perform the behaviour	52	98.1
3.1	Social support (unspecified)	27	50.9
12.5	Adding objects to the environment	21	39.6
1.1	Goal setting (behaviour)	19	35.8
2.2	Feedback on behaviour	16	30.2
6.1	Demonstration of the behaviour	15	28.3
1.4	Action planning	15	28.3
8.1	Behavioural practice/rehearsal	15	28.3
1.2	Problem solving	11	20.8
2.3	Self-monitoring of behaviour	8	15.1
3.2	Social support (practical)	7	13.2
5.1	Information about health consequences	7	13.2
12.1	Restructuring the environment	6	11.3
1.3	Goal setting (outcome)	5	9.4
7.1	Prompts/cues	5	9.4
2.6	Biofeedback	4	7.5
10.2	Material reward (behaviour)	4	7.5
10.3	Non-specific reward	3	5.7
13.1	Identification of self as role model	3	5.7
13.2	Framing/reframing	3	5.7
1.5	Review behaviour goal(s)	2	3.8
1.6	Discrepancy between current behaviour and goal	2	3.8

Behaviour change techniques (n=37)		N[a]	%[b]
1.7	Review outcome goal(s)	2	3.8
2.1	Monitoring of behaviour by others without feedback	2	3.8
6.3	Information about others' approval	2	3.8
1.8	Behavioural contract	1	1.9
2.7	Feedback on outcome(s) of behaviour	1	1.9
4.4	Behavioural experiments	1	1.9
5.3	Information about social and environmental consequences	1	1.9
5.6	Information about emotional consequences	1	1.9
6.2	Social comparison	1	1.9
8.3	Habit formation	1	1.9
8.7	Graded tasks	1	1.9
9.1	Credible source	1	1.9
9.2	Pros and cons	1	1.9
10.4	Social reward	1	1.9
15.1	Verbal persuasion about capability	1	1.9
Total number of BCTs identified in experimental arm		37	
Total number of BCTs identified in control arm		1	

[a] Number of training programmes where BCT coded as present (n=53); [b] Percentage of training programmes where BCT coded as present

Association with intervention fidelity

Thirty-five studies reported eligible fidelity data. Most (32/35; 91.4%) achieved a 'weak' overall quality assessment rating. Ten interventions (28.6%) were delivered with high fidelity, 18 with medium fidelity (51%) and seven with low fidelity (20%) (see Appendix 2.10 for domain ratings and fidelity classifications). Nineteen BCTs were associated with promising fidelity outcomes. The BCTs that held the highest promise ratio were 'Adding objects to the environment', 'Feedback on behaviour', 'Demonstration of the behaviour', 'Behavioural practice/rehearsal', and 'Goal setting (behaviour)'. Eleven BCTs were unique to promising interventions (see Table 2.4).

Table 2.4. Behaviour change techniques (BCTs) associated with promising fidelity outcomes, in descending order of promise ratio (N=35 studies)

BCT label [a]	Times BCT coded in a promising intervention (N=28)	Times BCT coded in a non-promising intervention (N=7)	Promise ratio [b]
Adding objects to the environment	12	1	12.0
Feedback on behaviour	12	0	12.0

Demonstration of the behaviour	11	1	11.0
Behavioural practice/rehearsal	11	0	11.0
Goal setting (behaviour)	10	1	10.0
Action planning	7	1	7.0
Instruction on how to perform the behaviour	28	6	4.7
Social support (practical)	4	0	4.0
Social support (unspecified)	14	4	3.5
Information about health consequences	3	0	3.0
Non-specific reward	3	0	3.0
Problem solving	5	2	2.5
Self-monitoring of behaviour	5	2	2.5
Discrepancy between current behaviour and goal	2	0	2.0
Biofeedback	2	0	2.0
Prompts/cues	2	0	2.0
Material reward (behaviour)	2	0	2.0
Restructuring the environment	2	0	2.0
Identification of self as role model	2	0	2.0
Goal setting (outcome)	2	2	1.0
Framing/reframing	1	1	1.0

[a] BCTs coded in at least two interventions with a fidelity classification

Moderate/high fidelity studies were significantly more likely to include theory-informed and shorter training programmes than low fidelity studies (see Table 2.5). All other differences between training features and fidelity outcomes were non-significant.

Table 2.5. Training features associated with promising fidelity outcomes (n=35 studies)

Training features	**Moderate /high fidelity** (N=28)	**Low fidelity** (N=7)	***p*-value**[a]
Mean number of BCTs used (±SD)	5.2 (± 3.6)	3.4 (± 2.4)	0.19
Number of studies reporting any theory/rationale used (%)	17 (85.0)	2 (28.5)	**<0.01**
Median hours of total training time (IQR)	11.6 (4.3–14.0)	3.9 (0.6–7.0)	0.22
Median number of training sessions (IQR)	2.0 (1.0–3.0)	2.0 (1.0–2)	0.85
Median training delivery period (months) (IQR)[b]	6.0 (1.8–12)	21.0 (15–24)	**0.02**

N=number of studies with available data; [a] based on Chi-square and Wilcoxon rank-sum tests (**bold**: p<0.05); [b] Period over which training delivered if more than one session delivered; IQR=interquartile range.

Impact on student activity behaviour

Fifteen studies reported eligible physical activity data for inclusion in meta-analysis and 11 reported eligible sedentary behaviour data. Six studies (6/16 studies; 37.5%) achieved a 'weak' overall quality assessment rating, eight studies (50.0%) achieved a 'moderate' rating and two studies (12.5%) achieved a 'strong' rating (see Appendix 2.11 for domain ratings).

Physical activity

The median follow-up period for physical activity outcomes was 3 months (IQR: 6 weeks-8 months). The pooled effect size estimate was 0.44 (95% CI: 0.18, 0.71), indicating a significant positive intervention effect on students' physical activity at follow-up (see Appendix 2.12). Heterogeneity was wide between studies (τ^2=0.25; 95% prediction interval: −0.67, 1.56). Egger's test indicated evidence of publication bias (p<0.01) (see Appendix 2.12). Heterogeneity was largely driven by two studies[214,215] that reported big effects and large adjusted SEs. When they were excluded from analyses, the pooled effect size estimate remained significant, 0.17 (95% CI: 0.02, 0.32), and Egger's test did not indicate publication bias (p>0.05) (see Appendix 2.12).

Meta-regressions were performed between BCTs eligible for analysis (n=9), total number of BCTs, total training time, number of training sessions, and training period, and changes in physical activity outcomes from baseline to follow-up (Table 2.6). I found significant associations for the BCTs 'Action planning' and 'Feedback on behaviour', and total number of BCTs used (see *Table 2.6*). No other significant associations were identified.

Table 2.6. Meta-regression showing univariate effects of training features on physical activity outcomes (n=15 studies)

Training features		**β**	**SE**	**95% CI**	***p***
Behaviour Change Techniques					
1.1	Goal setting (behaviour)	0.29	0.44	-0.67, 1.25	0.53
1.2	Problem solving	-0.04	0.51	-1.14, 1.06	0.94
1.4	Action planning	1.40	0.32	0.70, 2.10	**<0.01**
2.2	Feedback on behaviour	1.19	0.38	0.36, 2.02	**0.01**
3.1	Social support(unspecified)	0.24	0.45	-0.74, 1.22	0.61
6.1	Demonstration of the behaviour	-0.59	0.45	-1.55, 0.38	0.21
8.1	Behavioural practice/rehearsal	0.82	0.40	-0.03, 1.68	0.06

12.5	Adding objects to the environment	0.64	0.41	-0.26, 1.53	0.15
Total number of BCTs used		0.18	0.06	0.05, 0.31	**0.01**
Total training time (>1 day)		0.16	0.53	-1.01, 1.32	0.78
Total number of training sessions		0.63	0.45	-0.36, 1.62	0.19
Period training delivered over (months)		0.05	0.09	-0.16, 0.26	0.61

[a] '4.1 Instruction on how to perform the behaviour' not analysed due to collinearity; β = effect size estimate; SE = standard error; CI = confidence interval; **bold**: p<0.05

Sedentary behaviour

The median follow-up period for sedentary behaviour outcomes was 4 months (IQR: 6 weeks-10 months). The pooled effect size estimate was 0.06 (95% CI: -0.40, 0.53), indicating no effect on students' sedentary behaviour at follow-up (see Appendix 2.13). Heterogeneity was wide between studies (τ^2=0.59; 95% prediction interval: -0.20, 0.36). Inspection of funnel plot and Egger's test did not indicate publication bias (p>0.05; see Appendix 2.12). Meta-regressions between training features and changes in sedentary behaviour outcomes from baseline to follow-up showed no significant associations (see *Table 2.7*).

Table 2.7. Meta-regression showing univariate effects of training features on sedentary behaviour outcomes (n=11 studies)

Training features		**β**	**SE**	**95% CI**	***p***
Behaviour Change Techniques					
1.1	Goal setting (behaviour)	-0.49	0.49	-1.60, 0.62	0.35
3.1	Social support(unspecified)	-0.73	0.46	-1.76, 0.30	0.15
8.1	Behavioural practice/rehearsal	-0.34	0.52	-1.52, 0.84	0.53
12.5	Adding objects to the environment	-0.41	0.50	-1.54, 0.72	0.43
Total number of BCTs used		-0.08	0.09	-0.28, 0.11	0.37
Total training time (>1 day)		-0.09	0.53	-1.29, 1.10	0.87
Total number of training sessions		-0.52	0.48	-1.61, 0.56	0.31
Period training delivered over (months)		0.00	0.03	-0.07, 0.07	0.95

[a] '4.1 Instruction on how to perform the behaviour' not analysed due to collinearity; β=effect size estimate; SE=standard error; CI=confidence interval

2.5 Discussion

This is the first known systematic review to identify BCTs used in staff training programmes delivered within school-based intervention studies aimed at changing student activity behaviour. I identified 53 eligible training programmes and found evidence that 37 unique BCTs have been used to change teacher behaviour. I found evidence that 19 BCTs are positively associated with promising fidelity outcomes, and that moderate/high fidelity studies are more likely to include theory-based and shorter training programmes (≤ 6 months) than low fidelity studies. I also found training programmes that use more BCTs and those that use 'Action planning' and 'Feedback on the behaviour' are associated with significant changes to students' device-measured physical activity. I found no associations between training features and sedentary behaviour outcomes.

The mean number of BCTs identified per training programme suggests that few teacher-targeted BCTs have been used within school-based teacher-led activity behaviour interventions. The only frequently identified BCTs were 'Instruction on how to perform the behaviour' and 'Social support (unspecified)'. The literature suggests that the use of these BCTs alone is unlikely to achieve or sustain professional change.[153] Certain well-evidenced BCTs were absent across studies. For example, a large body of teacher professional development research has highlighted the importance of providing teachers with tools to notice change in their students to promote professional change.[216-218] Yet 'Feedback on outcome of the behaviour' was identified in just one training programme.[187]

Many study authors reported that the training was underpinned by some rationale or theory, but the theory underpinning the intervention aimed at the student was often conflated with the theory underpinning the staff training.[e.g.,175,219] In such instances, it was often unclear how the theory was used to inform the training. Few authors drew on relevant teacher professional development literature or theory to inform the design of programmes; this may help to explain the limited number of evidence-based BCTs identified across training programmes. Further, many authors provided no information[196,199] or confirmed that the training was not informed by any theory or rationale.[200,201,220,221]

I found evidence to support an association between 19 BCTs and teacher fidelity. The most promising BCTs I identified were 'Feedback on behaviour', 'Demonstration of the behaviour', 'Behavioural practice/rehearsal', and 'Goal setting (behaviour)'. Their use in future training programmes is supported by reviews examining causal components of effective teacher professional development for other school subjects.[89,153,154] 'Adding objects to the environment' is less frequently cited within the literature. The objects provided (e.g., maths bingo tiles, sports equipment, signage, standing desks)[190,196,222-224] may have prompted teachers to implement the intervention on an ongoing basis. Further research is needed to determine how teaching resources and their placement within school settings may promote implementation. Consistent with findings from recent reviews,[93,99,154] I found that training quality (i.e., theory-based training and use of evidence-based BCTs) rather than a longer training duration was associated with intervention fidelity.

I also found evidence to support the use of more BCTs and the use of 'Action Planning' and 'Feedback on behaviour' in staff training to increase students' physical activity. Conversely, I found no evidence to support an association between training features and sedentary behaviour outcomes. These findings may be explained by the small number of studies that observed significant intervention effects, that measured sedentary behaviour during teacher periods and that specifically targeted students' sedentary behaviour. Interventions must not just be effective but also feasible for teachers to implement and sustain within their workload. Recent research has found that participants often receive more implementation support in pilot interventions than those participating in larger-scale trials of the same or similar interventions.[76] Hence, it is also possible that the interventions were not feasible for teachers to deliver. Finally, quality teaching indicators[95] have yet to be identified within the context of student physical activity and sedentary behaviour. The techniques teachers were requested to implement, even when delivered with fidelity, may have been ineffective in changing students' activity behaviour.

Strengths and limitations of the review

I employed a comprehensive search to identify and extract data about staff training by using a standardised reporting checklist, searching across study publications and outputs, and contacting authors to overcome the limitations of existing reviews that observed poor reporting practices.[77] I achieved a high response rate from study authors and few changes were made to my partially completed forms, suggesting that data about the teacher training programmes was reliably extracted. I overcame limitations associated with recent teacher professional development reviews for other subjects,[153,154,225] by exploring training effects on both professional practice and student outcomes,[225] and by examining data from largely pre-registered[153,225] and medium-to-large-scale studies.[154]

Eligible studies and outputs may have been missed. To reduce the likelihood of missing outputs, all authors were contacted and requested to add study publications not listed. Due to resource limitations, all data extraction was conducted by a single reviewer, which may have resulted in extraction errors. Further, while a structured process was used to classify fidelity data into outcomes, this was conducted by a single reviewer and solely checked by a second. Studies conducted in low and middle-income countries and not published in English are likely disproportionately excluded due to eligibility criteria and databases used. Researchers and practitioners should be cautious about applying the findings to settings and populations underrepresented in this review. Where authors reported fidelity outcomes at multiple time points, [e.g., 182,191,193,214] I selected outcomes measured closest to the training start time. BCTs identified may hence promote short-term fidelity and should be used alongside evidence-based BCTs that promote sustained professional change (e.g., 'Habit formation').[153] Finally, effective training features that are beyond the scope of the BCTTv1 and TIDieR checklist may exist but were not explored in the current review.

Limitations of the underlying evidence

Most of the limitations associated with my findings relate to the quality of the evidence I reviewed. Consistent with previous reviews,[77,226,227] I observed poor reporting on staff training across studies. Consequently, it is difficult to discern whether the BCTs identified reflect what was delivered in practice. In line with previous reviews,[228] fidelity measures used across studies were methodologically weak. Many studies did not report on fidelity to all intervention components or at the individual level. The BCTs identified may therefore overestimate the extent to which their use can promote overall fidelity, and warrant testing across intervention components, teacher populations and school climates. I sought to include all quantitative fidelity data in my analyses to make the best use of available data,[229] but had to exclude 30% of studies as outcomes were reported in isolation of any identifiable target with which I could interpret the data.[e.g.,215,230] This reduced the number of studies on which I could base my findings. Associations between intervention fidelity and physical activity behaviour were not examined as this was beyond the scope of the review.

Implications

In line with existing guidance,[147] I recommend that researchers engage with discipline-specific experts and literature when designing and evaluating all intervention components. For the field to progress, complete and consistent reporting is needed to determine what interventions have been delivered to the various actors within activity behaviour intervention studies. I also advise that study authors use machine-readable tools[231] from the protocol stage to avoid inconsistent reporting within and across study outputs. Finally, valid, reliable and acceptable fidelity measures are needed to determine how school-based interventions are being implemented in practice. Progress is needed to understand the level of support teachers require for effective implementation, components teachers are most likely to deliver, and practices causally related to student activity behaviour change.

2.6 Conclusion

This review advances our understanding of how school-based interventions have been implemented, and identifies specific, replicable techniques that can be incorporated into future programmes to promote intervention fidelity and increase student physical activity. My findings suggest training programmes should be informed by relevant theory and literature and include a combination of BCTs that provide teachers with i) a demonstration of the desired behaviour, ii) an opportunity to practice the behaviour, iii) feedback on their performance of the behaviour, iv) a behavioural goal (self-defined or otherwise) and v) objects that facilitate and cue performance of the behaviour. My findings also suggest teachers should be prompted to make a detailed action plan regarding their performance of the behaviour. I encourage researchers to incorporate BCTs that have been shown to promote sustained professional change within the context of other school subjects, so that their effectiveness can be assessed within the context of physical activity and sedentary behaviour. Changes to reporting practices in the field will enable researchers in time to determine BCT combinations and features (e.g., frequency, sequence) that best predict desired outcomes for defined teacher and student populations.

Acknowledgements

Many thanks to Dr Veronica Phillips (School of Clinical Medicine, University of Cambridge) for her assistance in developing the search strategy and Stephen Sharp (MRC Epidemiology Unit, University of Cambridge) for his statistical advice. I would also like to thank all the corresponding authors of articles who responded to my information requests. Special thanks to Tom Kirk (Faculty of Education), who provided support in translating and communicating the findings from this review for a wider audience.

Chapter 3: Teacher professional development for PE, sport, and physical activity promotion: implementation of the Primary PE and Sport Premium

Contributions

I designed and conducted this study with input from my supervisors, Esther van Sluijs and Riikka Hofmann. I led study co-ordination (e.g., ethics, recruitment, funding), data collection and data management. Anna Melachrou, Tony Webb, Roger Bennett, and Rebecca Margieson provided data management and study coordination support. I cleaned and conducted the analyses, with input from my supervisors. I interpreted the data and wrote this chapter. Esther van Sluijs and Riikka Hofmann provided critical feedback on the interpretation of the findings and presentation of the study.

3.1 Introduction

This chapter describes the second study of my thesis and examines the features of teacher-targeted interventions and their potential effectiveness in facilitating professional change in a real-world context. To address these study aims, I collected primary data from a sample of teachers in England who participated in professional development programmes or activities related to Physical Education in the previous year. I used this data to determine the presence of evidence-based design features in the programmes attended by participants and explored if the presence of specific design features is associated with teachers' perceptions of impact.

3.2 Background

The Primary PE and Sport Premium

The Primary PE and Sport Premium (PE Premium) is the UK government's largest policy targeting physical activity promotion in primary schools in England. The policy was first introduced in 2013, following the London-based Olympic and Paralympic Games. The then Prime Minister, David Cameron, commented that the government wanted to ensure the Games counted for the future and inspire the next generation of professional athletes by encouraging all children to be active and enjoy sports.[232] The objectives of the school-based policy are to:

1) increase the confidence, knowledge and skills of all school staff in teaching PE and sport;
2) engage all pupils in regular physical activity;
3) raise the profile of PE and sport across the school as a tool for whole-school improvement;
4) broaden the experience of a range of sports and physical activities offered to all pupils; and
5) increase participation in competitive sport.[233]

Policy inputs, implementation and theory of change

To achieve the objectives of the policy, schools receive two key provisions: i) additional funding, and ii) information on potential actions teachers could take to realise the policy's objectives in their school. The exact sum each school receives varies depending on its size; a typical one-form entry primary school, with 250 students, receives £18,000 per year.[234] Schools must use the funding for the sole purpose of achieving the policy's objectives and spend the total amount within the same school year it is received. Funding cannot be used for capital expenditure (e.g., sports facility renovations, transportation services to off-site sports competitions), employing coaches solely to cover planning preparation and assessment arrangements, or teaching the minimum requirements of the national curriculum. All five objectives of the policy are intended to be realised through the actions of teachers.

To assist teachers in meeting these objectives, information is provided on a gov.uk webpage on how teachers might change their behaviour to support the aims of the policy (e.g., providing targeted activities, encouraging active travel, having active break times; website link).[233] The guidance highlights that schools should "see the continued professional development of teachers as a key priority" to facilitate the policy's objectives and ensure the PE Premium has a long-term impact. A schematic overview of the Primary PE and Sports Premium theory of change is illustrated in Figure 3.1.

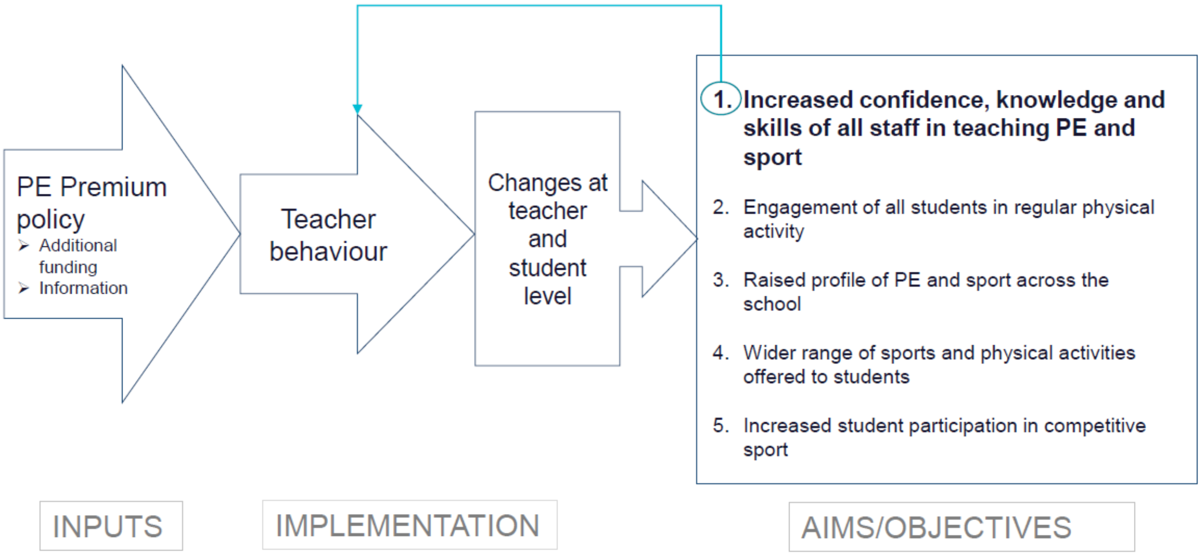

Figure 3.1. A schematic overview of the Primary PE and Sports Premium theory of change

Policy impact and implementation evaluations

Few process or impact evaluations of the PE Premium policy have been conducted to date,[235] resulting in a limited understanding of if and how the policy has achieved any of its objectives in the last 10 years. Total policy spending has exceeded £2.2 billion, and an additional £640 million has been committed for the 2023/2024 and 2024/2025 school years. Though all of the policy's objectives are intended to be realised through effective teacher instruction, evidence suggests primary school teachers in England receive insufficient initial training to provide quality PE lessons, engage students in sports participation, or promote physical activity throughout the school day.[236,237] Thus a key component that warrants evaluation relates to the support provided to teachers to help them achieve the objectives of the policy. As highlighted in Chapter 2, and in multiple other studies,[87,153] brief information interventions in and of themselves are largely ineffective in changing teachers' professional practice. Hence the information outlined on the government webpage, to which not all teachers are necessarily exposed, is unlikely to be an effective implementation strategy. Evidence suggests professional development can support teachers in changing their practice,[95] and some data indicates schools have used a portion of the PE Premium to pay for professional development.[238] However, data is lacking on the characteristics and support for this professional development, which, evidence suggests is necessary to inform an evaluation.[239]

Evaluating teacher professional development programmes

The findings reported in Chapter 2 suggest that certain design features may be important to include in professional development programmes/activities. These findings are supported by an independent systematic review examining features of effective teacher professional development for other school subjects (e.g., literacy, maths, science).[153] Sims and colleagues conducted a similar systematic review of randomised controlled trials (N=104), assessing interventions (teacher professional development programmes) for the presence of BCTs and other features, collectively termed 'mechanisms', and explored associations between mechanisms identified and observed outcomes at follow-up (student standardised test scores).[153] The results of their review align with the features reported in Chapter 2 (see Table 3.1), suggesting some consensus on important design features that facilitate professional change among teachers and their students.

Sims and colleagues also proposed and tested an additional theory in their review; that different design mechanisms (e.g., rehearsal) serve distinct functions. They proposed that professional development has four functions: i) to instil insights, ii) to motivate goals, iii) to teach techniques, and iv) to embed newly acquired knowledge into practice (see Appendix 3.1 for further details). They found evidence that professional development programmes which address each of these four functions (referred to as a 'balanced design') through the use of evidence-based mechanisms had larger effects compared to those with non-balanced designs.

Table 3.1. Review findings on features of effective professional development and their function [153]

Instil Insights[a]	**Motivate Goals**	**Teach Techniques**	**Embed Practice**
Manage cognitive load	Goal setting*	Instruction*	Prompts/ cues*
Revisit prior learning	Credible source	Modelling*	Action planning*
	Praise/reinforcement	Rehearsal*	Self-monitoring*
		Feedback*	Context-specific repetition
		Practical social support*	

[a] Mechanisms in the 'Instils Insights' category not assessed in Chapter 2 as not a 'behaviour change technique' (BCT); *Indicates mechanism identified in both systematic reviews as associated with

effective teacher professional development/staff training

The current study

The primary aim of this study is to determine the presence of evidence-based design features (mechanisms) in professional development programmes and activities attended by primary school teachers in England, funded by the PE Premium. Given that evidence suggests leadership and colleague support are important factors in enabling professional development impact,[240] the secondary aim of this study is to evaluate teachers' perceptions regarding broader school support for professional development. The final aim of the study is to explore if the number of professional development functions addressed by mechanisms and the provision of school support is associated with teachers’ perceptions of impact.

3.3 Methods

This study is written up in accordance with the STROBE (Strengthening the reporting of observational studies in epidemiology)[241] checklist (see Appendix 3.2). Operational definitions adopted for this study are outlined in *Table 3.2*.

Study design

A cross-sectional design was used to maximise participation and reduce attrition. Eligible participants were invited to take part in an online survey, estimated to take 10 minutes to complete (eligibility criteria described below). All data was collected between May and December 2022. As the primary research question was based on a systematic review, published just six months before data collection, survey items were based on the coding framework published in Sims and colleagues' review,[153] feedback from the main author, the BCT Taxonomy Version 1 (BCTTv1),[152] and the template for intervention description and replication (TIDieR) reporting checklist.[242] Items used to address the second research question were based on items included in a national survey of teacher professional development in England that was running concurrently for other school subjects.[243] Prior to data collection, I recruited a group of primary school teachers in England to ensure survey content, terminology used, and recruitment methods were appropriate (see below for further details).

Table 3.2. Operational definitions adopted for this study

Terminology	Definition
Design features	The processes by which the professional development content is delivered.
Internet 'bots'	Computer programmes that create algorithms to complete online forms.[244]
Mechanism	A component of professional development that could not be removed or altered without changing the impact of professional development on teaching and learning.[153]
Physical Education (PE)	"The planned teaching and learning programme in curriculum time that meets the requirements of the national curriculum for physical education."[238]
Professional development	"A specific set of activities and materials intended to improve teaching ability".[153]
Professional development providers	"Includes all those individuals or organisations (including schools) who directly provide expertise or facilitate professional development."[245]

Community and public involvement activities

A sample of five current or former primary school teachers in England were recruited to provide input into the development of the study. The main aim of this exercise was for teachers to engage as 'intelligent actors' and provide feedback about the relevance, appropriateness and accessibility of the survey as a whole and the questions therein.[246] Teachers were also asked about effective approaches to recruitment, appropriate incentives for participation, and inclusive methods to disseminate findings from the study.

All patient and public involvement activities were conducted in March 2022. Teachers were invited to take part through university mailing lists and personal and professional contacts. A £10 online voucher was offered to teachers to thank them for their time (20 minutes). A think-aloud interview approach was employed,[247] in which teachers were asked to read through the survey and discuss out loud how they interpreted the questions and response options. Interviews were conducted on Zoom or in person depending on the teacher's preference.

Additional feedback was also sought from other stakeholders (e.g., a Local Authority Lead Officer for PE and School Sport for Cambridgeshire and Peterborough City Councils, members of the Research and Evaluation team at Ofsted, and the Data Management team at the MRC Epidemiology Unit) to ensure the study design, survey questions and survey platform were appropriate and accessible.

Ethical approval

Ethical approval for the study was granted by the School of the Humanities and Social Sciences Research Ethics Committee University of Cambridge (reference number: HVS/2021/3530). Teachers were informed of the nature and aims of the study before they were asked to complete study eligibility criteria questions, and provide informed e-consent to participate in the study.

Eligibility criteria

Qualified primary school teachers in England were invited to take part in the study who were employed in a school that was eligible to receive the PE Premium, and who had participated in any professional development programme or activity related to PE or sport in the 2021-2022 or 2022-2023 school years. Teachers employed in special schools were excluded from participation as study questions and measures were largely informed by studies conducted in mainstream schools.

Recruitment

To overcome the challenge of low recruitment rates among teachers,[248] particularly during the Covid-19 pandemic,[249] I employed multiple additional evidence-based recruitment strategies to enhance participation. These included:

1. Monetary incentives:[250-252] Teachers were offered the opportunity to enter a prize draw, with a chance to win one of 50 £20 online vouchers.

2. Survey advertisement: I advertised the study through diverse channels, including social media platforms, organisations associated with the primary school teaching community (e.g., Ambition Institute, Association for Physical Education), university mailing lists, and personal and professional contacts. Non-respondents (stakeholders) were followed up via email and/or phone two weeks after the initial email. To thank them for their time, stakeholders were offered a summary of the findings and acknowledgement in study outputs.

3. Tailored communication:[253,254] Relevant stakeholders were approached with pre-prepared text, tailored to their target audience, to use in their mailing lists, newsletters and social media posts (e.g., Tweet: "📢 Primary school teachers in Wiltshire & Swindon, ❓ Have you done any CPD for PE in the last year? ….").

4. Invitation scheduling:[248,255] All stakeholders were asked to disseminate the link to their contacts throughout the data collection period (May-December 2020), with a particular emphasis on non-term times to maximise the prospects that teachers would have the capability to participate.

5. Snowball sampling:[256] Stakeholders were asked to provide details of other relevant organisations that work closely with the primary school PE and teaching community in England and their knowledge of pre-existing participant pools, comprising past research participants who have given permission for future contact. Teachers who participated in the survey were invited to share the link with their colleagues and other teachers at the end of the survey.

6. Study design:[248,254,255] In alignment with primary school teachers' research preferences, the survey was designed as a cross-sectional, online, and brief questionnaire. The final survey length was tested with colleagues using a timer to ensure completion within 10 minutes.

Data collection platform

All study data was collected and managed using REDCap (Research Electronic Data Capture), hosted at the MRC Epidemiology Unit, University of Cambridge.[257,258] REDCap is a secure, web-based software platform designed to support data capture for research studies. All data was collected and stored using REDCap on a Secure Research Drive. Access to the Secure Research Drive was restricted and managed by the Data Management team at the MRC Epidemiology Unit to protect participants' data.

Survey measures

After completing the eligibility criteria questions and providing consent, teachers were asked to think about all the PE-related professional development programmes/activities they had attended in the last school year. They were then asked a series of questions in relation to those programmes/activities. An overview of measures used in the survey is outlined in Table 3.3. Further details are outlined below. Appendix 3.3 provides a copy of the survey.

Table 3.3. Overview of survey sections, questions therein, and relevant sources/references

Survey measures		**Questions**	**Source/reference**
1	Characteristics of professional development	18	[155]
2	Presence of evidence-based mechanisms	19	[153]
3	Professional development impact	4	[259]
4	School support for professional development	7	[243]
5	School and teacher characteristics	8	[260]

1. Characteristics of professional development

Considering professional development as a behaviour change intervention, teachers were asked about professional development characteristics (e.g., location, duration, mode), guided by items included in the TIDieR checklist.

2. Presence of evidence-based mechanisms

To assess the presence of the 14 'mechanisms' (e.g., Feedback, Modelling), questions relating to the 'Procedures' component of the TIDieR checklist were guided by Sims and colleagues' coding framework in their systematic review.[153] Some mechanisms were addressed through multiple questions. Participants were asked about the presence of mechanisms in professional development programmes/activities undertaken (response options: Always/Often/Sometimes/Rarely/Never/Can't remember/Not applicable). Since participants could report on multiple professional development programmes/activities they engaged in over the last school year, I only considered mechanisms as 'included' if they were reported as 'Always' reported by the participant (sensitivity analyses described below). The programmes/activities attended by participants with at least one mechanism addressing each of the four functions of professional development (i.e., to instil insights, ii) to motivate goals, iii) to teach techniques, and iv) to embed practice) were classified as 'balanced'.

3. Professional development impact

Teachers were asked whether the professional learning activities had an impact on their practice' (response options: Not at all/Not a lot/Quite a lot/A lot).[259] Teachers who responded 'Not a lot', 'Quite a lot' or 'A lot' were asked to describe any one change they made as a result of the professional development in an open-ended question.

4. School support for professional development

To assess school support for professional development, teachers were asked about the extent to which they agreed with five statements relating to leadership support for PE professional development (response options: Strongly agree/Agree/Neither agree nor disagree/Strongly disagree/Don't know). Teachers were also asked to identify the actor(s) at their school who helped them to prioritise their professional development for PE (response options: Senior leadership team/PE subject lead/I am responsible for myself/Other). Questions were informed by measures used in Ofsted's national survey of teacher professional development for all school subjects that was running during the same period as data collection in the current study.[243]

5. School and teacher characteristics

Teachers were asked to report on the type of school they worked in. Data regarding school type (e.g., school size, proportion of pupils on free school meals) and teachers' characteristics (e.g., gender, age, professional qualifications) were collected to determine sample representativeness. Questions were based on the School Workforce Census[260] which uses data extracted from schools' management information systems rather than asking individual staff members to answer questions. The questions and response categories were developed to align with data reported in the School Workforce Census for the 2021/2022 academic year.

Data cleaning and data analysis

All data cleaning processes and analyses were conducted using Stata v16.1.

Removal of computer-generated responses

I employed a number of strategies to reduce the risk of unwanted traffic (e.g., using Google's CAPCHA, maximising additional security measures on REDCap). Despite these precautions, the survey received a suspiciously large number of responses (n=4,266). I then investigated if some of the responses were provided by 'bots'; computer programmes which use algorithms to complete online forms, including surveys.[244] An initial inspection of the data confirmed that the survey had received some bot responses. However, similar to others in recent years,[244,261] I identified that traditional approaches used to distinguish bots from genuine responses (e.g., survey response time, responses to open-ended questions) were inadequate. I, therefore, drew on recently published literature about this emerging issue[244,261] and sought out additional advice from the Data Management Team within the MRC Epidemiology Unit to inform my approach to data cleaning. Appendix 3.4 provides full details on the methods I developed to identify and screen out bot responses. Briefly, I initially identified a subsample of participant IDs deemed to be genuine responders; those who had both an IP address associated with the UK and those who provided an email address specific to schools or the UK (e.g.,. a 'sch.uk' account). Various exclusion criteria (e.g., IP address, response time, domain of email address) were then tested iteratively against this subsample of 'genuine' participants. If any criterion resulted in the removal of one or more genuine responders, it was combined with another criterion (e.g., survey timestamp) and re-tested until criteria did not result in the removal of the 'genuine' responders. All data cleaning processes were conducted within the secure offline network to ensure valid participants' identifiable data remained protected.

Data analysis

After the analytical sample had been finalised, descriptive statistics were calculated for categorical and continuous variables. Means and standard deviations (SDs), or medians and interquartile ranges (IQR), are reported based on the distribution of the data.

To investigate potential relationships between programme design features (i.e., number of functions addressed through mechanisms 'Always' reported) and teachers' perceptions of impact ('Not at all/Not a lot/Quite a lot' vs 'A lot'), I employed univariable logistic regression models. I also conducted multiple sensitivity analyses to examine the robustness of the findings, exploring the impact of different cut-off points for the exposure and outcome variables. Specifically, investigations were carried out to assess whether the results remained consistent when mechanisms were reported as 'Always' a feature compared to when they were reported as either 'Always' or 'Often' a feature (versus Sometimes/Rarely/Never). I also examined whether the findings changed when teachers reported the professional development had 'A lot' of impact, as opposed to when teachers reported it had either 'A lot' or 'Quite a lot' of impact (versus Not a lot/Not at all).

I similarly conducted univariable and multivariable logistic regression models to investigate the relationships between teachers' agreement with statements about school leadership support (relating to vision, culture, planning, prioritisation, barrier removal for professional development) and teachers' perceptions of programme/activity impact (Not at all/Not a lot/Quite a lot' vs 'A lot'). I similarly conducted sensitivity analyses to explore whether the findings changed when teachers reported the professional development had 'A lot' of impact, as opposed to when teachers reported it had either 'A lot' or 'Quite a lot' of impact (versus Not a lot/Not at all).

For all models, odds ratios and their 95% Confidence Intervals (CIs) are presented. Model assumptions were tested using a combination of diagnostic tools, including residual and normal probability plots, as well as Hosmer-Lemeshow tests.

To account for potential confounding variables at the school and teacher levels, I reviewed relevant literature to identify variables that may influence associations of interest. Variables including school size, percentage of students eligible for free school meals, years of participant's teaching experience, and teachers' educational qualifications were initially considered as potential confounders. However, after finding no moderate or strong correlations between these variables and the outcome of interest (teachers' perceptions of impact) (all Spearman's correlation coefficients: <0.5), I did not adjust for these variables in analyses. For all analyses, the level of statistical significance was set at an alpha level of 5%.

3.4 Results

Sample characteristics

Characteristics of participants included in the study (n=170) are outlined in Table 3.4. Teachers were predominantly female and had 10 or more years of teaching experience. A majority of participants (n=147, 86.5%) reported the professional development they attended was funded by the PE Premium; the remainder (13.5%) were unsure of the source of funding. See Appendix 3.5 for a flow chart showing participation and attrition in each section of the survey.

Table 3.4. Sample characteristics of survey participants (n=170)

	Total	
	N[a]	%
Total	170	
Gender, n female, %	72	69.2
Age (years)		
25-29	20	19.2
30-39	36	34.6
40-49	28	26.9
50-59	16	15.4
18-24/60 & over	4	3.9
School type		
A school maintained by the local authority	118	69.4
An academy	50	29.4
Other	2	1.2
School size (students)		
1 to 200	31	29.8
201 to 300	31	29.8
301 or more	42	40.4
Percentage of students eligible for free school meals		
Less than 5%	11	10.6
Between 5-9%	25	24.0
Between 10-20%	29	27.9
More than 20%	23	22.1
Don't know	16	15.4
Professional experience post QTS, median (IQR)		
Years teaching	10.5	5-20
Years teaching in current school	6	3-10
Educational qualifications		
Degree or higher	45	43.3
Bachelor of Education	15	14.4
Postgraduate Certificate of Education	41	39.4
Other	3	2.9

[a] n=66 (38.8%) missing, QTS Qualified Teacher Status

Professional development undertaken

Characteristics

Professional development was mostly delivered in-person (57.0%), through courses and sessions (64.7%), in group settings (82.4%), and at a school (teachers' own or otherwise; 58.4%). Professional development was primarily delivered over two days (median, interquartile range (IQR): 1-4 days), with a median time allocation of six hours (IQR: 3-8 hours). Providers were largely qualified PE specialists (62.2%). Participants frequently reported the professional development content was tailored to their ability (57.7%), but not their students' abilities (64.5%). Further details about professional development characteristics are outlined in *Table 3.5*.

Table 3.5. Characteristics of professional development, described in accordance with the TIDieR checklist [242]

Professional development characteristics	**N[a]**	**%**
	170	
Professional development undertaken		
In-person course/session	110	64.7
Online course/session	81	47.6
Education conference	49	28.8
Peer/self-observation and coaching as part of a formal school arrangement	42	24.7
Reading professional literature	26	15.3
Observation visit at another school	16	9.4
Formal qualification programme (e.g., afPE level 5/6)	12	7.1
Other (please provide details)	1	0.6
Professional development provider		
An accredited organisation	67	46.9
Local authority	37	25.9
Teacher(s) from another school	15	10.5
Teacher(s) from participant's school	10	7.0
Other (please provide details)	14	9.8
Provider's expertise/background		
A qualified PE specialist	89	62.2
Expert teacher	31	21.7
Don't know	11	7.7
Other	7	4.9
Can't remember	5	3.5
Mode of delivery		
In-person	81	57.0
Both in-person and online	43	30.3

Professional development characteristics	N[a]	%
Online	18	12.7
Format		
Group (e.g., whole school/key stage groups)	117	82.4
Both group and individual	15	10.6
Individual (e.g., one-to-one coaching)	10	7.0
Location		
Another school	37	29.6
Participant's school	36	28.8
Central location (hotel, government building etc.)	35	28.0
Training centre	10	8.0
Other	7	5.6
Infrastructure used		
Presentational (e.g., projector, whiteboard)	97	57.1
Physical (e.g., gym, classroom, equipment)	95	55.9
Other (please provide details)	3	1.8
No infrastructure was used	1	0.6
Duration		
Total time, hours (IQR)	6	3-8
Total days (if more than one day), (IQR)	2	1-4
Time period (if more than one day)		
Less than one month	6	7.8
1-2 months	22	28.6
3-6 months	21	27.3
More than 6 months	28	36.4
Tailoring		
To participant's teaching experience		
Yes, provider asked participant about their teaching experience before first session	10	7.0
Yes, provider asked participant about their teaching experience during session(s)	72	50.7
No	60	42.3
To participant's students' abilities		
Yes, provider asked participant about their students' abilities before first session	11	7.8
Yes, provider asked participant about their students' abilities during session(s)	39	27.7
No	91	64.5
Materials provided		
Yes	90	63.8
No	40	28.4
Can't remember	11	7.8
Could you keep these		
Yes	83	92.2
No	6	6.7
Can't remember	1	1.1

[a] *missingness varies, n=27-29, see Appendix 3.5 for a flow chart showing participation and attrition in*

each section of the survey.

Presence of evidence-based mechanisms

The median number of mechanisms reported as 'always' present by participants was three (IQR: 0-7, range: 0-14). 'Manages cognitive load' and 'Revisits prior learning' were the two most commonly reported mechanisms, reported by 61% and 56% of participants respectively. 'Prompts/cues' and 'Praise/reinforcement' were the two least commonly reported mechanisms, reported by 16% and 18% of participants. Percentages of reported mechanisms are outlined in Figure 3.2 and grouped by their hypothesised function. The majority of professional development programmes included mechanisms addressing at least one (73.2%) or two (54.5%) functions. A minority (24.1%) addressed all four functions.

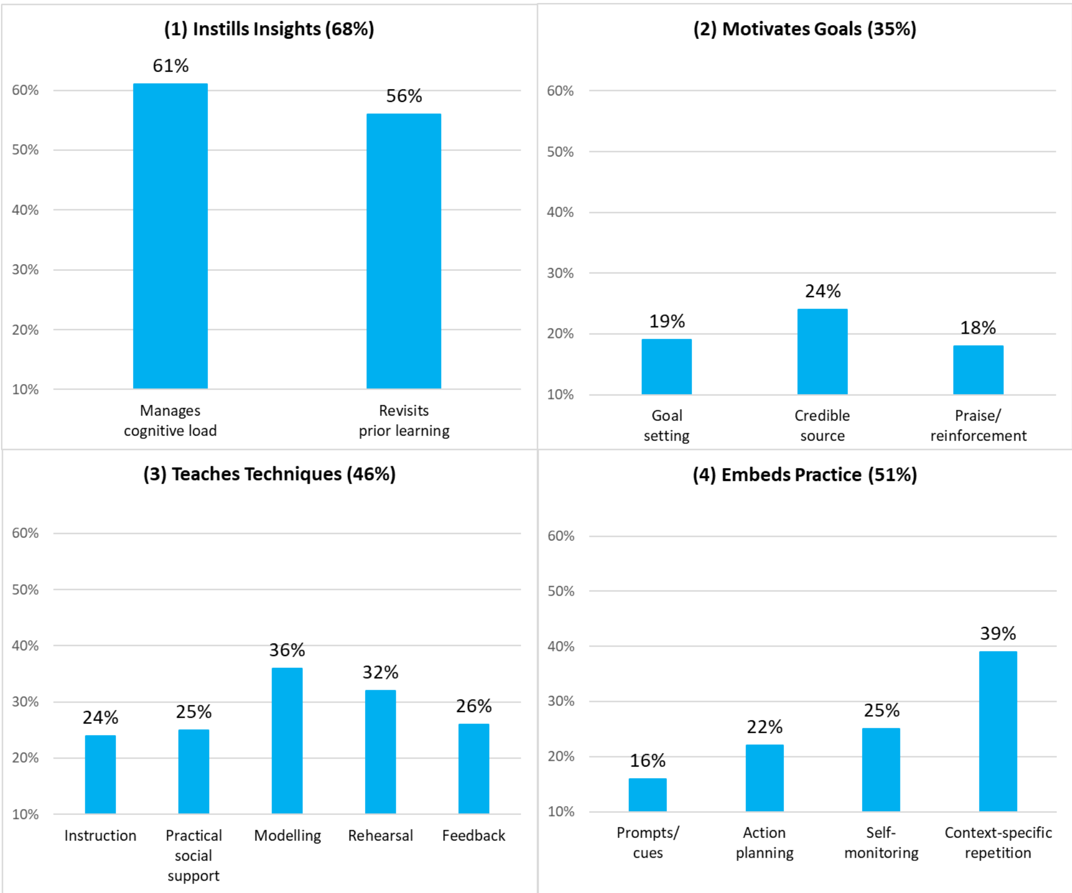

Figure 3.2. Mechanisms reported in programmes/activities attended by participants (n=109)

School support for professional development

The highest proportion of participants reported they were supported by a PE subject lead (41.3%) to prioritise their professional development. A smaller proportion reported they were supported by a member of the senior leadership team (37.5%); the remainder reported they were responsible for themselves. Almost half of participants (49.0%) strongly agreed or agreed with all statements about leadership support for professional development for PE at their school. The largest proportion of participants agreed that leaders at their school promote a culture valuing professional development for PE (79.8% ‘strongly agreed’ or ‘agreed’) (most widely supported statement). A slightly lower majority agreed with the statement that leaders at their school prioritise professional development for PE (60.6% ‘strongly agreed’ or ‘agreed’) (least widely supported statement) (see Appendix 3.6).

Associations between functions, leadership support and perceptions of impact

Among participants who reported teaching some or all PE lessons (n=101), over half (57/101; 56.4%) reported the professional development had 'quite a lot' of impact on their practice, followed by 27.7% who reported the professional development had 'a lot' of impact. Few participants reported that the professional development had 'not a lot' of impact (12.9%) or no impact ‘at all' (3.0%). Table 3.6 shows the results of univariable logistic regression analyses, which found statistically significant positive associations between the number of functions addressed and teachers’ perceptions of impact. Teachers reporting participation in a professional development programme/activity with a balanced design (addressing all four functions) had a 15.16 higher odds of reporting the professional development had ‘a lot’ of impact on their practice (95% Confidence Interval (CI): 2.97, 77.55). Planned sensitivity analyses, repeating the analyses using different cut-off points for the exposure and outcome variables, were not possible due to a lack of heterogeneity in the data.

Table 3.6. Associations between the number of functions addressed and teachers’ perceptions of professional development impact (‘Not at all’/‘Not a lot’/‘Quite a lot’ vs ‘A lot’)

			Univariable
	N	**%[a]**	OR [95% CI]
Number of purposes addressed	101		
None	28	27.7	Ref
One	18	17.8	3.71 [0.60, 22.87]
Two/three	29	28.7	4.95 [0.95, 25.86]
Four ('balanced’ design)	26	25.7	**15.16 [2.97, 77.55]**

[a] Percentages of participants reporting mechanisms were 'Always' a feature of the professional development attended; Participants with missing data and participants not teaching PE are removed from analyses (n=69); **bold: $p < 0.05$;** *OR* Odds Ratio; *CI* Confidence Interval

Univariable and multivariable logistic regression analyses were conducted to explore associations between agreement with leadership support statements and perceptions of impact. No statistically significant associations were identified in multivariable models (see Table 3.7). Repeating analyses using different cut-off points for the outcome variable did not change the findings (see Appendix 3.7 for results of sensitivity analyses).

Table 3.7. Leadership support statements associated with teachers' perceptions of professional development impact ('Not at all/Not a lot/Quite a lot' vs 'A lot')

			Univariable	Multivariable
	N	**%[a]**	OR [95% CI]	OR [95% CI]
Leadership support statements	97			
has a clear vision for PE professional development	74	76.3	1.05 [0.36, 3.04]	0.36 [0.08, 1.60]
promotes PE professional development culture	77	79.4	2.41 [0.64, 9.04]	2.84 [0.47, 17.16]
effectively plans PE professional development	62	63.9	1.38 [0.53, 3.61]	0.30 [0.05, 1.67]
prioritises PE professional development	56	57.7	2.49 [0.93, 6.67]	2.20 [0.39, 12.36]
helps overcome implementation barriers	65	67.0	**3.58 [1.12, 11.50]**	4.87 [0.84, 28.22]

[a] Percentages of participants who 'strongly agreed' or 'agreed' with individual leadership support statements; Participants with missing data and participants not teaching PE are removed from analyses (n=69); **bold: $p < 0.05$;** *OR* Odds Ratio; CI Confidence Interval

3.5 Discussion

Statement of main findings

This study provides novel insights into the use of evidence-based design features in professional development programmes and activities attended by primary school teachers in England, responsible for implementing the PE Premium policy. I found evidence that evidence-based mechanisms which help teachers learn new material are frequently incorporated into the design of programmes/activities attended by participants. However, just over one-quarter of participants attended programmes or activities that included mechanisms to address the four proposed functions of professional development (i.e., i) to instil insights, ii) to motivate goals, iii) to teach techniques, and iv) to embed practice). Previous research has suggested that addressing each of these functions may be important to promote professional learning and change among teachers[153], and evidence reported in the current study supports this theory. Participants who attended programmes that incorporated mechanisms addressing all four functions perceived that the professional development had a greater impact on their practice. Finally, although most participants reported receiving school support for professional development, I found no associations between school support and teachers' perceptions of impact.

Mechanisms reported and support for professional development

This study finds widespread use of some evidence-based mechanisms. Many participants indicated that the programmes they attended concentrated on one well-defined area and revisited essential concepts multiple times. Review-level evidence suggests that these mechanisms can enhance comprehension and facilitate teachers in learning new knowledge.[262,263] A majority of the providers also asked participants about their prior teaching experience, suggesting that a tailored approach was often taken. A tailored approach can help ensure that material is accessible and that teachers can build on existing knowledge, facilitating a more practical and potentially impactful professional development programme/activity.[89,106] A majority of participants reported receiving school support, not only in planning and prioritising their professional learning, but also in helping them to overcome barriers in implementing their new knowledge in practice. These findings are encouraging, given that peer and leadership support emerge as key facilitators to intervention delivery and sustainment in reviews of school-based physical activity promotion research.[264,265]

Holistic assessment of mechanisms reported

The overall range of professional development functions that programme mechanisms fulfilled was limited. For example, less than half of professional development programmes/activities reportedly included mechanisms which have been shown to help teachers in mastering new teaching techniques (e.g., use of a demonstration, rehearsal opportunity, provision of feedback). These findings align with an evaluation of 139 government-funded at-scale professional development programmes across 14 countries,[266] which similarly found that opportunities for teachers to rehearse new techniques or receive feedback were limited. I also found that almost half of programmes/activities did not include mechanisms which help teachers implement their new knowledge into practice (e.g., use of prompts/cues, action planning, self-monitoring). These findings align with Ofsted's nationally representative study of teacher professional development programmes/activities for all school subjects in primary and secondary schools, which similarly reported the use of these mechanisms was very limited.[243]

Consideration of wider programme characteristics

The small proportion of programmes/activities addressing the four theorised functions of professional development (24%) may be explained by certain characteristics described by participants. For example, a majority of the programmes/activities were delivered in a group format. Providers may have struggled to facilitate rehearsal opportunities or deliver feedback in this context. Additionally, the mean duration of these programmes/activities was relatively brief, averaging 6 hours and mostly delivered over two sessions. Providers could consider a longer, thinner approach to professional development (e.g., comprising 6 x 1hr sessions) to address these limitations. This format would allow providers to incorporate more mechanisms if not within, then between sessions. For instance, teachers could experiment with newly proposed practices in their classrooms between sessions and then share their experiences with colleagues in subsequent group meetings. By adopting this approach, providers could strike a balance, ensuring that programmes address more professional development functions, while avoiding a time-intensive approach, which teachers have been perceived to view as excessive.[266]

Strengths of the study

This study collected primary data to address important knowledge gaps in Public Health and Educational research that have practical implications. I provide novel insights into the characteristics of and school support for PE-related professional development available to primary school teachers in England. To ensure a comprehensive and evidence-based assessment of professional development programmes, I collected data on all items in the TIDieR checklist.[155] The survey measures were designed in collaboration with a group of primary school teachers in England to ensure questions and terminology were relevant to primary PE in England. This is also the first known study to examine Sims and colleagues' theory, suggesting that programmes with balanced designs (i.e., addressing the four functions) are associated with more effective professional development in real-world contexts. While the wide confidence intervals of the odds ratios indicate uncertainty in these findings, my findings are supported by two independent systematic reviews,[153,267] which identified similar features of effective teacher professional development. Findings are also based on a sample that is representative of all teachers in England by gender, age and teaching experience.[260] Finally, this study reports novel methods to identify and screen out bots. In Appendix 3.4, I also offer additional evidence-based preventative measures for researchers to consider employing (e.g., honey pot questions solely visible to bots), given the growing number of similar experiences reported in the literature.[268]

Limitations

The findings reported are limited by the sample size achieved, the use of non-validated measures, and the constraints associated with the study design employed. Low participation rates may have been the result of increased stress and workload levels during the data collection period as a result of the Covid-19 pandemic.[240] Some legitimate participants may have also been inadvertently removed during the data cleaning process, given the stringent criteria applied to remove bots. The findings are nevertheless limited by low statistical power. The absence of validated measures in the survey should also be considered when interpreting the results. The primary research question was based on a recently published systematic review and no validated items existed for the 14 mechanisms of interest. To assess leadership support for professional development, I had initially included a validated scale, developed in the US.[269] However, in the process of testing survey measures, teachers advised that the items were not relevant to PE in primary schools in England. This underscores the need for valid, contextually appropriate instruments to assess school support for professional development and implementation in schools. While efforts were made to mitigate biases associated with self-report measures (e.g., teachers' confidentiality and anonymity were protected), their use may have introduced bias in exposure and outcome measurement. Teachers may have struggled to recall all programme features if they did not complete the survey soon after attending the professional development. They may have also overestimated the impact that the professional development had on their practice. To enable a more rigorous assessment of professional development design features and their effects, future studies may consider collecting additional data from providers and teachers' students. Lastly, while a cross-sectional design was employed to maximise participation rates, this study design limits the ability to draw causal inferences from the study's findings.

3.6 Conclusions

This study contributes to our understanding of professional development offered to primary school teachers in England to support the implementation and outcomes of the PE Premium policy. The results indicate that while many professional development programmes assisted participants in learning new material, the majority did not support other key functions of professional development. This study indicates that programmes may be more impactful when they address the four proposed functions of professional development; i) to instil insights, ii) to motivate goals, iii) to teach techniques, and iv) to embed newly acquired knowledge into practice. As the aims of the PE Premium policy cannot currently be realised without providing teachers with effective professional development, greater emphasis should be placed on integrating a wider range of evidence-based design features into the programme/activities offered to teachers. Thereafter, both the professional development provided to teachers, and the PE Premium policy as a whole, warrant greater evaluation to maximise the prospects of facilitating policy learning and successful implementation.

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Chapter 4: Playground correlates of break time step cadence and cardio-respiratory fitness among a sample of primary school students in Australia

Contributions

This study was enabled through a research visit to the University of Newcastle, Australia and access to baseline data from a cluster randomised controlled trial. The study was conceptualised by Alix Hall (University of Newcastle). I then developed the study questions, methods, and analysis plan, with support from Christophe Lecathelinais, Alix Hall and Nicole Nathan. Due to restricted access to the trial dataset, Christophe Lecathelinais ran all analyses. I interpreted the data and wrote up the study. Alix Hall, Riikka Hofmann, and Esther van Sluijs provided critical feedback. The findings presented in this chapter are subject to final data checks by the AWARE trial team.

4.1 Introduction

This chapter describes the third study of my thesis. In the following two chapters, I move the focus from teacher-targeted programmes (Chapters 2 and 3) to consider the wider context in which interventions are delivered (Chapters 4 and 5). Here, I examine students' break time use of playground infrastructure and explore associations between infrastructure use, break time step cadence and cardio-respiratory fitness. I also assess whether associations vary by gender. To address my objectives, I analyse device-measured physical activity data and fitness test scores from a large sample of students (n= 686) enrolled in 13 primary schools in New South Wales, Australia.

4.2 Background

Physical activity and cardio-respiratory fitness benefits for children and adolescents

In Chapter 1, I highlighted that while regular physical activity is associated with a variety of benefits for young people, vigorous-intensity physical activity is particularly important for certain health outcomes,[38] including cardio-respiratory fitness.[270] Cardio-respiratory fitness is defined as "the ability of the circulatory and respiratory systems to supply oxygen during sustained physical activity".[271] It is associated with several additional positive outcomes for young people, including better academic performance.[272-275] While genetic factors account for some of the observed variation in cardio-respiratory fitness between individuals, regular vigorous-intensity physical activity is the primary known modifiable determinant of cardio-respiratory fitness.[276,277] Recognising the significance of both regular physical activity and higher cardio-respiratory fitness,[38,272-275] the WHO not only recommends young people engage in an average of 60 minutes of at least moderate-to-vigorous physical activity per day across the week, they also advise vigorous-intensity activities are incorporated at least three days per week.[6,9]

Physical inactivity and declining levels of cardio-respiratory fitness

A majority of young people worldwide are not meeting moderate-to-vigorous intensity physical activity guidelines.[32,33] While data on young people's compliance with vigorous-intensity physical activity guidelines is more limited, available evidence indicates youth cardio-respiratory fitness levels may have declined in recent years.[278,279] For instance, Tomkinson and colleagues pooled data from 19 high-income and upper-middle-income countries and observed a substantial decline (7.3% (95% CI:-7.8,-6.7) in cardio-respiratory fitness between 1981-2014 among young people (n=965,264).[278] The authors stressed that this decline is suggestive of a meaningful deterioration in population health.[278] While surveillance studies of young people's physical activity and cardio-respiratory fitness frequently observe considerable variation within and between countries, evidence consistently indicates that girls are less physically active and have lower levels of cardio-respiratory fitness than their male counterparts.[33,37,280,281] These gender disparities in physical activity and cardio-respiratory fitness are thought to be due to differences in young people's engagement in vigorous-intensity physical activity in many settings.[281]

School-level environmental correlates of physical activity

School playgrounds have been identified by public health researchers as a potential setting for promoting physical activity among young people.[282-284] For this reason, researchers have investigated the physical features of school playgrounds associated with student physical activity.[140,285,286] These studies have generated high-quality evidence to suggest that some general features of the school-built environment (e.g., sports facilities, playgrounds, and recreational spaces) are positively associated with young people's physical activity.[141] Experimental studies also provide support for these findings.[80,175,287,288] However, it is poorly understood if specific elements hold particular importance and if associations between playground features and physical activity differ by gender.[284] Playground correlates of cardio-respiratory fitness are also poorly understood.[140] Addressing these knowledge gaps is crucial for developing targeted and gender-equitable interventions in schools that promote compliance with all physical activity guideline recommendations.

Current study

This study, therefore, aims to explore overall and gender-specific associations between individual playground infrastructure items, student physical activity and cardio-respiratory fitness. Research questions are outlined below.

Research questions

1. What playground infrastructure do students use during their break times?
2. Are there overall and gender-specific associations between students' playground infrastructure use and their break time step cadence?
3. Are there overall and gender-specific associations between students' playground infrastructure use and their cardio-respiratory fitness levels?

4.3 Methods

The study is described in accordance with the STROBE (STrengthening the Reporting of OBservational studies in Epidemiology) checklist[289] (see Appendix 4.1). The terminology and definitions adopted for the study are outlined in Table 4.1.

Table 4.1. Terminology and definitions adopted for the study

Terminology	Definition
Cardio-respiratory fitness	"The ability of the circulatory and respiratory systems to supply oxygen during sustained physical activity".[290]
Playground infrastructure	The structures, amenities, features and facilities in which students undertake leisure.[291]
Playing field	An open space or sports ground that is adjacent to the school building.
Fixed equipment	Any equipment relatively fixed to the ground or a wall (e.g., monkey bars, swings, football goal posts).
Loose equipment	Any infrastructure that can be easily moved by students (e.g., balls, hoops, ropes).
Teacher-organised games	Any games led by teachers and/or other school staff that require physical activity.
Gender	Gender refers to "the socially constructed roles, behaviours, expressions and identities of girls, women, boys, men and gender diverse people."[292]
Break times	The collective term refers to multiple periods of break throughout the day (i.e., morning break and lunchtime combined).

Ethical approval

Ethical approval for the Active WeAR Everyday study was granted by the Hunter New England Local Health District Human Ethics Committee (2020/ETHO2602), the University of Newcastle Human Research Ethics Committee (H-2021-0013), the New South Wales Department of Education Human Research Ethics Committees (SERAP: 2020387), and the Catholic Schools Office (Diocese of Maitland-Newcastle).

Study design and setting

I performed exploratory cross-sectional analyses of baseline data collected as part of the Active WeAR Everyday (AWARE) cluster randomised controlled trial.[293] The trial aims to determine the impact of introducing an activity-enabling uniform on primary school students' fitness and physical activity. To test their intervention, researchers explicitly sought participation from primary schools with traditional uniform policies, namely government, catholic and independent schools, comprising largely fee-paying schools in New South Wales, Australia. Further details of the trial's aims and sample size calculations are reported in the protocol.[293] All baseline data was collected between May 2021-February 2022. The trial was registered with the Australian New Zealand Clinical Trials Registry (ACTRN12621000201875).

School, parent and student-level recruitment

As a consequence of the trial objectives, types of schools with stricter uniform policies (e.g., catholic and independent schools) were actively sought to participate in the AWARE study. Therefore, to inform the recruitment process, the websites of schools were initially checked to determine their type and uniform policies. Schools were then approached to participate in the study via email. Principals were provided with a study information package and given an opportunity to ask any questions regarding the trial. All students in schools allocated to the intervention arm were required to wear an activity-enabling uniform every day, comprising a uniform change for students. Principals, therefore, had to gain school-wide teacher and parent approval before consenting to the trial. Once the school had consented to the trial, all students in grades 4, 5 or 6 at baseline (aged approximately 9-12 years) were invited to participate in the data collection component of the intervention. A study information package was sent to parents of students in all participating schools. Parents/carers and students were asked to provide written informed consent to participate in the study. Parents and students had two weeks to consider participation. Students were asked to verbally consent to all data collection activities though they had the option of deciding on the day whether they would participate or complete individual data collection activities.

Measures

Exposure measures

Availability and student use of school playground infrastructure

Availability of playground infrastructure (playing field, fixed equipment, loose equipment, teacher-organised games) in schools during break times was determined based on self-report and observational data derived from multiple actors, including principals, research assistants and students. This approach aimed to enhance the reliability of the findings through data triangulation. Copies of survey items and observation checklists are provided in Appendix 4.2. Survey measures were not validated before data collection.

i) Principals were asked to report if loose equipment and teacher-organised games were available to students (response options: 'yes', 'no') in the online baseline survey.

ii) Research assistants were asked to determine the availability of playing fields, fixed equipment, and loose equipment in schools during visits for follow-up measures (October-December 2022). Due to the timing of school data collection visits, research assistants could not determine the availability of teacher-organised games during break times.

iii) Students were asked to report on their use of individual infrastructure items (playing field, fixed equipment, loose playground equipment, teacher-organised games) in the previous week (response options: 'We don't have a playing field', 'Never', 'Once or twice', 'A few times', 'Every day'). Availability was defined as any student response other than 'We don't have a playing field'.

Outcome measures

i) Break time step cadence

To estimate students' mean daily step cadence and steps per minute, students were asked to wear an ActiGraph GT9X wrist-worn accelerometer (ActiGraph Corporation, Pensacola, Florida, US) on their non-dominant wrist for one school week (Monday-Friday) for the whole school day (09:00-15:00). While wrist-worn accelerometers do not provide accurate data to reliably estimate intensity levels,[293] they have demonstrated high accuracy in detecting step count and cadence among free-living children.[294] Research assistants visited eligible classes in participating schools and demonstrated to teachers and students how to fit the accelerometer. Teachers distributed and collected the respective accelerometers from students at the beginning and end of each school day. Accelerometers were removed for the duration of any water-based activities. To be included in the analysis, students had to have worn the accelerometers for at least 80% of the school day on at least 3 school days.[295] Accelerometer non-wear time was estimated by adding the number of consecutive zero counts accumulated in strings ≥20 minutes. Total wear time was estimated by subtracting non-wear time from the total monitoring period.

ii) Cardio-respiratory fitness

To assess students' cardio-respiratory fitness, the 20-meter multistage fitness test (sometimes termed the 'shuttle run' or 'beep' test) was used. This is an accepted pragmatic field-based measure, with moderate criterion validity and high-to-very-high reliability in assessing the cardio-respiratory fitness levels of primary school-age children.[296] A 20-meter course was set up within school grounds on flat surfaces (e.g., asphalt courts or grassed areas). Students were instructed to run between two sets of lines, keeping pace with a pre-recorded cadence (indicated by a single 'beep' noise) with reduced time intervals passing each minute (indicated by three beeps). Students continued to run until they could not complete a shuttle (i.e., one 20m lap) before the beep sounded, on two consecutive shuttles. The Beep Test Pro App was used to record the number of 20m shuttles ('laps') that each student completed and assign a fitness test score to each student. The total number of laps was used to estimate students' maximal aerobic capacity (VO_2 peak), based on Léger and colleagues' equation.[297] The test was conducted by a trained team of research assistants experienced in administering such tests, PE or implementing school-based physical activity programmes. Research assistants facilitated an appropriate 5-10 minute warm-up and cool-down before and after they administered the fitness test. The test was conducted in small, within-class, gender-specific groups to ensure students were as comfortable as possible. The outcome of interest used in analysis was students' calculated fitness test score.

School and student characteristics

To assess school and student characteristics, principals and parents were invited to participate in an online survey at the time of providing written consent. They were asked to report on details including school postcode, students' date of birth, students' grade, and home postcode. All principal and parent consent and baseline survey data was collected and managed using REDCap (Research Electronic Data Capture), hosted at the Hunter New England Population Health.[257,258] REDCap is a secure, web-based software platform designed to support data capture for research studies. The amount of time schools allocated to break times was calculated based on bell time data collected from schools. School remoteness was based on the school's postcode and the Australian Bureau of Statistics' tool, 'Australian Statistical Geography Standard (ASGS) Remoteness Structure',[298] which classifies areas of Australia into five regions on the basis of relative access to services; i) Major cities of Australia, ii) Inner Regional Australia, iii) Outer Regional Australia, iv) Remote Australia, and v) Very Remote Australia. Schools were categorised as urban (including; major cities or inner regional), or rural (including: outer regional, remote and very remote). School postcodes were also used to estimate schools' relative socio-economic disadvantage classification based on the Australian Bureau of Statistics' 'Socio-Economic Indexes for Areas' (SEIFA) tool.[299] This index is based on information from Australia's five-yearly Census and informed by a number of factors, including income, education, employment, housing, and other socio-demographic factors. Further details on the construction and validation of the index are reported elsewhere.[299,300] To protect school and students' identities, aggregate data is presented here. In line with the tool's guidelines, school postcodes in the top 50% of New South Wales postcodes were categorised as ‘most disadvantaged’. School postcodes in the bottom 50% were categorised as ‘least disadvantaged’. Students’ home postcode was similarly used to categorise the socio-economic index of their locality according to SEIFA. Student gender was defined based on the question ‘Are you: Male/Female/Other?’

Analysis

All analyses were performed using SAS (v9.3). Descriptive statistics were used to report on school and student-level characteristics. Separate logistic regression analyses were used to explore associations between student gender and infrastructure use (e.g., ‘never’ vs ‘once or more’ and ‘never’ vs ‘daily’). Due to violations of proportional odds assumptions, mixed ordinal logistic regressions were deemed inappropriate.

Linear mixed-effects regression models were used to explore associations between use frequency of infrastructure items (playing field, fixed equipment, loose equipment, organised games) and step cadence (mean steps/min during break times). A separate model for each infrastructure item was conducted (i.e., playing field, fixed equipment, loose equipment, teacher-organised games). Models were repeated to assess associations between use frequency of infrastructure items and cardio-respiratory fitness (fitness test score). A subsequent set of interaction models were performed to assess whether associations between infrastructure use frequency and physical activity or cardio-respiratory fitness differed by gender.

All model assumptions were tested using residual and normal probability plots. Minimal school- and student-level confounders, based on literature and directed acyclic graphs (see Appendix 4.3), were included as fixed effects using the ‘GLIMMIX’ procedure (estimation method: residual-pseudo likelihood (RSPL)). For models with cardio-respiratory outcomes, gender and school SEIFA were controlled for. For models with step outcomes, accelerometer wear time was also controlled for. For all analyses, the level of statistical significance was set at an alpha level of 5%. All models also included a random intercept for schools and classes nested within the school.

4.4 Results

School and student-level characteristics

Thirteen schools in New South Wales consented to participate in the trial. The majority of participating schools were Catholic or Independent (69.2%), and located in an urban area of New South Wales (84.6%). Participating students (n=686) were aged 8 to 13 years (mean: 9.83, SD: 0.77), and approximately half of them (50.4%) were enrolled in grade 5. Further information about the characteristics of participating schools and students is outlined in Table 4.2.

Table 4.2. Characteristics of participating schools (N=13) and students (n=686)

	Total (n, %) with valid data	**Total (n, %) without valid data**
School-level characteristics (N=13)		
School location, n (%)		
Urban	11 (84.6)	
Rural	2 (15.4)	
School type, n (%)		
Catholic and Independent	9 (69.2)	
Government	4 (30.8)	
SEIFA measure assigned to postcode[a], n (%)		
Most disadvantaged	9 (69.2)	
Least disadvantaged	4 (30.8)	
Mean time allocated to break[b], mins/day (SD)	68.54 (6.0)	
Student-level variables (n=686)		
Gender, n (%) female	331 (48.5)	3 (0.4)
Age, mean years (SD)	9.83 (0.8)	10 (1.5)
Home location, n (%)		
Major City	458 (66.8)	
Inner Regional Australia	115 (16.8)	
Outer Regional Australia	113 (16.5)	
SEIFA measure assigned to postcode[a], n (%)		
Most disadvantaged	445 (64.9)	
Least disadvantaged	241 (35.1)	
School grade[c], n (%)		
Grade 4	287 (41.8)	
Grade 5	346 (50.4)	
Grade 6	53 (7.7)	
Students' steps during break times		
Mean break time wear, mins (SD)	68.17 (5.3)	
Mean steps/min, (SD)	33.8 (6.8)	58 (8.5)
Mean total step count, (SD)	2300.4 (478.4)	58 (8.5)

Students' cardio-respiratory fitness		
Mean fitness test score [d], (SD)	3.68 (1.6)	87 (12.7)
Mean estimated VO_2 peak[e], (SD)	44.9 (3.9)	87 (12.7)

SD standard deviation; [a] Based on the postcode of the school and student's home address; [b] Refers to entire period allocated to breaks, during which students may engage in various activities (e.g., eating, bathroom use); [c] Relates to students aged 9-12 years, [d] Calculated using the Beep Test Pro App, [e] Calculated using Léger and colleagues' equation;[297] *SEIFA* Socio-Economic Indexes for Areas

Physical activity infrastructure available to students

The majority of students reported that they had access to all infrastructure items of interest (see Table 4.3). Compared to students, a slightly lower percentage of principals reported the availability of teacher-organised games, and a lower percentage of research assistants reported the availability of a playing field compared to students.

Table 4.3. Reported availability of playground infrastructure by students (n=621), principals (n=12), and research assistants during visits in schools (N=12)

	Students[a]			**Principals[a]** n (%)	**Research assistants[b]** n (%)
	Boys n (%)	Girls n (%)	All n (%)	n (%)	n (%)
Infrastructure item					
Playing field	310 (97.2)	307 (99.7)	617 (98.4)	Not assessed	10 (83.3)
Fixed equipment (e.g., monkey bars)	291 (89.5)	266 (86.4)	557 (88.0)	Not assessed	11 (91.7)
Loose equipment (e.g., balls)	317 (96.9)	301 (97.7)	618 (97.3)	12 (92.3)	11 (91.7)
Teacher-organised games	320 (97.6)	301 (97.4)	621 (97.5)	11 (84.6)	Not assessed

[a] Based on baseline surveys, [b] Checklist forms were completed by research assistants in schools at follow-up. Data is missing from one school that dropped out of the trial after baseline measures were taken but is still included in the current study

What playground infrastructure do students use at break time?

Among all students, a playing field was the most frequently reported item used, with 40.0% of boys and 32.9% of girls reporting daily use. This was followed by loose equipment, organised games and fixed equipment. Boys reported higher daily use of all items except fixed equipment (7.5% of girls reported daily use vs 4.8% of boys; see

Table *4.4*). Boys also had significantly higher odds of reporting daily use of a playing field (Odds Ratio (OR): 1.44, 95% Confidence Interval (CI): 1.00, 2.07), loose equipment (OR: 3.27, 95% CI: 2.18, 4.91) and participation in teacher-organised games (OR: 1.78, 95% CI: 1.14, 2.78) than girls. No other statistically significant associations between infrastructure use and student gender were identified (Table *4.4*).

Table 4.4. Students self-reported use of available infrastructure (n=621)

	Boys		**Girls**		**OR [95% CI]** [b]	**ICC**
	n	%	n	%		
Reported use[a]						
Playing field (n=617)						
Daily use	124	40.0	101	32.9	**1.44 [1.00, 2.07]**	0.03
Once or more	164	52.9	178	58.0	1.31 [0.72, 2.38]	0.00
Never	22	7.1	28	9.1		
Loose equipment (n=618)						
Daily use	119	37.5	55	18.3	**3.27 [2.18, 4.91]**	0.07
Once or more	175	55.2	216	71.8	1.47 [0.82, 2.62]	0.00
Never	23	7.3	30	10.0		
Teacher-organised games (n=621)						
Daily participation	63	19.7	36	12.0	**1.78 [1.14, 2.78]**	0.00
Once or more	235	73.4	247	82.1	0.88 [0.46, 1.70]	0.01
Never	22	6.9	18	6.0		
Fixed equipment (n=557)						
Daily use	14	4.8	20	7.5	0.62 [0.31, 1.26]	0.00
Once or more	170	58.4	165	62.0	**0.66 [0.45, 0.99]**	0.07
Never	107	36.8	81	30.5		

[a] Students' self-reported use in the last week; [b] Based on split logistic regression models with a random intercept for schools and class comparing daily use between boys and girls and once or more/never between boys and girls; **bold: $p < 0.05$**; *OR* Odds Ratio; *CI* Confidence Interval; *ICC* Intraclass correlation coefficient

Is there an association between students' infrastructure use and their step cadence?

Table *4.5* below shows that a statistically significant positive association was observed between break time playing field use and break time step cadence. After adjusting for potential confounders, I found that daily use of a playing field is associated with a 3.92-unit higher step cadence (95% CI: 1.81, 6.03). All other associations were not statistically significant when adjusting for pre-specified confounders.

Do associations between students' infrastructure use and their step cadence differ by gender?

I found that associations between participation frequency in teacher-organised games and break time step cadence (steps/min) differed by gender (interaction term: β=-4.47, 95% CI: -8.21, -0.73). In contrast to boys (β=-0.90, 95% CI: -3.34, 1.53), girls who participated in teacher-organised games at least once a week had significantly higher steps, compared to those reporting no weekly participation in teacher-organised games (β=3.57, 95% CI: 0.75, 6.38). See Appendix 4.4 for gender-specific associations between students' infrastructure use and their step cadence.

Table 4.5. Associations between students' infrastructure use and their step cadence (steps/min) (n=599)

		Break time steps	**Unadjusted models**			**Adjusted models**		
Reported use[a]	N	Mean steps/min (SD)[b]	β [95% CI][c]	*p*-value	N	β [95% CI][c]	*p-value*	N
Playing field				**<0.001**	596		**<0.001**	493
Daily use	216	36.17 (6.29)	3.93 [2.14, 5.73]			3.92 [1.81, 6.03]		
Once or more	332	32.70 (6.67)	1.67 [0.02, 3.32]			1.52 [-0.39, 3.44]		
Never	49	30.17 (6.39)	Reference			Reference		
Fixed equipment				0.37	534		0.64	493
Daily use	32	32.76 (7.41)	0.05 [-2.08, 2.19]			-0.12 [-2.37, 2.13]		
Once or more	324	33.91 (6.93)	0.76 [-0.36, 1.89]			0.52 [-0.71, 1.75]		
Never	179	33.89 (6.89)	Reference			Reference		
Loose equipment				**0.01**	598		0.10	493
Daily use	171	35.99 (6.28)	0.70 [-1.10, 2.50]			-0.62 [-2.78, 1.55]		
Once or more	375	33.03 (6.78)	-0.90 [-2.52, 0.72]			-1.61 [-3.53, 0.31]		
Never	53	32.73 (6.55)	Reference			Reference		
Teacher-organised games				0.41	599		0.52	493
Daily participation	95	34.62 (7.76)	1.42 [-0.67, 3.51]			0.63 [-1.65, 2.90]		
Once or more	465	33.77 (6.44)	0.99 [-0.85, 2.83]			1.05 [-0.93, 3.03]		
Never	40	32.51 (8.09)	Reference			Reference		

[a] Students' self-reported use in the last week; [b] Assessed via accelerometer; [c] Based on linear mixed-effects models. All models include a random intercept for schools and class, and control for gender, school postcode-based index of disadvantage classification, and wear time. Unadjusted models include single infrastructure items. Adjusted models include all infrastructure items simultaneously; **bold: p < 0.05;** β Effect size estimate*; CI* Confidence Interval

Is there an association between students' infrastructure use and their cardio-respiratory fitness?

Statistically significant positive associations were identified between overall playing field use and students' cardio-respiratory fitness. After adjusting for potential confounders, I found that daily use of a playing field is associated with a 0.73-unit higher level of cardio-respiratory fitness (95% CI: 0.15, 1.30). Statistically significant positive associations were also identified between participation in teacher-organised games and cardio-respiratory fitness. I found that daily participation in teacher-organised games was associated with a 1.04-unit higher level of cardio-respiratory fitness (95% CI: 0.39, 1.68). All other associations between infrastructure use and cardio-respiratory fitness were not statistically significant when adjusting for confounders (see

Table *4.6* below).

Table 4.6. Associations between students' infrastructure use and their fitness test score (n=583)

		Fitness test score[b]	**Unadjusted models**			**Adjusted models**		
	N	Mean result (SD)	β [95% CI][c]	*p*-value	N	β [95% CI][c]	*p-value*	N
Reported use[a]								
Playing field				**<0.001**	580		**<0.001**	477
Daily use	215	4.17 (1.67)	**0.88 [0.39, 1.37]**			**0.73 [0.15, 1.30]**		
Once or more	319	3.43 (1.51)	0.08 [-0.38, 0.54]			-0.08 [-0.60, 0.45]		
Never	47	3.34 (1.45)	Reference			Reference		
Fixed equipment				0.12	519		0.51	477
Daily use	30	3.80 (1.89)	0.48 [-0.13, 1.10]			0.30 [-0.33, 0.92]		
Once or more	318	3.78 (1.68)	0.30 [-0.02, 0.62]			0.17 [-0.17, 0.51]		
Never	172	3.59 (1.54)	Reference			Reference		
Loose equipment				**0.02**	581		0.12	477
Daily use	169	4.02 (1.73)	0.29 [-0.21, 0.79]			-0.17 [-0.78, 0.43]		
Once or more	362	3.52 (1.53)	-0.14 [-0.60, 0.31]			-0.43 [-0.97, 0.11]		
Never	51	3.51 (1.46)	Reference			Reference		
Teacher-organised games				**<0.001**	583		**0.002**	477
Daily participation	93	4.25 (1.74)	**1.06 [0.48, 1.64]**			**1.04 [0.39, 1.68]**		
Once or more	454	3.61 (1.56)	0.48 [-0.04, 0.99]			0.45 [-0.11, 1.02]		
Never	37	3.11 (1.33)	Reference			Reference		

[a] Students' self-reported use in the last week; [b] Assessed using the validated 20-meter multi-stage fitness test (shuttle run test); [c] Based on linear mixed-effects models; All models include a random intercept for schools and class, and control for gender and school postcode-based index of disadvantage classification. Unadjusted models include single infrastructure items. Adjusted models include all infrastructure items simultaneously; *CI* Confidence Interval; β Effect size estimate; **bold: p < 0.05**

Do associations between students' infrastructure use and their cardio-respiratory fitness differ by gender?

I found that associations between daily use of a playing field and cardio-respiratory fitness differed by gender (interaction term: β=1.16, 95% CI: 0.21, 2.11). In contrast to girls (β=0.33, 95% CI: -0.32, 0.99), boys reporting daily use of a playing field had significantly higher levels of cardio-respiratory fitness, compared to those reporting no weekly use (β=1.50, 95% CI: 0.79, 2.21). I also found that associations between daily participation in teacher-organised games and cardio-respiratory fitness differed by gender (interaction term: β=1.45, 95% CI: 0.27, 2.63). In contrast to girls (β=0.21, 95% CI: -0.69, 1.11), boys reporting daily participation in teacher-organised games had significantly higher levels of cardio-respiratory fitness, compared to those reporting no weekly participation (β=1.66, 95% CI: 0.90, 2.43). See Appendix 4.5 for gender-specific associations between students' infrastructure use and their cardio-respiratory fitness.

4.5 Discussion

Summary of main findings

This study examined students' use of playground infrastructure and explored associations with break time step cadence and cardio-respiratory fitness among a sample of primary school students in Australia. The most commonly reported item used by all students was a playing field, followed by loose equipment, teacher-organised games, and fixed equipment. Gender differences were observed in infrastructure use, with boys reporting higher daily usage for all items except fixed equipment. For step outcomes, I found that the daily use of a playing field was associated with a higher break time cadence. For fitness outcomes, both the daily use of a playing field and daily participation in teacher-organised games were associated with higher cardio-respiratory fitness. The strength of some of the associations differed by gender. For example, associations between teacher-organised games and break time step cadence were stronger in girls. Conversely, associations between daily playing field use, daily participation in teacher-organised games, and cardio-respiratory fitness were stronger in boys.

Student use of playground infrastructure

Similar to findings from other countries,[301] I found that the most frequently used infrastructure item by all students was a playing field. Boys reported greater use of the majority of available playground infrastructure than girls. These findings may be explained by review-level evidence of qualitative research, suggesting that infrastructure use in playground settings is heavily influenced by gendered behaviours, which often result in male dominance of available resources.[302] The only infrastructure item used more frequently by girls than boys was fixed equipment. These findings are consistent with studies of playgrounds in other countries, whereby higher counts of girls have been reported in playground areas supporting climbing, and higher counts of boys have been reported in playground areas supporting ball sports.[284,285] Girls aged 8 to 10 years participating in a recent study conducted in New South Wales have reported a desire for increased space, softer surfaces and longer break times to facilitate multiple behaviours, including more physical activity.[303] It is important to note that students must engage in a variety of activities during their break times (e.g., eating, bathroom use). Hence, it is also possible that the space, playground surfaces, and time allocated to other activities may act as a greater barrier to infrastructure use among girls than boys.

Playground correlates of break-time step cadence

I found positive associations between playing field use and break time step cadence. Given associations with cardio-respiratory fitness were also identified, playing fields may be important in promoting different intensities of physical activity among all students. Previous studies have demonstrated the importance of both playing field access and space for physical activity promotion.[140] Schools with spatial constraints should have access to and be supported to make use of nearby parks to ensure all students have the resources necessary for a healthy break time. Schools may either consider employing staggered break times where possible to reduce student density. Greater loose equipment use, participation in teacher-organised games or fixed equipment use was not associated with higher break time step cadence among all students. It is possible that students playing with fixed equipment (e.g., monkey bars) engaged in muscle-strengthening physical activities or lower body movements not detected by the wrist-worn accelerometers used. However, previous research has also found that playground areas with fixed equipment tend to promote more social activities rather than physical activities relative to other playground areas (e.g., playing fields).[301] The strength of some associations differed by gender. In contrast to boys, girls had a higher step cadence who reported some participation in teacher-organised games compared to those reporting no weekly participation in teacher-organised games. This difference might be due to lower overall break time step cadence among girls than boys, greater interest among girls in certain teacher-organised games offered, and a greater sense of safety and protection when teachers are present, to engage in active play, especially in areas where fast ball games and social conflicts/bullying occur more frequently.[304]

Playground correlates of cardio-respiratory fitness

I also found some associations between infrastructure use and cardio-respiratory fitness differed by gender. In contrast to girls, boys reporting daily playing field use or daily participation in teacher-organised games had significantly higher levels of cardio-respiratory fitness, compared to their peers reporting no weekly playing field use or no weekly participation in teacher-organised games. This gender disparity may be explained by evidence from other Australian studies, [20,24] suggesting primary school-age boys accrue more vigorous-intensity physical activity during break times than girls, which can help to promote and maintain cardio-respiratory fitness.[270] Review-level evidence also indicates that girls are frequently indirectly excluded (e.g., by receiving fewer ball passes),[304] and as a result, assume an observational[301] or less physically active role (e.g., as a goalie)[305] within games than their male teammates. While it is possible observed differences in cardio-respiratory fitness levels may be attributable to gender differences in physical activity behaviours outside of break time or school hours, available evidence indicates that students gain the largest proportion of their total daily vigorous-intensity physical activity during school hours.[306] There is also limited evidence to suggest boys and girls accrue similar amounts of higher intensity physical activities when participating in the same break time activities.[284]

Strengths

This study addresses calls to explore components of physical activity promoting playgrounds.[143] I report on a large sample of students for the quality of data reported, and address limitations associated with existing studies,[307] by exploring potential benefits of individual infrastructure components and reporting on device-measured physical activity.[140] This is also one of the first known studies to explore associations between the school-built environment and student cardio-respiratory fitness. These findings are an important addition to the literature given the declining levels of fitness among young people in many countries worldwide, including Australia.[279] Finally, in recognition of well-documented gender-based differences in young people's physical activity and cardio-respiratory fitness, I also report on findings by gender. Researchers have long emphasised the need for more sensitive research that explicitly considers the influence of gender in behavioural science and health studies.[292] Despite these calls, gender-specific correlates of young people's physical activity and cardio-respiratory fitness remain poorly reported in studies conducted in many different settings, including schools.[302] This gender-agnostic approach may be inadvertently leading to the development of school playground interventions which confer greater benefits for boys than girls.[80,143]

Limitations

The sample recruited has implications for the descriptive and analytical findings. As a consequence of the trial objectives, this study reports on students enrolled in mostly advantaged schools. The postcode-based measure of school socioeconomic status presented likely misrepresents the population sampled. Indeed, the findings from a recent study surveying a large, representative, and random sample of primary schools in New South Wales[140] indicate that participants in this study have greater access to physical activity-promoting resources in their school compared to students in other schools in the state. Thus, the generalisability of the findings reported is cautioned. The cross-sectional design also does not rule out the possibility of reverse causality. Hence, student cardio-respiratory fitness levels may have been a determinant of break time playground infrastructure use, rather than the other way around. Associations may also be bi-directional. Measures of infrastructure use and physical activity were also not entirely aligned; students completed surveys about their infrastructure use one week before they wore accelerometers. Findings are therefore premised on the assumption that infrastructure use among students is relatively consistent across a two-week period, which, may have been impacted by factors, including weather. Finally, steps per minute was prioritised as the outcome of interest over mean total step count, as a proxy indicator of physical activity intensity;[308] an important component of current WHO guidelines.[6] Nevertheless, step cadence reflects just one measure of physical activity behaviour, it does not capture physical activity type and may not reflect total energy expenditure.[308]

Future studies

Future studies could build on these findings to investigate features of playing fields (e.g., size, surface, coverage) that encourage everyday use by all students throughout the school year. To address potential biases associated with self-report methods, additional measures of student infrastructure use could be employed (e.g., GPS data or observational tools).[309] The associations identified between teacher-organised games and student physical activity could also be explored. I showed in the previous two chapters that reliance upon teacher-led interventions requires high-quality professional development. Considering that the presence of a teacher alone may have a similar effect on student physical activity as a teacher-organised game,[284] future studies could examine the impact of different types of teacher involvement (e.g., supervision, game initiation, direction, participation) on student break time physical activity behaviour. Lastly, studies conducted in other contexts (e.g., public parks)[310] indicate that the availability of both physical activity-promoting infrastructure (e.g., playing fields) and sedentary behaviour-promoting infrastructure (e.g., benches, smartphones) are associated with young people's playground behaviour. Future studies could therefore incorporate measures of both types of infrastructure.

4.6 Conclusions

This study finds overall and gender-specific associations between infrastructure use, break time step cadence and cardio-respiratory fitness. My findings highlight the need for explicit reporting of break time interests and free play behaviours of all genders to design school-built environments that are inclusive in promoting healthy behaviours among both boys and girls. Playing fields and teachers may be important components of school playgrounds for physical activity and cardio-respiratory fitness promotion. Future research could build on these findings to explore playing field features and teacher behaviours that encourage regular and active use of the school playground.

Acknowledgements

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Chapter 5: Are school uniforms associated with gender inequalities in physical activity? A pooled analysis of population-level data from 135 countries

Contributions

I designed this study with Esther van Sluijs, Luiza Ricardo and Riikka Hofmann. Luiza Ricardo and I screened all studies for selection. I extracted all data, and Luiza Ricardo checked a random sample. Luiza Ricardo cross-checked data from surveillance studies reporting on secondary sources against original studies where available. I conducted analyses, with input from Luiza Ricardo and Esther van Sluijs. I led data interpretation and wrote this chapter. Luiza Ricardo, Nicole Nathan, Riikka Hofmann, and Esther van Sluijs provided critical feedback.

5.1 Introduction

This chapter describes the final study of my thesis and examines the potential importance of school policies relating to uniforms for student physical activity behaviour. The primary aim of the study is to determine associations between school uniforms and gender inequalities in physical activity. I address this question at a population level and explore whether associations differ by school level, country income classification, and physical activity assessment method. I pooled data from eight international physical activity surveillance initiatives that report on young people's compliance with physical activity guidelines. I collected primary data to determine the use of uniform practices in primary and secondary school settings across 135 countries.

5.2 Background

As described in Chapters 1 and 5, equalities in opportunities to be physically active vary within and between countries. However, gender disparities account for the largest proportion of global physical activity inequalities among children and adolescents worldwide.[19,37] The individual and societal-level costs associated with physical inactivity and associated inequalities are high.[311] Yet reasons why girls are less active than boys throughout childhood and adolescence are poorly understood.

Gender inequalities in physical activity appear early in life, between the ages of two and six years,[39,312,313] a time when children typically enter education. Girls report unique barriers to physical activity in a number of settings in their lives, including schools.[314] Consequently, researchers have examined various school-level correlates and determinants of physical activity among students, such as policies.[78,79,144] School policies refer to "organisational statements or rules that are intended to influence behaviour".[139] A wide range of school policies may have intentional or unintentional effects on student physical activity (e.g., as a consequence of indoor running restriction[315] or homework duration[316] policies). However, review-level evidence indicates that research to date has predominantly focused on school policies relating to limited periods of the whole school day, namely Physical Education and extra-curricular sports.[78,79,144] Comparatively few studies have examined school policies that cut across the whole school day. Further, while gender inequalities in physical activity are prevalent worldwide,[19,37] few studies have examined the potential role of school policies beyond high-income country contexts.

School policies related to uniforms are common in many countries.[317] Though some researchers have explored their relationship with other outcomes[318-321] (e.g., academic achievement[320] and social behaviour[321]), finding no or inconsistent correlations, studies examining associations between school uniforms and physical activity patterns are limited. Existing observational research suggests that girls perceive uniforms as a barrier to break time play[315,322] and school active travel.[323,324] Experimental evidence also suggests primary school-aged girls are more active and less sedentary on days when they are not wearing their regular uniform.[325,326] However, these studies come from a limited number of high-income countries, report on small sample sizes, and focus solely on school-time physical activity. Associations between uniforms and total weekly physical activity, which is most strongly associated with health and educational benefits,[9] have not been explored.

I, therefore, aimed to address this question using population-level data to determine associations between school uniforms and gender inequalities in physical activity, using country-level compliance with the WHO physical activity guidelines as my outcome. I also assessed whether associations differ by school level, country income classification, and physical activity assessment method.

5.3 Methods

This study is reported in accordance with the STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) statement for cross-sectional studies.[327] See Appendix 5.1.

Study design and data sources

I employed a cross-sectional design using published data on the proportion of children and adolescents meeting physical activity guidelines as the outcome. I conducted an online survey to determine the use of school uniform practices among countries with sex-stratified data on population-level estimates of physical activity guideline compliance. Based on data from the World Bank, I categorised children aged 6-11.99 years as primary school-age and adolescents aged 12-18.99 years as secondary school-age.[328] Further study measures are detailed below. Operational definitions adopted for this study are outlined in Appendix 5.2.

Physical activity data

Identification of eligible studies

I searched eight international surveillance initiatives for studies reporting population estimates of the percentage of boys and girls aged 6-18 years meeting physical activity guidelines.[31] Studies had to report on the: i) country from which participants were sampled, ii) age/age range of participants, iii) year(s) of data collection, iv) method used to assess physical activity (survey/device-measured), and v) guideline/reference used to estimate total physical activity (e.g., compliance with 2020 WHO guidelines[6]).

Thereafter, I applied inclusion and exclusion criteria to screen out studies not reporting data that addressed my research questions. Studies had to report the percentages of children and adolescents meeting physical activity guidelines by gender or provide sufficient information for this to be calculated. Participants had to be sampled from the general population. In instances where study authors reported device-measured data and did not publish guideline compliance by gender, I contacted them and requested this data. Following the aforementioned screening exercise, I still found that few studies reported on device-measured data. I, therefore, contacted the authors of the largest international surveillance initiative of device-measured physical activity[36] and requested unpublished data on guideline compliance by gender.

Study selection

If multiple studies reported on the same country and school-age category (e.g., three studies reporting on primary school-age children in Germany), I selected only one study for inclusion. I used a hierarchy to prioritise study inclusion at the country level (see Appendix 5.3). All study selection decisions were conducted independently by two members of the team. Disagreements were resolved via discussion by referring back to primary sources. Studies not selected for inclusion are listed in Appendix 5.4 with reason codes.

Data coding

If single studies reported multiple prevalence estimates for different age groups, I combined these into school-age categories of interest using formulae outlined in the Cochrane Handbook.[329] I used averages if sample sizes were not reported. If data on guideline compliance by gender crossed my school-age categories of interest (e.g., participants aged 8-12), samples were categorised as 'primary' or 'secondary' based on study participants' reported median age. An exception was the 'Health Behaviour in School-aged Children' study, in which study participants aged 11 were categorised as 'primary' or 'secondary' based on the mean secondary school starting age in that country.[328]

School uniform practices

I conducted an online survey to determine school uniform practices in countries with eligible physical activity data. To minimise error, two respondents per country were sought. I obtained survey responses through various channels, including social media advertisements, international societies and university mailing lists, inquiries made to embassies, high commissions, and consulates, and personal and professional contacts of the researchers. Survey participants were asked i) whether the majority (>50%) of primary and secondary schools in that country use uniforms or not (response options: Yes/No/Don't know) and ii) whether practices had significantly changed in the past decade. All data was collected between April-September 2022 using Qualtrics. Survey questions are outlined in Appendix 5.5. Where more than two responses were available for a given country and responses differed, the response supported by the majority was taken. Single responses were also accepted. Where exactly two responses were available and responses differed, data was coded as missing. Where data was unavailable or I solely received 'Don't know' responses, data was also coded as missing.

Income classification

Countries and regions were assigned income classifications based on groupings calculated by the World Bank.[330] I used income classifications from the year in which the largest proportion of physical activity data were collected or projected;[33] 2016.

Data extraction and checking

All data extraction was conducted by one member of the team. A random sample (10%) of the combined dataset (i.e., with population-level physical activity compliance estimates, uniform survey data, income classifications etc.) was independently checked by a second member to assess the accuracy of the extraction and pooling process (inter-rater agreement = 94.8%). In addition, all data extracted from physical activity surveillance studies reporting on secondary sources[32] was checked by one member of the team against primary study sources where available.

Statistical analysis

I calculated absolute and relative gender inequalities in physical activity for each country with corresponding physical activity and school uniform data. Absolute inequalities were calculated by subtracting the percentage of girls meeting physical activity guidelines from the percentage of boys meeting physical activity guidelines. Relative inequalities were calculated by dividing the percentage of boys meeting physical activity guidelines by the percentage of girls meeting physical activity guidelines. Descriptive statistics were calculated for categorical and continuous variables. Means and standard deviations (SDs), or medians and interquartile ranges (IQR), are reported based on the distribution of physical activity outcomes. Mann Whitney U tests were performed to compare median values between independent groups. Linear regression was used to explore associations between country-level uniform practices (yes/no) and gender inequalities in self-reported physical activity (absolute and relative inequalities). I obtained cluster-robust standard errors using the 'vce (cluster clustvar)' Stata command to account for instances where data was available for both primary and secondary school settings in a single country. All models were checked for assumptions necessary for linear regressions (residual and Q-Q plots). A set of pre-planned models were run with interaction terms between the exposure (country-level uniform practices) and the following moderators: school level (primary vs secondary) and income classification grouping**.** Countries/regions with missing data on the moderators were excluded from interaction analyses. The majority of countries with a low, lower-middle or upper-middle-income classification were reported to use uniforms, precluding meaningful interaction analyses. I present stratified summary statistics instead. To assess whether associations were affected by physical activity assessment method, I repeated primary analyses using device-measured data**.** For all analyses, Stata v.16 was used and the level of statistical significance was set at an alpha level of 5%.

5.4 Results

Characteristics of countries included

Data on both physical activity and uniform practices was available for 135 countries and regions. See Appendix 5.6 for a flow chart showing data availability, selection, and inclusion at each stage. Table 5.1 summarises the sample characteristics of all countries represented by physical activity assessment method. Here I focus on my primary outcome of interest: self-report measured physical activity. While countries from all income grouping classifications were represented, a higher proportion of high-income countries was represented (67.8% of all countries with a high-income classification in 2016 were included (N=78 countries), 62.5% countries with an upper-middle income classification (N=56), 54.7% of countries with a lower-middle income classification (N=53), and 25.8% of countries with a low-income classification (N=31)).

Table 5.1. Sample characteristics of countries and regions represented (N=135), by physical activity assessment method

	Self-report[a] N=135		Device-measured[b] N=24	
Income classification[c]				
Low	9	(6.2)	1	(4.2)
Lower-middle	29	(22.3)	-	-
Upper-middle	36	(27.7)	1	(4.2)
High	56	(43.1)	22	(91.7)
Uniform practices[d]				
Prevalent in >50% of primary schools				
Yes	104	(77.0)	7	(29.2)
No	31	(23.0)	17	(70.8)
Prevalent in >50% of secondary schools				
Yes	103	(76.3)	7	(29.2)
No	32	(23.7)	17	(70.8)
Physical activity data available, N (%)				
Primary school-age only	2	(1.5)	4	(16.7)
Secondary school-age only	98	(73.1)	5	(20.8)
Both school-age settings	35	(26.1)	15	(62.5)

[a] Countries/regions represented with self-report physical activity data, [b] Countries/regions represented with device-measured physical activity data, [c] 2016 World Bank Income classification groupings based on gross national income per capita, no classification grouping assigned to five regions included (3.8%); [d] Based on consensus from uniform survey data (n=391 respondents)

School uniform practices

In a majority of countries, school uniform practices were reported as common in primary (77.0%) and secondary (76.3%) school settings (see Figure 5.1 and Figure 5.2, respectively). See Appendix 5.7 for further information.

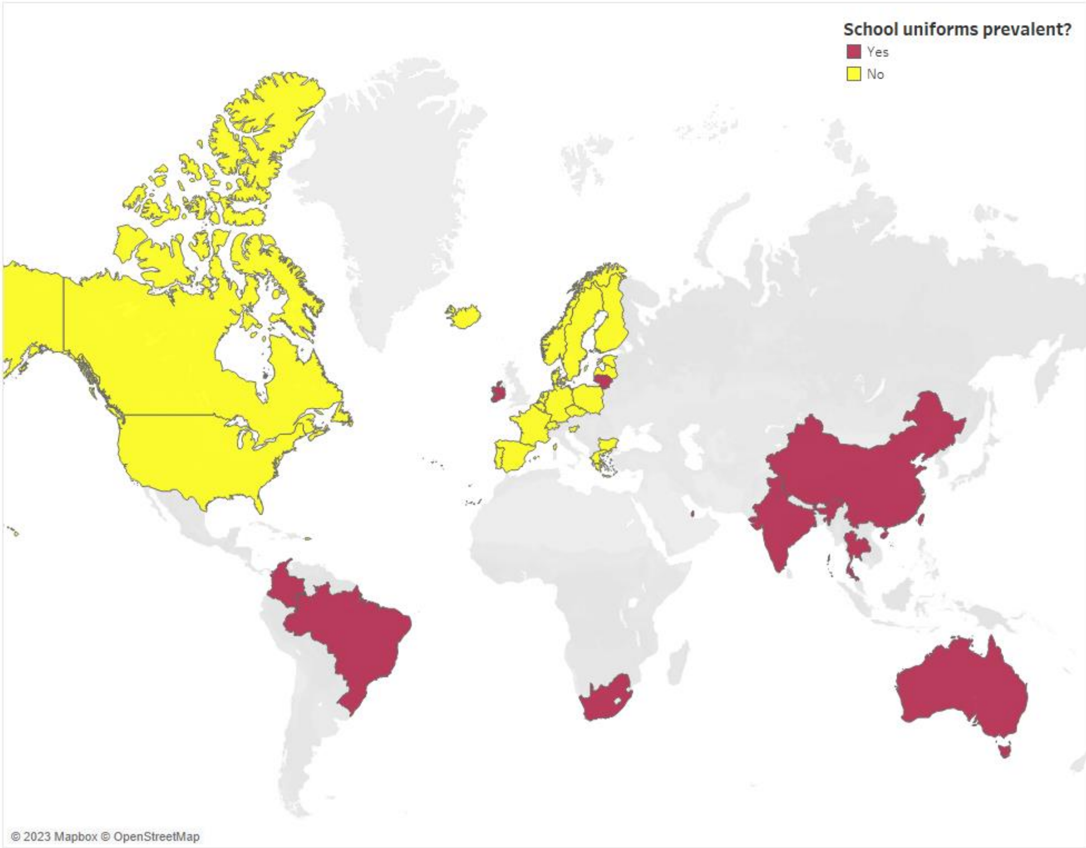

Figure 5.1. Uniform practices in primary school settings (N=37 countries)

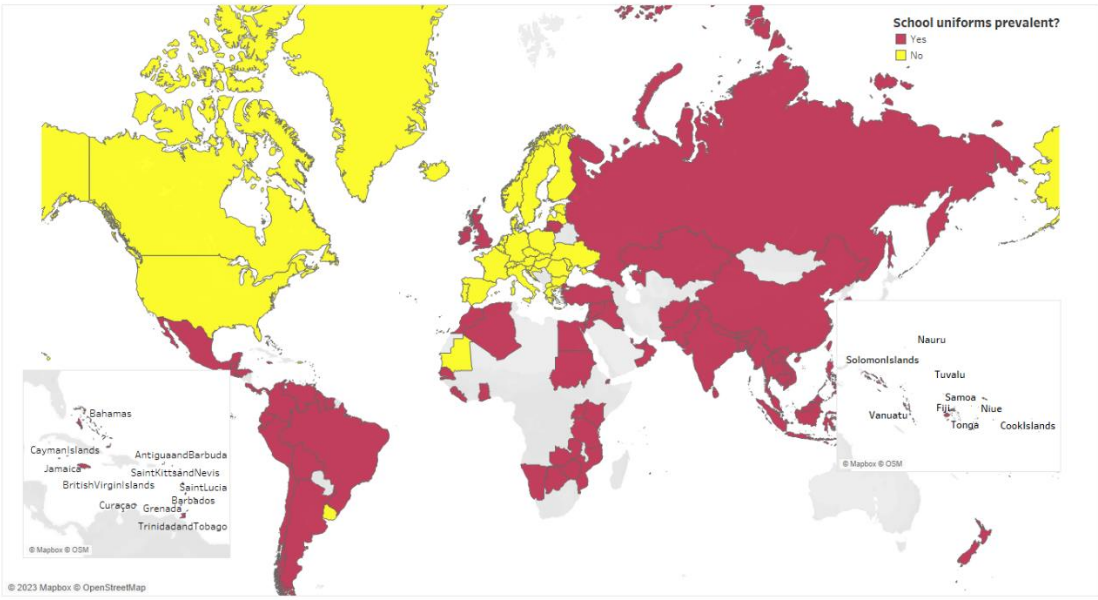

Figure 5.2. Uniform practices in secondary school settings (N=135)

Physical activity studies included

Sample characteristics of physical activity studies included are summarised in Table 5.2. Population-level estimates are based on self-reported data from 1,089,852 children and adolescents (median sample size per country: 3,427). Studies largely reported on secondary school-age students (78.2%).

Table 5.2. Sample characteristics of physical activity studies included (self-report and device-measured)

Physical activity studies (N=209)	Self-report N=170		Device-measured N=39	
Sample characteristics				
Total N[a], % female[b]	1,089,852	(51.4)	32,130	(51.3)
Study sample median, IQR	2,892	1,710-4,686	516	327-1,111
Country sample median[c], IQR	3,427	2,087-5,700	1,003	457-1583
School level represented				
Primary school-age (6<12 years), %	37	(21.8)	19	(48.7)
Secondary school-age (12-18 years), %	133	(78.2)	20	(51.3)
Year(s) of data collection,[d] range	2005-2018		1997-2018	
% meeting guidelines, median (range)				
Primary school-age boys	26.6	(5.8-80.0)	48.0	(12.5-96.3)
Primary school-age girls	20.0	(2.8-66.2)	21.0	(6.0-87.0)
Secondary school-age boys	19.6	(7.2-64.1)	35.0	(23.0-69.8)
Secondary school-age girls	12.3	(5.3-55.0)	11.8	(2.0-52.1)

[a] Data missing on total sample size from three self-report studies (1.8%) and two device-measured studies (5.1%), [b] Data missing about total sample size or gender-specific N/% from 65 self-report studies (48.1%) and eight device-measured studies (20.5%), [c] Where uniform and physical activity data available for both school age settings, [d] Indicates year(s) of physical activity data collection (or projection). Further details are provided in Appendix 5.8.

Association between school uniform practices and gender inequalities in physical activity

Pooled self-reported data showed that guideline compliance was significantly lower in countries with uniform practices (N=103) (median: 16.0%, IQR: 13.2-19.9) compared to those without (N=32) (median: 19.5%, IQR: 16.4-23.5) (z=3.04, p=0.002, Mann-Whitney U test).

Across all countries, the mean difference between the percentage of boys and girls meeting physical activity guidelines (absolute inequalities) across all ages was 7.6 percentage points (SD: 4.8). Boys were 1.5 (SD: 0.4) times more likely to meet physical activity guidelines than girls (relative inequalities). Linear regression showed no association between country-level uniform practices and population gender inequalities in physical activity (absolute inequalities: β=-0.2, 95% CI: -1.7, 1.3; relative inequalities: β=0.1, 95% CI: -0.1, 0.2) (see Table 5.3).

Differences by school level, income classification and assessment method

I found a significant interaction with school level (β=5.9, 95% CI: 0.8, 11.0), suggesting uniform use may be associated with greater gender inequalities in physical activity in primary school settings compared to secondary school settings. Subsequent stratified analyses suggested that among primary school-age children, absolute gender inequalities in physical activity guideline compliance were 4.3 percentage points higher in countries with uniform practices compared to those without (95% CI: -0.0, 8.6) (see Table 5.3 below).

In countries with a high-income classification, absolute physical activity inequalities were greater in countries with uniform practices (N=37) compared to those without (N=48) (9.1 (SD: 3.6) vs 7.8 percentage points (SD: 4.3) (z=-2.37, p<0.02, Mann-Whitney U test). Among countries with a low, lower-middle or upper-middle-income classification, differences in absolute physical activity inequalities between countries with uniform practices (N=74) compared to those without (N=6) were negligible (6.8 (SD: 5.6) vs. 6.7 percentage points (SD: 2.6)).

Using device-measured physical activity guideline compliance as the outcome did not alter my primary findings; I found no association between country-level uniform practices and population gender inequalities across both school levels (absolute inequalities: β=-2.2 percentage points, 95% CI: -10.8, 6.4; relative inequalities: β=-1.1, 95% CI: -2.3, 0.1) (see Table 5.3).

Table 5.3. Results of regression analyses, exploring associations between country-level uniform practices and population gender inequalities in physical activity guideline compliance

		Absolute inequalities		Relative inequalities	
	N[a]	**β**	**95% CI**	**β**	**95% CI**
Primary research question					
Uniform use (yes/no)	135	-0.2	[-1.7, 1.3]	0.1	[-0.1, 0.2]
Secondary research questions					
School level					
Interaction term					
Uniform use*school level (ref: secondary)	135	5.9	[0.8, 11.0]	0.3	[-0.1, 0.7]
Stratified analysis					
Primary school-age	37	4.3	[-0.0, 8.6]	0.2	[-0.1, 0.6]
Secondary school-age	133	-1.6	[-3.3, 0.6]	-0.1	[-0.3, 0.1]
Uniform use (yes/no) (device-measured)	24	-2.2	[-10.8, 6.4]	-1.08	[-2.3, 0.1]

[a] Number of countries/regions represented in model, β Beta coefficient, CI Confidence interval

5.5 Discussion

I found evidence that the common use of school uniforms is associated with lower compliance with international physical activity guidelines among school-aged children and adolescents. I found no association between country-level school uniform practices and gender inequalities in physical activity across all school levels, but evidence showed an association with greater gender inequalities in primary school settings. I also found preliminary evidence that associations between uniforms and gender inequalities in physical activity may be greater in high-income countries than in countries with other income classifications.

My finding that uniforms are associated with lower compliance with physical activity guidelines regardless of gender is a novel contribution to the literature. To date, boys have been reported not to perceive either whole day or PE uniforms as a barrier to their physical activity,[315,323,324,331] or have been excluded from studies prompting participants to consider their role.[322] Previous quantitative evidence suggests boys accumulate more vigorous-intensity physical activity[325] and are less sedentary[326] during break times when not wearing their regular uniform, but these studies did not report an association with total school-time physical activity. I examined associations between uniforms and physical activity guideline compliance across the week. My findings suggest associations between uniforms and physical activity beyond school hours and across genders may have been overlooked and underestimated.

My findings indicate uniforms are associated with greater gender inequalities in physical activity at the population level in primary but not secondary school settings. These findings may be explained by greater gender inequalities among younger children,[312] lower overall physical activity levels among secondary school-age adolescents, and marked differences in how and where children and adolescents accrue their physical activity. For example, primary school-age children accrue more of their physical activity from sporadic movements throughout the day, during which they may be wearing their uniform, whereas adolescents accrue a greater proportion of their total physical activity from structured activities (e.g., Physical Education, sport),[332] during which they may be encouraged or required to change. Primary school-age children may also gain a larger proportion of their total physical activity from active and risky play (e.g., hanging, balancing from heights, jumping). This may present greater challenges for girls if they are required or expected to wear skirts and dresses as part of their school uniform. My findings are supported by experimental research[325,326] but limited by power. Further research is therefore recommended on what may be driving the relationship between school uniforms and physical activity among primary school-age children.

This is the first known study to examine uniforms from a global physical activity perspective. Studies in which girls report uniforms as a barrier to physical activity have largely come from a limited number of high-income countries (i.e., Australia[315,322,325,326] and New Zealand[323,324]). My findings suggest associations between uniforms and gender inequalities in physical activity may be greater in high-income countries than in countries with other income classifications. This may reflect differences in gender-specific barriers and facilitators to physical activity across contexts. I grouped countries with a low, lower-middle, or upper-middle income classification as there was limited variation in uniform practices. My findings should therefore be interpreted with caution as this grouping may mask significant differences between countries.

Strengths and limitations

This study addresses calls to examine gender inequalities in physical activity among young people.[333] I pooled a large number of studies from international physical activity surveillance initiatives and used a rigorous method to select the best data to answer my research questions. I also report on unpublished data from the most comprehensive, high quality and large-scale surveillance initiative of harmonised device-measured physical activity to overcome data availability limitations. Study selection was conducted in duplicate using a systematic process, and a random sample of all data was checked to ensure extraction and pooling processes were accurate. All data reported in surveillance studies using secondary sources was cross-checked. Finally, I report novel country-level data about the prevalence of uniform practices; this can be used in future research.

I acknowledge that causation cannot be inferred as I aimed to maximise geographic coverage, and international surveillance initiatives predominantly employ cross-sectional designs. Countries with a high-income classification are over-represented despite evidence that the greatest burden of disease associated with physical inactivity is felt in middle-income countries,[334] and a rapidly increasing proportion of the global child and adolescent population are not based in high-income countries.[335] Surveillance initiatives also use measures of physical activity that have solely been tested in a small number of high-income countries; their validity, reliability, and cultural appropriateness beyond these contexts remain unknown.[30] My findings hence may reflect differential bias in the measures used. I solely included studies reporting on children and adolescents sampled from the general population. This may have led to biased guideline compliance estimates as many subgroups were inadvertently excluded (e.g., children and adolescents with additional health and educational needs). I used a binary variable to assess majority uniform practices at the country level; my results may underestimate associations in contexts with significant within-country variability. I also did not collect information about uniform design (e.g., restrictiveness of garments/footwear) as this may vary considerably within countries. Future studies should assess specific uniform features that facilitate or restrict physical activity. I was unable to stratify my analysis by socio-economic position but acknowledge evidence of socio-economic inequalities in physical activity within genders, particularly among primary school-age children.[336] I also did not explore associations among gender minority groups due to the measures used in surveillance initiatives. As evidence suggests country-level measures of gender inequality (e.g., Gini coefficient) are not globally positively associated with gender inequalities in physical activity,[337] I did not include them as covariates in my analyses. However, the origins of uniforms in many countries represented are a legacy of colonialism.[338,339] Hence, uniforms may serve as a proxy measure for some other shared cultural practice, value, or school policy, which I did not account for in my analyses.

5.6 Conclusions

All children and adolescents have "a fundamental right to physically active play – environments that do not support physical activity deny them that right".[30] My findings suggest school uniforms may be hindering students' fundamental right to engage in physically active play within and/or beyond formal educational environments. Given the costs associated with physical inactivity,[311] and data to suggest over 75% of countries represented in this study reportedly employ uniforms across primary and secondary school settings, my findings warrant further investigation. Future studies should include student-level measures of uniform wear time and physical activity intensity across the week to enable a better assessment of the influence uniforms have on child and adolescent health.

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Chapter 6: Overall discussion

6.1 Review of literature presented in Chapter 1 and thesis research objectives

Regular physical activity is important for children and adolescents to meet their multiple physical, mental and well-being needs.[5] Global surveillance studies have consistently shown that a substantial proportion (67-81%) of children and adolescents worldwide are not engaging in the recommended 60 minutes of moderate-to-vigorous intensity physical activity on average per day.[33,35] International intervention efforts aimed at increasing young people's physical activity have mostly focused on school settings.[63,64] Population surveillance data and intervention evaluation studies indicate that these interventions have had limited national or local success in changing students' physical activity.[67-70] The reasons for observed intervention outcomes are poorly understood.

Understanding the reasons why school-based physical activity interventions have failed is crucial to avoid further investment into similarly ineffective approaches and to drive progress in creating environments for young people that are conducive to physical activity. Theory and evidence from the fields of both Public Health and Educational research could help to enhance scientific understanding of intervention outcomes and the school context within which interventions are delivered. I, therefore, appraised and integrated literature from both of these disciplines to consider and address existing gaps in the field. In reviewing relevant literature, outlined in greater detail in Chapter 1, I identified opportunities to improve our understanding of the teacher-targeted programmes that have been commonly provided to support the delivery of physical activity interventions. I also found that some school-level environmental and policy correlates of student physical activity have been relatively underexplored in observational studies. Particularly few studies had examined relationships between individual features of school playgrounds, school uniforms, and student physical activity.

In identifying these gaps, I formulated five research objectives. These were:

1. To identify the features of teacher-targeted programmes that have been provided to support the delivery of school-based interventions targeting student physical activity (Chapters 2 and 3);
2. To examine associations between features of teacher-targeted programmes and teacher and student-level outcomes (Chapters 2 and 3);
3. To explore students' use of school playground infrastructure during break time, and study associations between infrastructure use, physical activity and cardio-respiratory fitness (Chapter 4);

4. To assess associations between school uniforms and students' total weekly physical activity (Chapter 5); and
5. To examine gender-based differences in associations between break time playground infrastructure use, school uniform policies, and student physical activity (Chapters 4 and 5).

In the following section, I will summarise the key findings from the studies I conducted to address these research questions.

6.2 Review of individual study aims and findings

Chapter 2

In Chapter 2, I addressed research objectives 1 and 2 to examine teacher-targeted programmes in research contexts. I conducted a systematic review and meta-analysis of staff training programmes that have been provided within randomised controlled trials to support the delivery of student-targeted physical activity interventions. The aims of the review were to identify the features of these programmes and investigate if specific features, including behaviour change techniques (BCTs) are associated with positive implementation and student physical activity outcomes.

The review reported on the features of 53 staff training programmes aimed at supporting the delivery of school-based physical activity interventions. An average of 5 BCTs were used per programme to change teacher behaviour (range=1–15). 'Instruction on how to perform the behaviour' was the most commonly identified BCT (used in 98% of programmes). Theory-based programmes and 19 BCTs were positively associated with implementation outcomes. Training programmes that used more BCTs and the BCTs 'Action planning' and 'Feedback on the behaviour' were associated with significant positive change to students' physical activity.

Chapter 3

The PE Premium policy study, described in Chapter 3 addressed research objectives 1 and 2 in a real-world context. In this study, I explored the UK government's largest policy targeting physical activity promotion in primary schools in England. I collected primary data from a sample of teachers in England to determine the presence of evidence-based design features in the professional development programmes provided to study participants. I also evaluated participants' perceptions of school support for professional development. Finally, I explored associations between the reported use of evidence-based design features, participants' perceptions of school support, and their perceptions of professional development impact.

My findings indicated that the programmes attended by participants often incorporated evidence-based design features which help teachers to learn new material ('instil insights'). However, the use of evidence-based features to facilitate other functions of professional development was limited. For example, less than half of participants attended a programme that included features that support teachers in mastering new techniques. Less than 30% attended a programme that included features that address all four proposed functions of professional development; to i) instil insights, ii) motivate goals, iii) teach techniques, and iv) embed practices).[153] Participants who attended programmes that addressed all functions reported experiencing greater impacts on their practice. No associations between teachers' perceptions of school support for professional development and their perceptions of impact were found.

Chapter 4

In Chapters 4 and 5, I addressed research objectives 3, 4, and 5 and focussed on relationships between the school-built environment, the school policy environment, and student physical activity. In Chapter 4, I examined students' use of playground infrastructure during their break times. Specifically, I examined their use of playing fields, fixed equipment, loose equipment, and teacher-organised games. I then explored overall and gender-specific associations between students' use of this infrastructure, their break time step cadence, and their cardio-respiratory fitness.

I found that the most commonly reported item used by all students was a playing field, followed by loose equipment, teacher-organised games, and fixed equipment. I found that, with the exception of fixed equipment, boys reported higher daily use of all infrastructure items during their break times than girls. For step outcomes, daily use of a playing field was associated with a higher break time step cadence. For fitness outcomes, both the daily use of a playing field and daily participation in teacher-organised games were associated with higher cardio-respiratory fitness. The strength of some of the associations differed by gender. Associations between teacher-organised games and break time step cadence were stronger in girls. Conversely, associations between daily playing field use, daily participation in teacher-organised games, and cardio-respiratory fitness were stronger in boys.

Chapter 5

In the final study of this thesis, I examined school uniform policies and their associations with gender inequalities in physical activity. This question was addressed at a population level, using national estimates of child and adolescent compliance with physical activity guidelines as the outcome.

My findings indicate that young people's compliance with physical activity guidelines is lower in countries with school uniforms compared to those without. I found no overall association between school uniforms and gender inequalities in physical activity across all school ages. However, among primary school-aged students, uniformed countries showed a greater gender gap in meeting activity guidelines, favouring boys, compared to countries without uniforms. I also found evidence to suggest that the relationship between school uniforms and gender inequalities in physical activity may be more pronounced in high-income countries, than in countries with other income classifications.

Within individual study chapters, I discussed my findings in light of relevant literature, reported my assessment of the strengths and limitations of the methods employed, proposed recommendations for future research, and listed my conclusions. In this overall discussion chapter, I will provide my perspective on the contributions of this overall body of work to Public Health and Educational literature, address overarching methodological considerations, and outline future directions for research and policy to consider.

Contributions

In identifying, appraising, and integrating literature from Public Health and Educational research, as well as designing and conducting my own studies, I made several contributions to the field. These include:

i) an interdisciplinary appraisal and integration of Public Health and Educational literature;
ii) an examination of teacher-targeted programmes for physical activity promotion;
iii) an initiative I undertook to improve reporting standards in intervention research; and
iv) an examination of school-level environmental and policy correlates.

6.3 Appraisal and integration of Public Health and Educational literature

A major contribution of this thesis is the interdisciplinary appraisal and integration of Public Health and Educational research concerning teacher and student behaviour related to physical activity in educational settings. Throughout this thesis, I offer new critical interpretations of Public Health research related to young people's physical activity through the lens of Educational research. This fresh and broadened perspective allows for a deeper examination of some of the theories and factors that Public Health researchers have both focused on (e.g., the socio-ecological model) and overlooked (e.g., school uniforms) in their studies of teacher and student behaviour.

I also introduce and appraise literature from the field of Educational research in recognition that there is valuable theory and evidence beyond the field of Public Health research that could be used to inform studies of young people's school-based physical activity. I translate the findings and terminology from this evidence base into language and concepts that are more familiar to a Public Health research audience (e.g., Educational research use of 'teacher training' ≠ Public Health research use of 'teacher training'). In doing so, I enable other Public Health researchers the opportunity to access and build on the findings from a broader range of disciplines who do not have the resources to independently search and familiarise themselves with literature, terminology, and concepts in another field. I also provide a critical assessment of the strengths and limitations of Educational research, as well as its relevance to the study and promotion of physical activity among young people to ensure the application of this evidence base is well-informed. The literature presented in this thesis hence serves as a valuable resource, saving other researchers time and effort, and allowing them access to a broader range of studies that they can readily integrate into their work.

Finally, I integrate these different perspectives to design and formulate interdisciplinary studies to address existing gaps, representing a novel approach in the field. International researchers have identified a clear need for a deeper understanding of the school environment to understand the contextual factors that may be underlying observed physical activity behaviours in educational settings.[124,340] To accomplish this, researchers have advocated for more participant and public engagement activities (e.g., with teachers and students) to improve understanding of the school setting.[340] While drawing on the expertise of teachers and other relevant stakeholders can provide valuable insights into the educational context, solely relying on these groups to inform and conduct research can potentially result in a narrow focus on local practice. It can also result in limited use of relevant theory and knowledge gained from other school-based studies. Hence, in appraising and integrating theory and evidence from both Public Health and Education to examine teacher-targeted programmes and the wider school context, I contribute a unique interdisciplinary perspective, facilitate dialogue between relevant fields and potentially accelerate progress in school-based physical activity promotion research.

6.4 Examination of teacher-targeted interventions for physical activity promotion

The second significant contribution of research presented in this thesis relates to the studies I conducted to examine the teacher-targeted programmes that have been provided to support the delivery of school-based physical activity interventions in research and real-world contexts. In Chapter 1, I highlighted that many school-based physical activity interventions heavily rely on teachers for intervention delivery. However, there has been a limited understanding to date of how teachers have been supported to deliver physical activity initiatives and whether specific approaches are more or less effective in promoting implementation. This acknowledged research gap in the field of Public Health has impeded progress in understanding some of the potential causal mechanisms that may be underlying (in)effective school-based physical activity promotion efforts.[77] Though a primary area of study in the field of Educational research is teacher professional learning and change, a majority of research in this field has focused on a limited number of core school subjects.[99,153] As a result, the evidence base has been too narrow in scope to determine i) how teachers are typically supported to deliver school-based physical activity interventions and ii) whether professional development programmes features, found to have been effective in subjects like maths, literacy, and science, are also effective in professional development programmes relating to student physical activity.

To address these research gaps, I conducted two studies to comprehensively examine the features of teacher-targeted programmes aimed at supporting the delivery of school-based physical activity initiatives. In Chapter 2, I conducted an extensive search for trial data to determine the features of 53 unique staff training programmes aimed at supporting the delivery of school-based physical activity initiatives in research contexts. In Chapter 3, I collected primary data to determine the features of PE-related professional development programmes aimed at supporting the delivery of a national policy targeting physical activity. To ensure a comprehensive and rigorous assessment of the teacher-targeted programmes delivered in both research and real-world contexts, I collected data on all items in the TIDieR checklist. I also explored associations between identified features and changes in teacher practice and student physical activity behaviour.

The findings from Chapters 2 and 3 provide comprehensive insights into the features of teacher-targeted programmes that have been provided in recent years to support the delivery of school-based physical activity promotion initiatives. They also shed light into why some of these interventions may be ineffective in bringing about desired changes in both teacher and student behaviour. Specifically, my results indicate that while many staff training and professional development programmes help teachers to learn new material, they mostly fail in providing them with opportunities to observe, rehearse, or receive feedback on their practices. Chapters 2 and 3 indicate that the omission of these features in programmes is associated with less effective outcomes for both teachers and their students.

These studies provide valuable insights into critical yet overlooked aspects of many school-based physical activity interventions. The insights from these studies can be used to inform programmes that more effectively support school staff tasked with delivering physical activity interventions. As reliance upon teachers is common in many other school-based health-promoting interventions (e.g., targeting mental health, smoking cessation),[341,342] my findings may have wider relevance beyond physical activity. These studies also advance knowledge within the field of Education, by examining the use of programme features and their effectiveness beyond maths, science and literacy. Chapter 3 also addresses contemporary discussions in Educational research concerning the most effective form and design features of professional development.[109] This study reports novel evidence from a real-world setting to support Sims and colleagues' theory,[153] suggesting that the functions that features facilitate may be more important than the higher-level form in which they appear (e.g., lesson study, instructional coaching, teacher learning communities). The findings may be used to increase the effectiveness of various forms of professional development, allowing for a more inclusive and flexible approach. This study also aligns with calls in Educational literature to shift research away from "current conceptions of 'good' [professional development] as comprising a collection of particular design features" and towards a "more nuanced understanding of how teachers learn and grow".[94]

6.5 Action taken to improve reporting standards in intervention research

The third contribution relates to an initiative I undertook to enhance the quality of reporting in future intervention studies. The need for this initiative was identified whilst conducting the systematic review described in Chapter 2. The systematic review was conducted, in part, because previous review efforts to address similar research questions were impeded by incomplete reports of interventions published between 1999–2015.[77] Given the greater availability and promotion of intervention reporting guidelines since 2015,[155] I specifically focused on interventions published from 2015 onwards, anticipating that reporting quality would have improved during this period. However, after conducting a comprehensive and inclusive search for details of teacher-targeted interventions, searching for information across multiple sources, including protocols, process evaluations, outcome evaluations, trial registries, and study websites (n=183 in total), I found that just one of 53 training programmes were reported in accordance with the TIDieR checklist. Hence 98% of trials published between 2015-2020 did not provide sufficient details on the teacher-targeted interventions to facilitate interpretation or replication. Basic details (e.g., use of theory, location of the intervention) were frequently missing. When I examined intervention outputs, I found that intervention descriptions primarily focused on the interventions aimed at the students. Some authors used checklists to describe these interventions. However, no checklists were reportedly used to describe the teacher-targeted interventions.

In the preceding systematic review that informed my study, the authors advocated for improved reporting on the teacher-targeted intervention.[77] As evidence indicated that these calls were largely not answered, I considered available literature to inform another approach. Given research suggesting that adherence to reporting guidelines is better in journals that endorse relevant guidelines,[343] I examined the websites of the 33 journals that published articles included in the review. I found that only one of them explicitly requested researchers to submit reporting checklists for all intervention components. I, therefore, contacted the editors of the other 32 journals and invited them to update their submission guidelines. I proposed that they endorse the use of reporting checklists for all intervention components, including those targeted at change agents (e.g., teachers/parents responsible for implementation). I received responses from 27 journals, and eight of them (30%) updated their submission guidelines in response to this request. Examples of journals that updated their guidelines include 'British Journal of Sports Medicine', 'Sport, Exercise, and Performance Psychology', 'Journal of Science and Medicine in Sport', and 'American Journal of Preventive Medicine'. To raise broader awareness of this issue, which goes beyond school-based research as reliance upon 'change agents' for intervention delivery is common in many other settings (e.g. hospitals, police custody suites, nursing homes),[344-346] I collaborated with colleagues to publish a commentary on the reporting practices I observed, and encouraged all journals to review their submission guidelines in response.[347] A copy of this commentary, published in Trials, is included in Appendix 6.1.

While I decided not to include this manuscript as a chapter in this thesis, I consider it an important contribution. This initiative is an important step towards improving reporting standards within the science community, and has the potential to effect substantial positive impacts on research and applied outcomes. The eight journals that have already updated their guidelines publish many intervention studies every year. Better reporting on these interventions enables other researchers to now:

i. understand the study's methods, procedures, and results,
ii. judge the validity and generalisability of the findings,
iii. replicate and test the intervention in other settings, and
iv. include the study in systematic reviews and meta-analyses.

These affordances substantially increase the scientific and applied value of intervention research.

6.6 Examination of school-level environmental and policy correlates

The final contribution of this thesis relates to the novel correlates of student physical activity and cardio-respiratory fitness I identified in Chapters 4 and 5. In Chapter 1, I commented that socio-ecological models of physical activity have often informed studies of young people's physical activity.[51] I hypothesised that perhaps as a consequence of how schools are represented within the model (as a 2D non-hierarchical structure), limited attention may have been paid to the potential spectrum of school-level factors that may be associated with student physical activity in educational settings. Prior to Chapter 4, remarkably few studies had explored associations between specific playground features and student physical activity and just one known study had examined playground correlates of cardio-respiratory fitness.[140] Chapter 5 is the first known study to examine school uniforms from a global physical activity perspective and very few smaller-scale studies have been conducted. This study addresses an important gap given evidence suggesting that uniforms are prevalent in in 75% of the 135 countries surveyed.

These studies expand our knowledge of the multi-level school-level contextual factors that may be influencing student physical activity and cardio-respiratory fitness within and potentially beyond educational settings. Findings may be used to inform interventions that target the wider school environment in which physical activity interventions are commonly delivered. A recent scoping review, which examined features of school-based interventions targeting student physical activity and cardio-respiratory fitness delivered in the last decade (n=178, published 2010-2019), suggests these factors are not commonly targeted in experimental studies.[86] In their review, Brandes and colleagues found that just 27% of interventions targeted any aspect of the school-built environment and only 7% targeted any aspect of the school policy environment.[86] The largest proportion (58%) targeted 'Health skills and education'; interventions encompassing any form of training or the provision of teaching materials related to the improvement of physical activity-related knowledge or movement skills.

These findings indicate that, while framed as school-based initiatives (i.e., targeting the school as a system), a majority of intervention efforts are typically confined to individuals, missing out the interconnectedness between individual behaviours, the school as an ecosystem, and wider population-level correlates and determinants of organisational-level behaviours (e.g., school accountability metrics, student socioeconomic position). Future observational and experimental studies could benefit from adopting systems approaches to explicitly focus on the 'chemistry' between, across and beyond levels of the school system.[348,349] This approach aligns with the WHO's

Global Action Plan on Physical Activity, described in Chapter 1, which stipulates that a systems-based approach is needed to reverse current trends.[43] By reporting both overall and gender-specific associations in both studies, my findings also provide valuable insights into the various factors that may be contributing to the maintenance of gender inequalities in physical activity in school settings. These findings can hence guide future research aimed at reducing these disparities.

6.7 Developments in school-based physical activity promotion research

When assessing these contributions, it is important to acknowledge some recent developments in the field of school-based physical activity promotion research. In chapter 1, I outlined findings from multiple systematic reviews of school-based physical activity interventions, which repeatedly found that they are not effective in changing young people's physical activity levels. In the time since some of these studies have been published, researchers have advocated for more i) context-driven interventions, ii) whole-of-school approaches, and iii) application of systems thinking methods. A detailed discussion on the origins and merits of these developments for school-based physical activity promotion is reported in greater detail elsewhere in the literature.[e.g.,65,340,350] In the below section, I briefly introduce these new developments alongside considerations of if and how the findings reported in this thesis have relevance for these new directions.

i) Context-driven interventions:

In recognition that contexts and populations vary greatly between schools, physical activity researchers have increasingly advocated for a move away from 'tightly-constructed' programmes, comprising prescribed intervention content and targets, to a greater focus on context-driven approaches, whereby interventions are informed by the specific needs identified within a school by multiple stakeholders.[340,351] An illustrative example of this approach is the 'Creating Active Schools' Framework,[352] which offers schools an evidence-based tool to guide a review of their current provision. The aim is to enable practitioners with context-specific knowledge of their school's strengths and opportunities for change to judge where and how they could most benefit from one or more reforms relating to their school policies, environments, and staff behaviour to promote physical activity among students.

As the intervention targets that emerge from context-driven approaches may differ from one school to another, this approach challenges previous emphasis placed on programme fidelity and whole of intervention scalability 'failures'.[353] Nevertheless, teacher professional development will likely remain a common component of many context-driven interventions as generalist teachers in many countries report low levels of confidence in delivering PE[354-356] and integrating physical activity into other lessons.[357,358] The findings reported in chapters 2 and 3 do not promote fidelity to a particular form of teacher professional development or delivery of specific content. Rather these studies provide support for the inclusion of certain functions and features of teacher professional development. Chapters 2 and 3 can therefore inform the development of various forms of teacher professional development and be tailored to the aims of the professional development and school context in which the professional development is delivered. As context-driven approaches focus on consulting end users of interventions, future researchers can build on these findings by considering how best these functions and features could be incorporated into professional development.

ii) A whole-of-school approach:

A second paradigm shift in the field relates to greater support for whole-of-school approaches to physical activity promotion in educational settings.[359] Previous school-based interventions have often targeted multiple components of educational settings to promote physical activity (e.g., Physical Education classes, after-school clubs, parent/carer engagement). However, such multi-component interventions still only focus on specific and hence limited aspects of the whole school day and/or environment (e.g., by targeting only a limited number of classes or year groups). In recent years, researchers have critiqued such approaches as being too narrow in scope to effect significant and sustainable change.[360-362] Researchers have argued that whole-of-school approaches are instead necessary, which seek to intervene across the entire school environment by considering physical activity in all policies, environments and time periods.

The contributions of this thesis remain relevant in the context of whole-of-school approaches. First, there is a recognised "lack of understanding of what constitutes a whole-school physical activity approach".[363] This can be improved through better reporting practices, as a consequence of the journal guideline initiative I led. Second, effective initial teacher training as well as effective professional development are hypothesised key facilitators of whole-of-school approaches,[65] particularly in relation to physically active learning[357] as existing professional development opportunities are reportedly limited in many countries.[358] Third, whole-of-school approaches encompass consideration of physical environments and policies within schools and their role in physical activity promotion.[359] The findings reported in chapters 4 and 5 can hence be used to inform the development of evidence-informed whole-of-school approaches, providing novel insights into playground features and school uniforms associated with student physical activity.

iii) Systems thinking methods:

A third major development in the field relates to increased calls for the use of systems thinking in designing and evaluating physical activity interventions targeting children and adolescents.[350,364] This shift is driven by the findings from many interventions, in which school practitioners have cited wider systemic obstacles to implementation and sustainment (e.g., competing educational priorities).[264,365,366] In response, researchers have increasingly stressed the importance of considering factors beyond the school setting to inform and evaluate physical activity interventions. Systems thinking methods consider the interrelationships between components of a system across multiple domains (e.g., political, social, cultural, economic-level factors), recognising interactions between these dynamic parts and related actors.[367] Additional principles of systems thinking (e.g., feedback loops, non-linear relationships) are reported elsewhere in the literature.[368]

Similar to whole-of-school approaches, agreement on what constitutes a systems thinking approach in the context of youth physical activity promotion remains poorly understood. A recent scoping review of the use and application of systems approaches in population physical activity research suggests that few researchers have "engaged robustly with systems concepts", approaches are still in the early stage of development, and that further methodological work may be needed to facilitate uptake.[51] Notably, this thesis solely focused on setting-level correlates and determinants, and did not examine wider systems-level factors associated with student physical activity behaviour (e.g., funding, initial teacher education, school performance metrics). As understanding and use of systems thinking methods mature, interdisciplinary collaborations between Public Health and Educational researchers will likely increase. Future researchers can benefit from the insights and experiences detailed in this thesis and consider my recommendations for future collaborations (see 'Reflections on Interdisciplinarity' section below).

6.8 Overarching methodological considerations

The scientific and applied value of my findings discussed in the previous section should be interpreted in light of methodological considerations. In Chapters 2-5, I discussed the strengths and limitations of the methods I employed in individual studies. In the upcoming section, I will address overarching methodological factors that could impact the internal and external validity of findings reported across these chapters.

6.8.1 Internal validity

I refer to internal validity as the extent to which observed findings are true for individuals participating in any given study. I will consider how the internal validity of my findings may have been threatened as a consequence of study design, confounding, chance, and error in measurement.

Study design

The systematic review reported in Chapter 2 evaluated randomised controlled trials, a majority of which were clustered at the school level. These study designs have several features (e.g., blinding and randomisation) that enhance confidence in attributing observed effects to the intervention of interest. However, design effects can still threaten the internal validity as students within the same cluster tend to be more similar to one another than to students in different clusters. This violates the assumption of independence in statistical methods. To address this issue, I adjusted my findings for design effects, by using the intra-cluster correlation coefficient. This improves the accuracy and reliability of the estimates I report and enhances the internal validity of my findings.

In the other chapters, my findings are based on observational and cross-sectional designs. While these study designs facilitate the ability to measure an association between an exposure and an outcome within a defined population, their limitations have several implications for the findings reported. For example, cross-sectional studies do not rule out the possibility of reverse causality or bi-directional associations. In the playground study, I report associations between infrastructure use and student fitness. While some evidence suggests students typically gain a large portion of their total weekly minutes of vigorous-intensity physical activity during school hours,[306] which is positively associated with cardio-respiratory fitness,[270] participants included in the trial may have accrued vigorous-intensity physical activity during non-school times (e.g., through organised sport). This is plausible since students participating in the trial were from mostly advantaged backgrounds and review-level evidence indicates young people with a higher socioeconomic position engage in more vigorous-intensity physical activity beyond school hours than young people with other socio-economic positions.[40] Hence, student fitness may have been a determinant of break time playground infrastructure use, rather than the other way around. Associations may also be bi-directional.

Reverse causation and bi-directional associations may be easier to rule out in other study chapters. For example, in Chapter 5, I report on associations between country-level uniform use and young people's compliance with physical activity guidelines. There is no evidence to suggest that school uniform practices are influenced by young people's physical activity. The origins of uniforms in many of the countries represented in my study are a reported legacy of colonialism.[338,369] The findings from my uniform study also indicate that uniform practices in a majority of countries have not changed for at least 10 years. Experimental evidence from other studies also provides support for my findings and indicates that primary school-age girls are more active and less sedentary on days when they are not wearing their regular uniform.[325,326]

Confounding

Confounding variables pose a threat to internal validity as they can distort the observed relationship between independent and dependent variables of interest. However, researchers can reduce the risk of confounding in a number of ways. They can analyse data from participants who have been randomised, adjust their analyses for relevant covariates or conduct sensitivity analyses. All of the studies I included in the systematic review were randomised controlled trials, and this helps to ensure that both known and unknown confounding variables were balanced across groups. In the PE Premium study, I examined variables that may influence associations of interest as part of my analysis (e.g., school size, percentage of students eligible for free school meals, years of participant's teaching experience). However, after finding no moderate or strong correlations between the exposure and outcome variables, I did not adjust for any confounders in my analysis. In the playground study, I controlled for school- and student-level confounders, based on literature and directed acyclic graphs (DAGs). This combined approach ensures that knowledge from previous studies was incorporated and my assumptions as a researcher about the relationships between variables were transparent, thereby facilitating an evidenced-based and open approach to analysis.[370] In the uniform study, I considered potential confounders at the country level. I had initially intended to adjust for country-level measures of gender inequality (e.g., Gini coefficient) based on findings from previous studies.[371] However, I decided against this at the time of analysis given emerging evidence that suggested country-level measures of gender inequality are not globally associated with gender inequalities in physical activity.[337]

Chance

In assessing the internal validity of research findings, it is important to consider whether observed findings may be due to random variation or chance, rather than a result of the variables under examination. The level of statistical significance was set at an alpha level of 5% across all studies, which is consistent with practices in both Public Health and Educational research. Point estimates and 95% confidence intervals are reported across chapters to communicate both the estimated magnitude and direction of observed findings, as well as the extent to which findings would likely change if the study was repeated many times.[372] Findings reported in Chapters 2, 4 and 5 are based on large sample sizes for studies of young people's physical activity. However, it is important to note that the findings in the review and uniform study are both based on aggregate data. While the use of aggregate data in both of these studies is appropriate, given the research questions and the amount of data available for analysis,[373] the effective sample size on which findings are based is the number of trials included in the review and the number of countries represented in the uniform study. To reduce the risk of making a type 1 error in the review, resulting in false positive findings, I excluded pilot, feasibility, and small-scale studies from inclusion. This decision is supported by a recently published meta-epidemiological study, which found that the inclusion of such studies in meta-analyses significantly inflates summary effect estimates.[73] In the uniform study, I prioritised studies for inclusion that reported on participants sampled from a national or regional population, thereby reducing the risk of chance findings. In Chapter 3, I highlight that while the PE Premium study sample is representative of all teachers in England by gender, age and years of teaching experience, findings are still based on a relatively small sample size. Though the associations I report are supported by review-level evidence, further studies are needed to determine whether my findings may be due to random variation or chance.

Error and bias in measurement

Finally, error and bias in measurement may also pose a threat to the internal validity of my findings as they introduce variability and uncertainty into variables of interest and potentially affect the accuracy and reliability of the findings reported.

Error and bias in exposures

Exposures of interest in both the systematic review and the PE Premium study were focused on staff training and professional development programmes provided to teachers. To ensure a comprehensive and evidence-based assessment of these programmes, I collected data on all items in the TIDieR reporting checklist.[155] In the review, I also assessed interventions for the presence of behaviour change techniques (BCTs). These were independently coded by a colleague and I, after we had both completed certified training in BCT coding. This approach to BCT coding enhances the reliability of the techniques I report. Both the TIDieR checklist and the BCT Taxonomy were also rigorously developed by researchers through a systematic and iterative process, involving literature reviews, multidisciplinary expert consultation, testing and refinement.[152,155] The use of both the checklist and the BCT Taxonomy in these studies helps to reduce error and bias in measurement. As discussed in Chapter 3, the majority of survey measures used in the PE Premium study had not been validated. I had initially included some validated scales, but a group of teachers that provided critical feedback on my survey measures advised that items were not relevant to PE-related professional development programmes in primary schools in England. This underscores the importance of public involvement and testing survey questions, including validated measures, with the target sample prior to data collection. My use of non-validated measures in the survey still introduces uncertainty and decreases confidence in some of my reported findings. However, my findings regarding the exposure of interest align with those reported by Ofsted, in their national survey of teacher professional development for all school subjects which was conducted during the same period.[122]

In the playground study, the exposure of interest (infrastructure use) was assessed using a self-report measure and items had not been validated. Although this approach could have introduced some error, students' reported infrastructure use aligns with findings from other studies that used objective measures (GPS data) to examine playground behaviour among a sample of similarly aged children.[374] In the uniform study, the exposure of interest was country-level uniform practices. This was measured using an online survey. Two participants per country were sought to minimise error and there was a high level of within-country agreement. Nevertheless, the survey was not offered in other languages, and I still included countries in the analysis if only one survey response was recorded. While this approach was taken to maximise geographic coverage, this may have introduced measurement error, particularly concerning data related to uniform practices in non-English speaking countries.

Outcomes

In three out of four studies, the outcome of interest was student physical activity. I report on device-measured data in all these studies. The value of device-based measures to assess physical activity among young people has been well-documented, particularly for children under 12 years of age.[25,26] However, it is important to acknowledge that threats to internal validity may still arise due to variations in the devices used and the processing methods employed to handle accelerometer data. Comprehensive efforts were therefore made across all studies to mitigate these concerns and reduce the risk of error and bias in physical activity measurement. In the systematic review, I calculated standardised mean differences, conducted random effects-meta analyses, and excluded studies from analyses that did not report on the mean and standard deviation of the same sample size at both baseline and follow-up. While this conservative approach led to the exclusion of some studies, the reported findings are likely less subject to bias. In the playground study, I calculated students' break time step cadence based on data derived from wrist-worn accelerometers. While other researchers have previously used data from wrist-worn accelerometers to estimate minutes of specific physical activity intensities (e.g., minutes of MVPA),[326] I focused on step cadence. This decision was informed by evidence, indicating that, with the exception of sedentary behaviour, wrist cut-points perform poorly in identifying physical activity intensities.[375] The conclusions drawn are therefore based on fewer but a more reliable measure of student physical activity. In the uniform study, I pooled data from studies reporting on both self-report and device-based measures of student physical activity data. While the use of self-report data may have introduced some bias and error, I tested my findings using device-measured physical activity as my outcome, and found that my result did not change. My primary outcome of interest in the PE Premium study was teachers' perceptions of professional development impact. This was assessed through a self-report measure, which relied on teachers' subjective evaluations of the effects. While efforts were made to mitigate biases associated with self-report measures (e.g., teachers' confidentiality and anonymity were protected), it is still important to acknowledge that participants may have overestimated the impact of professional development on their practice. Future studies could therefore consider collecting additional data (e.g., from students) to provide a more comprehensive assessment of the potential effects of professional development programmes on teachers' practice.

6.8.2 External validity

In the following section, I will examine potential threats to external validity, specifically focusing on selection bias, attrition bias, and generalisability. I refer to external validity as the extent to which my findings may be generalised to other populations and settings.

Selection and attrition bias

Selection bias occurs when the association between an exposure and outcome is different for those who complete a study than those who exist in the defined target population of interest. It can occur as a result of the factors that influence participation and drop-out in a study. Selection bias and attrition bias are an ongoing concern and challenge in school-based physical activity research; findings may be subject to sources of selection and attrition bias at several levels (e.g., school, teacher, parent and student). Researchers must therefore describe the methods they used to identify and select schools, teachers and students to take part in a study to enable others to assess the external validity of the findings they report. Drop-out rates must be similarly well-described. In each trial included in the systematic review, study authors described different selection processes, and reported different levels of attrition. The unit of selection also differed between trials. For example, in some studies, all classes within a year range were selected and invited to participate, while in others, just one class per year was chosen. In such cases, it often was not clear whether teachers self-selected for participation or whether the class was selected at random. In conducting the review, I also found that the majority of trial outputs focused on describing attrition at the school and student levels. Conversely, reports of attrition at the teacher level were limited. In the PE Premium study, I describe the recruitment and data collection methods I employed as well as dropout rates throughout the survey. While I made a comprehensive effort to design a study that minimised the potential for selection and attrition bias (e.g., the survey was online, cross-sectional, brief and advertised through various channels), findings may still be subject to limitations related to self-selection bias and non-response bias. In Chapter 4, I highlight that, as a consequence of the trial objectives, the findings are based on a sample of students enrolled in a select group of advantaged schools. The generalisability of my findings to other populations is therefore cautioned.

Generalisability

The majority of data reported in this thesis relates to students in high-income countries and primary school settings. The generalisability of the findings I report beyond the settings and populations represented needs testing. In the systematic review, I did not apply any language or geographic limitations to the eligibility criteria. However, my findings are based on trials conducted in 19 countries, half of which were conducted in Australia, the United States, and the UK. Primary school settings were also overrepresented (63%). Trials conducted in low and middle-income countries and trials not published in English were likely disproportionately excluded as a result of the eligibility criteria I applied (e.g., device-measured activity) and the databases I searched. In Chapter 3, I highlight that the PE Premium study sample is representative of all teachers in England by gender, age and teaching experience, and that the associations I identified are supported by previous reviews.[153,376] However, as previously discussed, the recruitment approach, data collection methods, and eligibility criteria employed may limit the generalisability of the findings. The associations I identified in the playground study similarly need further testing in different populations to ensure that the observed relationships are not specific to a particular socio-economic group. The generalisability of findings reported in the uniform study may be subject to biases associated with population-level studies, including ecological fallacy. This refers to a phenomenon whereby relationships observed at the group level are not always observed at the individual level, partially due to the inability of aggregate data to capture variation that exists among individuals within a group.[377] While small-scale studies provide support for my findings,[325,326] further student-level data is needed to explore the associations I identified in different populations.

6.9 Reflections on interdisciplinarity

In chapter 1, I proposed that existing gaps in school-based physical activity intervention research may be most effectively addressed by appraising and integrating relevant expertise beyond the scope of what has previously guided experimental and observational studies. In doing so, researchers could gain a different perspective as to why interventions may be failing to change student behaviour and identify new approaches and strategies that may yield better results. To this end, I committed to adopting an interdisciplinary approach, integrating knowledge from both Public Health and Educational research. In the following section I will reflect on i) whether and how this was achieved, ii) my public health focus, and iii) considerations for future interdisciplinary research projects.

As stated in chapter 1, interdisciplinarity encourages a reciprocal interaction between disciplines, moving beyond multidisciplinary approaches, in which researchers from distinct fields address a problem in parallel or sequentially, to instead actively challenge disciplinary boundaries to create new methodologies, perspectives, knowledge, or disciplines.[84] In chapter 1, I actively challenge the focus and limitations of existing Public Health and Educational research concerning school-based physical activity promotion and teacher professional development. I offer novel perspectives on the theories and factors that Public Health researchers have both focused on (e.g., the socio-ecological model) and overlooked (e.g., school uniforms) in their studies of teacher and student behaviour. I also introduce and appraise Educational literature in recognition of relevant theory and evidence that could be used to inform studies of young people's school-based physical activity. These novel perspectives, gained from challenging disciplinary boundaries, inform the focus of four studies described in chapters 2-4. Chapters 2 and 3 focus on teacher professional development within research and government-led physical activity interventions to create new knowledge for Public Health and Educational researchers. Chapters 4 and 5 consider school-level policies and infrastructure associated with student activity behaviour. However, while the focus of these studies is premised on Educational literature, suggesting that schools are dynamic complex ecosystems, with their own proximal and distal factors which interact to influence staff and student behaviour, I acknowledge chapters 4 and 5 make fewer and weaker references to Educational literature. In the current chapter, I consolidate the cross-cutting findings from these four studies, explore overarching methodological considerations, highlight contributions to both fields, and outline future directions for researchers and policy actors to consider.

It is important to acknowledge that although efforts were made to integrate literature and expertise from both disciplines in this thesis, the predominant focus is on young people’s physical activity; a public health-oriented outcome, rather than an education-focused outcome. The structure and writing style also align more closely with the conventions of Public Health research, and the thesis will be submitted for the degree of Doctor of Philosophy to the School of Clinical Medicine Degree Committee. Thesis conference contributions and journal submissions thus far are similarly public health-focused. Nevertheless, it should be noted that interdisciplinary research does not necessarily demand an equal contribution from two or more different fields; rather, the value of literature and its integration depends on its quality and its relevance to the research questions at hand.[378] The aims of this thesis were to integrate theory and research from Public Health and Educational research to enhance scientific understanding of teacher and student behaviour related to physical activity in educational settings. While several aspects of this thesis exhibit Public Health rather than Educational research qualities, I have succeeded in integrating theory and evidence from both these fields. This is substantiated by the body of literature referenced, the research questions formulated and the novel contributions these studies made in enhancing scientific understanding of teacher and student behaviour related to physical activity in educational settings (see previous 'Contributions' section).

Based on my own observations and existing literature, interdisciplinary research often presents distinct and additional challenges in comparison with research projects confined to a single disciplinary boundary.[379-381] Therefore, funders and researchers wishing to support or undertake interdisciplinary research projects should consider how commonly reported challenges will be addressed, particularly in cases where an even greater degree of disciplinary integration is anticipated than achieved in this thesis. I suggest four areas that require attention. First, institution-level structures and incentives should be appraised in light of their compatibility with interdisciplinary project aims. Second, research funders should critically review whether budgets and funding periods are appropriate for interdisciplinary PhD and research projects, taking into account additional costs and time typically associated with interdisciplinary learning (e.g., course attendance, literature reading), professional network development (e.g., conference attendance in multiple fields), and communication (e.g., building shared understandings between parties). It should also be highlighted that interdisciplinary researchers often seek to capitalise on the strengths of two or more disciplines, if not maintain the fundamental standards of their respective fields within a project. This commitment can result in heightened expectations, rather than compromises, and can impact on the time needed to complete multiple phases of a research project (e.g., protocol development, conduct, analyses, writing up). Beyond institution and funder-level considerations, department-level variables and constraints (e.g., location, IT systems, scheduling) also require attention to maximise participation/representation from all disciplines and minimise administrative burdens. Finally, clear and ongoing communication between all relevant parties is imperative to ensure expectations are shared concerning project aims, methods and outputs.

6.10 Recommendations tailored for stakeholder groups

Throughout this thesis, I provide recommendations for various stakeholder groups based on the findings reported in Chapters 2-5. These are consolidated in Table 6.1 below, tailored to four key stakeholder groups: 1) school-based physical activity intervention researchers, 2) teacher professional development providers, 3) research funders, and 4) principals, teachers and other school practitioners.

Table 6.1. Recommendations tailored for stakeholder groups

Stakeholder group		Recommendations
1.	**School-based physical activity intervention researchers**	**1. Incorporate wider expertise:** Engage relevant experts and literature from diverse fields, where relevant, to inform the development and evaluation of individual intervention components, acknowledging the limitations associated with the scope of research within public health. **2. Describe all intervention components:** Use reporting checklists to describe each of the interventions delivered to various actors involved (e.g., teachers, parents, peers) **3. Use available tools:** Employ available tools (e.g., the Paper Authoring Tool) from the protocol stage to avoid inconsistent reporting within and across study outputs. **4. Evaluate real-world interventions:** Conduct more evaluations of 'real-world' interventions (e.g., national policies) to facilitate policy learning and improve understanding of large-scale real-world interventions. **5. Enhance data security:** Consider additional security measures when developing online surveys, drawing on recently published literature and methods concerning best practices to mitigate the risk of a bot infiltration. **6. Analyse subgroup findings:** Report on findings of observational and experimental studies by key subgroups where possible, including gender **7. School-level environmental and policy correlates:** Examine more environmental and policy correlates at the school level, including playgrounds and uniforms (e.g., shoes, skirts/dresses), exploring if and how specific features are associated with physical activity intensities across population subgroups
2.	**Teacher professional development providers for Physical Education and physical activity promotion**	This thesis finds some evidence suggesting that specific design features of teacher professional development programmes are associated with professional learning and change among participants enrolled in Physical Education and physical activity-related programmes. It is crucial to acknowledge that these findings are mostly based on a relatively small sample of research studies conducted in high-income countries (largely the US, Australia, and the UK), focused on primary school settings. It is unknown whether these design elements can uniformly promote professional development and change in all contexts and among all teachers. Additionally, the extent to which these findings can be extrapolated to different professional development providers is uncertain. In light of these key considerations, this thesis finds evidence that:

1. Programme/activities that support four key functions are linked to more impactful professional development outcomes. These four functions are:
    a. Knowledge acquisition,
    b. Skill mastery,
    c. Motivation toward goal achievement, and
    d. Implementation of acquired knowledge into practice.

2. Certain features may effectively support these four functions. Examples of features that may promote these functions are detailed in the table below

a. **Knowledge acquisition**	**b.** **Skill mastery**	**c.** **Goal-oriented motivation**	**d.** **Promote knowledge implementation**
Focus on one well-defined area of teaching practice	Give explicit instructions on how to use a certain teaching technique	Include information sources credible to teachers in favour/against a technique (e.g., expert teacher, book/ research paper)	Provide resources/objects that cue implementation
Use language and images to communicate key information	Show examples of how to perform the technique (e.g., video/live demonstration)	Offer positive feedback on implementation progress	Provide methods/ materials to help teachers observe and track their implementation progress (e.g., reflective journal)
Return to key ideas multiple times within a session	Provide teachers with rehearsal opportunities	Develop clear professional development objectives with teachers	Support teachers' self-monitoring of implementation
Revisit key ideas within/across sessions	Give feedback to teachers on their practice rehearsal		Facilitate multiple rehearsal opportunities in realistic settings (e.g., teachers' own classroom)
Include tasks that require teachers to draw on their past learning	Arrange practical support to facilitate implementation		

3.	**Research funders supporting school-based physical activity research**	**1. Broaden evaluation criteria:** Encourage research grant applicants to include intervention measures that enable intervention learning, moving beyond the dominant focus on student outcomes (e.g., daily minutes of MVPA). **2. Interdisciplinary research support**: Consider the unique challenges and likely additional resource requirements associated with interdisciplinary research. Ensure related funding covers any additional costs, such as participation in conferences across multiple fields. **3. Incentivise guideline use**: Provide incentives for researchers to adhere to and complete reporting guidelines when submitting their manuscripts to journals. This would promote greater transparency and consistency in research reporting. **4. Support journals to review their submission guidelines**: Consider encouraging academic journals to review and update their reporting guidelines. This can improve the quality and transparency of research publications. **5. Fund real-world interventions**: Support more research focused on 'real-world' interventions or 'natural experiments', such as the PE Premium policy. These interventions can provide valuable insights into barriers and facilitators to implementation, but are often poorly evaluated.
4.	**Principals, teachers, and other school practitioners**	Regular physical activity is important for all young people aged 5-18 years as it helps them to meet their multiple physical, mental and well-being needs. Unfortunately, research studies show that many young people worldwide are not doing enough physical activity. Schools are frequently involved in intervention efforts aimed at encouraging children and adolescents to move more and sit less, within and beyond the school day. To this end, this thesis investigates if teacher professional development programmes, playground infrastructure usage and school uniform policies are linked to students' physical activity. The findings may be valuable for some principals, teachers and other school practitioners making decisions about student physical activity behaviour and school-based interventions. Before summarising these findings, it is important to note that the evidence reported in this thesis is heavily based on a relatively small sample of mostly primary school teachers and students participating in research studies in high-income countries (largely the US, Australia, and the UK). It is unknown if these findings can be generalised to all contexts, populations and ages. In one study of my studies I examine evidence about associations between school uniform policies in 135 countries and population-level student physical activity data. However, even then, what is observed at a group level does not always represent every individual in that group. Hence, the generalisability of thesis findings to all schools, teachers and students is cautioned. Finally, most of the studies report on correlations between variables, making it challenging to determine if the variables examined (teacher professional development, playground infrastructure usage, school uniforms) directly contribute to student physical activity behaviour. In light of these considerations, the findings suggest: **1. The design of teacher professional development programmes/activities** related to Physical Education and physical activity promotion initiatives (e.g., brain breaks, active lessons) may be

		linked to teacher and student outcomes. Specific features found to be associated with more impactful outcomes are professional development programmes/activities that: • Provide teachers with a clear demonstration of the activity. • Provide opportunities for teachers to practise or rehearse the activity. Give teachers clear feedback on their practice during training. • Support teachers in setting clear CPD objectives. • Allocate time for teachers to plan how and when they will implement the new activity into their practice. • Provide teachers with resources (like sports equipment or signage) that they can then see in their classrooms to prompt implementation of the new activity into the school day. **2. Encouraging daily use of a playing field during break times, where available,** may promote increased physical activity and cardio-respiratory fitness among primary school students. As use frequency may differ between student groups, schools may wish to engage students and staff in identifying and addressing barriers and facilitators to playing field use throughout the school year. **3. Teacher-organised games available to students during break times** should be considered from an inclusivity perspective, ensuring that all primary school students feel encouraged to actively participate. Schools may consider engaging relevant staff and a diverse group of students in discussion to ensure games, policies, and practices both promote inclusion and are feasible for school staff to implement. **4**. **The role of school uniforms** should be considered by schools wishing to adopt a whole-of-school approach to physical activity promotion. The thesis presents evidence indicating that school uniforms are associated with lower weekly levels of student physical activity and increased gender inequalities in physical activity in primary school settings. Schools could assess their distinct uniform characteristics (e.g., garment design, footwear) that might either enable or restrict students' physical activity, considering any potential gender differences.

6.11 Future directions

The thesis also highlights several implications for future research and policy to consider in relation to young people's physical activity. In Chapters 2-5, I outlined future directions identified from individual studies. Cross-cutting future directions for researchers and policy actors to consider are outlined below.

6.11.1 Future directions for research

1. Evidence-based, scalable teacher-targeted programmes that tend to school-specific needs

The findings presented in Chapters 2 and 3 underscore the importance of incorporating evidence-based features into teacher-targeted programmes to promote professional learning and change.

Researchers should also proactively consider scalability when designing such programmes, learning from past experiences in Educational research. Historically, effective research-developed programmes "offered by university faculty or nationally recognised providers" failed to reach large numbers of teachers. This approach largely resulted in the development of "'boutiques', serving [only] a handful of fortunate teachers while leaving many more to shop at the Wal-Marts of the professional development world".[382] Hence, researchers should consider early on how evidence-based professional development initiatives can be effectively scaled while preserving their essential components from "lethal mutations".[383] Finally, in keeping with recent developments in the field relating to context-driven approaches, programmes should avoid a one-size fits all approach and consider how programmes will meet the needs of specific teacher and student populations they aim to serve.

A promising model that fulfils these considerations is 'Quality Teaching Rounds'.[384] This approach establishes professional learning communities within schools where teachers engage in discussions around evidence-based indicators of quality teaching, focusing on pedagogical qualities rather than specific practices. These communities then conduct rounds of classroom observations, coding lessons for identified quality teaching indicators. Feedback is exchanged constructively between colleagues who have context-specific knowledge of students in that school.[384] While Quality Teaching Rounds has shown significant positive effects on students' standardised test scores in mathematics,[95] it has yet to be tested in the context of Physical Education or physical activity promotion. Researchers could explore evaluating a similar approach within physical activity interventions, examining its effects on teacher and student outcomes.

2. Setting and population-specific considerations in observational and experimental research

The findings presented in Chapters 4 and 5 underscore the importance of using relevant theory to guide observational studies exploring context-specific correlates of young people's physical activity. To ensure the development of targeted interventions, researchers should report associations based on key priority subgroups, including gender. Neglecting to consider setting and population-specific correlates could lead to the development of ineffective interventions and perpetuate or exacerbate inequalities in physical activity and cardiorespiratory fitness. Establishing more interdisciplinary collaborations could also advance research progress in this area. Public Health and Educational researchers may benefit from working with experts in architecture and textile materials to investigate the relationships identified between school playground infrastructure use, school uniforms, and student physical activity. These partnerships may provide valuable insights and innovative solutions for promoting physical activity in specific settings and among different populations.

6.11.2 Future directions for policy

1. Global surveillance of young people's physical activity

Physical activity surveillance studies are needed to determine the health status of young people. The WHO recommends governments worldwide monitor population levels of physical activity in order to assess guideline compliance.[43] The findings from the uniform study indicate that countries with middle and low-income classifications remain underrepresented in the surveillance literature. These findings are also supported by the WHO's recent global report, which found that surveillance data is more regularly published by high-income and upper-middle-income countries (89% and 90%), than lower-middle and low-income countries (67% and 32% respectively).[28] While physical inactivity among young people is observed in countries across all income levels, the greatest burden of disease associated with physical inactivity is currently felt in middle-income countries, largely due to the size of their populations.[334] Projection studies also indicate that an even larger proportion of young people worldwide will soon be based in middle and low-income countries. For example, by 2050, it is estimated that approximately 40% of the global child and adolescent population will be based in Africa alone.[335] Consequently, these populations warrant increased surveillance to ensure global intervention efforts are proportionate. These countries should be provided with increased support to conduct high-quality surveillance studies (e.g., using survey measures that have demonstrated reliability and validity after translation into local languages).[19]

2. Greater evaluation efforts to facilitate policy learning

Despite the substantial financial investments into nationwide interventions targeting physical activity, government policies are typically poorly evaluated.[385,386] A notable example of this is the PE Premium policy, which has resulted in Physical Education receiving the highest funding among all subjects in the primary school curriculum in England, considerably surpassing subjects such as mathematics (£2.2 billion vs £52 million total investment over 10 years).[387] This policy has not been subject to any high-quality evaluation since it was first introduced in 2012. The scope of this issue extends beyond school-based policies; a review found that only 8% of the £432 billion spent on major UK government policies in 2019 included a plan for a rigorous impact evaluation.[385]

Concerted efforts are needed to evaluate the implementation and effectiveness of all physical activity policies, particularly among key priority groups shown to be the least active (e.g., girls, adolescents, and individuals with a lower socio-economic position). More regular and rigorous policy evaluations could be conducted by embedding more researchers in government, or by providing more funding to researchers to conduct independent evaluations of existing policies. These approaches would enable policy actors to capitalise on existing expertise, and facilitate researchers in conducting more real-world intervention evaluations. All policy evaluations should have explicit commitments to and plans for how the findings will be integrated into future policies.

6.12 Conclusion

This thesis examined teacher-targeted programmes aimed at supporting the delivery of school-based physical activity interventions. It also examined if features of school playgrounds and uniforms are associated with student physical activity and cardio-respiratory fitness. My findings indicate that teachers responsible for implementing physical activity interventions are frequently provided with training and professional development programmes that are unlikely to change their behaviour. I conclude that greater emphasis should be placed on integrating more evidence-based design features into these programmes to support implementation. My findings also suggest that student use of playground infrastructure and school uniforms are associated with student physical activity and that some of these associations differ by gender. Researchers should therefore consider and report on gender-specific correlates and determinants of physical activity to support the development of gender-equitable interventions. The literature and studies presented in this thesis can contribute to the interpretation and development of existing and future interventions.

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Appendices

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Appendix A: Supplementary material for Chapter 2

Appendix 2.1. PRISMA checklist

Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist

Section and Topic	Item #	Checklist item	Location	
TITLE			Page(s)	Appendix
Title	1	Identify the report as a systematic review.	21	
ABSTRACT				
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	n/a	
INTRODUCTION				
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	22-23	
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	22-23	
METHODS				
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	24	(Table 2.2)
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	24	
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.		2.3
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	25-26	
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	26	
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g., for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	25-26	
	10b	List and define all other variables for which data were sought (e.g., participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	25-26	
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of	27	

Section and Topic	Item #	Checklist item	Location	
		automation tools used in the process.		
Effect measures	12	Specify for each outcome the effect measure(s) (e.g., risk ratio, mean difference) used in the synthesis or presentation of results.	28	
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g., tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	28	
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	28	Appendix 2.6
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	28	
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	28	
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g., subgroup analysis, meta-regression).	28	
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	28	
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	n/a	
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	28	
RESULTS				
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	29	(Figure 2.1)
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.		Appendix 2.7
Study characteristics	17	Cite each included study and present its characteristics.		Appendix 2.8
Risk of bias in studies	18	Present assessments of risk of bias for each included study.		Appendices 2.9 & 2.10
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g., confidence/credible interval), ideally using structured tables or plots.		Appendices 2.11 & 2.12
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	32-34	
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g., confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	32-34	
	20c	Present results of all investigations of possible causes	32-34	

Section and Topic	Item #	Checklist item	Location	
		of heterogeneity among study results.		
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	32-34	
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	32-34	
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	32-34	
DISCUSSION				
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	35-36	
	23b	Discuss any limitations of the evidence included in the review.	37	
	23c	Discuss any limitations of the review processes used.	36-37	
	23d	Discuss implications of the results for practice, policy, and future research.	37	
OTHER INFORMATION				
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	24	
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	24	Appendix 2.2
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	24	Appendix 2.2
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	iv	
Competing interests	26	Declare any competing interests of review authors.	Included in online publication	
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	Included in online publication	

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71For more information, visit: http://www.prisma-statement.org/

Appendix 2.2. PROSPERO form

A systematic review of staff training in school-based interventions targeting student physical activity behaviour

Citation

Mairead Ryan, Olivia Alliott, Riikka Hofmann, Esther van Sluijs. A systematic review of staff training in school-based interventions targeting student physical activity behaviour. PROSPERO 2020 CRD42020180624 Available from: https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42020180624

Review question

1. What behaviour change techniques (BCTs) have been used in school staff training programmes to change student physical activity behaviour?

2. Is there an association between staff training characteristics and intervention fidelity?

3. Is there an effect of staff training characteristics on student physical activity behaviour?

Searches [1 change]

The following databases will be searched: MEDLINE (via Ovid), ERIC, Applied Social Sciences Index & Abstracts (ASSIA), EMBASE (via Ovid), Scopus, Web of Science, SPORTDiscus

The reference lists of all included studies will be screened and forward citation tracking will be conducted using Scopus. Searches will be re-run prior to the final analysis. Searches will be limited to records published from 1st January 2015. No language or geographic limitations will be applied.

Types of study to be included

Any experimental design will be included but studies must report on outcomes that were measured any time period after the intervention was first introduced.

Condition or domain being studied

School-based physical activity promotion.

Participants/population

Inclusion: School staff participating in interventions aimed at changing student physical activity behaviour. More specifically, any members of school staff, including teachers, teaching assistants, head teachers, principals etc., who are responsible for delivering or overseeing the implementation of an intervention during school hours, the aim of which is to change student physical activity behaviour.

Exclusion: School staff participating in interventions mostly aimed at special student populations (e.g. students with special needs).

Intervention(s), exposure(s)

Any school staff training or professional development of any length, aiming to change staff practice, the broader aim of which is to change student physical activity behaviour

Comparator(s)/control

Any control will be included

Context

Interventions targeting staff practice in primary or secondary schools in all geographic locations. Staff training may occur in any context (i.e. it does not need to be delivered on a school premises or in person).

Main outcome(s) [1 change]

For all outcomes, data reported at the time point closest to the end of the intervention will be used.

i) Staff fidelity, defined as the extent to which an intervention is delivered by school staff as intended. Staff fidelity may be measured any time period after staff training is first delivered.

) Student physical activity behaviour, defined as any activity behaviour across the intensity spectrum, including sedentary behaviour. Only device-based measures of physical activity behaviour (e.g. accelerometer) will be considered. Student physical activity behaviour may be measured within and/or outside of school hours. Studies must report both baseline and follow-up measures.

Measures of effect

i) Fidelity: all measures of staff fidelity will be considered, including self-reported data (e.g. a lesson diary).

i) Student physical activity behaviour: the mean change score from baseline to the latest available follow-up will be calculated to determine the effect of the intervention on students' physical activity behaviour.

Additional outcome(s)

None.

Measures of effect

Not applicable.

Data extraction (selection and coding) [1 change]

Search results will be imported into EndNote for deduplication. Records will then be imported into Covidence for screening and recording decisions. Titles, abstracts, and full texts of records will be screened independently by two reviewers. Discussion with a third member of the review team will be sought if consensus cannot be reached. Eligibility for inclusion will be based on studies rather than records. If eligibility cannot be determined for a given record after full text screening, searches will be conducted for other records reporting on the study. For studies to be eligible, we must be able to obtain sufficient detail of staff training for at least one BCT to be identified. Studies must also report on the impact on i) staff fidelity and/or ii) student physical activity behaviour.

All records of the same study will be pooled for data extraction. Data extraction will be conducted by one reviewer using a pre-piloted form on MS Excel. A second reviewer will check for consistency.

Extracted information will include:

Study name and associated records retrieved

Study details (design, intervention description, duration, student characteristics, school setting etc.)

Staff training details based on the TiDieR checklist (Hoffmann et al., 2014)

Fidelity: how and by whom fidelity was assessed, including details of assessment tool, time points measured, and reported outcomes

Student physical activity behaviour: details of device used, monitoring protocol, cut points, baseline and follow up N, mean & SD

Any other study notes/comments

Following data extraction, the first and last author of the main trial paper will be contacted to obtain missing information and/or additional study records on staff training. Authors will be given three weeks to respond with a reminder email.

All staff training content will be independently coded by two members of the review team for BCTs using the BCT Taxonomy v1. Disagreements will be resolved through discussion.

Risk of bias (quality) assessment [1 change]

Risk-of-bias assessment will be conducted independently by two reviewers. Discussion with a third member of the review team will be sought if consensus cannot be reached. Judgements will be made at the outcome level and study design-specific tools will be used. Findings will be incorporated into summary of findings tables and used to interpret the estimated effect, either qualitatively or quantitatively if the data allow (i.e. to perform sensitivity analyses).

The revised Cochrane Risk-of-Bias 2 (RoB) tool will be used to judge risk-of-bias in randomised controlled studies. The RoB 2 tool assesses the following domains: bias arising from the randomisation process, deviations from the intended interventions, missing outcome data, measurement of the outcome and selection of the reported result. The possible risk-of-bias judgements are low, high or some concerns.

The ROBINS-I scale will be used to judge risk-of-bias in non-randomised studies. The ROBINS-I tool assesses the following domains: bias due to confounding, selection of participants into the study, classification of interventions, deviations from intended interventions, missing data, measurement of outcomes, and selection of the reported result. The possible risk-of-bias judgements are low, moderate, serious or critical risk-of-bias. Reviewers may also report NI if insufficient information is available to make a judgement.

Strategy for data synthesis [1 change]

The search results will be described and a PRISMA flowchart of studies included at each stage of screening will be presented. A brief description of study (e.g. study type, country, and setting) and training characteristics (e.g. duration, mode of delivery) of included studies will be provided. A description of BCTs used will be outlined (e.g. number, type, range). Cohen's kappa will be reported to establish inter-coder reliability of BCTs present and absent.

i) We anticipate considerable methodological and/or conceptual heterogeneity for fidelity measures. Hence we expect that studies will not be appropriately or meaningfully similar to allow for meta-analysis. Thus, we expect to provide a narrative synthesis of the data outlining the association between staff training characteristics and intervention fidelity. Methods for synthesis will be reported in accordance with Synthesis Without Meta-analysis (SWiM) guidelines. Differences between studies reporting high and low staff fidelity in terms of BCTs, and other training characteristics, will be described.

ii) We propose a meta-analysis for physical activity outcomes. Mean change scores from baseline to follow-up will be calculated for all device-measured physical activity behaviours of students. Pooled standard deviation changes in device-measured activity behaviour will be used and the standardised mean difference will be calculated using Hedges' (adjusted) g. Associations between BCTs (those identified in at least two studies) and standardised mean differences will be investigated using univariate meta-regression analyses if a sufficient number of studies are identified (minimum of 10 required as per current guidelines). Additional analysis investigating the effect of other training characteristics (e.g. duration/length) will be conducted if the data allow. Statistical heterogeneity will be assessed using forest plots and quantified using χ^2 and I^2 statistics. Publication bias will be assessed by visual inspection of funnel plots and Egger's test.

Analysis of subgroups or subsets

Provided there are sufficient data, subgroup analyses will also be considered for intervention characteristics (e.g. physical activity behaviour targeted, intervention length), participant characteristics (e.g. job title, years of teaching) and school context (e.g. education phase, school context).

Contact details for further information

Mairead Ryan

[*Email address redacted]

Organisational affiliation of the review

University of Cambridge

http://www.mrc-epid.cam.ac.uk/

Review team members and their organisational affiliations

Ms Mairead Ryan. University of Cambridge

Ms Olivia Alliott. University of Cambridge

Dr Riikka Hofmann. University of Cambridge

Dr Esther van Sluijs. University of Cambridge

Type and method of review [1 change]

Intervention, Meta-analysis, Narrative synthesis, Systematic review

Anticipated or actual start date [1 change]

01 May 2020

Anticipated completion date

01 December 2020

Funding sources/sponsors [1 change]

MR is funded by an ESRC Doctoral Training Partnership award (ES/P000738/1).

OA is funded by an NIHR School of Public Health Research studentship (SJAI/126 RG88936).

RH holds a Senior Lecturer post funded by the University of Cambridge.
EvS is supported by the Medical Research Council (MC_UU_12015/7).

Conflicts of interest

Language

English

Country

England

Stage of review

Review Ongoing

Subject index terms status

Subject indexing assigned by CRD

Subject index terms

Exercise; Humans; Motor Activity; Schools; Students

Date of registration in PROSPERO

05 May 2020

Date of first submission

17 April 2020

Details of any existing review of the same topic by the same authors [1 change]

Stage of review at time of this submission

Stage	Started	Completed
Preliminary searches	Yes	No
Piloting of the study selection process	Yes	No
Formal screening of search results against eligibility criteria	No	No
Data extraction	No	No
Risk of bias (quality) assessment	No	No
Data analysis	No	No

The record owner confirms that the information they have supplied for this submission is accurate and complete and they understand that deliberate provision of inaccurate information or omission of data may be construed as scientific misconduct.

The record owner confirms that they will update the status of the review when it is completed and will add publication details in due course.

Versions

05 May 2020

Appendix 2.3. Search terms and records identified

Database	Number of identified records
MEDLINE (via Ovid)	7,172
EMBASE (via Ovid)	10,909
Applied Social Sciences Index and Abstracts (ASSIA)	573
Scopus	3,633
Education Resources Information Center (ERIC)	3,043
Web of Science Core Collection	22,361
SPORTDiscus	2,471
Total	**50,162**

All searches were performed on May 15th 2020.

Search terms and records identified (MEDLINE (via Ovid))

Search	**MEDLINE** Terms	Records
1.	(child* or boy* or girl* or kid* or mid-adolescen* or adolescen* or youth* or (young adj (people or person)) or teen* or juvenile or student* or school* or pupil*).ti,ab.	2,506,455
2.	child/	1,673,861
3.	adolescent/	2,009,709
4.	students/	57,723
5.	1 or 2 or 3 or 4	4,164,657
6.	("physical* adj activ*" or sport* or cycle or cycling or bicycling or bicycle* or walk* or "physical education" or "physical training" or exercis* or (energy adj expenditure) or danc* or inactiv* or "physical fitness" or lifestyle or "active lesson*" or "aerobic fitness" or sedentar* or sit*).ti,ab.	3,135,158
7.	motor activity/	96,231
8.	sports/	30,073
9.	exercise/	107,801
10.	sedentary behavior/	9,091
11.	physical exertion/	56,223
12.	"physical education and training"/	13,414
13.	6 or 7 or 8 or 9 or 10 or 11 or 12	3,265,709
14.	("control* trial" or randomi* or randomly or trial* or evaluation or effect* or control* or cluster or intervention or pilot or feasibility or prospective* or observation* or longitudinal or follow-up* or followup* or (follow* adj up*) or cohort* or "process evaluation").ti,ab.	11,948,838
15.	randomized controlled trial/	505,469
16.	longitudinal studies/	133,769

Search	**MEDLINE** Terms	Records
17.	prospective studies/	537,453
18.	follow-up studies/	639,934
19.	cohort studies/	260,552
20.	14 or 15 or 16 or 17 or 18 or 19	12,250,964
21.	("case study" or "case report" or "abstract report" or letter).ti,ab.	458,585
22.	letter/	1,076,957
23.	historical article/	358,050
24.	case report/	2,096,342
25.	22 or 23 or 24	3,310,529
26.	20 not 25	11,696,728
27.	(acceleromet* or accelerometer-assessed or "counts per minute" or CPM or actigraph* or "heart rate" or pedomet* or "objective* measur*" or "device measur*" or "activity monitor" or MVPA or LIPA or ((process or program*) adj (evaluation* or monitoring)) or (qualitative adj (component* or aspect* or approach*)) or participant observation* or fidelity or adher* or monitor* or implement* or integrat* or adopt* or uptake or dosage or reach or dose or quality or sustainabil* or implement*).ti,ab.	4,444,538
28.	monitoring, ambulatory/	8,061
29.	actigraphy/	3,563
30.	Implementation Science/	335
31.	Process Assessment, Health Care/	4,625
32.	Program Evaluation/	62,399
33.	"Outcome and Process Assessment, Health Care"/	26,867
34.	27 or 28 or 29 or 30 or 31 or 32 or 33	4,496,078
35.	(school* or educat* or teach* or academi*).ti,ab.	994,685
36.	5 and 13 and 26 and 34 and 35	17,472
37.	limit 36 to yr="2015 -Current"	7,172

Search terms and records identified (EMBASE via Ovid)

Search	**EMBASE** Terms	**Records**
1.	(child* or boy* or girl* or kid* or mid-adolescen* or adolescen* or youth* or (young adj (people or person)) or teen* or juvenile or student* or school* or pupil*).ti,ab.	2,527,454
2.	child/	1,296,375
3.	adolescent/	1,158,670
4.	student/	101,733
5.	1 or 2 or 3 or 4	3,304,599

Search	EMBASE Terms	Records
6.	("physical* adj activ*" or sport* or cycle or cycling or bicycling or bicycle* or walk* or "physical education" or "physical training" or exercis* or (energy adj expenditure) or danc* or inactiv* or "physical fitness" or lifestyle or "active lesson*" or "aerobic fitness" or sedentar* or sit*).ti,ab.	3,193,475
7.	motor activity/	33,461
8.	sport/	40,511
9.	exercise/	226,290
10.	sedentary lifestyle/	13,782
11.	physical education/	8,268
12.	6 or 7 or 8 or 9 or 10 or 11	3,277,327
13.	("control* trial" or randomi* or randomly or trial* or evaluation or effect* or control* or cluster or intervention or pilot or feasibility or prospective* or observation* or longitudinal or follow-up* or followup* or (follow* adj up*) or cohort* or "process evaluation").ti,ab.	12,554,961
14.	randomized controlled trial/	556,538
15.	longitudinal study/	132,011
16.	prospective study/	577,754
17.	follow up/	1,463,848
18.	cohort analysis/	568,195
19.	13 or 14 or 15 or 16 or 17 or 18	12,860,162
20.	("case study" or "case report" or "abstract report" or letter).ti,ab.	484,817
21.	letter/	783,910
22.	20 or 21	1,231,470
23.	19 not 22	12,558,623
24.	(acceleromet* or accelerometer-assessed or "counts per minute" or CPM or actigraph* or "heart rate" or pedomet* or "objective* measur*" or "device measur*" or "activity monitor" or MVPA or LIPA or ((process or program*) adj (evaluation* or monitoring)) or (qualitative adj (component* or aspect* or approach*)) or participant observation* or fidelity or adher* or monitor* or implement* or integrat* or adopt* or uptake or dosage or reach or dose or quality or sustainabil* or implement*).ti,ab.	5,068,065
25.	ambulatory monitoring/	9,149
26.	actimetry/	8,920
27.	implementation science/	974
28.	program evaluation/	14,508
29.	24 or 25 or 26 or 27 or 28	5,076,977
30.	(school* or educat* or teach* or academi*).ti,ab.	1,148,009
31.	5 and 12 and 23 and 29 and 30	23,441
32.	limit 31 to yr="2015 -Current"	10,909

Search terms and records identified (Applied Social Sciences Index and Abstracts (ASSIA))

Search	**ASSIA** Terms	Records
1.	((ab((child* OR boy* OR girl* OR kids OR mid-adolescen* OR adolescen* OR youth* OR (young adj (people OR person)) OR teen* OR juvenile OR student* OR school* OR pupil*)) OR ti((child* OR boy* OR girl* OR kids OR mid-adolescen* OR adolescen* OR youth* OR (young adj (people OR person)) OR teen* OR juvenile OR student* OR school* OR pupil*))) OR MAINSUBJECT.EXACT("Children") OR MAINSUBJECT.EXACT("Adolescents") OR MAINSUBJECT.EXACT("Students"))	356,444*
	AND	
2.	((ab(("physical* adj activ*" or sport* or cycle or cycling or bicycling or bicycle* or walk* or "physical education" or "physical training" or exercis* or (energy adj expenditure) or danc* or inactiv* or "physical fitness" or lifestyle or "active lesson*" or "aerobic fitness" or sedentar* or sit*)) OR ti(("physical* adj activ*" or sport* or cycle or cycling or bicycling or bicycle* or walk* or "physical education" or "physical training" or exercis* or (energy adj expenditure) or danc* or inactiv* or "physical fitness" or lifestyle or "active lesson*" or "aerobic fitness" or sedentar* or sit*))) OR MAINSUBJECT.EXACT("Motor activity") OR MAINSUBJECT.EXACT("Sports") OR MAINSUBJECT.EXACT("Exercise") OR MAINSUBJECT.EXACT("Sedentary") OR MAINSUBJECT.EXACT("Sedentary people") OR MAINSUBJECT.EXACT("Physical education"))	70,805*
	AND	
3.	((ab(("control* trial" or randomi* or randomly or trial* or evaluation or effect* or control* or cluster or intervention or pilot or feasibility or prospective* or observation* or longitudinal or follow-up* or followup* or (follow* adj up*) or cohort* or "process evaluation")) OR ti(("control* trial" or randomi* or randomly or trial* or evaluation or effect* or control* or cluster or intervention or pilot or feasibility or prospective* or observation* or longitudinal or follow-up* or followup* or (follow* adj up*) or cohort* or "process evaluation"))) OR MAINSUBJECT.EXACT("Randomized controlled trials") OR MAINSUBJECT.EXACT("Clinical trials") OR MAINSUBJECT.EXACT("Longitudinal studies") OR MAINSUBJECT.EXACT("Prospective studies") OR MAINSUBJECT.EXACT("Followup studies") OR MAINSUBJECT.EXACT("Cohort analysis") OR MAINSUBJECT.EXACT("Clinical trials"))	511,361*
4.	((ab(("case study" OR "case report" OR "abstract report" OR letter)) OR ti(("case study" OR "case report" OR "abstract report" OR letter)) OR MAINSUBJECT.EXACT("Letters") OR MAINSUBJECT.EXACT("Case records")))	27,449*
5.	S3 NOT S4	500,883*

Search	**ASSIA** Terms	Records
6.	((ab((acceleromet* or accelerometer-assessed or "counts per minute" or CPM or actigraph* or "heart rate" or pedomet* or "objective* measur*" or "device measur*" or "activity monitor" or MVPA or LIPA or ((process or program*) adj (evaluation* or monitoring)) or (qualitative adj (component* aspect* or approach*)) or participant observation* or fidelity or adher* or monitor* or implement* or integrat* or adopt* or uptake or dosage or reach or dose or quality or sustainabil* or implement*)) OR ti((acceleromet* or accelerometer-assessed or "counts per minute" or CPM or actigraph* or "heart rate" or pedomet* or "objective* measur*" or "device measur*" or "activity monitor" or MVPA or LIPA or ((process or program*) adj (evaluation* or monitoring)) or (qualitative adj (component* or aspect* or approach*)) or participant observation* or fidelity or adher* or monitor* or implement* or integrat* or adopt* or uptake or dosage or reach or dose or quality or sustainabil* or implement*)) OR MAINSUBJECT.EXACT("monitoring") OR MAINSUBJECT.EXACT("actigraphy")))	241,298*
7.	ti(school* OR educat* OR teach* OR academi*) OR ab(school* OR educat* OR teach* OR academi*)	218,018*
8.	S1 AND S2 AND S5 AND S6 AND S7	2,015°
9.	S1 AND S2 AND S5 AND S6 AND S7 Limits applied	**573**

Search terms and records identified (Scopus)

Search	**Scopus** Terms	Records
1.	(TITLE-ABS (child* OR boy* OR girl* OR kids OR mid-adolescen* OR adolescen* OR youth* OR (young W/1 (people OR person)) OR teen* OR juvenile OR student* OR school* OR pupil*))	
2.	(TITLE-ABS ("physical* W/1 activ*" or sport* or cycle or cycling or bicycling or bicycle* or walk* or "physical education" or "physical training" or exercis* or (energy W/1 expenditure) or danc* or inactiv* or "physical fitness" or lifestyle or "active lesson*" or "aerobic fitness" or sedentar* or sit*))	
3.	(TITLE-ABS ("control* trial" or randomi* or randomly or trial* or evaluation or effect* or control* or cluster or intervention or pilot or feasibility or prospective* or observation* or longitudinal or follow-up* or followup* or (follow* W/1 up*) or cohort* or "process evaluation")) AND NOT (TITLE-ABS ("case study" OR "case report" OR "abstract report" OR letter))	
4.	(TITLE-ABS (acceleromet* OR accelerometer-assessed OR "counts per minute" OR cpm OR actigraph* OR "heart rate" OR pedomet* OR "objective* measur*" OR "device measur*" OR "activity monitor" OR mvpa OR lipa OR ((process OR program*) W/1 (evaluation* OR monitoring)) OR (qualitative W/1 (component* OR aspect* OR approach*)) OR participant AND observation* OR fidelity OR adher* OR monitor* OR implement* OR integrat* OR adopt* OR uptake OR dosage OR reach OR dose OR quality OR sustainabil* OR implement*))	
5.	(TITLE-ABS (school* or educat* or teach* or academi*))	

Search	**Scopus** Terms	Records
6.	#1 AND #2 AND #3 AND #4 AND #5 ()	
7.	#1 AND #2 AND #3 AND #4 AND #5 Limits applied	**3,633**

Search terms and records identified (Education Resources Information Center (ERIC))

Search	**ERIC** Terms	Records
1.	TI ((child* or boy* or girl* or kids or mid-adolescen* or adolescen* or youth* or (young adj (people or person)) or teen* or juvenile or student* or school* or pupil*)) OR AB ((child* or boy* or girl* or kids or mid-adolescen* or adolescen* or youth* or (young adj (people or person)) or teen* or juvenile or student* or school* or pupil*))	1,132,011
2.	DE "Children"	46,245
3.	DE "Adolescents"	50,656
4.	DE "Students"	4,948
5.	S1 OR S2 OR S3 OR S4	1,137,336
6.	TI (("physical* adj activ*" or sport* or cycle or cycling or bicycling or bicycle* or walk* or "physical education" or "physical training" or exercis* or (energy adj expenditure) or danc* or inactiv* or "physical fitness" or lifestyle or "active lesson*" or "aerobic fitness" or sedentar* or sit*)) OR AB (("physical* adj activ*" or sport* or cycle or cycling or bicycling or bicycle* or walk* or "physical education" or "physical training" or exercis* or (energy adj expenditure) or danc* or inactiv* or "physical fitness" or lifestyle or "active lesson*" or "aerobic fitness" or sedentar* or sit*))	172,311
7.	DE "Exercise"	2,367
8.	DE "Physical Fitness" OR DE "Health Related Fitness"	4,239
9.	DE "Physical Education" OR DE "Adapted Physical Education" OR DE "Movement Education"	13,253
10.	S6 OR S7 OR S8 OR S9	175,863
11.	TI (("control* trial" or randomi* or randomly or trial* or evaluation or effect* or control* or cluster or intervention or pilot or feasibility or prospective* or observation* or longitudinal or follow-up* or followup* or (follow* adj up*) or cohort* or "process evaluation")) OR AB (("control* trial" or randomi* or randomly or trial* or evaluation or effect* or control* or cluster or intervention or pilot or feasibility or prospective* or observation* or longitudinal or follow-up* or followup* or (follow* adj up*) or cohort* or "process evaluation"))	639,818
12.	DE "Randomized Controlled Trials"	1,527
13.	DE "Longitudinal Studies" OR DE "Followup Studies"	31,439
14.	S11 OR S12 OR S13	645,136

Search	**ERIC** Terms	Records
15.	TI (("case study" or "case report" or "abstract report" or letter)) OR AB (("case study" or "case report" or "abstract report" or letter))	66,091
16.	DE "Letters (Correspondence)"	1,680
17.	S15 OR S16	66,500
18.	S14 NOT S17	614,912
19.	TI ((acceleromet* or accelerometer-assessed or "counts per minute" or CPM or actigraph* or "heart rate" or pedomet* or "objective* measur*" or "device measur*" or "activity monitor" or MVPA or LIPA or ((process or program*) adj (evaluation* or monitoring)) or (qualitative adj (component* or aspect* or approach*)) or participant observation* or fidelity or adher* or monitor* or implement* or integrat* or adopt* or uptake or dosage or reach or dose or quality or sustainabil* or implement*)) OR AB ((acceleromet* or accelerometer-assessed or "counts per minute" or CPM or actigraph* or "heart rate" or pedomet* or "objective* measur*" or "device measur*" or "activity monitor" or MVPA or LIPA or ((process or program*) adj (evaluation* or monitoring)) or (qualitative adj (component* or aspect* or approach*)) or participant observation* or fidelity or adher* or monitor* or implement* or integrat* or adopt* or uptake or dosage or reach or dose or quality or sustainabil* or implement*))	368,716
20.	DE "Program Evaluation" OR DE "Program Implementation"	75,528
21.	S19 OR S20	406,269
22.	TI (school* or educat* or teach* or academi*) OR AB (school* or educat* or teach* or academi*)	1,153,012
23.	S5 AND S10 AND S18 AND S21 AND S22	**3,043**

Search terms and records identified (Web of Science)

Search	**Web of Science** Terms	Records
1.	TS=(child* or boy* or girl* or kids or mid-adolescen* or adolescen* or youth* or (young NEAR/1 (people or person)) or teen* or juvenile or student* or school* or pupil*)	
2.	TS=("physical* NEAR/1 activ*" or sport* or cycle or cycling or bicycling or bicycle* or walk* or "physical education" or "physical training" or exercis* or (energy NEAR/1 expenditure) or danc* or inactiv* or "physical fitness" or lifestyle or "active lesson*" or "aerobic fitness" or sedentar* or sit*)	
3.	TS=("control* trial" or randomi* or randomly or trial* or evaluation or effect* or control* or cluster or intervention or pilot or feasibility or prospective* or observation* or longitudinal or follow-up* or followup* or (follow* NEAR/1 up) or cohort* or "process evaluation")	
4.	TS=("case study" or "case report" or "abstract report" or letter)	
5.	#3 NOT #4	
6.	TS=(acceleromet* OR accelerometer-assessed OR "counts per minute" OR cpm OR actigraph* OR "heart rate" OR pedomet* OR "objective*	

Search	**Web of Science** Terms	Records
	measur*" OR "device measur*" OR "activity monitor" OR mvpa OR lipa OR ((process OR program*) NEAR/1 (evaluation* OR monitoring)) OR (qualitative NEAR/1 (component* OR aspect* OR approach*)) OR participant AND observation* OR fidelity OR adher* OR monitor* OR implement* OR integrat* OR adopt* OR uptake OR dosage OR reach OR dose OR quality OR sustainabil* OR implement*)	
7.	TS=(school* or educat* or teach* or academi*)	
8.	#1 AND #2 AND #5 AND #6 AND #7 (57,564)	
9.	#1 AND #2 AND #5 AND #6 AND #7 limits applied (); Web of Science Core Collection & 2015-2020	**22,361**

Search terms and records identified (SPORTDiscus)

Search	**SPORTDiscus** Terms	Records
1.	TI ((child* or boy* or girl* or kids or mid-adolescen* or adolescen* or youth* or (young adj (people or person)) or teen* or juvenile or student* or school* or pupil*)) OR AB ((child* or boy* or girl* or kids or mid-adolescen* or adolescen* or youth* or (young adj (people or person)) or teen* or juvenile or student* or school* or pupil*))	
2.	DE "CHILDREN" OR DE "SCHOOL children"	
3.	DE "TEENAGERS"	
4.	DE "STUDENTS"	
5.	S1 OR S2 OR S3 OR S4	
6.	TI (("physical* adj activ*" or sport* or cycle or cycling or bicycling or bicycle* or walk* or "physical education" or "physical training" or exercis* or (energy adj expenditure) or danc* or inactiv* or "physical fitness" or lifestyle or "active lesson*" or "aerobic fitness" or sedentar* or sit*)) OR AB (("physical* adj activ*" or sport* or cycle or cycling or bicycling or bicycle* or walk* or "physical education" or "physical training" or exercis* or (energy adj expenditure) or danc* or inactiv* or "physical fitness" or lifestyle or "active lesson*" or "aerobic fitness" or sedentar* or sit*))	
7.	DE "SPORTS"	
8.	DE "EXERCISE"	
9.	DE "SEDENTARY behavior"	
10.	DE "PHYSICAL fitness"	
11.	DE "PHYSICAL education"	
12.	S6 OR S7 OR S8 OR S9 OR S10 OR S11	
13.	TI (("control* trial" or randomi* or randomly or trial* or evaluation or effect* or control* or cluster or intervention or pilot or feasibility or prospective* or observation* or longitudinal or follow-up* or followup* or (follow* adj up*) or cohort* or "process evaluation")) OR AB (("control* trial" or randomi* or randomly or trial* or evaluation or effect* or control* or cluster or intervention or pilot or feasibility or prospective* or observation* or longitudinal or follow-up* or followup* or (follow* adj up*) or cohort* or "process evaluation"))	
14.	TI (("case study" or "case report" or "abstract report" or letter)) OR AB (("case study" or "case report" or "abstract report" or letter))	
15.	S13 NOT S14	

Search	**SPORTDiscus** Terms	Records
16.	TI ((acceleromet* or accelerometer-assessed or "counts per minute" or CPM or actigraph* or "heart rate" or pedomet* or "objective* measur*" or "device measur*" or "activity monitor" or MVPA or LIPA or ((process or program*) adj (evaluation* or monitoring)) or (qualitative adj (component* aspect* or approach*)) or participant observation* or fidelity or adher* or monitor* or implement* or integrat* or adopt* or uptake or dosage or reach or dose or quality or sustainabil* or implement*)) OR AB ((acceleromet* or accelerometer-assessed or "counts per minute" or CPM or actigraph* or "heart rate" or pedomet* or "objective* measur*" or "device measur*" or "activity monitor" or MVPA or LIPA or ((process or program*) adj (evaluation* or monitoring)) or (qualitative adj (component* or aspect* or approach*)) or participant observation* or fidelity or adher* or monitor* or implement* or integrat* or adopt* or uptake or dosage or reach or dose or quality or sustainabil* or implement*))	
17.	TI ((school* or educat* or teach* or academi*)) OR AB ((school* or educat* or teach* or academi*))	
18.	S5 AND S12 AND S15 AND S16 AND S17	5,810
19.	S5 AND S12 AND S15 AND S16 AND S17 Year limits applied	**2,471**

Appendix 2.4. Structured process to classify fidelity outcomes

Context:

To be eligible for inclusion, studies had to report either staff fidelity (any quantitative measure), or any pre-post device measured physical activity behaviour

Definitions:

Fidelity: "the extent to which the intervention is delivered[1] as intended".[148]

Issue:

I observed considerable methodological and conceptual heterogeneity for fidelity measures. Intervention evaluation authors either provided different definitions of fidelity, or definitions were not clearly stated. Perhaps as a result, we observed wide variation in measures of fidelity, the number of fidelity measures taken, the number of time points where fidelity measures were taken, and the level at which fidelity outcomes were measured (e.g., at school vs teacher level). To account for these differences, a systematised approach was employed to categorise fidelity outcomes reported into three groups: low, medium and high fidelity. This approach is outlined below.

Approach:

Measures that solely focus on teachers'/other school staff fidelity to the intervention were prioritised above summary scores that include other actors' roles in the intervention (e.g., how active children were in new PE programme). Where multiple fidelity outcomes were reported for feasibility, efficacy and effectiveness trials reported within a paper, the effectiveness fidelity outcome was used (in line with review inclusion criteria). Where multiple teacher/school staff measures of fidelity were reported, a summary score was calculated; the mean of multiple teacher/staff fidelity scores was taken as the indicator of overall fidelity. Authors' own overall interpretation of the overall fidelity score they report was not used (e.g., "teachers delivered the intervention with high fidelity"). The authors must have provided an overall or component specific quantitative target outcome score to compare the reported fidelity score against (e.g., teachers were requested to deliver 3 active maths lessons per week, and initiate one recess activity per week). Fidelity outcomes were thereafter interpreted using the following criteria: staff fidelity was considered high, medium or low if the reported or calculated fidelity outcomes were between 80-100%, 50-79% or 0-49% respectively.[162] In cases where calculations resulted in decimal portions, values greater than or equal to 0.5 were

[1] Delivered by a teacher/or other member of school staff within an intervention arm

rounded up; all others values were rounded down. Where fidelity scores at multiple time points were reported, the fidelity measure taken at the time point closest to the exposure of interest (i.e., the staff training) was used.

Studies excluded from fidelity outcomes:

Given that the definition of fidelity adopted for the purposes for this review was "the extent to which teachers delivered the intervention as intended",[148] studies that solely reported fidelity outcomes in the absence of any quantitative goal/aim to compare outcomes against were excluded (e.g., fidelity scores were solely compared against the control group only or fidelity outcomes reported in other studies).

Appendix 2.5. Hierarchies used to select activity behaviour outcomes

Where more than one of either activity behaviour reported at both baseline and follow-up was reported within a study, I applied a hierarchy to focus on outcomes closest to the review's exposure of interest (i.e., staff training). The hierarchies I used with colleagues to select outcomes for both activity behaviours are outlined below. Where multiple follow-up measures were reported for either activity behaviour were reported, outcomes measured closest to the end of the student-targeted intervention were extracted (i.e., post-intervention priortised above mid-intervention or maintenance measures).

Physical activity outcomes were selected in the following numerical and then alphabetical order

1) **Teacher period (e.g., active lesson only)**
   a) time spent in moderate-to-vigorous physical activity
   b) total physical activity
   c) vigorous physical activity
   d) moderate physical activity
   e) light physical activity

2) **School hours (e.g., 09:00-15:00)**
   a) time spent in moderate-to-vigorous physical activity
   b) total physical activity
   c) vigorous physical activity
   d) moderate physical activity
   e) light physical activity

3) **Weekdays (e.g., Monday 07:00-21:00)**
   a) time spent in moderate-to-vigorous physical activity
   b) total physical activity
   c) vigorous physical activity
   d) moderate physical activity
   e) light physical activity

4) **Whole of week (including weekends)**
   a) time spent in moderate-to-vigorous physical activity
   b) total physical activity
   c) vigorous physical activity
   d) moderate physical activity
   e) light physical activity

Sedentary behaviour outcomes were selected in the following numerical and then alphabetical order

1) **Teacher period (e.g., active lesson only)**
   a) time spent in any sedentary behaviour

2) **School hours (e.g., 09:00-15:00)**
   a) time spent in any sedentary behaviour

3) **Weekdays (e.g., Monday 07:00-21:00)**
   a) time spent in any sedentary behaviour

4) **Whole of week (including weekends)**
   a) time spent in any sedentary behaviour

Appendix 2.6. Formulae used for meta-analyses of physical activity and sedentary behaviour outcomes.

Standardised mean differences (SMDs) were calculated based on the number, mean, and standard deviations (SDs) of the treatment and control groups at baseline and follow-up. Formulae used for physical activity (PA) outcomes are outlined below and based on the Cochrane handbook.[388] The same formulae were used for sedentary behaviour analyses.

I calculated the difference in means (MD) between treatment (E) and control groups (C) as:

$$MD= M_E - M_C$$

where M_E is the mean difference between baseline and follow-up in the treatment group and M_c is the mean difference between baseline and follow-up in the control group.

I imputed the change-from-baseline SDs (SD'change) for treatment and control groups separately using a correlation coefficient (Corr):

$$SD'change=\sqrt{SD^2,baseline + SD^2,follow\text{-}up - (2*Corr*SD,baseline* SD,follow\text{-}up)},$$

where Corr was set at 0.5[389] based on similar reviews and studies.[68,390] I performed sensitivity analyses by varying the correlation coefficient between 0.5 and 0.95.

Given that groups were dissimilar in size, I calculated the weighted and pooled SD (SD*pooled) of MDs for treatment and control groups as:

$$SD\_pool=\sqrt{(((n_c-1)*SD'change_c^2+(n_E-1)* SD'change_E^2)/(N-2))}$$

where n_c is the is the number of participants in the control group, $SD'change_c$ is the change-from-baseline SD in the control group, n_E is the number of participants in the treatment group, $SD'change_E$ is the change-from-baseline SD in the treatment group and N is the number of participants in treatment and control groups.

The SMD was calculated as:

$$SMD=(MD)/SD\_pool$$

A bias correction (SMD_bias) using Hedges' adjusted *g* was applied to studies that reported on small sample sizes (defined as <50 participants):

$$SMD\_bias = SMD*(1-3/(4*N-9))$$

where N is the number of participants in treatment and control groups.

The standardised error (SE) of the SMD (SE(SMD)) was calculated as:

$$SE(SMD)=\sqrt{(1/(N)+SMD^2/(2*N))}*\sqrt{(2*(1-Corr))},$$ [169]

where N is the number of participants in treatment and control groups and Corr was set at 0.5.

The SEs of SMDs were corrected using the intra-cluster correlation coefficient (ICC), where reported. The design effect (DE) was calculated as:

$$DE=1+(m-1)*\rho,$$ [391]

where m is the average cluster size and ρ is the ICC. Where study authors did not report the ICC, we used estimates from similar studies (0.11 for physical activity; 0.22 for sedentary behaviour).[392]

Estimated design effects were used to produce an adjusted SE (SE_adj):

$$SE\_adj=\sqrt{(DE)}*SE(SMD).$$

SMDs and their adjusted SEs were used to perform random-effects meta-analyses.

Appendix 2.7. Publications excluded with reasons at stages 1 and 2 of full-text screening

Title	Authors	Year	Exclusion reason
Stage 1 (n=490)			
No title identified	Lawlor et al	2016	Exclusion reason: stage 1 - Conference abstract/poster
The effect of a school-based active video game intervention on children's aerobic fitness, physical activity level, and exercise related psychological variables: A preliminary RCT trial	Lau et al	2015	Exclusion reason: stage 1 - Conference abstract/poster
Bright spots, physical activity investments that work: the Finnish Schools on the Move programme	Blom et al	2018	Exclusion reason: stage 1 - Conference abstract/poster
Bright spots physical activity investments that work: Youth-Physical Activity Towards Health (Y-PATH)	Belton et al	2019	Exclusion reason: stage 1 - Conference abstract/poster
The impact of long-term school-based physical activity interventions on body mass index of primary school children - a meta-analysis of randomized controlled trials	Mei et al	2016	Exclusion reason: stage 1 - Conference abstract/poster
Partnering with Schools to Implement Physical Activity Interventions	McClary King et al	2018	Exclusion reason: stage 1 - Conference abstract/poster
Understanding "agency" in the translation of a health promotion program	Page-Reeves et al	2015	Exclusion reason: stage 1 - Conference abstract/poster
Scaling-up an efficacious comprehensive school-based physical activity intervention: development, evaluation and dissemination of the iPLAY program	Lonsdale et al	2019	Exclusion reason: stage 1 - Conference abstract/poster
The mediating effects of breaking up classroom sitting with cognitively engaging or simple active breaks on children's cognition	Mazzoli et al	2019	Exclusion reason: stage 1 - Conference abstract/poster
The Application of an Implementation Science Framework to Comprehensive School Physical Activity Programs: Be a Champion!	Moore et al	2018	Exclusion reason: stage 1 - Conference abstract/poster
Physically Active Lessons: Evaluation Report and Executive Summary	Miller et al	2015	Exclusion reason: stage 1 - Conference abstract/poster
Effects of a school-based intervention program on metabolic syndrome parameters in school-aged youth	Cocca et al	2016	Exclusion reason: stage 1 - Conference abstract/poster
Bright spots, physical activity investments that work: JUMP-in: promoting physical activity and healthy nutrition at primary schools in Amsterdam	Busch et al	2018	Exclusion reason: stage 1 - Conference abstract/poster

Title	Authors	Year	Exclusion reason
Beyond the randomised controlled trial and BMI--evaluation of effectiveness of through-school nutrition and physical activity programmes	Rush et al	2015	Exclusion reason: stage 1 - Conference abstract/poster
Are benefits from an 8-month exercise intervention in pre-and peri-pubertal children maintained after 1 year of detraining? Follow-up data from the CAPO kids trial	Beck et al	2017	Exclusion reason: stage 1 - Conference abstract/poster
Adding Context: Process evaluation of a childhood obesity prevention trial (the WAVES study)	Griffin et al	2015	Exclusion reason: stage 1 - Conference abstract/poster
Process evaluation of the school-based Girls Active programme	Gorely et al	2019	Exclusion reason: stage 1 - Conference abstract/poster
The physical education and physical literacy (pepl) approach: a multicomponent primary school intervention targeting physical literacy	Telford et al	2019	Exclusion reason: stage 1 - Conference abstract/poster
A Process Evaluation of A Fitness Curriculum To Meet Physical Activity Policy Requirements: A Pilot Study	Esquivel et al	2019	Exclusion reason: stage 1 - Conference abstract/poster
A little more time around the track may go a long way: Implications of increasing moderate to vigorous physical activity in pre-adolescents	Farukhi et al	2019	Exclusion reason: stage 1 - Conference abstract/poster
A 7-year school-based exercise intervention improves musculoskeletal traits in both genders and reduces in girls with each year with the program the fracture risk	Rosengren et al	2015	Exclusion reason: stage 1 - Conference abstract/poster
Impact of height-adjustable desks on adolescents' energy expenditure, adiposity and perceived musculoskeletal discomfort	Ayala et al	2019	Exclusion reason: stage 1 - Conference abstract/poster
Research on the influence of Tai Chi teaching on physical fitness based on virtual reality technology	Wang et al	2018	Exclusion reason: stage 1 - Conference abstract/poster
Integrating movement in academic classrooms: Understanding, applying and advancing the knowledge base	Webster et al	2015	Exclusion reason: stage 1 - Conference abstract/poster
Research on the construction of student' physical fitness assessment model from the perspective of health promotion	Yan et al	2018	Exclusion reason: stage 1 - Conference abstract/poster
Effect of Active Lessons on Physical Activity, Academic, and Health Outcomes: A Systematic Review	Martin et al	2017	Exclusion reason: stage 1 - Conference abstract/poster
Evaluation of school-based interventions of active breaks in primary schools: A systematic review and meta-analysis	Masini et al	2020	Exclusion reason: stage 1 - Conference abstract/poster
A Review of Implementation Outcome Measures of School-based Physical Activity Interventions	Shah et al	2017	Exclusion reason: stage 1 - Conference abstract/poster

Title	Authors	Year	Exclusion reason
The effectiveness of interventions on sustained childhood physical activity: A systematic review and meta-analysis of controlled studies	Sims et al	2015	Exclusion reason: stage 1 - Conference abstract/poster
Pedagogical Approaches to and Effects of Fundamental Movement Skill Interventions on Health Outcomes: A Systematic Review	Tompsett et al	2017	Exclusion reason: stage 1 - Conference abstract/poster
Indoor school environments, physical activity, sitting behaviour and pedagogy: a scoping review	Ucci et al	2015	Exclusion reason: stage 1 - Conference abstract/poster
Effect of classroom-based physical activity interventions on academic and physical activity outcomes: A systematic review and meta-analysis	Watson et al	2017	Exclusion reason: stage 1 - Conference abstract/poster
School-based intervention programs for preventing obesity and promoting physical activity and fitness: A systematic review	Yuksel et al	2020	Exclusion reason: stage 1 - Conference abstract/poster
Physical activity interventions and nutritional education to combat childhood obesity in school: Systematic review	Serra et al	2018	Exclusion reason: stage 1 - Conference abstract/poster
A mixed-studies systematic review and meta-analysis of school-based interventions to promote physical activity and/or reduce sedentary time in children	Jones et al	2020	Exclusion reason: stage 1 - Conference abstract/poster
Effect of school-based interventions to control childhood obesity: A review of reviews	Amini et al	2015	Exclusion reason: stage 1 - Conference abstract/poster
Characteristics of physical activity interventions and effects on cardiorespiratory fitness in children aged 6-12 years-A systematic review	Braaksma et al	2018	Exclusion reason: stage 1 - Conference abstract/poster
Efficacy of School-Based Interventions for Improving Muscular Fitness Outcomes in Adolescent Boys: A Systematic Review and Meta-analysis	Cox et al	2020	Exclusion reason: stage 1 - Conference abstract/poster
Utilising active play interventions to promote physical activity and improve fundamental movement skills in children: a systematic review and meta-analysis	Johnstone et al	2018	Exclusion reason: stage 1 - Conference abstract/poster
What Works in Sedentary Behavior Interventions for Youth: A Review of Reviews	dos Santos et al	2019	Exclusion reason: stage 1 - Conference abstract/poster
A systematic review of randomized and case-controlled trials investigating the effectiveness of school-based motor skill interventions in 3-to 12-year-old children.	Eddy et al	2019	Exclusion reason: stage 1 - Conference abstract/poster
The Project P.A.T.H.S. in Hong Kong: Work Done and Lessons Learned in a Decade	Shek et al	2016	Exclusion reason: stage 1 - Conference abstract/poster
Developmental Physical Education: How to Implement a Peer-assistance Program to Help Low Performers	Gagnon et al	2016	Exclusion reason: stage 1 - Conference abstract/poster

Title	Authors	Year	Exclusion reason
Systematic Review of Physical Education-Based Physical Activity Interventions Among Elementary School Children	Errisuriz et al	2018	Exclusion reason: stage 1 - Conference abstract/poster
School and family-based interventions for promoting a healthy lifestyle among children and adolescents in Italy: a systematic review	Gorga et al	2016	Exclusion reason: stage 1 - Conference abstract/poster
Measuring implementation fidelity of school-based obesity prevention programmes: A systematic review	Schaap et al	2018	Exclusion reason: stage 1 - Conference abstract/poster
A systematic review of school-based physical activity interventions on children's wellbeing	Rafferty et al	2016	Exclusion reason: stage 1 - Conference abstract/poster
Effectiveness of school-based physical activity programmes on cardiorespiratory fitness in children: a meta-analysis of randomised controlled trials	Pozuelo-Carrascosa et al	2018	Exclusion reason: stage 1 - Conference abstract/poster
Implementing health promotion programmes in schools: a realist systematic review of research and experience in the United Kingdom	Pearson et al	2015	Exclusion reason: stage 1 - Conference abstract/poster
Physically active lessons as physical activity and educational interventions: A systematic review of methods and results	Norris et al	2015	Exclusion reason: stage 1 - Conference abstract/poster
Physical activity interventions in schools for improving lifestyle in European countries	Mura et al	2015	Exclusion reason: stage 1 - Conference abstract/poster
Classroom standing desks and sedentary behavior: A systematic review	Minges et al	2016	Exclusion reason: stage 1 - Conference abstract/poster
School-Based Interventions to Improve Cardiorespiratory Fitness in Adolescents: Systematic Review with Meta-analysis	Minatto et al	2016	Exclusion reason: stage 1 - Conference abstract/poster
Classroom-Based Physical Activity and Sedentary Behavior Interventions in Adolescents: A Systematic Review and Meta-Analysis	McMichan et al	2018	Exclusion reason: stage 1 - Conference abstract/poster
Evaluation of physical activity interventions in children via the reach, efficacy/effectiveness, adoption, implementation, and maintenance (RE-AIM) framework: A systematic review of randomized and non-randomized trials	McGoey et al	2016	Exclusion reason: stage 1 - Conference abstract/poster
Studies of Physical Education in the United States Using SOFIT: A Review	McKenzie et al	2017	Exclusion reason: stage 1 - Conference abstract/poster
Interventions aimed at preventing and reducing overweight/obesity among children and adolescents: a meta-synthesis	Kobes et al	2018	Exclusion reason: stage 1 - Conference abstract/poster
Ceria, respek, gigih, aktif, sihat (C.E.R.G.A.S.): Factors influencing sustainability of a school-based obesity intervention for young adolescents	Hoe et al	2019	Exclusion reason: stage 1 - Conference abstract/poster

Title	Authors	Year	Exclusion reason
Academic, cognitive and physical outcomes of two strategies to integrate movement in classroom: active lessons and active breaks	Mendez-Gimenez et al	2020	Exclusion reason: stage 1 - Conference abstract/poster
A school-based health promotion program to promote physical activity among young adolescents in Hong Kong	Abraham et al	2015	Exclusion reason: stage 1 - Conference abstract/poster
Evaluation of the Carol M. White Physical Education Program: Final Report	Jones et al	2015	Exclusion reason: stage 1 - Conference abstract/poster
Increasing Children's Physical Activity During the School Day	Hatfield et al	2015	Exclusion reason: stage 1 - Conference abstract/poster
A new way to prevent obesity for kids aged between 8-10 years	Knopf et al	2018	Exclusion reason: stage 1 - Conference abstract/poster
Adoption, implementation and sustainability of school-based physical activity and sedentary behaviour interventions in real-world settings: A systematic review	Cassar et al	2019	Exclusion reason: stage 1 - Conference abstract/poster
The perfect physical activity program-to not reduce adolescent risk	Feldstein Ewing et al	2017	Exclusion reason: stage 1 - Conference abstract/poster
Scale-up and dissemination of a school-based resistance training program: RE-AIM evaluation of impact	Kennedy et al	2019	Exclusion reason: stage 1 - Conference abstract/poster
Feasibility of the SWITCH Classroom Module and its Effect on Classroom Engagement	Long et al	2016	Exclusion reason: stage 1 - Conference abstract/poster
United for healthier kids program experience-is it on track to achieve its goals: Country experiences from Pakistan and Mexico	Das et al	2017	Exclusion reason: stage 1 - Conference abstract/poster
'Fitness for princess'-a study to improve physical fitness among school going children in Western India	Harihara Prakash et al	2015	Exclusion reason: stage 1 - Conference abstract/poster
Health education program at the "happy life, healthy heart" school: A randomized clinical trial	Alievi Mari et al	2019	Exclusion reason: stage 1 - Conference abstract/poster
Implementation of Brain Breaks in the Classroom and Effects on Attitudes toward Physical Activity in a Macedonian School Setting	Popeska et al	2018	Exclusion reason: stage 1 - Duplicate
Trends in physical activity, health-related fitness, and gross motor skills in children during a two-year comprehensive school physical activity program	Brusseau et al	2018	Exclusion reason: stage 1 - Insufficient detail on teacher role

Title	Authors	Year	Exclusion reason
The ‘uptake’ of a sport-for-development programme in South Africa	Burnett et al	2015	Exclusion reason: stage 1 - Insufficient detail on teacher role
The impact of playworks on boys' and girls' physical activity during recess	Bleeker et al	2015	Exclusion reason: stage 1 - Insufficient detail on teacher role
Exploring the impact of high intensity interval training on adolescents' objectively measured physical activity: Findings from a randomized controlled trial	Costigan et al	2018	Exclusion reason: stage 1 - Insufficient detail on teacher role
Use of Stand-Biased Desks to Reduce Sedentary Time in High School Students: A Pilot Study	Pickens et al	2016	Exclusion reason: stage 1 - Insufficient detail on teacher role
Long-term effects of comprehensive school health on health-related knowledge, attitudes, self-efficacy, health behaviours and weight status of adolescents	Ofosu et al	2018	Exclusion reason: stage 1 - Insufficient detail on teacher role
Evaluation of a Walking-Track Intervention to Increase Children's Physical Activity during Primary School Break Times	Powell et al	2018	Exclusion reason: stage 1 - Insufficient detail on teacher role
Health Empowers You: Impact of a School-Based Physical Activity Program in Elementary School Students, Georgia, 2015-2016	Hyde et al	2020	Exclusion reason: stage 1 - Insufficient detail on teacher role
Implementation intentions improve exercise self-efficacy and exercise behavior regardless of task difficulty	Shen et al	2019	Exclusion reason: stage 1 - Insufficient detail on teacher role
A Multi-Week Assessment of a Mobile Exergame Intervention in an Elementary School	Garde et al	2018	Exclusion reason: stage 1 - Insufficient detail on teacher role
Increasing physical activity of children during school recess	Hayes et al	2015	Exclusion reason: stage 1 - Insufficient detail on teacher role

Title	Authors	Year	Exclusion reason
Evaluation of a Novel Mobile Exergame in a School-Based Environment	Garde et al	2016	Exclusion reason: stage 1 - Insufficient detail on teacher role
Trajectories of objectively measured sedentary time among secondary students in Manitoba, Canada in the context of a province-wide physical education policy: A longitudinal analysis	Zuo et al	2016	Exclusion reason: stage 1 - Insufficient detail on teacher role
Measuring the Implementation of a School Wellness Policy	Snelling et al	2017	Exclusion reason: stage 1 - Insufficient detail on teacher role
Elementary School-Based Obesity Intervention Using an Educational Curriculum	Lynch et al	2016	Exclusion reason: stage 1 - Insufficient detail on teacher role
Long term impact of one daily unit of physical exercise at school on cardiovascular risk factors in school children	Muller et al	2016	Exclusion reason: stage 1 - Insufficient detail on teacher role
Moderate-to-vigorous physically active academic lessons and academic engagement in children with and without a social disadvantage: a within subject experimental design	Mullender-Wijnsma et al	2015	Exclusion reason: stage 1 - Insufficient detail on teacher role
Effectiveness of the Healthy Lifestyles Programme (HeLP) to prevent obesity in UK primary-school children: a cluster randomised controlled trial	Lloyd et al	2018	Exclusion reason: stage 1 - Insufficient detail on training or no training provided
Improving Cognitive Performance of 9-12 Years Old Children: Just Dance? A Randomized Controlled Trial	van den Berg et al	2019	Exclusion reason: stage 1 - Insufficient detail on training or no training provided
PACE: A group randomised controlled trial to increase children's break-time playground physical activity	Parrish et al	2016	Exclusion reason: stage 1 - Insufficient detail on training or no training provided
Unravelling the Effects of the Healthy Primary School of the Future: For Whom and Where Is It Effective?	Bartelink et al	2019	Exclusion reason: stage 1 - Insufficient detail on

Title	Authors	Year	Exclusion reason
			training or no training provided
Evaluation of a concept-based physical education unit for energy balance education	Chen et al	2018	Exclusion reason: stage 1 - Insufficient detail on training or no training provided
How Feedback and Goal-Setting Impact Children's Recess Physical Activity	Koufoudakis et al	2016	Exclusion reason: stage 1 - Insufficient detail on training or no training provided
Promoting physical activity at the school playground: a quasi-experimental intervention study	López-Fernández et al	2016	Exclusion reason: stage 1 - Insufficient detail on training or no training provided
Feasibility of implementing an outdoor walking break in Italian middle schools	Brustio et al	2018	Exclusion reason: stage 1 - Insufficient detail on training or no training provided
Effects of Common Core State Standards on Student Physical Activity Rates and Student and Teacher Perceptions in Physical Education	Seymour et al	2019	Exclusion reason: stage 1 - Insufficient detail on training or no training provided
Evaluation of Daily Physical Activity (DPA) policy implementation in Ontario: surveys of elementary school administrators and teachers	Allison et al	2016	Exclusion reason: stage 1 - Insufficient detail on training or no training provided
How 'The Daily Mile™' works in practice: A process evaluation in a UK primary school	Harris et al	2019	Exclusion reason: stage 1 - Insufficient detail on training or no training provided
Exploring the effectiveness of a school-based physical activity policy in British Columbia, Canada: a mixed-methods observational study	Weatherson et al	2019	Exclusion reason: stage 1 - Insufficient detail on

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			training or no training provided
Lessons learned and insights from the implementation of a food and physical activity policy to prevent obesity in Mexican schools: An analysis of nationally representative survey results	Theodore et al	2018	Exclusion reason: stage 1 - Insufficient detail on training or no training provided
The effect of a school-centered multicomponent intervention on daily physical activity and sedentary behavior in primary school children: The Active Living study	Van Kann et al	2016	Exclusion reason: stage 1 - Insufficient detail on training or no training provided
Effect of gymnastic school lessons on the student's physical activity levels: jump in young and adult education (YAE)	Batista Lemes et al	2017	Exclusion reason: stage 1 - Insufficient detail on training or no training provided
Maybe it is not a goal that matters: a report from a physical activity intervention in youth	Bronikowski et al	2018	Exclusion reason: stage 1 - Insufficient detail on training or no training provided
COPE: A Pilot Study With Urban-Dwelling Minority Sixth-Grade Youth to Improve Physical Activity and Mental Health Outcomes	Hoying et al	2016	Exclusion reason: stage 1 - Insufficient detail on training or no training provided
The relationship between school-level characteristics and implementation fidelity of a coordinated school health childhood obesity prevention intervention	Lederer et al	2015	Exclusion reason: stage 1 - Insufficient detail on training or no training provided
The Daily Mile as a public health intervention: a rapid ethnographic assessment of uptake and implementation in South London, UK	Hanckel et al	2019	Exclusion reason: stage 1 - Insufficient detail on training or no training provided
Effects of School Gardening Lessons on Elementary School Children's Physical Activity and Sedentary Time	Rees-Punia et al	2017	Exclusion reason: stage 1 - Insufficient detail on

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			training or no training provided
Impact of goal setting on physical activity in physical education	Chase et al	2018	Exclusion reason: stage 1 - Insufficient detail on training or no training provided
Active and Healthy Lifestyle - Nationwide Programs in Israeli Schools	Zach et al	2018	Exclusion reason: stage 1 - Insufficient detail on training or no training provided
Changes in school-day step counts during a physical activity for Lent intervention: a cluster randomized crossover trial of the Savior's Sandals	Kahan et al	2019	Exclusion reason: stage 1 - Insufficient detail on training or no training provided
Active learning improves on-task behaviors in 4th grade children	Bartholomew et al	2018	Exclusion reason: stage 1 - Insufficient detail on training or no training provided
Intervention fidelity in the definitive cluster randomised controlled trial of the Healthy Lifestyles Programme (HeLP) trial: Findings from the process evaluation	Lloyd et al	2017	Exclusion reason: stage 1 - Insufficient detail on training or no training provided
Effects of Sharing Data With Teachers on Student Physical Activity and Sedentary Behavior in the Classroom	Hodgin et al	2020	Exclusion reason: stage 1 - Insufficient detail on training or no training provided
A classroom-based physical activity intervention for urban kindergarten and first-grade students: a feasibility study	Reznik et al	2015	Exclusion reason: stage 1 - Insufficient detail on training or no training provided
Effects of Music on Physical Activity Rates of Elementary Physical Education Students	Barney et al	2015	Exclusion reason: stage 1 - Insufficient detail on

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			training or no training provided
An integrated curriculum approach to increasing habitual physical activity in deprived South Asian children	Eyre et al	2016	Exclusion reason: stage 1 - Insufficient detail on training or no training provided
Implementation of Local Wellness Policies in Schools: Role of School Systems, School Health Councils, and Health Disparities	Hager et al	2016	Exclusion reason: stage 1 - Insufficient detail on training or no training provided
The Effect of a Comprehensive School Physical Activity Program on Physical Activity and Health-Related Fitness in Children From Low-Income Families	Brusseau et al	2016	Exclusion reason: stage 1 - Led by external provider/specialist
The effect of sport for LIFE: All island in children from low socio-economic status: A clustered randomized controlled trial	Breslin et al	2019	Exclusion reason: stage 1 - Led by external provider/specialist
Maximizing children's physical activity using the LET US Play principles	Brazendale et al	2015	Exclusion reason: stage 1 - Led by external provider/specialist
Pragmatic evaluation of the Go2Play Active Play intervention on physical activity and fundamental movement skills in children	Johnstone et al	2017	Exclusion reason: stage 1 - Led by external provider/specialist
The effect of educational intervention based on the Theory of Planned Behavior on thephysical activity of female students in Behbehan City (2016)	Leila et al	2017	Exclusion reason: stage 1 - Led by external provider/specialist
The effects of integrating physical activity into mathematic lessons on mathematic test performance, body mass index and short term memory among 10 year old children	Fakri et al	2020	Exclusion reason: stage 1 - Led by external provider/specialist
Proposal for an Enhanced Physical Education Program in the Primary School: Evaluation of Feasibility and Effectiveness in Improving Physical Skills and Fitness	Dallolio et al	2016	Exclusion reason: stage 1 - Led by external provider/specialist

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Fit "N" Cool Kids: The Effects of Character Modeling and Goal Setting on Children's Physical Activity and Fruit and Vegetable Consumption	Larson et al	2018	Exclusion reason: stage 1 - Led by external provider/specialist
Evaluation of the computer-based intervention program stayingfit Brazil to promote healthy eating habits: The results from a school cluster-randomized controlled trial	Da Silva et al	2019	Exclusion reason: stage 1 - Led by external provider/specialist
Effects of School-based Health Promotion Intervention on Health Behaviors among School Adolescents in North Lima and Callao, Peru	Sharma et al	2018	Exclusion reason: stage 1 - Led by external provider/specialist
Cost and Cost-Effectiveness of Students for Nutrition and eXercise (SNaX)	Ladapo et al	2016	Exclusion reason: stage 1 - Led by external provider/specialist
Preliminary Efficacy and Feasibility of "Thinking While Moving in English": A Program with Physical Activity Integrated into Primary School English Lessons	Mavilidi et al	2018	Exclusion reason: stage 1 - Led by external provider/specialist
Physically active vs. sedentary academic lessons: A dose response study for elementary student time on task	Grieco et al	2016	Exclusion reason: stage 1 - Led by external provider/specialist
Mediators of Physical Activity Behavior Change in the "Girls on the Move" Intervention	Robbins et al	2019	Exclusion reason: stage 1 - Led by external provider/specialist
Integrating mindfulness training in school health education to promote healthy behaviors in adolescents: Feasibility and preliminary effects on exercise and dietary habits	Salmoirago-Blotcher et al	2018	Exclusion reason: stage 1 - Led by external provider/specialist
Observing the Delivery of a Curriculum-Integrated Dance Programme Across Four New Zealand Primary Schools	Sharma et al	2019	Exclusion reason: stage 1 - Led by external provider/specialist
Evaluation of the Good Start Program: a healthy eating and physical activity intervention for Maori and Pacific Islander children living in Queensland, Australia	Mihrshahi et al	2017	Exclusion reason: stage 1 - Led by external provider/specialist

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Efficacy of the health promotion model-based intervention in enhancing the health responsibility of middle school female student: A randomized controlled trial	Dawood et al	2019	Exclusion reason: stage 1 - Led by external provider/specialist
Effects of an empowerment-based health-promotion school intervention on physical activity and sedentary time among adolescents in a multicultural area	Froberg et al	2018	Exclusion reason: stage 1 - Led by external provider/specialist
Effects of a Three-Tiered Intervention Model on Physical Activity and Fitness Levels of Elementary School Children	Dauenhauer et al	2016	Exclusion reason: stage 1 - Led by external provider/specialist
Effects of a structured recess intervention on physical activity levels, cardiorespiratory fitness, and anthropometric characteristics in primary school children	Casolo et al	2019	Exclusion reason: stage 1 - Led by external provider/specialist
Effects of a Physical Education Supportive Curriculum and Technological Devices on Physical Activity	Clapham et al	2015	Exclusion reason: stage 1 - Led by external provider/specialist
Does the Healthy Body Image program improve lifestyle habits among high school students? A randomized controlled trial with 12-month follow-up	Sundgot-Borgen et al	2019	Exclusion reason: stage 1 - Led by external provider/specialist
Assessing the impact of a physical education project based on games approach on the actual motor competence of primary school children	Sgro et al	2019	Exclusion reason: stage 1 - Led by external provider/specialist
Adolescent girls' physical activity, fitness and psychological well-being during a health club physical education approach	McNamee et al	2017	Exclusion reason: stage 1 - Led by external provider/specialist
Outcomes and process evaluation of a programme integrating physical activity into the primary school mathematics curriculum: The EASY Minds pilot randomised controlled trial	Riley et al	2015	Exclusion reason: stage 1 - Led by external provider/specialist
Outcomes of a four-year specialist-taught physical education program on physical activity: A cluster randomized controlled trial, the LOOK study	Telford et al	2016	Exclusion reason: stage 1 - Led by external provider/specialist

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Elementary student and teacher perceptions of a mindfulness and yoga-based program in school: A qualitative evaluation	Reindl et al	2020	Exclusion reason: stage 1 - Led by external provider/specialist
Exploring Gender Differences within Forest Schools as a Physical Activity Intervention	Trapasso et al	2018	Exclusion reason: stage 1 - Led by external provider/specialist
Lessons Learned: A Strategic Alliance to Improve Elementary Physical Education in an Urban School District	Thompson et al	2015	Exclusion reason: stage 1 - Led by external provider/specialist
Changes in sedentary and active lifestyle, diet quality and body composition nine months after an education program in Polish students aged 11-12 years: Report from the ABC of healthy eating study	Wadolowska et al	2019	Exclusion reason: stage 1 - Led by external provider/specialist
'A really good balance': Thematic analysis of stakeholders' views on classroom- and games-based positive choices interventions for primary school children	McCullogh et al	2019	Exclusion reason: stage 1 - Led by external provider/specialist
A non-equivalent group pilot trial of a school-based physical activity and fitness intervention for 10-11 year old english children: born to move	Fairclough et al	2016	Exclusion reason: stage 1 - Led by external provider/specialist
A clustered randomized controlled trial to determine impacts of the Harvest of the Month program	LaChausse et al	2017	Exclusion reason: stage 1 - Led by external provider/specialist
Fuel for Fun: a cluster-randomized controlled study of cooking skills, eating behaviors, and physical activity of 4th graders and their families	Cunningham-Sabo et al	2016	Exclusion reason: stage 1 - Led by external provider/specialist
'Project Spraoi': A randomized control trial to improve nutrition and physical activity in school children	Coppinger et al	2016	Exclusion reason: stage 1 - Led by external provider/specialist
Positive Effects of Promoting Physical Activity and Balanced Diets in a Primary School Setting with a High Proportion of Migrant School Children	Weber et al	2017	Exclusion reason: stage 1 - Led by external provider/specialist

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Physical activity and situational interest in mobile technology integrated physical education: A preliminary study	Xihe et al	2016	Exclusion reason: stage 1 - Led by external provider/specialist
Influence of sport education on high school students' motivational response: A gender perspective	Burgueño et al	2020	Exclusion reason: stage 1 - Led by external provider/specialist
A Community-Based Participatory Research Approach for Preventing Childhood Obesity: The Communities and Schools Together Project	Johnson-Shelton et al	2015	Exclusion reason: stage 1 - Led by external provider/specialist
A Nurse-Led and Teacher-Assisted Adolescent Healthy Weight Program to Improve Health Behaviors in the School Setting	Dupart et al	2019	Exclusion reason: stage 1 - Led by external provider/specialist
Intervention of childhood and adolescents obesity in Shantou city	Guo et al	2015	Exclusion reason: stage 1 - Led by external provider/specialist
The CHIRPY DRAGON intervention in preventing obesity in Chinese primaryschool-aged children: A cluster-randomised controlled trial	Li et al	2019	Exclusion reason: stage 1 - Led by external provider/specialist
Effect of a 12-Week Physical Activity Program on Gross Motor Skills in Children	Burns et al	2017	Exclusion reason: stage 1 - Led by external provider/specialist
Participants' physical activity levels and evaluations of a school sport programme in Papua New Guinea	Hanrahan et al	2019	Exclusion reason: stage 1 - Led by external provider/specialist
Effects of Moderate Interval Training on Heart Rate Variability among Primary School Children	Ketelhut et al	2017	Exclusion reason: stage 1 - Led by external provider/specialist
Effects of a school based intervention on children's physical activity and healthy eating: A mixed methods study	Khan et al	2019	Exclusion reason: stage 1 - Led by external provider/specialist

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Empowering aspects for healthy food and physical activity habits: adolescents' experiences of a school-based intervention in a disadvantaged urban community	Holmberg et al	2018	Exclusion reason: stage 1 - Led by external provider/specialist
The Impact of Playworks on Students' Physical Activity by Race/Ethnicity: Findings from a Randomized Controlled Trial	James-Burdumy et al	2016	Exclusion reason: stage 1 - Led by external provider/specialist
Multi-teaching styles approach and active reflection: Effectiveness in improving fitness level, motor competence, enjoyment, amount of physical activity, and effects on the perception of physical education lessons in primary school children	Invernizzi et al	2019	Exclusion reason: stage 1 - Led by external provider/specialist
Effects of a strategy for the promotion of physical activity in students from Bogotá	Gutiérrez-Martínez et al	2018	Exclusion reason: stage 1 - Led by external provider/specialist
The use of information communication technology in teachers' practical training in the framework of physical education	Majerič et al	2019	Exclusion reason: stage 1 - Led by external provider/specialist
Effects of combined physical education and nutritional programs on schoolchildren's healthy habits	Gallotta et al	2016	Exclusion reason: stage 1 - Led by external provider/specialist
Effect of a school-based intervention on nutritional knowledge and habits of low-socioeconomic school children in Israel: A cluster-randomized controlled trial	Kaufman-Shriqui et al	2016	Exclusion reason: stage 1 - Led by external provider/specialist
Physical fitness of school age children post-implementation of an educational intervention to prevent childhood obesity in Morelos, Mexico. [Spanish]	Gatica-Dominguez et al	2019	Exclusion reason: stage 1 - Led by external provider/specialist
Health education: Effects on classroom climate and physical activity	Efstathiou et al	2016	Exclusion reason: stage 1 - Led by external provider/specialist
The effectiveness of the COPE healthy lifestyles TEEN program: a school-based intervention in middle school adolescents with 12-month follow-up	Ardic et al	2017	Exclusion reason: stage 1 - Led by external provider/specialist

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The Effects of the Physical Best Health-Related Fitness Curriculum on Physical Activity Levels of Primary-Aged Physical Education Students	Deutsch et al	2019	Exclusion reason: stage 1 - Led by external provider/specialist
Mental training can improve physical activity behavior in adolescent girls	Najafabadi et al	2017	Exclusion reason: stage 1 - Led by external provider/specialist
Recess environment and curriculum intervention on children's physical activity: IPlay	Nigg et al	2019	Exclusion reason: stage 1 - Led by external provider/specialist
Energy Balance 4 Kids with Play: Results from a Two-Year Cluster-Randomized Trial	Madsen et al	2015	Exclusion reason: stage 1 - Led by external provider/specialist
Newham's Every Child a Sports Person (NECaSP): A Summative Process Evaluation of a School- and Community- Based Intervention in East London, United Kingdom	Curry et al	2016	Exclusion reason: stage 1 - Led by external provider/specialist
An active play intervention to improve physical activity and fundamental movement skills in children of low socioeconomic status: Feasibility cluster randomised controlled trial	Johnstone et al	2019	Exclusion reason: stage 1 - Led by external provider/specialist
Impact and Moderating Variables of an Intervention Promoting Physical Activity Among Children: Results From a Pilot Study	Gourlan et al	2018	Exclusion reason: stage 1 - Led by external provider/specialist
The effects of persuasive communication and planning on intentions to be more physically active and on physical activity behaviour among low-active adolescents	Tessier et al	2015	Exclusion reason: stage 1 - Led by external provider/specialist
Psychologically informed physical fitness practice in schools: A field experiment	Vazou et al	2019	Exclusion reason: stage 1 - Led by external provider/specialist
Using a co-creational approach to develop, implement and evaluate an intervention to promote physical activity in adolescent girls from vocational and technical schools: A case control study	Verloigne et al	2017	Exclusion reason: stage 1 - Led by external provider/specialist

Title	Authors	Year	Exclusion reason
Impact of combined theory-based intervention on psychological effects and physical activity among chinese adolescents	Zhang et al	2020	Exclusion reason: stage 1 - Led by external provider/specialist
HybridPLAY: A New Technology to Foster Outdoors Physical Activity, Verbal Communication and Teamwork	Diaz et al	2016	Exclusion reason: stage 1 - Led by external provider/specialist
Effectiveness of solution-focused brief counselling in dealing with problems with physical education among senior students	Indriūnienė et al	2017	Exclusion reason: stage 1 - Led by external provider/specialist
Does School-Based Health Promotion Affect Physical Activity on Weekends? And, Does It Reach Those Students Most in Need of Health Promotion?	Bastian et al	2015	Exclusion reason: stage 1 - Led by external provider/specialist
Targeting bone and fat with novel exercise for peripubertal boys: the CAPO kids trial	Nogueira et al	2015	Exclusion reason: stage 1 - Led by external provider/specialist
Using the Step it UP! Game to increase physical activity during physical-education classes	Normand et al	2020	Exclusion reason: stage 1 - Led by external provider/specialist
Evaluating Mailed Motivational, Individually Tailored Postcard Boosters for Promoting Girls' Postintervention Moderate-to-Vigorous Physical Activity	Bakhoya et al	2016	Exclusion reason: stage 1 - Not a school-based intervention
Anthropology in the design of preventive behavioral health programs for children and families living in disadvantaged neighborhoods	Azevedo et al	2015	Exclusion reason: stage 1 - Not a school-based intervention
"The Stomp and Catch Was Too Easy!" Children's and Teachers' Perceptions of Inclusive High and Low Autonomy Motor Skills Instruction	Buchanan et al	2019	Exclusion reason: stage 1 - Not school-based
Classroom-Based Physical Activity: Minimizing Disparities in School-Day Physical Activity Among Elementary School Students	Calvert et al	2018	Exclusion reason: stage 1 - Not school-based
Mixed-Methods Evaluation of a Healthy Exercise, Eating, and Lifestyle Program for Primary Schools	Cochrane et al	2017	Exclusion reason: stage 1 - Not school-based

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Promoting Healthy Diet, Physical Activity, and Life-Skills in High School Athletes: Results from the WAVE Ripples for Change Childhood Obesity Prevention Two-Year Intervention	Meng et al	2018	Exclusion reason: stage 1 - Not school-based
Student obesity prevalence and behavioral outcomes for the massachusetts childhood obesity research demonstration project	Franckle et al	2017	Exclusion reason: stage 1 - Not school-based
From surveillance to intervention: Overview and baseline findings for the active city of Liverpool active schools and sportslinx (A-CLASS) project	McWhannell et al	2018	Exclusion reason: stage 1 - Not school-based
Using outdoor adventure to enhance intrinsic motivation and engagement in science and physical activity: An exploratory study	Mackenzie et al	2018	Exclusion reason: stage 1 - Not school-based
Effects of the Girls on the Move randomized trial on adiposity and aerobic performance (secondary outcomes) in low-income adolescent girls	Pfeiffer et al	2019	Exclusion reason: stage 1 - Not school-based
Changes in developmental assets and physical activity frequency among 3rd-5th grade girls participating in a girl-focused sport-based positive youth development program	DeBate et al	2016	Exclusion reason: stage 1 - Not school-based
Promoting Physical Activity and Science Learning in an Outdoor Education Program	Finn et al	2018	Exclusion reason: stage 1 - Not school-based
WAVE~ripples for change obesity two-year intervention in high school soccer players: Process evaluation, best practices, and youth engagement	Meng et al	2018	Exclusion reason: stage 1 - Not school-based
Increases in lifestyle activities as a result of experience Corps participation	Parisi et al	2015	Exclusion reason: stage 1 - Not school-based
Effect of augmented reality game Pokemon GO on cognitive performance and emotional intelligence in adolescent young	Ruiz-Ariza et al	2018	Exclusion reason: stage 1 - Not school-based
Decreasing sedentary behavior: Effects on academic performance, meta-cognition, and sleep	Pilcher et al	2017	Exclusion reason: stage 1 - Not school-based
Challenges and Facilitators to the Implementation of a Sport Education Season: The Voices of Teacher Candidates	Braga et al	2017	Exclusion reason: stage 1 - Not school-based
Effect of a Physical Education Training Program on the Physical Education Teaching Efficacy of Classroom Teacher Candidates	Unlu et al	2019	Exclusion reason: stage 1 - Not school-based
Influence of Visual and Auditory Stimuli on Exercise Intensity Among School-Age Children	Sandoval et al	2019	Exclusion reason: stage 1 - Not school-based
Preventing weight-related problems among adolescent girls: A cluster randomized trial comparing the Brazilian 'New Moves' program versus observation	Dunker et al	2018	Exclusion reason: stage 1 - Not school-based

Title	Authors	Year	Exclusion reason
Organization of domiciliary sports and physical training and recreation activities with children (the case of Irkutsk)	Abramovich et al	2015	Exclusion reason: stage 1 - Not school-based
A School- and Home-Based Intervention to Improve Adolescents' Physical Activity and Healthy Eating: A Pilot Study	Robbins et al	2020	Exclusion reason: stage 1 - Not school-based
A cluster randomized controlled trial of a positive physical activity intervention	Ho et al	2020	Exclusion reason: stage 1 - Not school-based
Active children through incentive vouchers - evaluation (ACTIVE): a mixed-method feasibility study	Christian et al	2016	Exclusion reason: stage 1 - Not school-based
Development of a Workplace Intervention for Child Care Staff: Caring and Reaching for Health's (CARE) Healthy Lifestyles Intervention	Arandia et al	2020	Exclusion reason: stage 1 - Not school-based
Longitudinal data from a school-based intervention - The ACORDA project.	Aires et al	2015	Exclusion reason: stage 1 - Not school-based
Foundations for Fitness: A Multi-Cohort Pediatric Weight Management Intervention	Morrison et al	2018	Exclusion reason: stage 1 - Not school-based
Lessons from a peer-led obesity prevention programme in English schools	Bell et al	2017	Exclusion reason: stage 1 - Not teacher-led
One- and two-year effects of the healthy primary school of the future on children's dietary and physical activity behaviours: A quasi-experimental study	Bartelink et al	2019	Exclusion reason: stage 1 - Not teacher-led
Modifying the classroom environment to increase standing and reduce sitting	Aminian et al	2015	Exclusion reason: stage 1 - Not teacher-led
The health Oriented pedagogical project (HOPP) - a controlled longitudinal school-based physical activity intervention program	Fredriksen et al	2017	Exclusion reason: stage 1 - Protocol paper
A cluster randomized control trial to assess the impact of active learning on child activity, attention control, and academic outcomes: The Texas I-CAN trial	Bartholomew et al	2017	Exclusion reason: stage 1 - Protocol paper
Evaluation overview for the Massachusetts Childhood Obesity Research Demonstration (MA-CORD) project	Davison et al	2015	Exclusion reason: stage 1 - Protocol paper
Effects of a multi-level intervention on the pattern of physical activity among in-school adolescents in Oyo state Nigeria: a cluster randomised trial	Oluwasanu et al	2017	Exclusion reason: stage 1 - Protocol paper
Design and methods for "Commit to Get Fit" - A pilot study of a school-based mindfulness intervention to promote healthy diet and physical activity among adolescents	Salmoirago-Blotcher et al	2015	Exclusion reason: stage 1 - Protocol paper

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Development of the 'Sigue la Huella' physical activity intervention for adolescents in Huesca, Spain	Murillo Pardo et al	2019	Exclusion reason: stage 1 - Protocol paper
Physical activity across the curriculum (PAAC3): Testing the application of technology delivered classroom physical activity breaks	Szabo-Reed et al	2020	Exclusion reason: stage 1 - Protocol paper
Background and evaluation design of a community-based health-promoting school intervention: Fit Lifestyle at School and at Home (FLASH)	van Dongen et al	2019	Exclusion reason: stage 1 - Protocol paper
A cluster randomised controlled trial to evaluate the effectiveness and cost-effectiveness of the GoActive intervention to increase physical activity among adolescents aged 13-14 years	Brown et al	2017	Exclusion reason: stage 1 - Protocol paper
Design, randomization and methodology of the TriAtiva Program to reduce obesity in school children in Southern Brazil	Friedrich et al	2015	Exclusion reason: stage 1 - Protocol paper
One Step Forward: Development of a Program Promoting Active School Transportation	Lindqvist et al	2018	Exclusion reason: stage 1 - Protocol paper
How To Increase The Daily Physical Activity During The School Day? Example Of An Interdisciplinary Project Between Physical Education And Mathematics	Carriedo et al	2019	Exclusion reason: stage 1 - Protocol paper
Improving the well-being of children and youths: a randomized multicomponent, school-based, physical activity intervention	Smedegaard et al	2016	Exclusion reason: stage 1 - Protocol paper
Activating schoolyards: study design of a quasi-experimental schoolyard intervention study	Andersen et al	2015	Exclusion reason: stage 1 - Protocol paper
A cluster-randomised controlled trial to promote physical activity in adolescents: the Raising Awareness of Physical Activity (RAW-PA) Study	Ridgers et al	2017	Exclusion reason: stage 1 - Protocol paper
Evaluation of a comprehensive school physical activity program: Be a Champion!	Singletary et al	2019	Exclusion reason: stage 1 - Protocol paper
Study design and protocol for a mixed methods evaluation of an intervention to reduce and break up sitting time in primary school classrooms in the UK: The CLASS PAL (Physically Active Learning) Programme	Routen et al	2017	Exclusion reason: stage 1 - Protocol paper
Effectiveness of a universal parental support programme to promote healthy dietary habits and physical activity and to prevent overweight and obesity in 6-year-old children: The healthy school start study, a cluster-randomised controlled trial	Nyberg et al	2015	Exclusion reason: stage 1 - Special population (e.g., children with overweight, obesity or ASD)

Title	Authors	Year	Exclusion reason
Longitudinal levels and bouts of objectively measured sedentary time among young Australian children in the HAPPY study	Carson et al	2016	Exclusion reason: stage 1 - Special population (e.g., children with overweight, obesity or ASD)
Juara Sihat: Assessing the sustained impact of a school-based obesity intervention	Mok et al	2018	Exclusion reason: stage 1 - Special population (e.g., children with overweight, obesity or ASD)
Promoting physical activity and improving dietary quality of Singaporean adolescents: Effectiveness of a school-based fitness and wellness program	Loong et al	2018	Exclusion reason: stage 1 - Special population (e.g., children with overweight, obesity or ASD)
Effectiveness of structured physical activity intervention on physical activity and body mass index among adolescents - a pilot study	Sumathy et al	2018	Exclusion reason: stage 1 - Special population (e.g., children with overweight, obesity or ASD)
Holistic Health Promotion for Adolescent Girls in an Alternative School Setting: Lessons Learned	Saltzman et al	2015	Exclusion reason: stage 1 - Special population (e.g., children with overweight, obesity or ASD)
Effects of 28 weeks of high-intensity interval training during physical education classes on cardiometabolic risk factors in Chilean schoolchildren: a pilot trial	Delgado-Floody et al	2018	Exclusion reason: stage 1 - Special population (e.g., children with overweight, obesity or ASD)
Vocational Education Students' Perceptions About The Effects Of A Positive Development Program (Responsibility Hellison's Model)	Caballero et al	2015	Exclusion reason: stage 1 - Special population (e.g., children with overweight, obesity or ASD)
Implementation and evaluation of a collaborative gymnastic strategy	Ávalos Ramos et al	2019	Exclusion reason: stage 1 - Special population (e.g., children with overweight, obesity or ASD)

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One size does not fit all-qualitative process evaluation of the Healthy School Start parental support programme to prevent overweight and obesity among children in disadvantaged areas in Sweden	Norman et al	2016	Exclusion reason: stage 1 - Special population (e.g., children with overweight, obesity or ASD)
Reducing children's classroom sitting time using sit-to-stand desks: findings from pilot studies in UK and Australian primary schools	Clemes et al	2016	Exclusion reason: stage 1 - Teacher has little/no role e.g., structural changes
Trends in sedentary behavior, physical activity, and motivation during a classroom-based active video game program	Fu et al	2019	Exclusion reason: stage 1 - Teacher has little/no role e.g., structural changes
The Effects of Active Videogame Feedback and Practicing Experience on Children's Physical Activity Intensity and Enjoyment	Chen et al	2017	Exclusion reason: stage 1 - Teacher has little/no role e.g., structural changes
Effect of the Shaping Healthy Choices Program, a Multicomponent, School-Based Nutrition Intervention, on Physical Activity Intensity	Fetter et al	2018	Exclusion reason: stage 1 - Teacher has little/no role e.g., structural changes
Low-cost and Scalable Classroom Equipment to Promote Physical Activity and Improve Education	McCrady-Spitzer et al	2015	Exclusion reason: stage 1 - Teacher has little/no role e.g., structural changes
Standing desks in a grade 4 classroom over the full school year	Parry et al	2019	Exclusion reason: stage 1 - Teacher has little/no role e.g., structural changes
Active Living: Development and quasi-experimental evaluation of a school-centered physical activity intervention for primary school children Energy balance-related behaviours	Van Kann et al	2015	Exclusion reason: stage 1 - Teacher has little/no role e.g., structural changes
Self-directed learning: An innovative strategy for sport and physical education	Toto et al	2019	Exclusion reason: stage 1 - Teacher has little/no role e.g., structural changes
The Impact and Feasibility of Introducing Height-Adjustable Desks on Adolescents' Sitting in a Secondary School Classroom	Sudholz et al	2016	Exclusion reason: stage 1 - Teacher has little/no role e.g., structural changes

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A feasibility study of 'The StepSmart Challenge' to promote physical activity in adolescents	Corepal et al	2019	Exclusion reason: stage 1 - Teacher has little/no role e.g., structural changes
A Multicomponent Schoolyard Intervention Targeting Children's Recess Physical Activity and Sedentary Behavior: Effects After One Year	Van Kann et al	2016	Exclusion reason: stage 1 - Teacher has little/no role e.g., structural changes
A process evaluation of the PLAN-A intervention (Peer-Led physical Activity iNtervention for Adolescent girls)	Sebire et al	2019	Exclusion reason: stage 1 - Teacher has little/no role e.g., structural changes
The Impact of Classroom Physical Activity Breaks on Middle School Students' Health-Related Fitness: An Xbox One Kinetic Delivered 4-Week Randomized Controlled Trial	Yli-Piipari et al	2016	Exclusion reason: stage 1 - Teacher has little/no role e.g., structural changes
Effects of school-based exergaming on urban children's physical activity and cardiorespiratory fitness: A quasi-experimental study	Ye et al	2019	Exclusion reason: stage 1 - Teacher has little/no role e.g., structural changes
Do stand-biased desks in the classroom change school-time activity and sedentary behavior?	Swartz et al	2019	Exclusion reason: stage 1 - Teacher has little/no role e.g., structural changes
Exploring the acceptability and usability of a novel social innovation to encourage physical activity: The iStep prototype	Grindell et al	2019	Exclusion reason: stage 1 - Teacher has little/no role e.g., structural changes
Impact of a pedometer-based goal-setting intervention on children’s motivation, motor competence, and physical activity in physical education	Gu et al	2018	Exclusion reason: stage 1 - Teacher has little/no role e.g., structural changes
Does a classroom standing desk intervention modify standing and sitting behaviour and musculoskeletal symptoms during school time and physical activity during waking time?	Ee et al	2018	Exclusion reason: stage 1 - Teacher has little/no role e.g., structural changes
The effect of playground-and nature-based playtime interventions on physical activity and self-esteem in UK school children	Barton et al	2015	Exclusion reason: stage 1 - Teacher has little/no role e.g., structural changes

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Do they need goals or support? A report from a goal-setting intervention using physical activity monitors in youth	Bronikowski et al	2016	Exclusion reason: stage 1 - Teacher has little/no role e.g., structural changes
e-Gibalec: Mobile application to monitor and encourage physical activity in schoolchildren	Janko et al	2017	Exclusion reason: stage 1 - Teacher has little/no role e.g., structural changes
Changes in physical activity and sedentary time in the Finnish Schools on the Move program: a quasi-experimental study	Haapala et al	2017	Exclusion reason: stage 1 - Teacher has little/no role e.g., structural changes
Feasibility and efficacy of the Great Leaders Active StudentS (GLASS) program on children's physical activity and object control skill competency: A non-randomised trial	Nathan et al	2017	Exclusion reason: stage 1 - Teacher has little/no role e.g., structural changes
The evaluation of outdoor learning activities in primary school	Henrietta et al	2019	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
Studying the Effectiveness of Physical Education in the Secondary School (by the Example of Kazakhstan)	Botagariyev et al	2016	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
The effect of a content knowledge teacher professional workshop on enacted pedagogical content knowledge and student learning in a throwing unit	Chang et al	2020	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
A cluster-randomized controlled trial to improve student experiences in physical education: Results of a student-centered learning intervention with high school teachers	Bechter et al	2019	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
Monitoring and evaluation of sports load for primary and middle school students	Luo et al	2018	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
Effects of a School-Based Social-Emotional and Character Development Program on Health Behaviors: A Matched-Pair, Cluster-Randomized Controlled Trial	Bavarian et al	2016	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)

Title	Authors	Year	Exclusion reason
Effects of physical activity and breaks on mathematics engagement in adolescents	Owen et al	2018	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
Health promotion initiatives at school related to overweight, insulin resistance, hypertension and dyslipidemia in adolescents: a cross-sectional study in Recife, Brazil	de Assuncao Bezerra et al	2018	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
Implementing differentiated instruction approach in physical training and sports lesson	Özbal et al	2019	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
Effect of applied health-oriented exercises in physical and sport education on musculoskeletal system of female students	Bendíková et al	2018	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
Promoting schoolchildren's self-esteem in physical education: testing the effectiveness of a five-month teacher training	Rubeli et al	2020	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
A successful nationwide implementation of the 'FIFA 11 for Health' programme in Brazilian elementary schools	Fuller et al	2015	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
An evaluation of the developed physical education curriculum from the viewpoint of teachers at the governorate of Irbid, Jordan	Deity et al	2019	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
An examination of Greek physical educators' implementation and perceptions of Spectrum teaching styles	Syrmpas et al	2016	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
Quality of local school wellness policies for physical activity and resultant implementation in Pennsylvania schools	Francis et al	2018	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
Perceptions and measurement of playtime physical activity in English primary school children: The influence of socioeconomic status	McWhannell et al	2019	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)

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Changes in weight status, quality of life and behaviours of South Australian primary school children: results from the Obesity Prevention and Lifestyle (OPAL) community intervention program	Bell et al	2019	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
Benefits of Strength and Skill-based Training During Primary School Physical Education	Faigenbaum et al	2015	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
Understanding implementation and change in complex interventions. From single- to multi-methodological research on the promotion of youths' participation in physical education	Agergaard et al	2018	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
A school-based intervention improved dietary intake outcomes and reduced waist circumference in adolescents: a cluster randomized controlled trial	Ochoa-Aviles et al	2017	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
Advancing School and Community Engagement Now for Disease Prevention (ASCEND): A Quasi-experimental Trial of School-Based Interventions to Prevent Childhood Obesity	Treu et al	2017	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
School-based physical education: Physical activity and implementation barriers in Vietnamese elementary schools	To et al	2020	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
A school educational intervention based on a serious game to promote a healthy lifestyle	Marchetti et al	2018	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
High-intensity training enhances executive function in children in a randomized, placebo-controlled trial	Moreau et al	2017	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
Relationship of Physical Education Curriculum Implementation and Mathematics Achievement in Chinese Youth	Wang et al	2019	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
The Reality of Sustaining Community-Based Sport and Physical Activity Programs to Enhance the Development of Underserved Youth: Challenges and Potential Strategies	Whitley et al	2015	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)

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Active School Lesson Breaks Increase Daily Vigorous Physical Activity, but Not Daily Moderate to Vigorous Physical Activity in Elementary School Boys	Wilson et al	2017	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
"Now we help ourselves more": Team-teachinq and social classroom climate. Experience with Sport Education	Calderón et al	2016	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
A model for promoting physical activity among rural South African adolescent girls	Kinsman et al	2015	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
Cluster-randomized, controlled evaluation of a teacher led multi factorial school based back education program for 10 to 12-year old children	Dullien et al	2018	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
Development and optimisation of an in-service teacher training programme on motivational assessment in physical education	Slingerland et al	2017	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
The Role of School in Helping Children and Adolescents Reach the Physical Activity Recommendations: The UP&DOWN Study	Grao-Cruces et al	2019	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
Development of coordination capacities through dancing among primary school children	Nanu et al	2018	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
Superheroes and education for leisure: description of a pedagogical proposal in Physical Education classes	Rossi Filho et al	2019	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
Teens Implementing a Childhood Obesity Prevention Program in the Community: Feasibility and Perceptions of a Partnership with HSTA and iCook 4-H	Hagedorn et al	2018	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
The implementation of health education in Subcarpathian schools after the introduction of the new core curriculum as viewed by PE teachers	Zadarko-Domaradzka et al	2015	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)

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The relationship between physical activity and content of the physical education classes in 11-12 years old lithuanian schoolchildren. The pilot study	Emeljanovas et al	2015	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
Innovation with change: developing a community of practice to help teachers move beyond the ‘honeymoon’ of pedagogical renovation	Goodyear et al	2015	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
A classroom-based intervention to help teachers decrease students' amotivation	Cheon et al	2015	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
Positive experiences in physical education through teacher intervention in the teaching unit futsal	Abos Catalan et al	2015	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
Implementation of Kenyan comprehensive school health program: improvement and association with students' academic attainment	Akiyama et al	2020	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
A Professional Development Program to Enhance Primary School Teachers' Knowledge and Operationalization of Physical Literacy	Edwards et al	2019	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
Effect of educational intervention based on Self-Efficacy on preventive behaviors of overweight and obesity among secondary-school female students in Mashhad. [Persian]	Hejazi et al	2017	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
The Flipped Classroom Through The Smartphone: Effects Of Its Experimentation In High School Physical Education	Gomez Garcia et al	2015	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
Teaching-Learning In The Physical Education Classs	Garcia Pena et al	2018	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
An Intervention to Improve Teachers' Interpersonally Involving Instructional Practices in High School Physical Education: Implications for Student Relatedness Support and In-Class Experiences	Sparks et al	2017	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)

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Teacher And Administrative Opinions On Physical Education Course Efficiency In Ib-Pyp Applied Schools In Ankara	Bulut et al	2018	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
Improving children's physical self-perception through a school-based physical activity intervention: The Move for Well-being in School study	Christiansen et al	2018	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
The Co-Construction of Cooperative Learning in Physical Education With Elementary Classroom Teachers	Dyson et al	2016	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
Aerobic Gymnastics On Kangoo-Jumps Boots And Its Impact On Students' Fitness	Germina et al	2015	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
Assessment of the Sport Schools program: Body composition, physical activity and cardiorespiratory fitness in adolescents	Grao-Cruces et al	2015	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
A school-based physical activity intervention to promote motor proficiency among adolescent girls: A randomized controlled trial	Hajihosseini et al	2016	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
Acute effects of reducing sitting time in adolescents: a randomized cross-over study	Penning et al	2017	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
One-year changes in physical activity and sedentary behavior among adolescents: The Croatian Physical Activity in Adolescence Longitudinal Study (CRO-PALS)	Stefan et al	2018	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
Effects of a Participatory School-Based Intervention on Students' Health-Related Knowledge and Understanding	Strobl et al	2020	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
Physical activity in physical education: are longer lessons better?	Smith et al	2015	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)

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Investigating Children's Short-Term Responses to Imposed or Restricted Physical Activity	Ridgers et al	2018	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
Mapping physical education teachers’ professional learning and impacts on pupil learning in a community of practice in South Korea	Yoon et al	2017	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
Manipulation of the task constraints in Physical Education: A proposal from nonlinear pedagogy	Arias et al	2016	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
Assessing the Implementation Fidelity of a School-Based Teaching Personal and Social Responsibility Program in Physical Education and Other Subject Areas	Escartí et al	2018	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
Off-Balance: The Integration of Physical Education Content Learning and Irish Language Learning in English-Medium Primary Schools in Ireland	Ní Chróinín et al	2016	Exclusion reason: stage 1 - Wrong intervention (e.g., social inclusion)
'Maths on the move': Effectiveness of physically-active lessons for learning maths and increasing physical activity in primary school students	Vetter et al	2020	Exclusion reason: stage 1 - Wrong outcome(s)
Relationship Between Teacher Fidelity and Physical Education Student Outcomes	Loflin et al	2015	Exclusion reason: stage 1 - Wrong outcome(s)
The effectiveness of an Autonomy-Supportive Teaching Structure in Physical Education.	How Yew et al	2016	Exclusion reason: stage 1 - Wrong outcome(s)
Building healthy communities: A comprehensive school health program to prevent obesity in elementary schools	Centeio et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)
Active Learning Increases Children's Physical Activity across Demographic Subgroups	Bartholomew et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)
School-based intervention on healthy behaviour among Ecuadorian adolescents: effect of a cluster-randomized controlled trial on screen-time	Andrade et al	2015	Exclusion reason: stage 1 - Wrong outcome(s)
Effectiveness and Cost-Effectiveness of daily School Sport in the Primary School - Project "fit for pisa"	Liersch et al	2015	Exclusion reason: stage 1 - Wrong outcome(s)
Implementation practices of the Rugby-5 into the physical education of schoolchildren 12-13 years old using information technology	Ashanin et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)

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Program Reach and Implementation Feasibility of a Physical Activity School Health Program: A Qualitative Study of Teachers' Perception	Guldager et al	2019	Exclusion reason: stage 1 - Wrong outcome(s)
Team-teaching in physical education for promoting coordinative motor skills in children: the more you invest the more you get	Bardaglio et al	2015	Exclusion reason: stage 1 - Wrong outcome(s)
The outcomes of health-promoting communities: Being active eating well initiative- A community-based obesity prevention intervention in Victoria, Australia	Bolton et al	2017	Exclusion reason: stage 1 - Wrong outcome(s)
Positive Impact on Physical Activity and Health Behaviour Changes of a 15-Week Family Focused Intervention Program: "juniors for Seniors"	Bronikowski et al	2016	Exclusion reason: stage 1 - Wrong outcome(s)
Supporting active school travel: A qualitative analysis of implementing a regional safe routes to school program	Buttazzoni et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)
School-Based Obesity Intervention Associated with Three Year Decrease in Student Weight Status in a Low-Income School District	Cadzow et al	2015	Exclusion reason: stage 1 - Wrong outcome(s)
School Physical Activity Programming and Gross Motor Skills in Children	Burns et al	2017	Exclusion reason: stage 1 - Wrong outcome(s)
Satisfaction in the Physical Education classroom and intention to be physically active in Primary school children	Enríquez et al	2020	Exclusion reason: stage 1 - Wrong outcome(s)
Physical activity school intervention: context matters	Guldager et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)
Promoting Healthy Lifestyle Behaviour through the Life-Orientation Curriculum: Teachers' Perceptions of the HealthKick Intervention	Hill et al	2015	Exclusion reason: stage 1 - Wrong outcome(s)
Using the critical incident technique for qualitative process evaluation of interventions: The example of the "Let's Move It" trial	Kostamo et al	2019	Exclusion reason: stage 1 - Wrong outcome(s)
Voices from Pupil Participation in the Health Promotion Intervention "Pulse for Learning and Health PuLH " in Primary and Middle School	Lindgren et al	2019	Exclusion reason: stage 1 - Wrong outcome(s)
A Preliminary Evaluation of a Cost-effective, In-class Physical Activity and Nutrition Education Intervention for 3rd through 6th Grade Students	Mouttapa et al	2016	Exclusion reason: stage 1 - Wrong outcome(s)
Implementing and Evaluating Environmental and Policy Interventions for Promoting Physical Activity in Rural Schools	Baker et al	2017	Exclusion reason: stage 1 - Wrong outcome(s)
Prospective effects of pedometer use and class competitions on physical activity in youth: A cluster-randomized controlled trial	Suchert et al	2015	Exclusion reason: stage 1 - Wrong outcome(s)

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CDC childhood physical activity strategies fail to show sustained fitness impact in middle school children	Seibert et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)
An intervention to promote physical activity in Mexican elementary school students: building public policy to prevent noncommunicable diseases	Polo-Oteyza et al	2017	Exclusion reason: stage 1 - Wrong outcome(s)
School-based systems change for obesity prevention in adolescents: outcomes of the Australian Capital Territory 'It's Your Move!'	Malakellis et al	2017	Exclusion reason: stage 1 - Wrong outcome(s)
A stepped-wedge implementation and evaluation of the healthy active peaceful playgrounds for youth (HAPPY) intervention	Dudley et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)
Implementation of the HealthKick intervention in primary schools in low-income settings in the Western Cape Province, South Africa: a process evaluation	de Villiers et al	2015	Exclusion reason: stage 1 - Wrong outcome(s)
'No one ever asked us': a feasibility study assessing the co-creation of a physical activity programme with adolescent girls	Corr et al	2019	Exclusion reason: stage 1 - Wrong outcome(s)
Initial experience with the Sport Education model in primary school first-grade. Students and teachers' perceptions	de Ojeda et al	2019	Exclusion reason: stage 1 - Wrong outcome(s)
Evaluation of a pilot school-based physical activity challenge for primary students	Passmore et al	2017	Exclusion reason: stage 1 - Wrong outcome(s)
The Positive Effects of a Combined Program of Creative Dance and BrainDance on Health-Related Quality of Life as Perceived by Primary School Students	Olga et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)
Understanding the Importance of Context: A Qualitative Study of a Location-Based Exergame to Enhance School Childrens Physical Activity	Robertson et al	2016	Exclusion reason: stage 1 - Wrong outcome(s)
Playing Fair: The Contribution of High-Functioning Recess to Overall School Climate in Low-Income Elementary Schools	London et al	2015	Exclusion reason: stage 1 - Wrong outcome(s)
Effects of Generalization of Engagement in Parkour from Physical Education to Recess on Physical Activity	Coolkens et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)
Bilingual physical education: the effects of CLIL on physical activity levels	Salvador-García et al	2019	Exclusion reason: stage 1 - Wrong outcome(s)
An Evaluation of an Unstructured and Structured Approach to Increasing Recess Physical Activity	Behrens et al	2019	Exclusion reason: stage 1 - Wrong outcome(s)
Effectiveness Of A School-Based Multicomponent Intervention On Nutritional Status Among Primary School Children In Bangkok, Thailand	Chawla et al	2017	Exclusion reason: stage 1 - Wrong outcome(s)

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Effectiveness of the Sport Education Fitness Model on Fitness Levels, Knowledge, and Physical Activity	Pritchard et al	2015	Exclusion reason: stage 1 - Wrong outcome(s)
Effectiveness of a school-based program focusing on diet and health habits taught through physical exercise	Pablos et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)
School-Based Health Promotion Initiative Increases Children's Physical Activity	Cluss et al	2016	Exclusion reason: stage 1 - Wrong outcome(s)
Improvements in fundamental movement skill competency mediate the effect of the SCORES intervention on physical activity and cardiorespiratory fitness in children	Cohen et al	2015	Exclusion reason: stage 1 - Wrong outcome(s)
The Effect of Organized Versus Supervised Recess on Elementary School Children's Participation, Physical Activity, Play, and Social Behavior: A Cluster Randomized Controlled Trial	Coolkens et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)
Long-term effects of physically active academic lessons on physical fitness and executive functions in primary school children	de Greeff et al	2016	Exclusion reason: stage 1 - Wrong outcome(s)
Sport Education model effects in the social climate classroom, perceived competence and intent to be physically active: an extended study in primary education	de Ojeda Perez et al	2016	Exclusion reason: stage 1 - Wrong outcome(s)
Targeting the Body and the Mind: Evaluation of a P.E. Curriculum Intervention for Adolescents	Loukaitou-Sideris et al	2015	Exclusion reason: stage 1 - Wrong outcome(s)
Twelve-Month Effects of the COPE Healthy Lifestyles TEEN Program on Overweight and Depressive Symptoms in High School Adolescents	Melnyk et al	2015	Exclusion reason: stage 1 - Wrong outcome(s)
The daily mile: Teachers' perspectives of the barriers and facilitators to the delivery of a school-based physical activity intervention	Malden et al	2019	Exclusion reason: stage 1 - Wrong outcome(s)
Teachers' and students' perspectives of participating in the 'Active Classrooms' movement integration programme	Martin et al	2017	Exclusion reason: stage 1 - Wrong outcome(s)
Increasing physical activity levels in primary school physical education: The SHARP Principles Model	Powell et al	2016	Exclusion reason: stage 1 - Wrong outcome(s)
The Personal and Social Responsibility Model to Enhance Innovation in Physical Education	Prat et al	2019	Exclusion reason: stage 1 - Wrong outcome(s)
Teacher perceptions on the delivery and implementation of movement integration strategies: The CLASS PAL (Physically Active Learning) Programme	Routen et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)
Promoting Healthy Lifestyles to Children at School: Using a Multidisciplinary Train-the-Trainer Approach	Sanders et al	2015	Exclusion reason: stage 1 - Wrong outcome(s)

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Implementation of brain breaks in the classroom and effects on attitudes toward physical activity in a macedonian school setting	Popeska et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)
Impacts of an intervention to reduce sedentary behaviour on measures of obesity in primary school children: A cluster controlled study	Loosemore et al	2019	Exclusion reason: stage 1 - Wrong outcome(s)
"I want to do it all day!"-Students' experiences of classroom movement integration	McMullen et al	2019	Exclusion reason: stage 1 - Wrong outcome(s)
"I Just Like the Feeling of It, Outside Being Active": Pupils' Experiences of a School-Based Running Program, a Qualitative Study	Chalkley et al	2020	Exclusion reason: stage 1 - Wrong outcome(s)
'FIFA 11 for Health' for Europe. 1: effect on health knowledge and well-being of 10-to 12-year-old Danish school children	Fuller et al	2017	Exclusion reason: stage 1 - Wrong outcome(s)
Effects of a school based intervention to promote healthy habits in children 8-11 years old, living in the lowland area of Bologna Local Health Unit	Sacchetti et al	2015	Exclusion reason: stage 1 - Wrong outcome(s)
Effects of a futsal periodized program on physical fitness of female students of 13 and 14 years of age	Fiorante et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)
Effectiveness of Secondary School Conceptual Physical Education: A 20-Year Longitudinal Study	Kulinna et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)
Effectiveness of a School Based Intervention for Prevention of Non-communicable Diseases in Middle School Children of Rural North India: A Randomized Controlled Trial	Saraf et al	2015	Exclusion reason: stage 1 - Wrong outcome(s)
Effectiveness of a Playground Intervention for Antisocial, Prosocial, and Physical Activity Behaviors	Mayfield et al	2017	Exclusion reason: stage 1 - Wrong outcome(s)
Effectiveness of a 5-year school-based intervention programme to reduce adiposity and improve fitness and lifestyle in Indian children; the SYM-KEM study	Bhave et al	2016	Exclusion reason: stage 1 - Wrong outcome(s)
Effectiveness evaluation of a health promotion programme in primary schools: a cluster randomised controlled trial	Grillich et al	2016	Exclusion reason: stage 1 - Wrong outcome(s)
Effective implementation of primary school-based healthy lifestyle programmes: a qualitative study of views of school staff	Day et al	2019	Exclusion reason: stage 1 - Wrong outcome(s)
Effect of an Elementary School Walking Program on Physical Activity and Classroom Behavior	Lassiter et al	2019	Exclusion reason: stage 1 - Wrong outcome(s)
Disseminating Evidence-Based Physical Education Practices in Rural Schools: The San Luis Valley Physical Education Academy	Belansky et al	2016	Exclusion reason: stage 1 - Wrong outcome(s)

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Assessing the Wider Implementation of the SHARP Principles: Increasing Physical Activity in Primary Physical Education	Powell et al	2020	Exclusion reason: stage 1 - Wrong outcome(s)
An innovative school-based intervention to promote healthy lifestyles	Piana et al	2017	Exclusion reason: stage 1 - Wrong outcome(s)
Adolescents' perspectives on a school-based physical activity intervention: A mixed method study	Jong et al	2020	Exclusion reason: stage 1 - Wrong outcome(s)
Project FIT: A School, Community and Social Marketing Intervention Improves Healthy Eating Among Low-Income Elementary School Children	Alaimo et al	2015	Exclusion reason: stage 1 - Wrong outcome(s)
Feasibility of breaking up sitting time in mainstream and special schools with a cognitively challenging motor task	Mazzoli et al	2019	Exclusion reason: stage 1 - Wrong outcome(s)
Implementation of an intervention program with physical activity and healthy diet for health promotion at school: A possible challenge	Tkac et al	2017	Exclusion reason: stage 1 - Wrong outcome(s)
The effects of an enhanced quality Physical Education programme on the physical activity levels of Grade 7 learners in Potchefstroom, South Africa	Tian et al	2017	Exclusion reason: stage 1 - Wrong outcome(s)
Long-term follow-up on biological risk factors, adiposity, and cardiorespiratory fitness development in a physical education intervention: a natural experiment (CHAMPS-study DK)	Tarp et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)
Process evaluation of a pilot multi-component physical activity intervention - active schools: Skelmersdale	Taylor et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)
Project SoL-A community-based, multi-component health promotion intervention to improve eating habits and physical activity among Danish families with young children. Part 1: Intervention development and implementation	Toft et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)
Implementation of KEIGAAF in Primary Schools: A Mutual Adaptation Physical Activity and Nutrition Intervention	Verjans-Janssen et al	2020	Exclusion reason: stage 1 - Wrong outcome(s)
A retrospective qualitative evaluation of barriers and facilitators to the implementation of a school-based running programme	Chalkley et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)
Barriers and facilitators to the implementation of a school-based physical activity policy in Canada: application of the theoretical domains framework	Weatherson et al	2017	Exclusion reason: stage 1 - Wrong outcome(s)
A Mixed Methods Study to Examine the Influence of CLIL on Physical Education Lessons: Analysis of Social Interactions and Physical Activity Levels	Salvador-Garcia et al	2020	Exclusion reason: stage 1 - Wrong outcome(s)

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A Pilot Intervention Using Gamification to Enhance Student Participation in Classroom Activity Breaks	Beemer et al	2019	Exclusion reason: stage 1 - Wrong outcome(s)
Negotiating the Daily Mile Challenge; looking-like a walking break from the classroom	Ward et al	2019	Exclusion reason: stage 1 - Wrong outcome(s)
An Exploratory Study of Elementary Classroom Teachers' Physical Activity Promotion From a Social Learning Perspective	Webster et al	2015	Exclusion reason: stage 1 - Wrong outcome(s)
Building school-based cardiovascular health promotion capacity in youth: a mixed methods study	Woodgate et al	2015	Exclusion reason: stage 1 - Wrong outcome(s)
Predicting physical exercise changes in Chinese rural adolescents: the application of the health action process approach model	Xu et al	2019	Exclusion reason: stage 1 - Wrong outcome(s)
Impact evaluation of educational-motivational intervention "Como Jugando" to prevent obesity in school children of Cercado de Lima: results in the first year	Aparco et al	2017	Exclusion reason: stage 1 - Wrong outcome(s)
Transferring primary generalists' positive classroom pedagogy to the physical education setting: a collaborative PE-CPD process	Morgan et al	2019	Exclusion reason: stage 1 - Wrong outcome(s)
Qualitative Evaluation Of A School Intervention For The Promotion Of Physical Activity: Learning From The Perspective Of The Target Population	Javier Beltran-Carrillo et al	2017	Exclusion reason: stage 1 - Wrong outcome(s)
Improvement in game performance and adherence after an aligned TGfU floorball unit in physical education	MoralesBelando et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)
Project Energize: intervention development and 10 years of progress in preventing childhood obesity	Rush et al	2016	Exclusion reason: stage 1 - Wrong outcome(s)
The Daily Mile: What factors are associated with its implementation success?	Ryde et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)
Promoting motor skills in low-income, ethnic children: The Physical Activity in Linguistically Diverse Communities (PALDC) nonrandomized trial	Okely et al	2017	Exclusion reason: stage 1 - Wrong outcome(s)
The effect of the implementation of a planned peer group session model on obesity prevention among students of an integrated islamic primary school in Makassar	Hadi et al	2019	Exclusion reason: stage 1 - Wrong outcome(s)
A Self-determination theory based intervention to promote healthy eating and physical activity in school-aged children.	Girelli et al	2016	Exclusion reason: stage 1 - Wrong outcome(s)
A School-Based Motivational Intervention to Promote Physical Activity from a Self-Determination Theory Perspective	González-Cutre et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)

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Enhancing Physical Education with Exergames and Wearable Technology	Lindberg et al	2016	Exclusion reason: stage 1 - Wrong outcome(s)
Effectiveness of a school-based program to prevent obesity	Perez Solis et al	2015	Exclusion reason: stage 1 - Wrong outcome(s)
Study and promotion of healthy eating habits and physical activity among Spanish adolescents: TAS program (you and Alicia for health)	Pareja Sierra et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)
A quasi-experimental examination of how school-based physical activity changes impact secondary school student moderate- to vigorous- intensity physical activity over time in the COMPASS study	Hunter et al	2016	Exclusion reason: stage 1 - Wrong outcome(s)
When mathematics meets physical activity in the school-aged child: The effect of an integrated motor and cognitive approach to learning geometry	Hraste et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)
Effects of the COPE Cognitive Behavioral Skills Building TEEN Program on the Healthy Lifestyle Behaviors and Mental Health of Appalachian Early Adolescents	Hoying et al	2016	Exclusion reason: stage 1 - Wrong outcome(s)
Effects of a sports-oriented primary school on students' physical literacy and cognitive performance	Demetriou et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)
Sport education model versus traditional model: effects on motivation and sportsmanship	Mendez-Gimenez et al	2015	Exclusion reason: stage 1 - Wrong outcome(s)
Evaluation of an Intervention to Increase Physical Activity in Low-Income, Urban Middle Schools	Gill et al	2019	Exclusion reason: stage 1 - Wrong outcome(s)
The effects of introducing Tabata interval training and stability exercises to school children as a school-based intervention program	Ekstrom et al	2019	Exclusion reason: stage 1 - Wrong outcome(s)
A Physical Activity Intervention and Changes in Body Mass Index at a Middle School With a Large American Indian Population, Oklahoma, 2004-2009	Eichner et al	2016	Exclusion reason: stage 1 - Wrong outcome(s)
The Effect of Music- and Video-Distraction on High School Physical Education Student Exercise Intensity	Higginson et al	2019	Exclusion reason: stage 1 - Wrong outcome(s)
The effect of nutritional and physical activity interventions on nutritional status and obesity in primary school children: A cluster randomized controlled study	Akdemir et al	2017	Exclusion reason: stage 1 - Wrong outcome(s)
Reducing Obesity in Students Everywhere (ROSE): A Brief, Interactive, School-Based Approach to Promoting Health	Alert et al	2015	Exclusion reason: stage 1 - Wrong outcome(s)
Barriers and facilitators to adoption, implementation and sustainment of obesity prevention interventions in schoolchildren- a DEDIPAC case study	Hayes et al	2019	Exclusion reason: stage 1 - Wrong outcome(s)

Title	Authors	Year	Exclusion reason
Physical education of students, considering their physical fitness level	Andres et al	2017	Exclusion reason: stage 1 - Wrong outcome(s)
Adiposity and response to an obesity prevention intervention in Pakistani and Bangladeshi primary school boys and girls: a secondary analysis using the BEACHeS feasibility study	Cezard et al	2016	Exclusion reason: stage 1 - Wrong outcome(s)
Effect of a 20-week physical activity intervention on selective attention and academic performance in children living in disadvantaged neighborhoods: A cluster randomized control trial	Gall et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)
One-Year Follow-up of the CAPO Kids Trial: Are Physical Benefits Maintained?	Nogueira et al	2017	Exclusion reason: stage 1 - Wrong outcome(s)
Effects of a brief physical activity program on young students' physical fitness	Hayes et al	2015	Exclusion reason: stage 1 - Wrong outcome(s)
Cluster randomised trial of a school-community child health promotion and obesity prevention intervention: findings from the evaluation of fun 'n healthy in Moreland!	Waters et al	2017	Exclusion reason: stage 1 - Wrong outcome(s)
Virtual field trips as physically active lessons for children: a pilot study	Norris et al	2015	Exclusion reason: stage 1 - Wrong outcome(s)
Examining the impact of a province-wide physical education policy on secondary students' physical activity as a natural experiment	Hobin et al	2017	Exclusion reason: stage 1 - Wrong outcome(s)
The effect of a two-year school-based daily physical activity intervention on a clustered CVD risk factor score-The Sogndal school-intervention study	Resaland et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)
Effects of a School-Based Pedometer Intervention in Adolescents: 1-Year Follow-Up of a Cluster-Randomized Controlled Trial	Isensee et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)
Effects of a Randomised Controlled School-Based Health Promotion Intervention on Obesity Related Behavioural Outcomes of Children with Migration Background	Kobel et al	2017	Exclusion reason: stage 1 - Wrong outcome(s)
Food, Health, & Choices: Curriculum and Wellness Interventions to Decrease Childhood Obesity in Fifth-Graders	Koch et al	2019	Exclusion reason: stage 1 - Wrong outcome(s)
A professional development system to optimize the implementation of a daily physical activity program in a school setting	Beaudoin et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)
Lessons learned from the AFLY5 RCT process evaluation: implications for the design of physical activity and nutrition interventions in schools	Jago et al	2015	Exclusion reason: stage 1 - Wrong outcome(s)
Long term effect of a school based intervention to prevent chronic diseases in Tunisia, 2009-2015	Ghammam et al	2017	Exclusion reason: stage 1 - Wrong outcome(s)

Title	Authors	Year	Exclusion reason
Does health promotion in primary schools work? A randomized waiting list control group study for the Klasse2000 program	Kolip et al	2017	Exclusion reason: stage 1 - Wrong outcome(s)
Active breaks to improve class attention: Educational Interventions	Suarez-Manzano et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)
Exploring the use of a gamified intervention for encouraging physical activity in adolescents: A qualitative longitudinal study in Northern Ireland	Corepal et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)
Effect of an obesity prevention program focused on motivating environments in childhood: a school-based prospective study	Yang et al	2017	Exclusion reason: stage 1 - Wrong outcome(s)
Implementing School-Based Policies to Prevent Obesity: Cluster Randomized Trial	Ickovics et al	2019	Exclusion reason: stage 1 - Wrong outcome(s)
Effects of an Integrated Health Care Program for Children	Kim et al	2017	Exclusion reason: stage 1 - Wrong outcome(s)
The Viennese Prevention Study (EDDY): initial results	Poeppelmeyer et al	2016	Exclusion reason: stage 1 - Wrong outcome(s)
Evaluation of Let's Move! active schools activation grants	Miller et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)
Evaluation of a classroom movement integration training delivered in a low socioeconomic school district	Stewart et al	2019	Exclusion reason: stage 1 - Wrong outcome(s)
Using Family-Focused Garden, Nutrition, and Physical Activity Programs To Reduce Childhood Obesity: The Texas! Go! Eat! Grow! Pilot Study	Spears-Lanoix et al	2015	Exclusion reason: stage 1 - Wrong outcome(s)
System-Activity Approach Implemented At Physical Education Lessons	Sinyavsky et al	2015	Exclusion reason: stage 1 - Wrong outcome(s)
"“FIFA 11 for Health” for Europe in the Faroe Islands: Effects on health markers and physical fitness in 10-to 12-year-old schoolchildren."	Skoradal et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)
Effectiveness of a creative physical education intervention on elementary school students' leisure-time physical activity motivation and overall physical activity in Finland	Kokkonen et al	2019	Exclusion reason: stage 1 - Wrong outcome(s)
Professional Development for Increased Classroom-based Physical Activity: Elements and Strategies to Reduce Barriers and Facilitate Implementation	O'Hara Tompkins et al	2019	Exclusion reason: stage 1 - Wrong outcome(s)
Promoting physical activity with a school-based dance mat exergaming intervention: qualitative findings from a natural experiment	Burges Watson et al	2016	Exclusion reason: stage 1 - Wrong outcome(s)

Title	Authors	Year	Exclusion reason
The daily mile: 15 minutes running improves the physical fitness of italian primary school children	Brustio et al	2019	Exclusion reason: stage 1 - Wrong outcome(s)
Association of a behaviorally based high school health education curriculum with increased exercise	Annesi et al	2015	Exclusion reason: stage 1 - Wrong outcome(s)
The effects of autonomy support in physical education classes	Antonio Moreno-Murcia et al	2016	Exclusion reason: stage 1 - Wrong outcome(s)
Effect of a multidimensional physical activity intervention on body mass index, skinfolds and fitness in south african children: Results from a cluster-randomised controlled trial	Muller et al	2019	Exclusion reason: stage 1 - Wrong outcome(s)
Effectiveness Of Yoga-Aerobic Means' Application In Physical Education Of Primary School Pupils	Mykhno et al	2016	Exclusion reason: stage 1 - Wrong outcome(s)
Case study of a health optimizing physical education-based comprehensive school physical activity program	Egan et al	2019	Exclusion reason: stage 1 - Wrong outcome(s)
Actions of the School Health Program and school meals in the prevention of childhood overweight: experience in the municipality of Itapevi, Sao Paulo State, Brazil, 2014	Alves Batista et al	2017	Exclusion reason: stage 1 - Wrong outcome(s)
A prevention program for multiple health-compromising behaviors in adolescence: Baseline results from a cluster randomized controlled trial	Allara et al	2015	Exclusion reason: stage 1 - Wrong outcome(s)
Effects of a prevention program on multiple health-compromising behaviours in adolescence: A cluster randomized controlled trial	Allara et al	2019	Exclusion reason: stage 1 - Wrong outcome(s)
Teachers' Training and Involvement in School Health Programme in Oyo State, Southwest Nigeria	Adebayo et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)
Implementation practices in school health promotion: findings from an Austrian multiple-case study	Adamowitsch et al	2017	Exclusion reason: stage 1 - Wrong outcome(s)
Improving students' predisposition towards physical education by optimizing their motivational processes in an acrosport unit	Abós et al	2017	Exclusion reason: stage 1 - Wrong outcome(s)
Executive Function, Behavioral Self-Regulation, and School Related Well-Being Did Not Mediate the Effect of School-Based Physical Activity on Academic Performance in Numeracy in 10-Year-Old Children. The Active Smarter Kids (ASK) Study	Aadland et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)
Physically Active Math and Language Lessons Improve Academic Achievement: A Cluster Randomized Controlled Trial	Mullender-Wijnsma et al	2016	Exclusion reason: stage 1 - Wrong outcome(s)
Implementation of triple the time spent on physical education in pre-school to 6th grade: A qualitative study from the programme managers' perspective	Nielsen et al	2018	Exclusion reason: stage 1 - Wrong outcome(s)

Title	Authors	Year	Exclusion reason
Implementation of a successful long-term school based physical education intervention: Exploring provider and programme characteristics	Nielsen et al	2019	Exclusion reason: stage 1 - Wrong outcome(s)
Stage 2 (n=98)			
Two-year process evaluation of a pilot program to increase elementary children's physical activity during school	Webster et al	2018	Exclusion reason: stage 2 - feasibility/pilot
Partnerships for active elementary schools: Physical education outcomes after 4 months of a 2-year pilot study	Weaver et al	2017	Exclusion reason: stage 2 - feasibility/pilot
Partnerships for Active Children in Elementary Schools: Outcomes of a 2-Year Pilot Study to Increase Physical Activity During the School Day	Weaver et al	2018	Exclusion reason: stage 2 - feasibility/pilot
An Intervention to Increase Students' Physical Activity: A 2-Year Pilot Study	Weaver et al	2018	Exclusion reason: stage 2 - feasibility/pilot
Initial Outcomes of a Participatory-Based, Competency-Building Approach to Increasing Physical Education Teachers' Physical Activity Promotion and Students' Physical Activity: A Pilot Study	Weaver et al	2018	Exclusion reason: stage 2 - feasibility/pilot
Process evaluation of a classroom active break (ACTI-BREAK) program for improving academic-related and physical activity outcomes for students in years 3 and 4	Watson et al	2019	Exclusion reason: stage 2 - feasibility/pilot
A pilot primary school active break program (ACTI-BREAK): Effects on academic and physical activity outcomes for students in Years 3 and 4	Watson et al	2019	Exclusion reason: stage 2 - feasibility/pilot
The UP4FUN Intervention Effect on Breaking Up Sedentary Time in 10- to 12-Year-Old Belgian Children: The ENERGY Project	Verloigne et al	2015	Exclusion reason: stage 2 - feasibility/pilot
Evaluation of a pilot school-based physical activity clustered randomised controlled trial-active schools: Skelmersdale	Taylor et al	2018	Exclusion reason: stage 2 - feasibility/pilot
Acceptability and Feasibility of Single-Component Primary School Physical Activity Interventions to Inform the AS:Sk Project	Taylor et al	2018	Exclusion reason: stage 2 - feasibility/pilot
Effects of the Quest to Lava Mountain Computer Game on Dietary and Physical Activity Behaviors of Elementary School Children: A Pilot Group-Randomized Controlled Trial	Sharma et al	2015	Exclusion reason: stage 2 - feasibility/pilot
The feasibility and acceptability of a primary school-based programme targeting diet and physical activity: The PhunkyFoods Programme	Sahota et al	2019	Exclusion reason: stage 2 - feasibility/pilot

Title	Authors	Year	Exclusion reason
Healthy for life pilot study: A multicomponent school and home based physical activity intervention for disadvantaged children	Pearce et al	2019	Exclusion reason: stage 2 - feasibility/pilot
Evaluation of an intervention to reduce adolescent sitting time during the school day: The 'stand Up for Health' randomised controlled trial	Parrish et al	2018	Exclusion reason: stage 2 - feasibility/pilot
Feasibility and Preliminary Efficacy of a Teacher-Facilitated High-Intensity Interval Training Intervention for Older Adolescents	Leahy et al	2019	Exclusion reason: stage 2 - feasibility/pilot
Randomised controlled feasibility study of a school-based multi-level intervention to increase physical activity and decrease sedentary behaviour among vocational school students	Hankonen et al	2017	Exclusion reason: stage 2 - feasibility/pilot
Introducing physically active lessons in UK secondary schools: Feasibility study and pilot cluster-randomised controlled trial	Gammon et al	2019	Exclusion reason: stage 2 - feasibility/pilot
The Daily Mile makes primary school children more active, less sedentary and improves their fitness and body composition: A quasi-experimental pilot study	Chesham et al	2018	Exclusion reason: stage 2 - feasibility/pilot
Feasibility study and pilot cluster-randomised controlled trial of the GoActive intervention aiming to promote physical activity among adolescents: outcomes and lessons learnt	Corder et al	2016	Exclusion reason: stage 2 - feasibility/pilot
Stand Out in Class: restructuring the classroom environment to reduce sitting time - findings from a pilot cluster randomised controlled trial	Clemes et al	2020	Exclusion reason: stage 2 - feasibility/pilot
A Pilot School Sports Program in a Remote Canadian First Nation: Evaluation of Process and Outcomes	Gates et al	2016	Exclusion reason: stage 2 - feasibility/pilot
Implementing a Nutrition and Physical Activity Curriculum in Head Start Through an Academic-Community Partnership	Zahnd et al	2017	Exclusion reason: stage 2 - not an RCT
Teaching Games for Understanding Intervention to Promote Physical Activity among Secondary School Students	Wang et al	2018	Exclusion reason: stage 2 - not an RCT
Process evaluation of the IDEFICS school intervention: Putting the evaluation of the effect on children's objectively measured physical activity and sedentary time in context	Verloigne et al	2015	Exclusion reason: stage 2 - not an RCT
Effectiveness of the IDEFICS intervention on objectively measured physical activity and sedentary time in European children	Verbestel et al	2015	Exclusion reason: stage 2 - not an RCT
Effect of Integrated Physical Activities with Mathematics on Objectively Assessed Physical Activity	Vazou et al	2018	Exclusion reason: stage 2 - not an RCT
Implemented or not implemented? Process evaluation of the school-based obesity prevention program DOiT and associations with program effectiveness	van Nassau et al	2016	Exclusion reason: stage 2 - not an RCT

Title	Authors	Year	Exclusion reason
"... because there's nobody who can just sit that long."	Stylianou et al	2016	Exclusion reason: stage 2 - not an RCT
Teacher Fidelity to a Physical Education Curricular Model and Physical Activity Outcomes	Stylianou et al	2016	Exclusion reason: stage 2 - not an RCT
Purposeful Movement: The Integration of Physical Activity into a Mathematics Unit	Snyder et al	2017	Exclusion reason: stage 2 - not an RCT
Impact of a classroom standing desk intervention on daily objectively measured sedentary behavior and physical activity in youth	Silva et al	2018	Exclusion reason: stage 2 - not an RCT
Can High Schools Be an Effective Setting to Promote Healthy Lifestyles? Effects of a Multiple Behavior Change Intervention in Adolescents	Sevil et al	2019	Exclusion reason: stage 2 - not an RCT
Changes in physical activity, physical fitness and well-being following a school-based health promotion program in a Norwegian region with a poor public health profile: A non-randomized controlled study in early adolescents	Schmidt et al	2020	Exclusion reason: stage 2 - not an RCT
An Evaluation of a Video-based Physical Activity Intervention in the Classrooms of Elementary Schoolchildren	Schmidt et al	2017	Exclusion reason: stage 2 - not an RCT
Students' physical activity and teachers' motivational styles in physical education	Rupprich et al	2016	Exclusion reason: stage 2 - not an RCT
Skipping Hearts Goes to School: Short-Term Effects. / Skipping Hearts macht Schule: Kurzzeiteffekte des Projekts	Postler et al	2017	Exclusion reason: stage 2 - not an RCT
Using the RE-AIM framework to evaluate a school-based municipal programme tripling time spent on PE	Nielsen et al	2018	Exclusion reason: stage 2 - not an RCT
A mixed-methods exploration of implementation of a comprehensive school healthy eating model one year after scale-up	Naylor et al	2016	Exclusion reason: stage 2 - not an RCT
Effects of the 3-year Sigue la Huella intervention on sedentary time in secondary school students	Murillo Pardo et al	2015	Exclusion reason: stage 2 - not an RCT
Improving academic performance of school-age children by physical activity in the classroom: 1-year program evaluation	Mullender-Wijnsma et al	2015	Exclusion reason: stage 2 - not an RCT
Preliminary findings of Active Classrooms: An intervention to increase physical activity levels of primary school children during class time	Martin et al	2015	Exclusion reason: stage 2 - not an RCT
Teacher Physical Education Practices and Student Outcomes in a Sample of Middle Schools Participating in the Presidential Youth Fitness Program	Lucas et al	2019	Exclusion reason: stage 2 - not an RCT

Title	Authors	Year	Exclusion reason
The effects of teacher fidelity of implementation of pathways to health on student outcomes	Little et al	2015	Exclusion reason: stage 2 - not an RCT
Process Evaluation of an Early Care and Education Intervention: The California Childhood Obesity Research Demonstration Study (CA-CORD)	Lin et al	2020	Exclusion reason: stage 2 - not an RCT
Results of a 3-year, nutrition and physical activity intervention for children in rural, low-socioeconomic status elementary schools	King et al	2015	Exclusion reason: stage 2 - not an RCT
Classroom standing desks and time-series variation in sedentary behavior and physical activity among primary school children	Kidokoro et al	2019	Exclusion reason: stage 2 - not an RCT
Increasing Physical Activity in Schools: Strategies for School Health Practitioners	Kelly et al	2019	Exclusion reason: stage 2 - not an RCT
The Role of Classroom Teacher Social Capital in a Comprehensive School Physical Activity Program	Jordan et al	2018	Exclusion reason: stage 2 - not an RCT
The effect of a curriculum-based physical activity intervention on accelerometer-assessed physical activity in schoolchildren: A non-randomised mixed methods controlled before-and-after study	Innerd et al	2019	Exclusion reason: stage 2 - not an RCT
Evaluation of a student participatory, low-intensity program to improve school wellness environment and students' eating and activity behaviors	Hoelscher et al	2016	Exclusion reason: stage 2 - not an RCT
Tactical Games Model and Its Effects on Student Physical Activity and Gameplay Performance in Secondary Physical Education	Hodges et al	2018	Exclusion reason: stage 2 - not an RCT
Gender and School-Level Differences in Students' Moderate and Vigorous Physical Activity Levels When Taught Basketball Through the Tactical Games Model	Harvey et al	2016	Exclusion reason: stage 2 - not an RCT
Evaluation of a School-Community Linked Physical Activity Intervention Targeting 7- to 12-Year-Olds: A Sociocultural Perspective	Griffiths et al	2019	Exclusion reason: stage 2 - not an RCT
Effect Of Spark On Physical Activity, Cardiorespiratory Endurance, And Motivation In Middle-school Students	Fu et al	2015	Exclusion reason: stage 2 - not an RCT
Young Children's School Day Sedentary Behavior and Physical Activity in Interactive versus Non-Interactive Active Video Games	Fu et al	2019	Exclusion reason: stage 2 - not an RCT
Academic-Based and Aerobic-Only Movement Breaks: Are There Differential Effects on Physical Activity and Achievement?	Fedewa et al	2018	Exclusion reason: stage 2 - not an RCT
Partnerships for Active Children in Elementary Schools (PACES): First year process evaluation	Egan et al	2018	Exclusion reason: stage 2 - not an RCT

Title	Authors	Year	Exclusion reason
The effect of the daily mile on primary school children's aerobic fitness levels after 12 weeks: A controlled trial	de Jonge et al	2020	Exclusion reason: stage 2 - not an RCT
The effect of an intervention on physical activity of moderate-and-vigorous intensity, and sedentary behavior during adolescents' time at school	Costa et al	2019	Exclusion reason: stage 2 - not an RCT
Involving the headteacher in the development of school-based health interventions: A mixed-methods outcome and process evaluation using the RE-AIM framework	Christian et al	2020	Exclusion reason: stage 2 - not an RCT
Impact of a Georgia elementary school-based intervention on physical activity opportunities: A quasi-experimental study	Cheung et al	2019	Exclusion reason: stage 2 - not an RCT
Implementing classroom physical activity breaks: Associations with student physical activity and classroom behavior	Carlson et al	2015	Exclusion reason: stage 2 - not an RCT
Contextual factors related to implementation of classroom physical activity breaks	Carlson et al	2017	Exclusion reason: stage 2 - not an RCT
School Day Classroom-Based Physical Activity and Sedentary Behavior	Calvert et al	2019	Exclusion reason: stage 2 - not an RCT
Classroom active breaks: a feasibility study in Southern Italy	Calella et al	2019	Exclusion reason: stage 2 - not an RCT
Effect of a Comprehensive School Physical Activity Program on School Day Step Counts in Children	Burns et al	2015	Exclusion reason: stage 2 - not an RCT
Can Fundamental Movement Skill Mastery Be Increased via a Six Week Physical Activity Intervention to Have Positive Effects on Physical Activity and Physical Self-Perception?	Bryant et al	2016	Exclusion reason: stage 2 - not an RCT
The Physical Activity Leader and Comprehensive School Physical Activity Program Effectiveness	Brusseau et al	2018	Exclusion reason: stage 2 - not an RCT
Physical activity patterns associated with a pedagogical intervention in six to eight year old children in an urban school	Briceno et al	2019	Exclusion reason: stage 2 - not an RCT
Effects of Music on Physical Activity Rates of Junior High School Physical Education Students	Brewer et al	2016	Exclusion reason: stage 2 - not an RCT
A program evaluation of an in-school daily physical activity initiative for children and youth	Bremer et al	2018	Exclusion reason: stage 2 - not an RCT
Impact of an Elementary School-Based Intervention on Physical Activity Time and Aerobic Capacity, Georgia, 2013-2014	Braun et al	2017	Exclusion reason: stage 2 - not an RCT

Title	Authors	Year	Exclusion reason
Evaluation of the dissemination of SNaX, a middle school-based obesity prevention intervention, within a large US school district	Bogart et al	2018	Exclusion reason: stage 2 - not an RCT
Using School Staff Members to Implement a Childhood Obesity Prevention Intervention in Low-Income School Districts: the Massachusetts Childhood Obesity Research Demonstration (MA-CORD Project), 2012-2014	Blaine et al	2017	Exclusion reason: stage 2 - not an RCT
Bridging Public Health and Education: Results of a School-Based Physical Activity Program to Increase Student Fitness	Barrett-Williams et al	2017	Exclusion reason: stage 2 - not an RCT
The Longitudinal Impact of NFL PLAY 60 Programming on Youth Aerobic Capacity and BMI	Bai et al	2017	Exclusion reason: stage 2 - not an RCT
Effects of "Fair Play Game" Strategy on Moderate to Vigorous Physical Activity in Physical Education	Azevedo et al	2016	Exclusion reason: stage 2 - not an RCT
The impact of height-adjustable desks and prompts to break-up classroom sitting on adolescents' energy expenditure, adiposity markers and perceived musculoskeletal discomfort	Ayala et al	2018	Exclusion reason: stage 2 - not an RCT
Impact of an 8-month trial using height-adjustable desks on children's classroom sitting patterns and markers of cardio-metabolic and musculoskeletal health	Ayala et al	2016	Exclusion reason: stage 2 - not an RCT
Children's segment specific light physical activity across two years of schoolbased program	Arto et al	2015	Exclusion reason: stage 2 - not an RCT
Development of an educational intervention to promote healthy eating and physical activity in Mexican school-age children	Amaya-Castellanos et al	2015	Exclusion reason: stage 2 - not an RCT
School and classroom effects on Daily Physical Activity (DPA) policy implementation fidelity in Ontario classrooms: a multi-level analysis	Allison et al	2018	Exclusion reason: stage 2 - not an RCT
The Patterns of Moderate to Vigorous Physical Activity and Physical Education Enjoyment Through a 2-Year School-Based Program.	Gråstén et al	2019	Exclusion reason: stage 2 - not an RCT
Children's segment specific moderate to vigorous physical activity through a school-initiated physical activity program	Gråstén et al	2015	Exclusion reason: stage 2 - not an RCT
Effectiveness of school-initiated physical activity program on secondary school students' physical activity participation	Grasten et al	2015	Exclusion reason: stage 2 - not an RCT
Children’s Physical Activity and On-Task Behavior Following Active Academic Lessons	Goh et al	2017	Exclusion reason: stage 2 - not an RCT

Title	Authors	Year	Exclusion reason
Impact of exergaming on young children's school day energy expenditure and moderate-to-vigorous physical activity levels	Gao et al	2017	Exclusion reason: stage 2 - not an RCT
Effects of active video games on children's psychosocial beliefs and school day energy expenditure	Gao et al	2019	Exclusion reason: stage 2 - not an RCT
Training teachers to implement physical activity: Applying social cognitive theory	Hivner et al	2019	Exclusion reason: stage 2 - not an RCT
The impact of 10-minute activity breaks outside the classroom on male students' on-task behaviour and sustained attention: A randomised crossover design	Wilson et al	2016	Exclusion reason: stage 2 - small scale study
Physical activity levels and motivational responses of boys and girls: A comparison of direct instruction and tactical games models of games teaching in physical education	Smith et al	2015	Exclusion reason: stage 2 - small scale study
Physical activity levels, game performance and friendship goals using two different pedagogical models: Sport Education and Direct Instruction	Rocamora et al	2019	Exclusion reason: stage 2 - small scale study
Impact of a Sustained TPSR Program on Students' Responsibility, Motivation, Sportsmanship, and Intention To Be Physically Active	Merino-Barrero et al	2020	Exclusion reason: stage 2 - small scale study
The influence of content knowledge on teaching and learning in Traditional and Sport Education contexts: an exploratory study	Iserbyt et al	2016	Exclusion reason: stage 2 - small scale study
Investigation of Pupils' Levels of MVPA and VPA During Physical Education Units Focused on Direct Instruction and Tactical Games Models	Harvey et al	2015	Exclusion reason: stage 2 - small scale study
Interdependent Group Contingency to Promote Physical Activity in Children	Foote et al	2017	Exclusion reason: stage 2 - small scale study
Effects of an Interdisciplinary Approach Integrating Mathematics and Physical Education on Mathematical Learning and Physical Activity Levels	Cecchini et al	2020	Exclusion reason: stage 2 - small scale study
Effects of Classroom-Based Energizers on Primary Grade Students' Physical Activity Levels	Bailey et al	2015	Exclusion reason: stage 2 - small scale study

Appendix 2.8. Table of descriptive characteristics of studies included in review

Study	Design	Intervention (student-targeted)	Participants (student)	Teacher role	PA measurement	SB measurement
Trial name [References] Lead author of publication Year of publication Country	Study design; level of randomisation (where applicable)	Intervention study duration School setting Number of schools at baseline Main aim of intervention PA/SB targeted in any non-school settings? (e.g., via homework/after-school club, parent engagement?) (yes/no)	Number of students at baseline Students' mean age: years (± SD) at baseline	Description of teacher role Training duration Any theory/rationale used to inform training? (yes/no) BCTs in intervention group (see Table 3 for further details) Quantitative fidelity data reported? (yes/no)	Eligible data reported Device used Cut points used PA intensity, units and outcome period selected for review PA follow-up time closest to intervention end-point	Eligible data reported Device used Cut points used SB outcome and period selected for review SB follow-up time closest to intervention end-point
ASK[1] Aadland et al 2019 Norway	Cluster RCT School level	7-month intervention Primary school setting 57 schools at baseline Aim: to create a number of varied PA activities that could be carried out in small groups and which encouraged an inclusive and joyful learning environment, generating an additional 165 mins/week of PA PA/SB targeted outside of school time - Yes	1,129 students at baseline Students' mean age: 10.2yrs (±0.3)	Teacher role: to implement physically active educational lessons (3 × 30 mins/week) in the subjects Norwegian, mathematics, and English, and PA breaks during classroom lessons (5 mins/school day) 60 hours of teacher training Any rationale/theory used to inform training? Yes - the competence motivation theory, the achievement goal theory, and the self-determination theory 3 BCTs identified ✓ Teacher fidelity data reported	✓ PA data reported Device used: ActiGraph Cut points: Evenson 2008 MVPA mins during school hours 7-month FU after baseline	✓ SB data reported Device used: ActiGraph Cut points: Evenson 2008 Sedentary mins during school hours 7-month FU after baseline

The West Midlands ActiVe lifestyle and healthy Eating in School children (WAVES)[2] Adab et al 2018 United Kingdom	Cluster RCT School level	12-month intervention Primary school setting 54 schools at baseline Aim: To prevent excess weight in primary school children PA/SB targeted outside of teacher period - Yes	1,397 students at baseline Students' mean age: 6.3yrs (±0.3)	Teacher role: to introduce daily opportunity for additional 30 mins of moderate to vigorous physical activity in bouts of >5 mins through classroom or playground routines, supervise class participation in a healthy lifestyle programme, and hand out two signposting sheets promoting physical activity and directing children/families to activity opportunities available in their local area 7 hours of teacher training Any rationale/theory used to inform training? No 3 BCTs identified ✓ Teacher fidelity data reported	✓ PA data reported Device used: Actiheart Cut points: WHO 1995 MVPA mins per day (any day, including weekends) 15-month FU after baseline	✓ SB data reported Device used: Actiheart Cut points: WHO 1995 Sedentary mins per day (any day, including weekends) 15-month FU after baseline
KIDS OUT![3] Aittasalo et al 2019 Finland	Cluster RCT School level	3-week intervention Secondary school setting 14 schools at baseline Aim: to promote physical activity and reduce screen time PA/SB targeted outside of school time - Yes	1,476 students at baseline Students' mean age: 13.9yrs (±0.5)	Teacher role: to integrate specific content on PA and SB into routinely scheduled three Health Education lessons with the help of educational material 1 hour of teacher training Any rationale/theory used to inform training? No 1 BCT identified ✓ Teacher fidelity data reported	X eligible PA data not reported	X eligible SB data not reported
Active for Life Year 5 (AFLY5)[4] Anderson et al	Cluster RCT School level	12-month intervention Primary school setting 60 schools at baseline	2,123 students at baseline Students' mean age: 9.5yrs (±0.3)	Teacher role: teachers were instructed to deliver 16 lessons, 10 of which had associated homework. 8.5 hours of teacher training	✓ PA data reported Device used: ActiGraph	✓ SB data reported Device used: ActiGraph

2016 United Kingdom		Aim: to increase physical activity, reduce sedentary behaviours and improve diet PA/SB targeted outside of school time - Yes		Any rationale/theory used to inform training? - Not reported 3 BCTs identified ✓ Teacher fidelity data reported	Cut points: Evenson 2008 MVPA mins per day (any day, including weekends) 12-month FU after baseline	Cut points: Evenson 2008 Sedentary mins per day (any day, including weekends) 12-month FU after baseline
Youth-Physical Activity Towards Health (Y-PATH)[5] Belton et al 2019 Ireland	Cluster RCT School level	24-month intervention Secondary school setting 20 schools at baseline Aim: a whole-school multi-component intervention programme, aimed at reducing the age-related decline of MVPA in adolescents PA/SB targeted outside of school time - Yes	490 students at baseline Students' mean age: 12.8yrs (±0.4)	Teacher role: teachers asked to change focus, direction and philosophy of delivery within exiting PE curriculum 4 hours of teacher training Any rationale/theory used to inform training? Yes - the Youth Physical Activity Promotion model, the Self-determination theory, and the socio-ecological model 3 BCTs identified X No eligible fidelity data reported	✓ PA data reported Device used: ActiGraph Cut points: Evenson 2008 MVPA mins per day (any day, including weekends) 24-month FU after baseline	X eligible SB data not reported
Sydney Playground Project[6] Bundy et al 2017 Australia	Cluster RCT School level	13-week intervention Primary school setting 12 schools at baseline Aim: to promote play through an intervention and using this process, enhance physical activity, social skills, and perceived competence/social acceptance of 5- to 7-year-old children in a school playground environment	221 students at baseline Students' mean age: 6.0yrs (±0.6)	Teacher role: to tolerate more risk during free play 2 hours of teacher training Any rationale/theory used to inform training? Yes - the International Classification of Functioning, Disability and Health was used as the broad basis for the study with the idea that changing the environment (social and physical) would change participating children's	✓ PA data reported Device used: ActiGraph Cut points: Evenson 2008 MVPA total counts during teacher period 13-week FU after baseline	✓ SB data reported Device used: ActiGraph Cut points: Evenson 2008 Sedentary mins during teacher period 13-week FU after baseline

		PA/SB targeted outside of school time - Yes		experiences. The social cognitive theory was used as a basis for the adult risk reframing intervention. 5 BCTs identified X No eligible fidelity data reported		13-week FU after baseline
An Assessment-based intervention on Fundamental Movement Skills (A+FMS)[7] Chan et al 2019 Hong Kong	Cluster RCT Class level	13-week intervention Primary school setting 5 schools at baseline Aim: to examine whether the implementation of Assessment for Learning (AfL) strategies in PE classrooms can improve FMS proficiency in jumping, hopping, skipping, catching, dribbling, and overhand throwing. PA/SB targeted outside of school time - No	276 students at baseline Students' mean age: 8.4yrs (±0.6)	Teacher role: to integrate the AfL strategies in their prescribed fundamental movement skills curriculum content for 550 min of PE class time. 6 hours of teacher training Any rationale/theory used to inform training? Yes - the Competence Motivation Theory (Harter 1978) underpinned the design of the A+FMS intervention. 4 BCTs identified ✓ Teacher fidelity data reported	X eligible PA data not reported	X eligible SB data not reported
SPACE for physical activity[8] Christiansen et al 2017 Denmark	Cluster RCT School level	12-month intervention Primary and secondary school settings 14 schools at baseline Aim: multicomponent school-based intervention study aimed at improving PA levels among adolescents PA/SB targeted outside of school time - Yes	1,348 students at baseline Students' mean age: 12.5yrs (±0.6)	Teacher role: to facilitate and motivate PA during recess, and a mandatory outdoor recess and/ or access to gym/sports hall 22 hours of teacher training Any rationale/theory used to inform training? Yes - three of the intervention components involved some degree of teacher training. The rationale for the kick-starters education was initiation and organisation of recess activities. There were no underpinning theory except the rationale of	✓ PA data reported Device used: ActiGraph Cut points: Evenson 2008 Overall PA - counts/minute during teacher period 24-month FU after baseline	✓ SB data reported Device used: ActiGraph Cut points: Evenson 2008 Sedentary mins per day (any day, including weekends) 24-month FU after baseline

				offering/showing more opportunities for the students during recess. The rationale for coordinators of the Students-play-patrol, was to help older students initiating play and games for minor students. The rationale for teen-fitness instructors was initiation of fitness for the young age group primarily after school. 1 BCT identified X No eligible fidelity data reported		
Supporting Children's Outcomes using Rewards, Exercise and Skills (SCORES)[9] Cohen et al 2015 Australia	Cluster RCT School level	12-month intervention Primary school setting 8 schools at baseline Aim: to increase PA and improve fundamental movement skills competency among children attending primary schools in low-income communities PA/SB targeted outside of school time - Yes	460 students at baseline Students' mean age: 8.5yrs (±0.6)	Teacher role: to implement six PA policies to support the promotion of PA and fundamental movement skills competency within the school 7 hours of teacher training Any rationale/theory used to inform training? Yes - the competence motivation theory and the self-determination theory 3 BCTs identified ✓ Teacher fidelity data reported	✓ PA data reported Device used: ActiGraph Cut points: Evenson 2008 MVPA mins in school hours 12-month FU after baseline	X eligible SB data not reported
No specific trial name[10] Drummy et al 2016 United Kingdom	Cluster RCT Class level	12-week intervention Primary school setting 7 schools at baseline Aim: to improve PA levels and maintain BMI PA/SB targeted outside of school time - No	120 students at baseline Students' mean age: 9.5yrs (±not reported)	Teacher role: to lead a 5-min activity break three times per day for 12 weeks. Hours of teacher training not reported Theory/rationale used to inform training? No 2 BCTs identified	✓ PA data reported Device used: ActiGraph Cut points: Trost 1998 MVPA mins per weekday 12-week FU after baseline	X eligible SB data not reported

				X No eligible fidelity data reported		
The Healthy Homework Study[11] Duncan et al 2019 New Zealand	Cluster RCT School level	8-week intervention Primary school setting 16 schools at baseline Aim: to promote physical activity and healthy eating in children PA/SB targeted outside of school time - Yes	675 students at baseline Students' mean age: 8.7yrs (±1.0)	Teacher role: to implement in-class exercises for three 1.5-h sessions delivered on different days throughout each week (including one session reviewing the previous week's homework) 3.5 hours of teacher training Any rationale/theory used to inform training? Yes - the Control Theory 2 BCTs identified X No eligible fidelity data reported	✓ PA data reported Device used: pedometer Cut points: not reported Overall PA steps/day during school hours 8-week FU after baseline	X eligible SB data not reported
The Active School Study[12] Dyrstad 2018 Norway	Cluster RCT School level	10-month intervention Primary school setting 9 schools at baseline Aim: to increase children's physical activity levels in school PA/SB targeted outside of school time - Yes	449 students at baseline Students' mean age: not reported	Teacher role: to deliver at least two 45-min physically active academic lessons per week, direct one daily 10-min physically active recess, and assign a daily 10-min physically active homework (e.g., jumping rope, running, strength training) 17.5 hours of teacher training Any rationale/theory used to inform training? Yes - implementation theory (Durlak & Dupre 2008) 6 BCTs identified ✓ Teacher fidelity data reported	✓ PA data reported Device used: ActiGraph Cut points: Evenson 2008 MVPA mins per day (any day, including weekends) 10-month FU after baseline	✓ SB data reported Device used: ActiGraph Cut points: Evenson 2008 Sedentary mins per day (any day, including weekends) 10-month FU after baseline
No specific trial name[13] Escriva-Boulley et al	Cluster RCT School level	8-month intervention Primary school setting	293 students at baseline	Teacher role: to increase their need-supportive motivating style within PE delivery	X eligible PA data not reported	X eligible SB data not reported

2018 France		13 schools at baseline Aim: to assess whether professional development would have a positive impact on teachers' motivating style and on their students' MVPA PA/SB targeted outside of school time - No	Students' mean age: 8.3yrs (±1.1)	12 hours of teacher training Any rationale/theory used to inform training? Yes - the self-determination theory; video footages of PE teaching were used to illustrate each component of the teachers' motivating style because Tessier et al. (2010) showed that teachers implemented more need-supportive strategies after they observed their own motivating style from video footages of their own lessons. 6 BCTs identified ✓ Teacher fidelity data reported		
Fortaleça sua Saúde[14] Filho et al 2016 Brazil	Cluster RCT School level	4-month intervention Primary school setting 6 schools at baseline Aim: to promote active and healthy lifestyles among students from schools in low Human Development Index areas PA/SB targeted outside of school time - Yes	1,182 students at baseline Students' mean age: not reported	PE teachers Teacher role: to conduct lessons on different health issues, to structure predominantly active PE classes, even in classes with a theoretical content, to promote opportunities for PA practice within the school and to encourage it during out-of-school time, as well as to disseminate information on the importance of an active and healthy lifestyle 18 hours of teacher training Any rationale/theory used to inform training? Yes - all programme content was designed based on the Health Promoting Schools framework (which included curriculum elements as one of the pillars of the intervention).	X eligible PA data not reported	X eligible SB data not reported

				8 BCTs identified ✓ Teacher fidelity data reported		
Choice, Control and Change[15] Gray et al 2015 United States	Cluster RCT School level	8-10 week intervention Middle school setting 10 schools at baseline Aim: to impact middle school students' energy balance-related behaviours: eating more fruits and vegetables, drinking more water, increasing physical activity and decreasing intakes of sweetened beverages and packaged snacks, eating at fast food restaurants and leisure screen time PA/SB targeted outside of school time - No	1,136 students at baseline Students' mean age: 12.0yrs (SD not reported)	Teacher role: to deliver 24 lessons in science classes most school days over 8-10 weeks 6 hours of teacher training Any rationale/theory used to inform training? Yes - the rationale/theory for the teacher training was the same as it was for the curriculum so the teachers could experience the theory-based determinants as the students would. This was a combination of social cognitive theory and Self-determination theory. 4 BCTs identified ✓ Teacher fidelity data reported	X eligible PA data not reported	X eligible SB data not reported
No specific trial name[16] Ha et al 2017 Hong Kong	Cluster RCT Class level	4-week intervention Secondary school setting 12 schools at baseline Aim: to design an intervention which students, especially girls, would find interesting as well as increase activity levels PA/SB targeted outside of school time - No	731 students at baseline Students' mean age: 14.4yrs (±1.1)	Teacher role: to add a 15-min rope skipping activity to PE at the start of four consecutive PE lessons 4 hours of teacher training Any rationale/theory used to inform training? Yes - the Self-determination theory 6 BCTs identified ✓ Teacher fidelity data reported	✓ PA data reported Device used: ActiGraph Cut points: Evenson 2008 % of time in MVPA during teacher period 2-week FU after baseline	X eligible SB data not reported
Self-determined Exercise and Learning	Cluster RCT School level	4-month intervention Secondary school setting	667 students at baseline	Teacher role: to be more need supportive, use music to enhance enjoyment of PE lessons and to	✓ PA data reported Device used: ActiGraph	✓ SB data reported

For FITness (SELF-FIT)[17] Ha et al 2020 Hong Kong		26 schools at baseline Aim: to increase students' MVPA during school PE PA/SB targeted outside of school time - No	Students' mean age: 14.4yrs (±0.8)	enhance the instruction methods for fitness activities that already existed in the curriculum 7 hours of teacher training Any rationale/theory used to inform training? Yes - based on tenets of the Self-determination theory 9 BCTs identified ✓ Teacher fidelity data reported	Cut points: Evenson 2008 MVPA mins during teacher period 4-month FU after baseline	Device used: ActiGraph Cut points: Evenson 2008 Sedentary mins during teacher period 4-month FU after baseline
Girls Active[18] Harrington et al 2018 United Kingdom	Cluster RCT School level	14-month intervention Secondary school setting 20 schools at baseline Aim: to empower adolescent girls to influence school decisions, develop themselves as role models, and promote PA to peers PA/SB targeted outside of school time - Yes	1,752 students at baseline Students' mean age: 12.8yrs (±0.8)	Teacher role: to review PA in school, sport and PE provision, culture and practice to girls 7 hours of teacher training Any rationale/theory used to inform training? No - (the elements of the "off-the-shelf" programme were mapped to constructs in social cognitive theory post-hoc by the academic team) 6 BCTs identified X No eligible fidelity data reported	✓ PA data reported Device used: accelerometer Cut points: Hildebrand MVPA mins during school hours 14-month FU after baseline	✓ SB data reported Device used: accelerometer Cut points: Hildebrand Sedentary mins during school hours 14-month FU after baseline
No specific trial name[19] Have et al 2018 Denmark	Cluster RCT School level	9-month intervention Primary school setting 12 schools at baseline Aim: to investigate the effect on mathematical achievement of incorporating physical activity in math teaching for 7-year-old schoolchildren	505 students at baseline Students' mean age: 7.2yrs (±0.3)	Teacher role: to integrate active math into the curriculum for mathematics for one school year 28 hours of teacher training Any rationale/theory used to inform training? Not reported	✓ PA data reported Device used: ActiGraph Cut points: Evenson 2008 Overall PA counts/min during teacher period	X eligible SB data not reported

		PA/SB targeted outside of school time - No		4 BCTs identified ✓ Teacher fidelity data reported	24-month FU after baseline	
Academic Achievement and Physical Activity Across the Curriculum (A + PACC)[20] Hillman et al 2017 United States	Cluster RCT School level	36-month intervention Primary school setting 17 schools at baseline Aim: to provide increased MVPA while maintaining academic instruction time PA/SB targeted outside of school time - No	698 students at baseline Students' mean age: 8.1yrs (±0.6)	Teacher role: to deliver two, 10-min lessons per day (~4-5 METs) in the subject of their choice; one in the morning and one in the afternoon, 5 days per week, 100 min/week 14 hours of teacher training Any rationale/theory used to inform training? Yes - the Social cognitive theory with emphasis on teacher self-efficacy 6 BCTs identified ✓ Teacher fidelity data reported	X eligible PA data not reported	X eligible SB data not reported
Knowledge in Action (KIA)[21] Hodges et al 2016 United States	RCT Class level	7-week intervention Primary school setting 10 schools at baseline Aim: to investigate the effectiveness of the Knowledge in Action (KIA) fitness lesson segments on Health Related Fitness Knowledge (i.e., a student learning outcome) among fifth grade students in physical education PA/SB targeted outside of school time - No	633 students at baseline Students' mean age: 10.1yrs (±0.5)	Teacher role: to implement the KIA fitness during the fitness segment of their 5th grade physical education classes Hours of teacher training not reported Any rationale/theory used to inform training? Not reported 4 BCTs identified ✓ Teacher fidelity data reported	X eligible PA data not reported	X eligible SB data not reported
'Physical Activity 4 Everyone' (PA4E1)[22] Hollis et al 2016	Cluster RCT School level	21.5m intervention Secondary school setting 10 schools at baseline	1,233 students at baseline	Teacher role: to implement strategies to maximise student activity levels within Physical Education classes Hours of teacher training not reported	✓ PA data reported Device used: ActiGraph	X eligible SB data not reported

Australia		Aim: to assess the effectiveness of a multi-component school-based intervention in reducing the decline in physical activity among students attending secondary schools located in disadvantaged communities PA/SB targeted outside of school time - Yes	Students' mean age: 12.0yrs (SD not reported)	Any rationale/theory used to inform training? Not reported 10 BCTs identified ✓ Teacher fidelity data reported	Cut points: Evenson 2008 MVPA mins per day (any day, including weekends) 24-month FU after baseline	
PLAYgrounds[23] Janssen et al 2015 The Netherlands	Prospective controlled trial School level	10-month intervention Primary school setting 8 schools at baseline Aim: to increase the intensity of PA, focusing on the morning recess PA/SB targeted outside of school time - Yes	1,486 students at baseline Students' mean age: 8.7yrs (±1.5)	Teacher role: to supervise recess, actively encourage PA, and modify PE content 7.13 hours of teacher training Any rationale/theory used to inform training? Yes - the social-ecological model of behaviour change (total programme). Specific for teacher training; logic model of change 9 BCTs identified ✓ Teacher fidelity data reported	✓ PA data reported Device used: ActiGraph Cut points: Trost 1998 Overall PA - energy expenditure (kcal/kg/min) during teacher period 19 sampling moments (every 2 weeks)	X eligible SB data not reported
The COPE (Creating Opportunities for Personal Empowerment) Healthy Lifestyles TEEN (Thinking, Emotions, Exercise, Nutrition) Program [24] Kelly et al 2015 United States	RCT School level	15-week intervention Secondary school setting 11 schools at baseline Aim: to empower teens to engage in healthy lifestyle behaviours (nutrition, physical activity, positive strategies to cope with stress, problem-solving, regulation of negative mood and goal setting)	779 students at baseline Students' mean age: 14.7yrs (±0.7)	Teacher role: to implement COPE 1 day per week during their regular scheduled health class (50 min in length) 7 hours of teacher training Any rationale/theory used to inform training? No 5 BCTs identified ✓ Teacher fidelity data reported	X eligible PA data not reported	X eligible SB data not reported

		PA/SB targeted outside of school time - Yes				
Resistance Training for Teens[25] Kennedy et al 2018 Australia	Cluster RCT School level	10-week intervention Secondary school setting 16 schools at baseline Aim: to improve muscular fitness and provide adolescents with the knowledge, motivation, and skills to engage in resistance training PA/SB targeted outside of school time - Yes	607 students at baseline Students' mean age: 14.1yrs (±0.5)	Teacher role: to deliver student seminars and a structured PE programme, to facilitate a minimum of 5 lunchtime sessions over the 10-wk intervention period 5 hours of teacher training Any rationale/theory used to inform training? Yes - the Self-determination theory, the Social cognitive theory, and recommendations from Su and Reeve (2011) to support autonomy and task engagement, through both knowledge and skill-based training practices. 8 BCTs identified ✓ Teacher fidelity data reported	✓ PA data reported Device used: GENEActiv accelerometer Cut points: Phillips 2013 MVPA mins per weekday 3-month FU after baseline	X eligible SB data not reported
Classes in Motion (Bewegte Klasse)[26] Kien et al 2018 Austria	Cluster RCT Class level	18-month intervention Primary school setting 45 schools at baseline Aim: to improve the pupils' positive emotional and social school experience, increase their levels of physical activity, foster their motoric skills, and improve their well-being and attention PA/SB targeted outside of school time - No	800 students at baseline Students' mean age: 8.7yrs (±0.4)	Teacher role: to include active breaks in the regular curriculum and to include curriculum-focused active breaks that also comprise academic content 32 hours of teacher training Any rationale/theory used to inform training? No theory underpinned the teacher training. Although the rationale was that knowledge about the intervention and the capability of carrying out the intervention as well as a positive attitude towards the intervention should improve the implementation of the intervention.	X eligible PA data not reported	X eligible SB data not reported

				2 BCTs identified ✓ Teacher fidelity data reported		
Extra Fit! (EF!)[27] Kocken et al 2016 The Netherlands	Cluster RCT School level	24-month intervention Primary school setting 45 schools at baseline Aim: to prevent or reduce overweightness in primary school children, decrease consumption of high-energy or high-fat foods and sugar-sweetened drinks; promoting a healthy breakfast; increase consumption of fruits and vegetables; reduce television viewing and computer gaming/browsing; and increase physical activities at school and outside school hours PA/SB targeted outside of school time - Yes	1,112 students at baseline Students' mean age: 9.2yrs (±0.6)	Teacher role: to deliver EF! Lessons; a variety of theory and practical lessons on nutrition and physical activity Hours of teacher training not reported Any rationale/theory used to inform training? Yes - the theory of planned behaviour as this was the framework on which the curriculum was based 1 BCT identified ✓ Teacher fidelity data reported	✓ PA data reported Device used: ActiGraph Cut points: Freedson 1998/Trost 2000 MVPA mins per day (any day, including weekends) 24-month FU after baseline	X eligible SB data not reported
Let's Move It[28] Koykka et al 2019 Finland	Cluster RCT School level	2-month intervention Secondary school setting 6 schools at baseline Aim: to promote physical activity and reduce sedentary behaviour among older adolescents PA/SB targeted outside of school time - Yes	1,166 students at baseline Students' mean age: 18.5yrs (SD not reported)	Teacher role: to reduce sedentary behaviour in class rooms, to implement activity breaks 4.5 hours of teacher training Any rationale/theory used to inform training? Yes - the reasoned action approach, evidence-based strategies for habit formation 15 BCTs identified ✓ Teacher fidelity data reported	X eligible PA data not reported	X eligible SB data not reported

Activity and Motivation in Physical Education (AMPED)[29] Lonsdale et al 2019 Australia	Two-arm cluster RCT School level	7.5-month intervention Secondary-level educational setting 14 schools at baseline Aim: to maximise opportunities for students to be active during PE lessons and enhance adolescents' motivation towards PE and PA PA/SB targeted outside of school time - No	1,421 students at baseline Students' mean age: 13.0yrs (±0.5)	Teacher role: to implement AMPED, set PA action plan, implement AMPED strategies during PE lessons, and have mentoring conversation with another teacher 23 hours of teacher training Any rationale/theory used to inform training? Yes - Based on previous large scale trials and tenets of the Self-determination theory 12 BCTs identified ✓ Teacher fidelity data reported	✓ PA data reported Device used: ActiGraph Cut points: Evenson 2008 % of time in MVPA during teacher period 7.5-month FU after baseline	✓ SB data reported Device used: ActiGraph Cut points: Evenson 2008 Sedentary mins during teacher period 7.5-month FU after baseline
'Active Teen Leaders Avoiding Screen-time' (ATLAS)[30] Lubans et al 2016 Australia	Group RCT School level	20-week intervention Secondary-level educational setting 14 schools at baseline Aim: to improve boys' self-efficacy for resistance-based exercise, by explicitly targeting resistance training movement skill competency PA/SB targeted outside of school time - Yes	361 students at baseline Students' mean age: 12.7yrs (±0.5)	Teacher role: to deliver face-to- face physical activity sessions during the school sport period (20 × ~90 min, in addition to regular PE lessons) 13 hours of teacher training Any rationale/theory used to inform training? Yes - the Self-determination theory and the Social cognitive theory 6 BCTs identified ✓ Teacher fidelity data reported	✓ PA data reported Device used: ActiGraph Cut points: Evenson 2008 % of time in MVPA per weekday 8-month FU after baseline	X eligible SB data not reported
Active Classrooms[31] Martin et al 2017 Ireland	Cluster RCT Class level	8-week intervention Primary school setting 10 schools at baseline Aim: to educate, train and enable primary teachers to change their	197 students at baseline Students' mean age: 8.9yrs (±1.0)	Teacher role: to incorporate at least 1 active English lesson idea and 1 active mathematics lesson idea into their teaching each day 1 hour of teacher training	✓ PA data reported Device used: ActiGraph Cut points: Evenson 2008	✓ SB data reported Device used: ActiGraph Cut points: Evenson 2008

		teaching methods toward engaging children in physical activity while learning the academic content of English and mathematics lessons PA/SB targeted outside of school time - No		Any rationale/theory used to inform training? Yes - the Capability, Opportunity, Motivation, Behaviour (COM-B) model 7 BCTs identified X No eligible fidelity data reported	MVPA mins during teacher period 8-week FU after baseline	Sedentary mins during teacher period 8-week FU after baseline
Action Schools! BC (AC! BC)[32] McKay et al 2015 Canada	Cluster RCT School level	20-month intervention Primary school setting 30 schools at baseline Aim: to provide a school environment where students had more opportunities to be more active more often, and facilitate supportive community and provincial-level environments PA/SB targeted outside of school time - Yes	1,529 students at baseline Students' mean age: not reported	Teacher role: to identify school priorities and create action plans about how to promote PA, two prescriptive, experiential components within the Classroom Action Zone: a minimum of 15 additional mins of PA (over and above physical education) per day (15×5) and jumping exercises 3×/ day (Bounce at the Bell) 4 hours of teacher training Any rationale/theory used to inform training? Yes - the team designed the training using their expertise in the provincial curriculum and physical education. The training followed the principles of professional development (experiential learning) and reflected common knowledge of self-efficacy theory. Through the training, the Support Team aimed to provide teachers with a positive experience learning about and engaging in physical activities with their peers. 5 BCTs identified ✓ Teacher fidelity data reported	X eligible PA data not reported	X eligible SB data not reported
The Professional Learning for	Cluster RCT	7-week intervention	168 students at baseline	Teacher role: to deliver a 7-week PE curriculum designed to promote PA	✓ PA data reported	X eligible SB data not reported

Understanding Games Education (PLUNGE) program[33] Miller et al 2015 Australia	School level	Primary school setting 7 schools at baseline Aim: to evaluate the efficacy of a game-centered learning programme for the improvement of fundamental movement skills, to evaluate the improvement of in-class PA and the potential of this approach to improve perceived sporting competence in elementary school students. PA/SB targeted outside of school time - No	Students' mean age: 11.2yrs (±1.0)	10 hours of teacher training Any rationale/theory used to inform training? Yes - the mentoring model and the situated learning theory 6 BCTs identified ✓ Teacher fidelity data reported	Device used: Pedometer Cut points: Scruggs 2013 Overall PA - steps/min during teacher period 8-week FU after baseline	
No specific trial name[34] Morris et al 2019 United Kingdom	Stratified RCT School level	6-week intervention Primary school setting 6 schools at baseline Aim: to evaluate the effectiveness of a physically active learning intervention on children's PA levels using subgroup analysis to reveal stratified intervention effects highlighted by pre-intervention PA levels PA/SB targeted outside of school time - Yes	154 students at baseline Students' mean age: 9.9yrs (±0.3)	Teacher role: to integrate movement within their lessons both within and outside of the classroom environment 4 hours of teacher training Any rationale/theory used to inform training? No 3 BCTs identified X No eligible fidelity data reported	✓ PA data reported Device used: ActiGraph Cut points: Evenson 2008 % of time in MVPA per day (any day, including weekends) 6-week FU after baseline	✓ SB data reported Device used: ActiGraph Cut points: Evenson 2008 Sedentary mins per day (any day, including weekends) 6-week FU after baseline
Virtual Traveller[35] Norris et al 2018 United Kingdom	Cluster RCT School level	6-week intervention Primary school setting 10 schools at baseline Aim: to test the effect of the "Virtual Traveller" intervention on children's	219 students at baseline Students' mean age: 8.6yrs (±0.5)	Teacher role: to deliver a programme of pre-prepared physically active lesson sessions on whiteboards 30 mins of teacher training Any rationale/theory used to inform training?	✓ PA data reported Device used: Actigraph Cut points: Evenson 2008 MVPA mins during teacher period	✓ SB data reported Device used: Actigraph Cut points: Evenson 2008

		physical activity and SB, on-task behavior, and student engagement PA/SB targeted outside of school time - No		Yes - the Capability, Opportunity, Motivation, Behaviour model 7 BCTs identified ✓ Teacher fidelity data reported	7-week FU after baseline	Sedentary mins during teacher period 7-week FU after baseline
Generating Rural Options for Weight Healthy Kids and Communities (GROW HKC)[36] Nader et al 2018 United States	Cluster RCT School level	8 -month intervention Primary school setting 6 schools at baseline Aim: to investigate the collective relationship of teacher-level factors with the implementation of the Balanced Energy, Physical Activity Toolkit PA/SB targeted outside of school time - No	1,103 students at baseline Students' mean age: 9.0yrs (SD not reported)	Teacher role: to implement PA breaks across the day 1.25 hours of teacher training Any rationale/theory used to inform training? Not reported 1 BCT identified X No eligible fidelity data reported	X eligible PA data not reported	X eligible SB data not reported
Project Spraoi[37] O Leary et al 2019 Ireland	Cluster RCT School level	24 -month intervention Primary school setting 4 schools at baseline Aim: evaluate an intervention targeting increased PA, reduced sedentary time and improved nutritional habits among primary school children PA/SB targeted outside of school time - Yes	231 students at baseline Students' mean age: not reported	Teacher role: to promote of 20 min 'huff and puff' (MVPA) each day, improve students' nutritional habits and knowledge through targeted class-based activities, and promote increased habitual PA and reduced sedentary time. 88.58 hours of teacher training (a maximum of 1.5 days a week was spent in schools over 2 year period) Any rationale/theory used to inform training? Yes - the social ecological model of health behaviour 9 BCTs identified ✓ Teacher fidelity data reported	✓ PA data reported Device used: ActiGraph Cut points: Evenson 2008 MVPA mins per day (any day, including weekends) 24-month FU after baseline	X eligible SB data not reported

Michigan Model for Health[38] O Neill et al 2015 United States	Cluster RCT School level	12-week intervention Primary school setting 52 schools at baseline Aim: to assess a comprehensive health education curriculum focused on nutrition, physical fitness, and safety PA/SB targeted outside of school time - No	1,983 students at baseline Students' mean age: 9.6yrs (±0.7)	Teacher role: to deliver 40 min Michigan Model for Health lessons focusing on nutrition, physical fitness, and safety attitudes and skills. 14 hours of teacher training Any rationale/theory used to inform training? Yes - the training and support were based upon the model used by the organisation that publishes and distributes the Michigan Model for Health materials 2 BCTs identified ✓ Teacher fidelity data reported	X eligible PA data not reported	X eligible SB data not reported
Girls in Sport[39] Okely et al 2017 Australia	Cluster RCT School level	18 -month intervention Secondary school setting 24 schools at baseline Aim: to prevent a decline in participation in MVPA levels among girls over the course of the intervention PA/SB targeted outside of school time - Yes	1,518 students at baseline Students' mean age: 13.6yrs (±>0.0)	Teacher role: to try to engage girls for at least 50% of the class time in MVPA while reducing time spent in management tasks, and to promote physical activity in and out of class 48 hours of teacher training Any rationale/theory used to inform training? Yes - the Action Learning Framework and Quality Teaching and Learning Model 8 BCTs identified ✓ Teacher fidelity data reported	✓ PA data reported Device used: ActiGraph Cut points: Trost 2002 MVPA mins per day (any day, including weekends) 18-month FU after baseline	✓ SB data reported Device used: ActiGraph Cut points: Trost 2002 Sedentary mins per day (any day, including weekends) 18 month FU after baseline
(Encouraging Activity to Stimulate Young Minds) EASY Minds[40] Riley et al	Cluster RCT Class level	6-week intervention Primary school setting 8 schools at baseline	240 students at baseline Students' mean age: 11.1yrs (±0.7)	Teacher role: to embed movement-based learning in their students' daily mathematics program in three lessons per week for 6-weeks	✓ PA data reported Device used: ActiGraph	✓ SB data reported Device used: ActiGraph

2016 Australia		Aim: to evaluate the impact of a primary school-based physical activity integration programme delivered by teachers on objectively measured physical activity and key educational outcomes PA/SB targeted outside of school time - No		7 hours 15 mins of teacher training Any rationale/theory used to inform training? Yes - a diffusion of innovations model 10 BCTs identified ✓ Teacher fidelity data reported	Cut points: Evenson 2008 MVPA mins during teacher period 6-week FU after baseline	Cut points: Evenson 2008 Sedentary mins during teacher period 6-week FU after baseline
FitQuest[41] Robertson et al 2018 United Kingdom	Cluster RCT School level	5-week intervention Primary school setting 10 schools at baseline Aim: to evaluate whether a theory based location-based exergame (FitQuest) could increase self-efficacy and PA at school compared to standard provision in physical education (PE) classes PA/SB targeted outside of school time - No	10,215 students at baseline Students' mean age: not reported	Teacher role: to use FitQuest, a smartphone game, during at least one hour of mandated PE lessons per week 45 mins of teacher training Any rationale/theory used to inform training? No 2 BCTs identified ✓ Teacher fidelity data reported	✓ PA data reported Device used: NL 1000 piezoelectric accelerometer Cut points: accelerometers were set to record MVPA using the manufacturer default of 3.6 METs or above (level 4) (New Lifestyles Inc, Lee's Summit, Missouri, USA) MVPA mins during school hours 6-week FU after baseline	X eligible SB data not reported
No specific trial name[42] Seibert et al 2019 United States	Stratified RCT School level	9 -month intervention Middle school 49 schools at baseline	4,894 students at baseline Students' mean age: 11.1yrs (±0.1)	Teacher role: to implement 4 CDC recommended evidenced-based strategies to promote increased physical activity in schools including: (1) increasing the amount of time spent in moderate to vigorous physical activity in physical education class, (2)	X eligible PA data not reported	X eligible SB data not reported

		Aim: to assess if large-scale implementation of CDC-recommended strategies increase fitness levels of students in low SES schools compared to routine physical activity programming PA/SB targeted outside of school time - Yes		encouraging active classroom breaks, (3) providing organized physical activity opportunities during recess, and (4) providing organized physical activity opportunities before and after school Hours of teacher training not reported Any rationale/theory used to inform training? Not reported 3 BCTs identified ✓ Teacher fidelity data reported		
Move for Wellbeing in School[43] Smedegaard et al 2017 Denmark	Stratified RCT School level	12-month intervention Primary school setting 24 schools at baseline Aim: to improve psychosocial well-being among school-aged children and youths from 4th to 6th grade (10-13 yrs) through the development, implementation, and evaluation of a multicomponent, school-based, physical activity intervention. PA/SB targeted outside of school time - No	2,916 students at baseline Students' mean age: not reported	Teacher role: to conduct two daily brain breaks lasting five mins per class, to facilitate new activities during recess three times per week lasting 30 min; to complete three theme days focusing on well-being and PA; and to spend half of physical education classes teaching the Move for Wellbeing in School lesson plans designed for the intervention 28 hours of teacher training Any rationale/theory used to inform training? Yes - the self-determination theory 3 BCTs identified ✓ Teacher fidelity data reported	X eligible PA data not reported	X eligible SB data not reported
No specific trial name[44] Sutherland et al 2017	Cluster RCT School level	6-month intervention Primary school setting 46 schools at baseline	1,139 students at baseline Students' mean age: not reported	Teacher role: to improve the quality of PE lessons including fundamental movement skills and increasing MVPA and supervise recess and lunch breaks at least 2 days per week	X eligible PA data not reported	X eligible SB data not reported

Australia		Aim: to assess the implementation of school-based practices known to increase students' moderate-to-vigorous physical activity PA/SB targeted outside of school time - Yes		1.5 hours of teacher training Any rationale/theory used to inform training? Not reported 11 BCTs identified ✓ Teacher fidelity data reported		
Learning, Cognition and Motion (LCoMotion)[45] Tarp et al 2016 Denmark	Cluster RCT School level	20-week intervention Secondary school setting 14 schools at baseline Aim: to increase physical activity levels overall as well as in school by targeting classroom, recess and leisure-time activity and through active transportation PA/SB targeted outside of school time - Yes	632 students at baseline Students' mean age: 12.9yrs (±0.6)	Teacher role: to deliver activities involving PA during academic subjects; to conduct moderate to vigorous physical activities in recess with their students 7 hours of teacher training Any rationale/theory used to inform training? No 5 BCTs identified ✓ Teacher fidelity data reported	✓ PA data reported Device used: ActiGraph Cut points: Evenson 2008 % of time in MVPA during teacher period 10-week FU after baseline	X eligible SB data not reported
The Move Project[46] Tymms et al 2016 United Kingdom	Cluster RCT School level	6-week intervention Secondary school setting 60 schools at baseline Aim: to increase physical activity and well-being of secondary school students through education interventions PA/SB targeted outside of school time - Yes	1,235 students at baseline Students' mean age: 11.8yrs (±0.4)	**Peer mentoring:** Teacher role: supervise peer mentoring sessions 2 hours of teacher training Any rationale/theory used to inform training? Not reported 1 BCT identified ✓ Teacher fidelity data reported	**Peer mentoring:** X eligible PA data not reported	**Peer mentoring:** X eligible SB data not reported

				Participative learning: Teacher role: deliver lessons to help students develop an understanding of how their environment may influence their health and well-being using mapping techniques in GIS software 2 hours of teacher training Any rationale/theory used to inform training? Not reported 1 BCT identified ✓ Teacher fidelity data reported	**Participative learning:** ✓ PA data reported Device used: ActiGraph Cut points: Evenson 2008 MVPA mins per day (any day, including weekends) 12-week FU after baseline	**Participative learning:** X eligible SB data not reported
No specific trial name[47] van den Berg et al 2019 The Netherlands	Cluster RCT Class level	5-week intervention Primary school setting 9 schools at baseline Aim: to assess the effects of integrating juggling with math practice in primary school children, on multiplication memorisation performance and enjoyment during the math lessons PA/SB targeted outside of school time - No	323 students at baseline Students' mean age: 11.0yrs (±0.5)	Teacher role: to implement juggling maths lessons Hours of teacher training not reported Any rationale/theory used to inform training? Not reported 3 BCTs identified ✓ Teacher fidelity data reported	X eligible PA data not reported	X eligible SB data not reported
UP4FUN - The ENERGY Project[48] Verloigne et al 2018 Belgium	Cluster RCT School level	6-month intervention Primary and secondary school settings 19 schools at baseline Aim: to evaluate the effect of implementing standing desks in	322 students at baseline Students' mean age: 12.9yrs (±2.5)	Teacher role: to use a rotation system to make sure that all pupils had equal access to the desks, rotating pupils from the traditional desks to standing desks approximately every 25 mins 10 mins of teacher training	X eligible PA data not reported	X eligible SB data not reported

		classrooms in primary and secondary schools on pupils' sitting-related behaviour and determinants PA/SB targeted outside of school time - No		Any rationale/theory used to inform training? Yes - teachers were provided with a manual and presentation based on the rationale that teachers can be considered as "agents" of pupils' sedentary behaviour, suggesting that we focused on changing their knowledge. The aim of the materials was to provide an evidence-based rationale to implement standing desks in a classroom. Researchers wanted to make sure that the teachers saw the intervention from a health perspective (i.e.,reducing sedentary behaviour). 5 BCTs identified ✓ Teacher fidelity data reported		
UP4FUN[49] Vik et al 2015 Belgium, Germany, Greece, Hungary and Norway	Cluster RCT School level	6-week intervention Primary and secondary school settings 62 schools at baseline Aim: to reduce sitting time in school and at home, with special emphasis on television and personal computer/electronic games PA/SB targeted outside of school time - Yes	3,325 students at baseline Students' mean age: not reported (students aged 10-12yrs)	Teacher role: to spend one school hour (45 mins) to teach a pre-planned lesson each week for 5 weeks 1.5 hours of teacher training Any rationale/theory used to inform training? Yes - the five steps of the Model of Planned Promotion for Population Health and framed in a socioecological model with strategies targeting the child, family and school 5 BCTs identified X No eligible fidelity data reported	X eligible PA data not reported	✓ SB data reported Device used: ActiGraph Cut points: Evenson 2008 Sedentary mins per day (any day, including weekends) 6 week FU after baseline

Fueling Learning Through Exercise (FLEX)[50] Wright et al 2019 United States	Cluster RCT School level	16-month intervention Primary school setting 18 schools at baseline Aim: to evaluate the relative impact of two programmes on children's school-time and total daily MVPA. PA/SB targeted outside of school time 100 Mile Club: Yes CHALK/Just Move: No	979 students at baseline Students' mean age: 8.7yrs (±0.7)	**100 Mile Club** Teacher role: to deliver a programme that encourages children to either walk, jog, or run 100 miles over the course of the school year (approximately 3 miles per week) and to log their miles 35 mins of teacher training Any rationale/theory used to inform training? No 3 BCTs identified ✓ Teacher fidelity data reported	**100 Mile Club** X eligible PA data not reported	**100 Mile Club** X eligible SB data not reported
				CHALK/Just Move Teacher role: to deliver a programme of structured classroom-based PA breaks that combines high- and low-intensity movements (e.g., jumping jacks, squats, yoga poses) to provide PA for children while learning. 30 mins of teacher training Any rationale/theory used to inform training? No 2 BCTs identified ✓ Teacher fidelity data reported	**CHALK/Just Move** X eligible PA data not reported	**CHALK/Just Move** X eligible SB data not reported
The Childhood Health, Activity and Motor Performance Study (Chinese CHAMPS)[51]	Cluster RCT School level	8-month intervention Primary and secondary school settings 12 schools at baseline	680 students at baseline Students' mean age: 12.7yrs (±0.6)	**School Physical Education (SPE) intervention** (afterschool programme intervention (ASP) not assessed as after school teacher behaviour targeted)	✓ PA data reported Device used: ActiGraph	✓ SB data reported Device used: ActiGraph

Zhou et al 2019 China		Aim: to increase the amount of time in MVPA and vigorous physical activity during school hours. In addition, nutrition education was introduced to provide students with knowledge of healthy eating. PA/SB targeted outside of school time - No		Teacher role: to implement a modified PE programme 14 hours of teacher training Any rationale/theory used to inform training? Yes - the Social Cognitive Theory/ the Theory of Planned Behaviour 9 BCTs identified ✓ Teacher fidelity data reported	Cut points: Evenson 2008 % of time in MVPA during school hours 8-month FU after baseline	Cut points: Evenson 2008 Sedentary mins per weekday 8-month FU after baseline

m=months; FU=follow-up; PA= physical activity; SB=sedentary behaviour; BCTs=behaviour change techniques; n=number; SD=standard deviation; mins=minutes; MVPA=moderate to vigorous intensity physical activity; BMI= body mass index; PE=physical education; not reported=indicates information could not be identified from study outputs or information was not provided by study authors in the case of teacher training details

Study outputs and sources identified within data extraction period

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[52] **Zhou et al., Chinese CHAMPS**

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Zhou, Z., Li, S., Yin, J., Fu, Q., Ren, H., Jin, T., ... & Yin, Z. (2019). Impact on Physical Fitness of the Chinese CHAMPS: A Clustered Randomized Controlled Trial. *International journal of environmental research and public health*, *16*(22), 4412.

Zhou, Z., Dong, S., Yin, J., Fu, Q., Ren, H., & Yin, Z. (2018). Improving physical fitness and cognitive functions in middle school students: Study protocol for the Chinese childhood health, activity and motor performance study (Chinese CHAMPS). *International journal of environmental research and public health*, *15*(5), 976.

Behaviour change techniques (BCTs) identified in treatment and control groups of training programmes (n =53) Trials identified in review. Programmes shown in alphabetical order, based on study lead author's last name

	Aadland ASK	Adab WAVES	Aittasalo KIDS OUT!	Anderson AFLY5	Belton Y-PATH	Bundy Sydney Playground	Chan A+FMS	Christiansen SPACE	Cohen SCORES	Drummy No trial name	Duncan the Healthy	Dyrstad the Active School	Escriva-Boulley No trial	Filho Fortaleça sua Saúde	Gray Choice, Control and	Ha No trial name	Ha SELF-FIT	**N**	**%**
4.1 Instruction - behavioural performance	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	52	98.1
3.1 Social support (unspecified)	☑											☑		☑	☑		☑	27	50.9
12.5 Adding objects to the environment	☑			☑		☑			☑					☑			☑	21	39.6
1.1 Goal setting (behaviour)				☑	☑		☑			☑		☑		☑		☑	☑	19	35.8
2.2 Feedback on behaviour							☑		☑			☑	☑					16	30.2
6.1 Demonstration of the behaviour																☑	☑	15	28.3
1.4 Action planning													☑		☑			15	28.3
8.1 Behavioural practice/rehersal												☑	☑			☑	☑	15	28.3
1.2 Problem solving													☑		☑	☑	☑	11	20.8
2.3 Self-monitoring of behaviour							☑										☑	8	15.1
3.2 Social support (practical)												☑		☑		☑		7	13.2
5.1 Information about health consequences											☑			☑				7	13.2
12.1 Restructuring the environment														☑				6	11.3
1.3 Goal setting		☑																5	9.4
7.1 Prompts/cues																		5	9.4
2.6 Biofeedback																		4	7.5
10.2 Material reward (behaviour)																		4	7.5
10.3 Non-specific reward																		3	5.7
13.1 Identification of self as role model					☑													3	5.7
13.2 Framing/reframing		☑				☑												3	5.7
1.5 Review behaviour goal(s)													☑					2	3.8
1.6 Discrepancy - behavior vs. goal																	☑	2	3.8
1.7 Review outcome goal(s)																		2	3.8
2.1 Behaviour monitoring without feedback																		2	3.8
6.3 Information about others' approval						☑												2	3.8
1.8 Behavioural contract																		1	1.9
2.7 Feedback on outcome(s) of behaviour																		1	1.9
4.4 Behavioural experiments																		1	1.9
5.3 Infomation social & environmental impact														☑				1	1.9
5.6 Information - emotional impact																		1	1.9
6.2 Social comparison																		1	1.9
8.3 Habit formation																		1	1.9
8.7 Graded tasks																		1	1.9
9.1 Credible source																		1	1.9
9.2 Pros and cons						☑												1	1.9
10.4 Social reward																		1	1.9
15.1 Verbal persuasion about capability																		1	1.9
BCTs identified (treatment)	3	3	1	3	3	5	4	1	3	2	2	6	6	8	4	6	9		
BCTs identified (control)	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0		
Grey tick indicates BCT coded in both experimental and control arm of intervention																			

	Harrington Girls Active	Have No trial name	Hillman A+PACC	Hodges KIA	Hollis PA4E1	Janssen PLAYgrounds	Kelly COPE TEEN	Kennedy Resistance	Kien Bewegte Klasse	Kocken EF!	Köykkä Let's Move It	Lonsdale AMPED	Lubans ATLAS	Martin Active Classrooms	McKay AC! BC!	Miller PLUNGE	Morris No trial name	Nader GROW HKC	N	%
4.1 Instruction - behavioural performance	☑	☑	☑	☑	☑	☑	☑	☑	☑		☑	☑	☑	☑	☑	☑	☑	☑	52	98.1
3.1 Social support (unspecified)	☑	☑	☑		☑	☑				☑	☑	☑			☑	☑	☑		27	50.9
12.5 Adding objects to the environment				☑	☑	☑		☑			☑	☑	☑		☑				21	39.6
1.1 Goal setting (behaviour)			☑	☑				☑						☑					19	35.8
2.2 Feedback on behaviour			☑		☑	☑	☑	☑				☑	☑			☑			16	30.2
6.1 Demonstration of the behaviour				☑			☑	☑	☑			☑	☑			☑	☑		15	28.3
1.4 Action planning	☑					☑		☑			☑	☑		☑	☑				15	28.3
8.1 Behavioural practice/rehersal					☑	☑	☑	☑			☑	☑				☑			15	28.3
1.2 Problem solving	☑										☑			☑					11	20.8
2.3 Self-monitoring of behaviour								☑			☑	☑		☑					8	15.1
3.2 Social support (practical)		☑			☑														7	13.2
5.1 Information about health consequences											☑		☑						7	13.2
12.1 Restructuring the environment						☑					☑			☑					6	11.3
1.3 Goal setting					☑							☑			☑				5	9.4
7.1 Prompts/cues					☑						☑			☑					5	9.4
2.6 Biofeedback							☑					☑							4	7.5
10.2 Material reward (behaviour)	☑		☑		☑														4	7.5
10.3 Non-specific reward												☑	☑						3	5.7
13.1 Identification of self as role model			☑			☑													3	5.7
13.2 Framing/reframing						☑													3	5.7
1.5 Review behaviour goal(s)																			2	3.8
1.6 Discrepancy - behavior vs. goal												☑							2	3.8
1.7 Review outcome goal(s)	☑																		2	3.8
2.1 Behaviour monitoring without feedback		☑																	2	3.8
6.3 Information about others' approval											☑								2	3.8
1.8 Behavioural contract																			1	1.9
2.7 Feedback on outcome(s) of behaviour					☑														1	1.9
4.4 Behavioural experiments											☑								1	1.9
5.3 Infomation social & environmental impact																			1	1.9
5.6 Information - emotional impact																			1	1.9
6.2 Social comparison											☑								1	1.9
8.3 Habit formation											☑								1	1.9
8.7 Graded tasks																☑			1	1.9
9.1 Credible source																			1	1.9
9.2 Pros and cons																			1	1.9
10.4 Social reward											☑								1	1.9
15.1 Verbal persuasion about capability																			1	1.9
BCTs identified (treatment)	6	4	6	4	10	9	5	8	2	1	15	12	6	7	5	6	3	1		
BCTs identified (control)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1		
Grey tick indicates BCT coded in both experimental and control arm of																				

	Norris Virtual Traveller	O'Leary Project Spraoi	O'Neill Michigan Model for	Okely Girls in Sport	Riley EASY Minds	Robertson FitQuest	Seibert No trial name	Smedegaard Move for	Sutherland No trial name	Tarp LCoMotion	Tymms Peer mentoring vs	Tymms Participative learning	van den Berg No trial name	Verloigne UP4FUN - The	Vik UP4FUN	Wright 100 mile vs control	Wright Chalk vs control	Zhou SPE vs control	**N**	**%**
4.1 Instruction - behavioural performance	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	52	98.1
3.1 Social support (unspecified)	☑	☑	☑	☑	☑		☑	☑	☑						☑	☑	☑		27	50.9
12.5 Adding objects to the environment		☑			☑				☑	☑				☑	☑			☑	21	39.6
1.1 Goal setting (behaviour)	☑	☑			☑				☑	☑				☑				☑	19	35.8
2.2 Feedback on behaviour					☑				☑				☑					☑	16	30.2
6.1 Demonstration of the behaviour	☑	☑			☑	☑							☑						15	28.3
1.4 Action planning	☑	☑		☑	☑				☑									☑	15	28.3
8.1 Behavioural practice/rehersal					☑			☑	☑									☑	15	28.3
1.2 Problem solving				☑	☑				☑							☑			11	20.8
2.3 Self-monitoring of behaviour				☑						☑									8	15.1
3.2 Social support (practical)		☑					☑												7	13.2
5.1 Information about health consequences	☑													☑	☑				7	13.2
12.1 Restructuring the environment														☑				☑	6	11.3
1.3 Goal setting				☑															5	9.4
7.1 Prompts/cues									☑						☑				5	9.4
2.6 Biofeedback		☑																☑	4	7.5
10.2 Material reward (behaviour)									☑										4	7.5
10.3 Non-specific reward					☑														3	5.7
13.1 Identification of self as role model																			3	5.7
13.2 Framing/reframing																			3	5.7
1.5 Review behaviour goal(s)		☑																	2	3.8
1.6 Discrepancy - behavior vs. goal																			2	3.8
1.7 Review outcome goal(s)				☑															2	3.8
2.1 Behaviour monitoring without feedback																		☑	2	3.8
6.3 Information about others' approval																			2	3.8
1.8 Behavioural contract										☑									1	1.9
2.7 Feedback on outcome(s) of behaviour																			1	1.9
4.4 Behavioural experiments																			1	1.9
5.3 Infomation social & environmental impact																			1	1.9
5.6 Information - emotional impact	☑																		1	1.9
6.2 Social comparison																			1	1.9
8.3 Habit formation																			1	1.9
8.7 Graded tasks																			1	1.9
9.1 Credible source				☑															1	1.9
9.2 Pros and cons																			1	1.9
10.4 Social reward																			1	1.9
15.1 Verbal persuasion about capability									☑										1	1.9
BCTs identified (treatment)	7	9	2	8	10	2	3	3	11	5	1	1	3	5	5	3	2	9		
BCTs identified (control)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Grey tick indicates BCT coded in both																				

[a] Number of training programmes where BCT coded as present (n=53); [b] Percentage of training programmes where BCT coded as present

Appendix 2.10. Quality assessment ratings and classification results for fidelity outcomes

Lead author	Study name	Selection bias	Study design	Confounders	Blinding	Data collection	Withdrawals & drop-outs	Global rating	Fidelity classification result[a]
Aadland et al	ASK	Moderate	Strong	Weak	Weak	Weak	Strong	Weak	High
Adab et al	WAVES	Weak	Strong	Strong	Weak	Strong	Strong	Weak	Low
Aittasalo et al	KIDS OUT!	Strong	Strong	Strong	Weak	Weak	Strong	Weak	High
Anderson et al	AFLY5	Weak	Strong	Strong	Weak	Weak	Weak	Weak	Medium
Chan et al	A+FMS	Weak	Strong	Weak	Moderate	Weak	Strong	Weak	High
Cohen et al	SCORES	Weak	Strong	Strong	Weak	Weak	Strong	Weak	Medium
Dyrstad et al	the Active School Study	Weak	Strong	Strong	Weak	Weak	Strong	Weak	Medium
Escriva-Boulley et al	No specific study name	Weak	Strong	Strong	Moderate	Strong	Weak	Weak	Excluded
Filho et al	Fortaleça sua Saúde	Strong	Strong	Strong	Weak	Weak	Strong	Weak	Excluded
Gray et al	Choice, Control and Change	Weak	Strong	Strong	Weak	Weak	Strong	Weak	Medium
Ha et al	No specific study name	Moderate	Strong	Strong	Moderate	Weak	Strong	Moderate	High
Ha et al	SELF-FIT	Weak	Strong	Strong	Weak	Weak	Strong	Weak	Medium
Have et al	No specific study name	Weak	Strong	Strong	Weak	Weak	Strong	Weak	Excluded
Hillman et al	A+PACC	Moderate	Strong	Strong	Weak	Strong	Strong	Moderate	Medium
Hodges et al	KIA	Weak	Strong	Weak	Weak	Weak	Strong	Weak	Medium
Hollis et al	PA4E1	Moderate	Strong	Strong	Weak	Weak	Strong	Weak	Medium
Janssen et al	PLAYgrounds	Weak	Strong	Strong	Weak	Weak	Strong	Weak	High
Kelly et al	COPE TEEN	Weak	Strong	Strong	Moderate	Strong	Weak	Weak	Medium
Kennedy et al	Resistance Training for Teens	Weak	Strong	Strong	Weak	Weak	Strong	Weak	High
Kien et al	Bewegte Klasse	Moderate	Strong	Weak	Weak	Weak	Strong	Weak	Medium
Kocken et al	EF!	Weak	Strong	Strong	Weak	Weak	Strong	Weak	Low
Koykka et al	Let's Move It	Moderate	Strong	Strong	Weak	Weak	Strong	Weak	Medium

Lead author	Study name	Selection bias	Study design	Confounders	Blinding	Data collection	Withdrawals & drop-outs	Global rating	Fidelity classification result[a]
Lonsdale et al	AMPED	Moderate	Strong	Strong	Moderate	Weak	Strong	Moderate	Medium
Lubans et al	ATLAS	Moderate	Strong	Strong	Weak	Weak	Strong	Weak	Medium
McKay et al	AC! BC!	Weak	Strong	Weak	Weak	Weak	Weak	Weak	Excluded
Miller et al	PLUNGE	Moderate	Strong	Strong	Weak	Weak	Strong	Weak	Excluded
Norris et al	Virtual Traveller	Weak	Strong	Weak	Weak	Weak	Strong	Weak	Medium
Nader et al	GROW HKC	Weak	Strong	Weak	Weak	Weak	Strong	Weak	High
O Leary et al	Project Spraoi	Weak	Strong	Strong	Weak	Weak	Strong	Weak	Excluded
O Neill et al	Michigan Model for Health	Weak	Strong	Strong	Weak	Weak	Strong	Weak	High
Okely et al	Girls in Sport	Weak	Strong	Strong	Strong	Weak	Strong	Weak	Low
Riley et al	EASY Minds	Weak	Strong	Strong	Weak	Weak	Strong	Weak	High
Robertson et al	FitQuest	Weak	Strong	Weak	Weak	Weak	Strong	Weak	Low
Seibert et al	No specific study name	Moderate	Strong	Strong	Weak	Weak	Weak	Weak	Medium
Smedegaard et al	Move for Wellbeing in School	Weak	Strong	Strong	Weak	Weak	Strong	Weak	Medium
Sutherland et al	No specific study name	Moderate	Strong	Strong	Weak	Weak	Strong	Weak	Excluded
Tarp et al	LCoMotion	Moderate	Strong	Weak	Weak	Weak	Strong	Weak	Low
Tymms et al	Peer mentoring	Weak	Strong	Strong	Weak	Weak	Strong	Weak	Medium
Tymms et al	Participative learning	Weak	Strong	Strong	Weak	Weak	Strong	Weak	Medium
van den Berg et al	No specific study name	Weak	Strong	Strong	Weak	Weak	Strong	Weak	High
Verloigne et al	UP4FUN - The ENERGY Project	Weak	Strong	Strong	Weak	Weak	Weak	Weak	Excluded
Wright et al	FLEX - 100 Mile Club	Weak	Strong	Strong	Weak	Weak	Strong	Weak	Low
Wright et al	FLEX – CHALK/Just Move	Weak	Strong	Strong	Weak	Weak	Strong	Weak	Low
Zhou et al	Chinese CHAMPS	Moderate	Strong	Weak	Weak	Strong	Strong	Weak	Excluded

[a] We employed a structured process to classify fidelity outcomes (see Appendix 2.4 for further details). Studies that solely reported fidelity outcomes in the absence of any quantitative goal/aim to compare outcomes against were excluded (e.g., fidelity scores were solely compared against the control group only or fidelity outcomes reported in other studies).

Appendix 2.11. Quality assessment ratings for physical activity and sedentary behaviour outcomes

Lead author	Trial name	Selection bias	Study design	Confounders	Blinding	Data collection	Withdrawals & drop-outs	Global rating
Aadland et al	ASK	Moderate	Strong	Strong	Weak	Strong	Strong	Moderate
Adab et al	WAVES	Weak	Strong	Strong	Moderate	Strong	Strong	Moderate
Anderson et al	AFLY5	Strong	Strong	Strong	Moderate	Strong	Weak	Moderate
Belton et al	Y-PATH	Strong	Strong	Strong	Weak	Strong	Weak	Weak
Bundy et al	Sydney Playground Project	Moderate	Strong	Strong	Weak	Strong	Strong	Moderate
Christiansen et al	SPACE	Moderate	Strong	Strong	Weak	Strong	Strong	Moderate
Cohen et al	SCORES	Moderate	Strong	Strong	Weak	Strong	Weak	Weak
Drummy et al	No specific trial name	Weak	Strong	Strong	Weak	Strong	Weak	Weak
Dyrstad et al	the Active School Study	Moderate	Strong	Strong	Weak	Strong	Strong	Moderate
Ha et al	No specific trial name	Moderate	Strong	Strong	Strong	Strong	Strong	Strong
Ha et al	SELF-FIT	Weak	Strong	Strong	Moderate	Strong	Strong	Moderate
Harrington et al	Girls Active	Moderate	Strong	Strong	Moderate	Strong	Moderate	Strong
Hollis et al	PA4E1	Strong	Strong	Strong	Moderate	Strong	Strong	Strong
Janssen et al	PLAYgrounds	Weak	Strong	Strong	Weak	Strong	Weak	Weak
Kennedy et al	Resistance Training for Teens	Weak	Strong	Strong	Weak	Strong	Moderate	Moderate
Kocken et al	EF!	Weak	Strong	Strong	Weak	Weak	Moderate	Weak
Lonsdale et al	AMPED	Moderate	Strong	Weak	Strong	Strong	Strong	Moderate
Lubans et al	ATLAS	Moderate	Strong	Strong	Moderate	Strong	Moderate	Strong
Martin et al	Active Classrooms	Moderate	Strong	Strong	Weak	Strong	Strong	Moderate
Miller et al	PLUNGE	Moderate	Strong	Strong	Moderate	Strong	Strong	Strong
Morris et al	No specific trial name	Weak	Strong	Strong	Weak	Strong	Strong	Weak
Norris et al	Virtual Traveller	Weak	Strong	Strong	Weak	Strong	Moderate	Weak
Okely et al	Girls in Sport	Weak	Strong	Strong	Strong	Strong	Strong	Moderate
Riley et al	EASY Minds	Weak	Strong	Strong	Weak	Strong	Strong	Weak
Robertson et al	FitQuest	Weak	Strong	Strong	Weak	Strong	Strong	Weak

Tarp et al	LCoMotion	Moderate	Strong	Strong	Weak	Strong	Strong	Moderate
Zhou et al	Chinese CHAMPS	Moderate	Strong	Strong	Moderate	Strong	Moderate	Strong

Appendix 2.12. Forest and funnel plots for physical activity outcomes

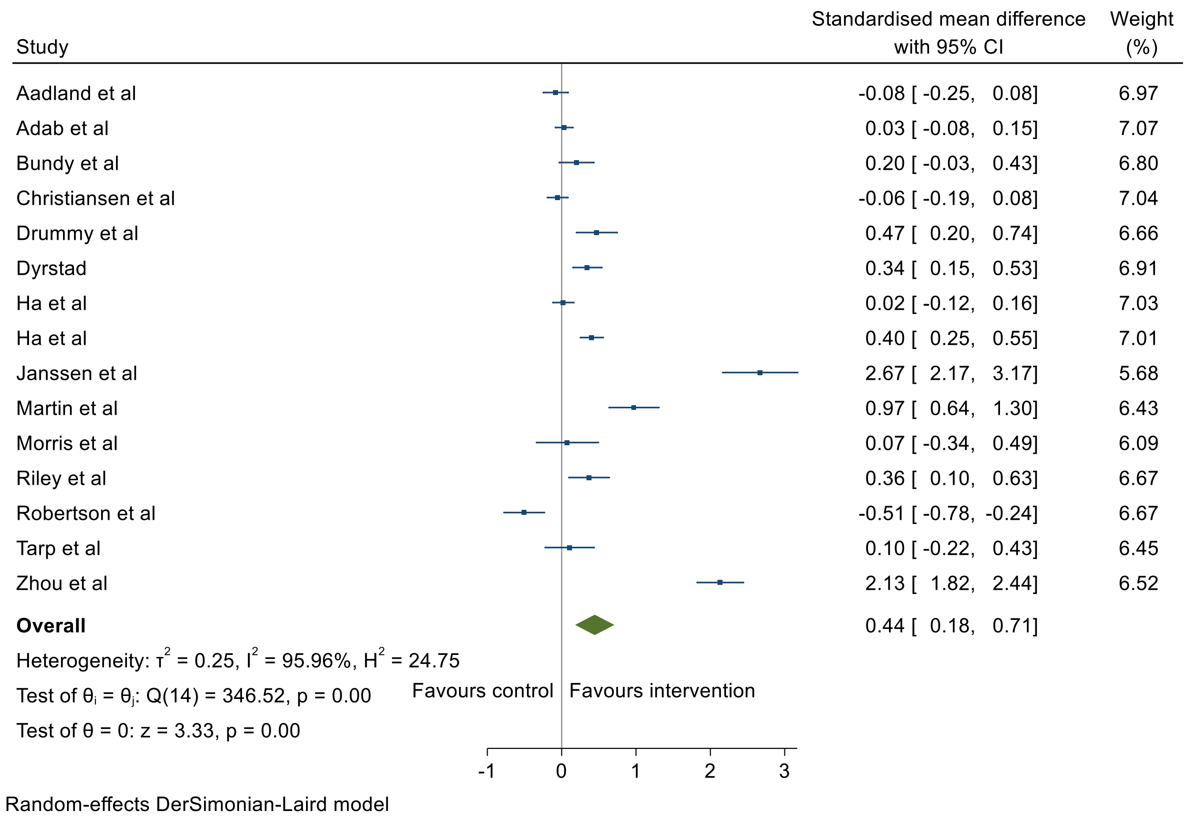


Figure 1. Forest plot of standardised mean difference of change in physical activity between intervention and control groups of school-based physical activity interventions

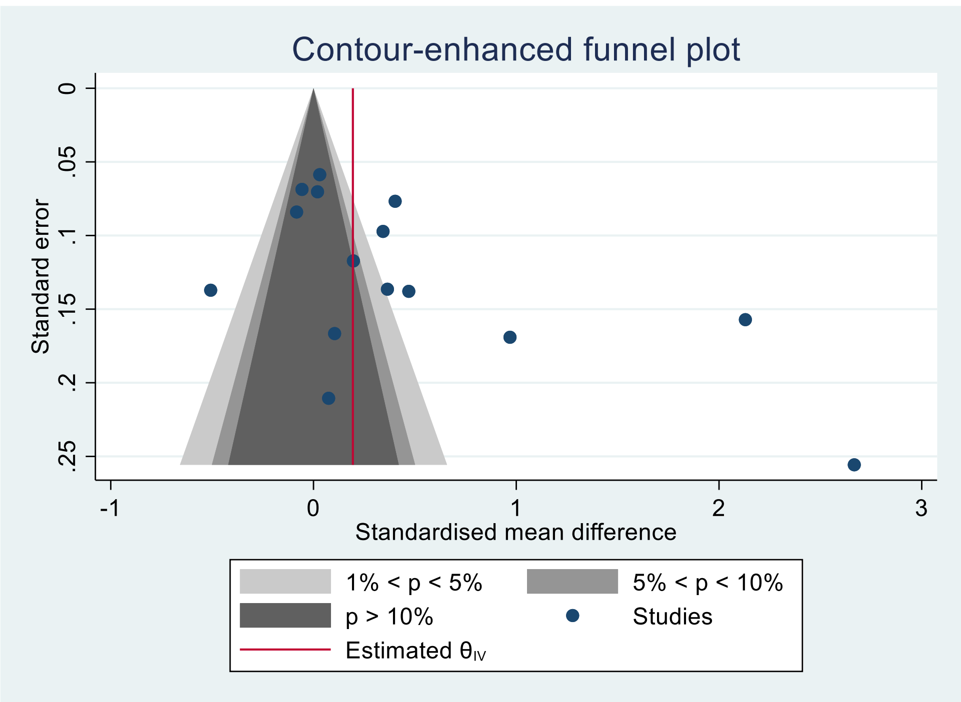


Figure 2. Funnel plot for physical activity outcomes

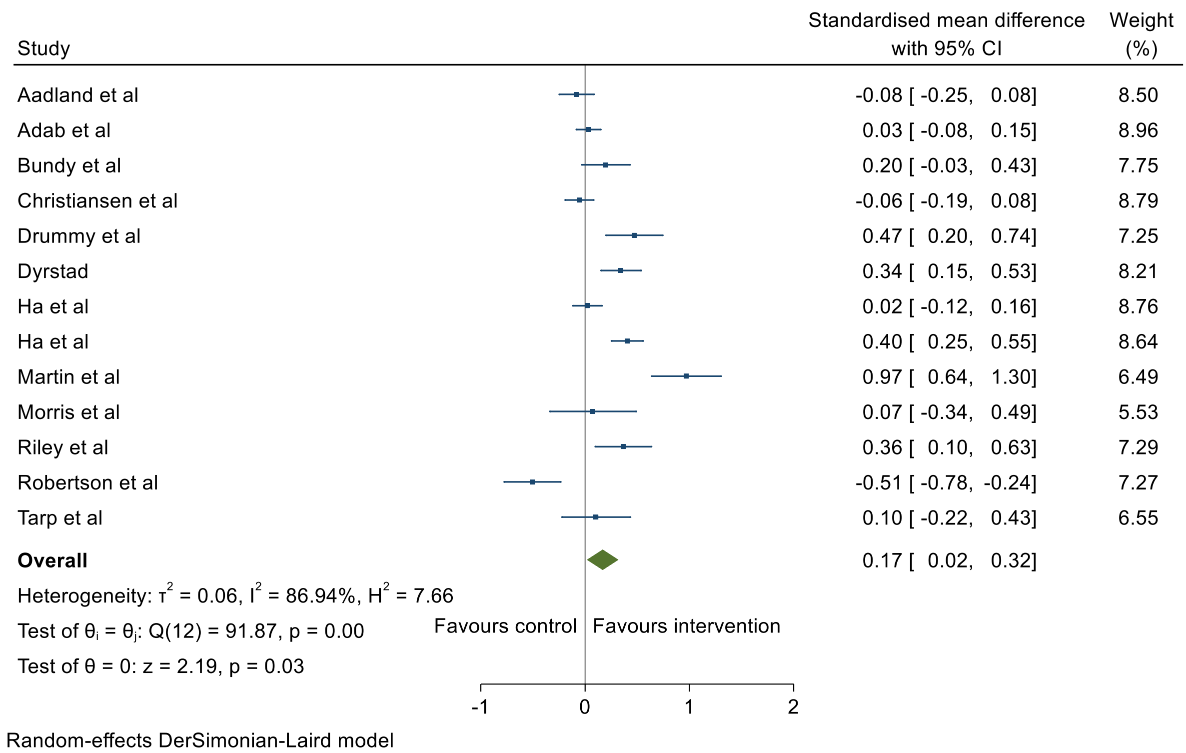


Figure 3. Forest plot of standardised mean difference of change in physical activity between intervention and control groups of school-based physical activity interventions, with outcomes from PLAYgrounds[214] and Chinese CHAMPS[215] removed.

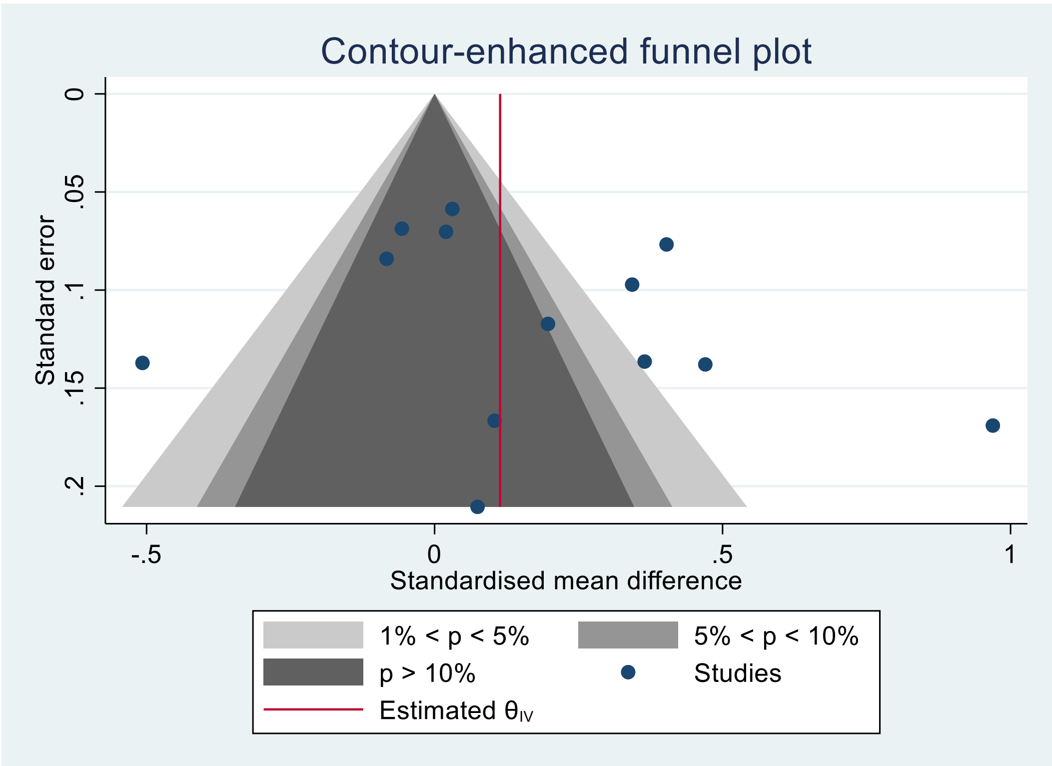


Figure 4. Funnel plot for physical activity outcomes with studies removed

Appendix 2.13. Forest plots and funnel plots for sedentary behaviour outcomes

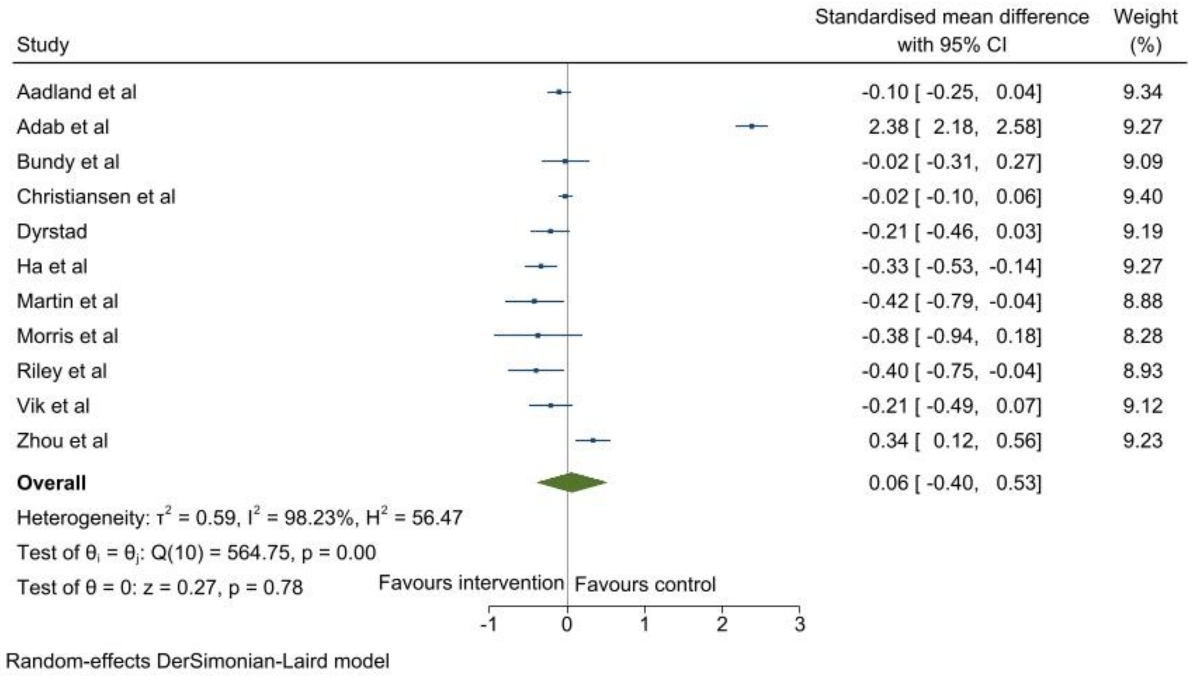


Figure 1. Forest plot of standardised mean difference of change in sedentary behaviour between intervention and control groups of school-based physical activity interventions

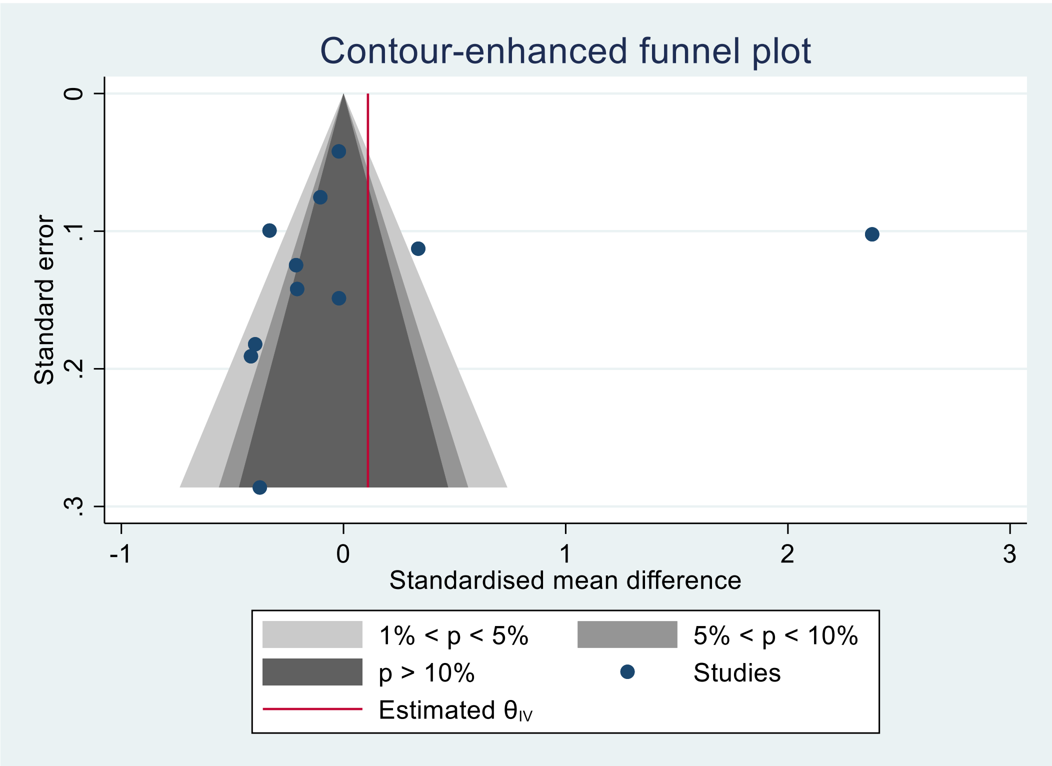


Figure 2. Funnel plot for sedentary behaviour outcomes

Appendix B: Supplementary material for Chapter 3

Appendix 3.1: Functions of professional development

Sims and colleagues proposed four functions of teacher profesionnal development[153]

Function name	Description	Example
Instil insight	Helping a teacher to gain a new, evidence-based understanding of teaching, their students, or themselves.	Helping a teacher gain a new, evidence-based understanding of the benefits of incorporating active lessons into the school week to improve student focus and well-being.
Motivate goals	Encouraging a teacher to pursue specific, conscious aims through their actions.	Encouraging a teacher to set a specific goal of increasing the number of outdoor lessons each month.
Teach techniques	Assisting a teacher in mastering new teaching practices.	Assisting a teacher in mastering new teaching techniques that can be integrated into the curriculum to make Physical Education classes more engaging for students.
Embed practice	Supporting a teacher in consistently applying techniques, acting on insights, or pursuing goals in the classroom following professional development.	Supporting a teacher to consistently implement short bursts of physical activity (e.g., brain breaks) throughout the school year, after attending relevant professional development.

Appendix 3.2: STROBE Statement

STROBE Statement — Checklist of items that should be included in reports of ***cross-sectional studies***

Section	Item	Recommendation	Page	Appendix
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	n/a	
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	n/a	
Introduction				
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	41-44	
Objectives	3	State specific objectives, including any pre-specified hypotheses	44	
Methods				
Study design	4	Present key elements of study design early in the paper	45	
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	45	
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	46	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	48-49	3.3
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	48-49	3.3
Bias	9	Describe any efforts to address potential sources of bias	46-47, 51	
Study size	10	Explain how the study size was arrived at		
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	50-51	
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	50-51	
		(*b*) Describe any methods used to examine subgroups and interactions	50-51	
		(*c*) Explain how missing data were addressed		
		(*d*) If applicable, describe analytical methods taking account of sampling strategy		
		(*e*) Describe any sensitivity analyses	50-51	

Section	Item	Recommendation	Page	Appendix
Results				
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	52	3.5
		(b) Give reasons for non-participation at each stage	unknown	
		(c) Consider use of a flow diagram		3.5
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders		(Table 3.4)
		(b) Indicate number of participants with missing data for each variable of interest		(Table 3.4)
Outcome data	15*	Report numbers of outcome events or summary measures	53-56	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	56-57	3.6
		(*b*) Report category boundaries when continuous variables were categorized		
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period		
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses		3.7
Discussion				
Key results	18	Summarise key results with reference to study objectives	58	
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	60	
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	59-61	
Generalisability	21	Discuss the generalisability (external validity) of the study results	59-61	
Other information				
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	iv, 62	

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

PE Premium survey

Section 1: About the CPD	
In this school year, which of the following continuing professional development (CPD) activities did you attend? (please select all that apply)	☐ In-person course/session ☐ Online course/session ☐ Education conference ☐ Formal qualification programme (e.g. afPE level 5/6) ☐ Observation visit at another school ☐ Peer/self-observation and coaching as part of a formal school arrangement ☐ Reading professional literature (e.g. reading a book relating to teaching or some research) ☐ Other (please provide details)
Please provide details:	__________________________
Were you required to attend or did you volunteer?	○ Required ○ Volunteered ○ A mix of both
Did another teacher from your school or federation attend?	○ Yes ○ No ○ Prefer not to say
Who provided the training?	○ Teacher(s) from my school ○ Teacher(s) from another school ○ Local authority ○ An accredited organisation ○ Other (please provide details)
Please provide details:	__________________________
What was the name of the CPD provider/organisation? (if known) The name of any CPD provider will not be mentioned in any report. Your answer will be treated as strictly confidential. This information helps us to assess the number of survey respondants who received training from the same provider.	__________________________
What was the CPD provider's background? (if known)	○ A qualified PE specialist ○ Expert teacher ○ Other (please provide details) ○ Don't know ○ Can't remember
Please provide details:	__________________________
Where was the training provided?	○ In-person ○ Online ○ Both in-person and online

Where did the majority of the face-to-face training take place?	◯ My school ◯ Another school ◯ Central location (hotel, government building etc.) ◯ Training centre ◯ Other
Was any infrastructure used? (select all that apply)	☐ Physical (e.g. gym, classroom, equipment) ☐ Presentational (e.g. projector, white board) ☐ Other (please provide details) ☐ No infrastructure was used
Please provide details:	______________________
How was the CPD provided?	◯ Individual (e.g. one-to one coaching) ◯ Group (e.g. whole school/key stage groups) ◯ Both
What was the total duration of the CPD? (to the nearest hour)	______________________ (hour(s))
Over how many separate days was the CPD provided? (if single session, please answer 1)	______________________ (day(s))
Over what time period were the first and last CPD sessions provided?	◯ Less than one month ◯ 1-2 months ◯ 3-6 months ◯ More than 6 months
Do you currently teach PE? (some teachers receive PE CPD regardless of whether they teach PE)	◯ Yes, I deliver all of the PE ◯ Yes, I deliver some of the PE alongside someone else (e.g. a PE specialist) ◯ No, someone else delivers all of the PE (e.g. a PE specialist)
Was the CPD content based on some kind of an assessment of your students' abilities?	◯ No ◯ Yes, CPD provider asked me about my students' abilities during session(s) ◯ Yes, CPD provider asked me to provide information about student ability in advance of the first session
Was the CPD content based on some kind of an assessment of your teaching experience/knowledge?	◯ No ◯ Yes, CPD provider asked me about my teaching experience during session(s) ◯ Yes, CPD provider asked me to provide information about my teaching experience in advance of the first session
Were any materials provided? (e.g. lesson plans or equipment)	◯ Yes ◯ No ◯ Can't remember
Please provide details:	______________________

Were these materials available for you to keep?	◯ Yes ◯ No ◯ Can't remember

Section 2: About the CPD activities

Thinking about all of the PE CPD that you received this school year, please answer the following questions.

How often...

	Always	Often	Sometimes	Rarely	Never	Can't remember	Not applicable
Did the CPD focus on one well-defined area of teaching practice?	○	○	○	○	○	○	○
Did the CPD provider use both language and images to communicate key information?	○	○	○	○	○	○	○
Did the CPD provider return to key ideas multiple times within a session?	○	○	○	○	○	○	○
Did the CPD provider revisit key ideas across multiple sessions?	○	○	○	○	○	○	○
Were there tasks that required you to draw on past learning? (e.g. from ITT)	○	○	○	○	○	○	○
Were you asked to set CPD objectives?	○	○	○	○	○	○	○
Were you presented with convincing information in favour of or against a teaching technique from a person or source deemed credible to you? (e.g. an expert teacher, a book or research paper)	○	○	○	○	○	○	○
Were you provided with explicit instructions on how to use a certain teaching technique?	○	○	○	○	○	○	○
Did the CPD provider give multiple examples of instances where you could perform that technique?	○	○	○	○	○	○	○
Were you shown examples of how to perform the technique? (e.g. video or live demonstration)	○	○	○	○	○	○	○
Were you provided with opportunities to rehearse the technique?	○	○	○	○	○	○	○
Were rehearsal opportunities in a realistic setting (e.g. a gym or outdoor space?)	○	○	○	○	○	○	○

Were you provided with feedback during rehearsal?	○	○	○	○	○	○	○
Were you asked to create an action plan for implementation? (e.g. lesson planning)	○	○	○	○	○	○	○
Were you provided with methods or materials to help you observe and track progress towards implementation? (e.g. a reflective journal)	○	○	○	○	○	○	○
Did the CPD provider arrange practical support to facilitate implementation?	○	○	○	○	○	○	○
Following the CPD, were you sent reminders to encourage implementation? (e.g. an email reminder)	○	○	○	○	○	○	○
Did the CPD provider observe your classroom practice for implementation?	○	○	○	○	○	○	○
Did the CPD provider offer positive feedback on implementation progress?	○	○	○	○	○	○	○

Section 3: CPD completion	
Will you have any more PE CPD this school year?	◯ Yes ◯ No ◯ Don't know
Have you completed all of the follow-up activities associated with the PE CPD you did this school year? (e.g. reflective exercises)	◯ Yes ◯ No ◯ Don't know ◯ Not applicable (CPD had no follow-up activities)
Did any of the CPD have an impact on your practice?	◯ Not at all ◯ Not a lot ◯ Quite a lot ◯ A lot
Can you describe any one change that you made as a result of the CPD?	__________________________

Section 4: School support for PE CPD
Next, we are interested in the PE CPD climate at your school and support systems to promote implementation.

Please note: Your answers will be treated as strictly confidential.

To what extent do agree or disagree that current leaders at your school...

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Don't know
have a clear vision of CPD for PE?	◯	◯	◯	◯	◯	◯
promote a culture of valuing CPD for PE?	◯	◯	◯	◯	◯	◯
effectively plan CPD for PE?	◯	◯	◯	◯	◯	◯
prioritise CPD for PE?	◯	◯	◯	◯	◯	◯
help overcome barriers to support implementation of PE CPD?	◯	◯	◯	◯	◯	◯

Who supports you to prioritise your CPD for PE?

- ◯ Senior leadership team
- ◯ PE subject lead
- ◯ I am responsible for myself
- ◯ Other (please provide details)

Please provide details: ______________________________

Is there anything else you would like to add about school support for PE CPD?

Section 5: You and your school

Finally, please answer the below questions about you and your school.

The following questions provide us with vital information for us to assess how representative the survey respondents are of the total primary school workforce in England. Your answers will be treated as strictly confident

Approximately how many pupils are in your school?	◯ 1 to 200 pupils ◯ 201 to 300 pupils ◯ 301 or more pupils
Approximately what % of pupils in your school are on Free School Meals?	◯ Less than 5% ◯ Between 5-9% ◯ Between 10-20% ◯ More than 20% ◯ Don't know
What is your sex?	◯ Female ◯ Male
Is the gender you identify with the same as your sex registered at birth?	◯ Yes ◯ No ◯ Prefer not to say
Enter gender identity: (optional)	______________________
How old are you?	◯ 18 to 24 ◯ 25 to 29 ◯ 30 to 39 ◯ 40 to 49 ◯ 50 to 59 ◯ 60 and over ◯ Prefer not to say
How many years have you worked as a teacher? (post QTS)	______________________ (year(s) (including this school year))
How many years have you worked as a teacher at your current school? (post QTS)	______________________ (year(s) (including this school year))
What is the highest level of formal education you have completed?	◯ Degree or higher ◯ Bachelor of Education ◯ Postgraduate Certificate of Education ◯ Certificate of Education ◯ Non-UK teaching qualification ◯ Other (please provide details) ◯ Prefer not to say
Please provide details:	______________________

Survey process data	
How did you learn about this survey? (please select all that apply)	☐ Social media (e.g. Twitter) ☐ Newsletter ☐ Friend or colleague ☐ Event ☐ Other (please provide details) ☐ Prefer not to say
Please provide details:	__________________________
Please provide an email address if you would like to enter a draw to win a £20 voucher:	__________________________
Would you like to be sent a copy of the findings from this study?	◯ Yes ◯ No
Please provide an email address (if different to an email address you have already provided).	__________________________

projectredcap.org

Appendix 3.4. Methods used to identify, test, and screen out bots

Background

Despite implementing several strategies to reduce the risk of unwanted traffic (e.g., using Google's CAPCHA (version 2) and maximising available security measures available to REDCap users, similar to others,[244,261] the survey was infiltrated by a large number of Internet 'bots'; computer programmes that use algorithms to complete online forms.[244] They are reportedly used to test algorithms and gain financial rewards associated with online surveys, often advertised on social media platforms (e.g., Twitter). Bot programmers are using increasingly sophisticated technologies to bypass security measures and provide human-like meta-data (e.g., local IP addresses, realistic survey response times) and/or responses (e.g., to open-ended questions). Since these technologies have outpaced many conventional practices employed by researchers to prevent and detect bots, I drew on recently published literature about this emerging issue[244,261] to inform my data cleaning approach, and sought out additional advice from the Data Management Team within the MRC Epidemiology Unit. All data cleaning processes were conducted within a secure offline network to ensure valid participants' identifiable data (e.g., email addresses) remained protected, preventing the use of tools that did not have downloadable tools (e.g., websites with email address checkers or lists of IP addresses indicating bots).

Elimination process

Exclusion criteria were based on several participant characteristics (e.g., survey response time, IP address) and responses to open-ended questions. To ensure accuracy, each criterion was tested against a subset of participants who were considered genuine responders.

I included participants in this 'genuine responder' subgroup, who had an IP address associated with the UK and who provided an email address specific to schools or the UK (e,g,. sch.uk or co.uk). I then scrutinised their responses to open-ended questions for the presence of local language not used elsewhere in the survey (e.g., 'SGOs'). Based on this screening exercise, I determined an initial subsample of participants deemed to be 'certainly genuine' (n=79).

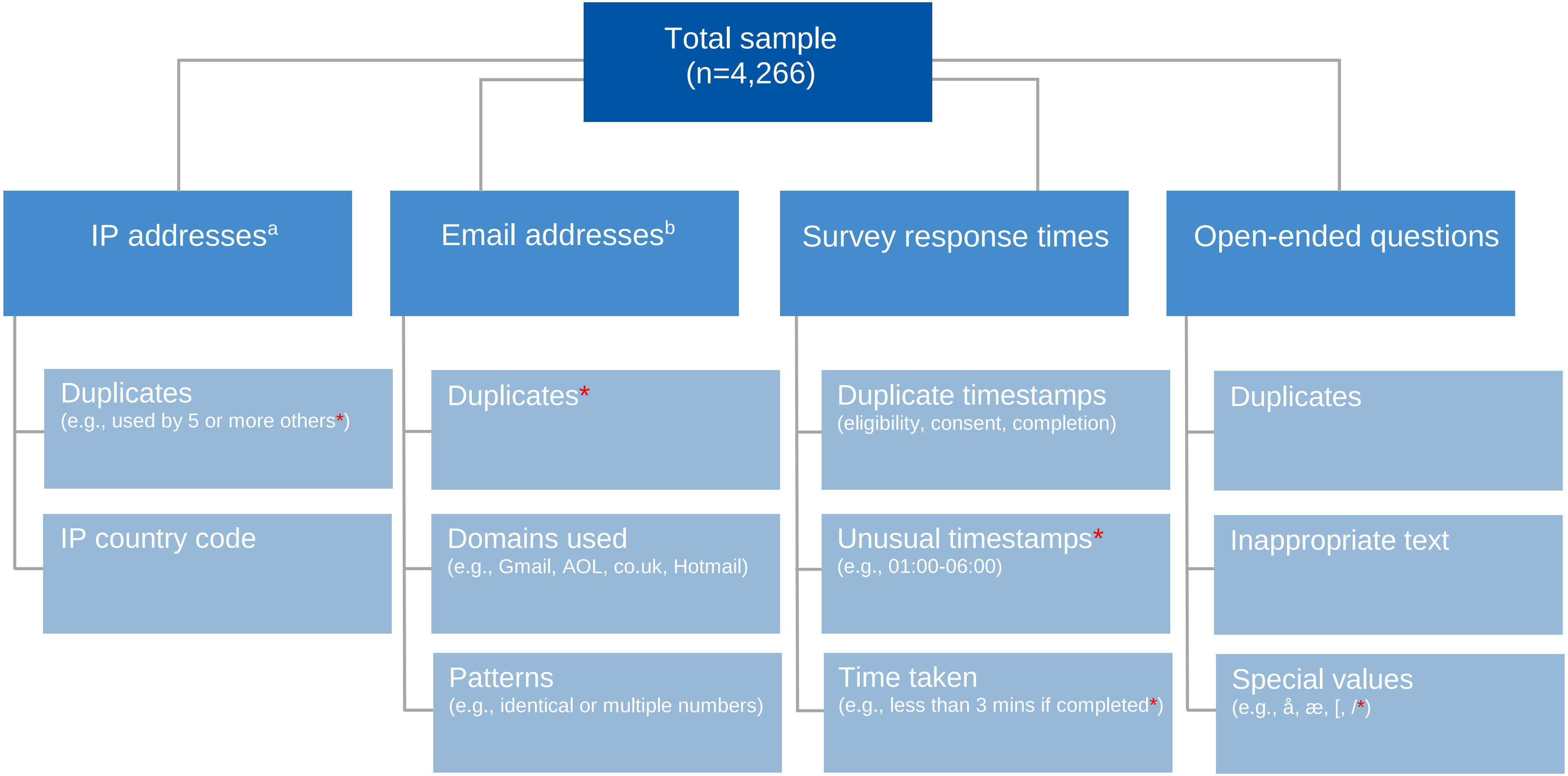
Each evidence-based criterion listed in Flow Chart 1 was then iteratively tested line by line against the subsample of participant IDs deemed to be certainly genuine. If a single criterion (e.g., special character responses in open-ended questions) resulted in the removal of one or more of these certainly genuine responders, it was combined with another criterion (e.g., geolocation associated with an IP address), re-tested, and then applied to the whole sample.

At the final stages of screening, where evidence-based criterion and their combinations were increasingly resulting in the removal of certainly genuine responders or other responders suspected to be genuine, responses were flagged as suspicious at the individual level (e.g., if suspicious responses were provided to open-ended questions, e.g., 'Can you describe any one change that you made as a result of the CPD?'). All responses and survey data from that participant were then checked and removed if more than one evidence-based criterion indicating a potential bot was identified (e.g., patterned email address).

Future directions

Conventional practices employed by researchers to prevent and detect bot access to online surveys are likely no longer sufficient. Researchers should consider the use of additional evidence-based preventative measures, including 'honey pot' questions solely visible to bots, duplicate demographics questions (e.g., date of birth and age), and open-ended questions that require local knowledge or language.[244,261,393] While some researchers have encouraged tighter measures (e.g., multi-step screening processes),[394] I echo concerns from others that the introduction of any measure should be balanced with consideration of its likely influence on deterring valid participants from discovering, starting, or completing an online research survey.[393]

Flow Chart 1: Criteria used to identify, test, and exclude bots, resulting the inclusion of 170 participants



* Indicates all participants with this criterion excluded.

[a] IP addresses

I used IP2Location's LITE Edition tool, a free downloadable package available from http://www.ip2location.com, to determine whether participant IP addresses fell within the lower and upper bounds of IP address ranges assigned to the UK. The tool reports an accuracy of 98.0% at the country level. To speed up database queries, participants' IP addresses provided by REDCap were converted from their dot-decimal notation (e.g., 192.168.0.1) to their integer value using the following equation:

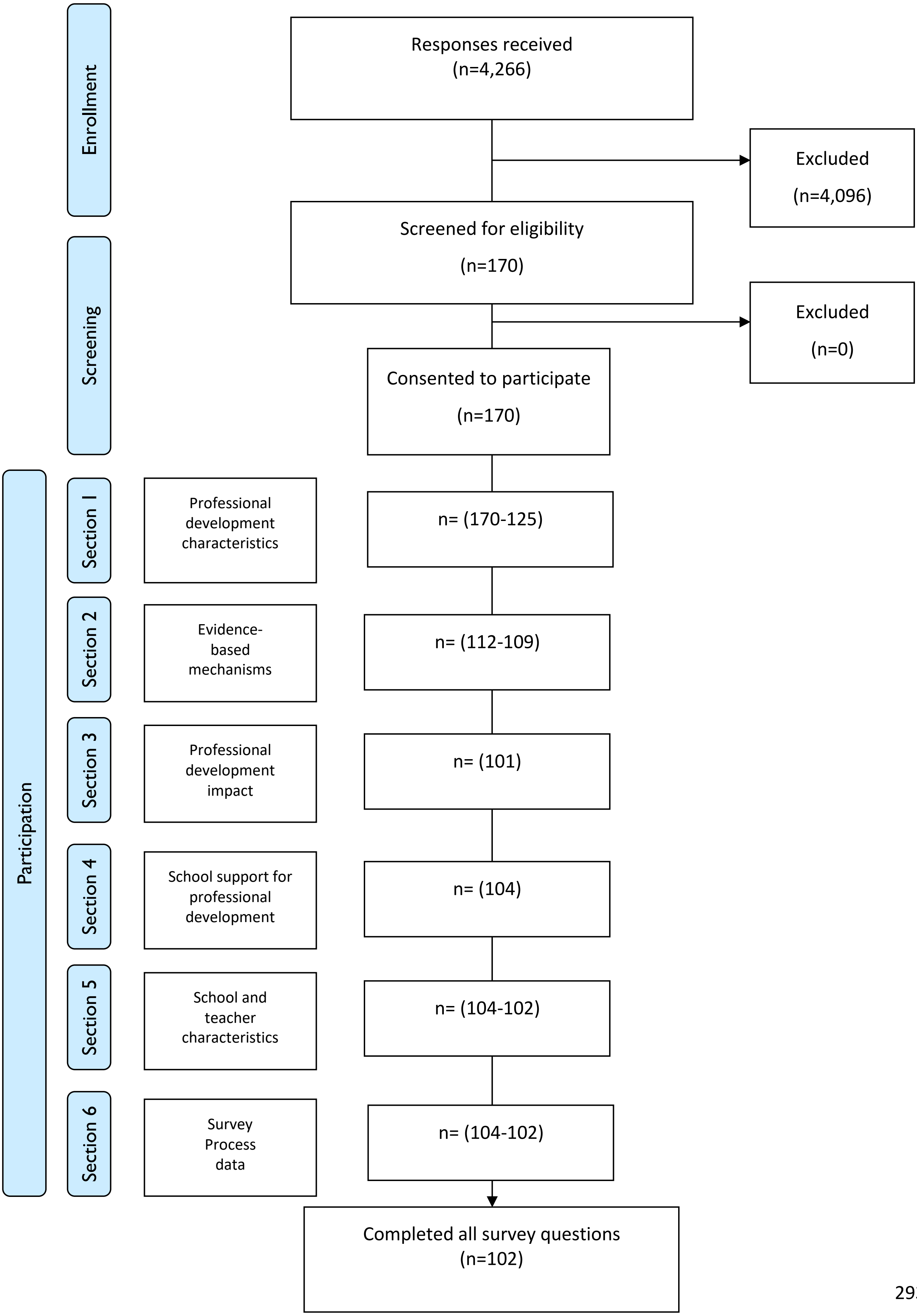
$$\text{IP Integer} = (A \times 256^3) + (B \times 256^2) + (C \times 256^1) + D$$

Given the city-level accuracy drops to 60.0%, I did not use it to further assess regional geolocations (e.g., cities within Scotland, Northern Ireland, and Wales, which may indicate suspicious responders; teachers had to based within schools in England to participate).

[b] Email addresses

Participant email addresses were categorised based on i) the domain used (e.g., Gmail.com) and ii) the presence of specific patterns (e.g., identical or multiple numbers in a row -'247dd7@hotmail.com') indicating a suspicious email.

Appendix 3.5. Study participation and attrition at each stage



Appendix 3.6. Agreement with leadership support statements

Leadership support statements (n=104)	**Strongly agree/ agree**		**Neither agree nor disagree**		**Disagree/ Strongly disagree**	
	N	**%**	**N**	**%**	**N**	**%**
promotes PE professional development culture	83	79.8	15	14.4	6	5.8
has a clear vision for PE professional development	80	76.9	15	14.4	9	8.7
helps overcome implementation barriers	71	68.3	25	24.0	8	7.7
effectively plans PE professional development	68	65.4	24	23.1	12	11.5
prioritises PE professional development	63	60.6	26	25.0	15	14.4

Appendix 3.7. Sensitivity analyses

Leadership support statements associated with teachers' perceptions of professional development impact (Not at all/Not a lot/Quite a lot/A lot)

Univariable and multivariable logistic regression analyses were conducted to explore the relationship between teachers' agreement with leadership support statements and their perceptions of professional development impact. No statistically significant associations were identified in multivariable models in the main analyses.

Repeating analyses using different cut-off points for the outcome variable, exploring if the findings changed when teachers' reported the professional development had either 'Quite a lot' or 'A lot' of impact (compared to just 'A lot' of impact in the main analysis), did not change the findings. See Table 3.

Table 3. Sensitivity analyses: Leadership support statements associated with teachers' perceptions of professional development impact ('Not at all/Not a lot' vs ***'Quite a lot'/'A lot'****)*

			Univariable	Multivariable
	N	**%[a]**	OR [95% CI]	OR [95% CI]
Leadership support statements	97			
has a clear vision for PE professional development	74	76.3	**10.61 [3.11, 36.18]**	2.73 [0.63, 11.82]
promotes PE professional development culture	77	79.4	**9.68 [2.87, 32.55]**	1.98 [0.42, 9.4]
effectively plans PE professional development	62	63.9	**10.26 [2.65, 39.73]**	1.11 [0.17, 7.21]
prioritises PE professional development	56	57.7	**28.51 [3.56, 228.36]**	7.4 [0.52, 104.92]
helps overcome implementation barriers	65	67.0	**12.4 [3.18, 48.40]**	1.97 [0.34, 11.42]

[a] Percentages of participants who 'Strongly agreed' or 'Agreed' with individual leadership support statements; Participants with missing data and participants not teaching PE are removed from analyses (n=69); **bold: $p < 0.05$;** *OR* Odds Ratio; *CI* Confidence Interval

Appendix C: Supplementary material for Chapter 4

Appendix 4.1. STROBE checklist

STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) checklist of items that should be included in reports of cross-sectional studies[241]

Section	Item	Recommendation	Page	Appendix
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract		
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	n/a	
Introduction				
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	64-65	
Objectives	3	State specific objectives, including any pre-specified hypotheses	65	
Methods				
Study design	4	Present key elements of study design early in the paper	66	
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	66	
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	66	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	67-70	4.2
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*67-70*	*4.2*
Bias	9	Describe any efforts to address potential sources of bias	70	
Study size	10	Explain how the study size was arrived at		4.2
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable,	70	

Section	Item	Recommendation	Page	Appendix
		describe which groupings were chosen and why		
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	70	
		(*b*) Describe any methods used to examine subgroups and interactions	70	
		(*c*) Explain how missing data were addressed	68	
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	n/a	
		(*e*) Describe any sensitivity analyses		
Results				
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	71 (to follow in trial publication)	
		(b) Give reasons for non-participation at each stage		
		(c) Consider use of a flow diagram		
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	71	
		(b) Indicate number of participants with missing data for each variable of interest	71	(Table 4.2)
Outcome data	15*	Report numbers of outcome events or summary measures	71	(Table 4.2)
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	72-75	
		(*b*) Report category boundaries when continuous variables were categorized		
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period		
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses		4.2, 4.5
Discussion				

Section	**Item**	**Recommendation**	**Page**	**Appendix**
Key results	18	Summarise key results with reference to study objectives	76	
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	78	
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	79	
Generalisability	21	Discuss the generalisability (external validity) of the study results	78-79	
Other information				
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	80, iv	

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Appendix 4.2. Exposure measures

Principal survey measures

Does the school provide sports equipment at lunch times for the students?

- Yes
- No

Does the school provide any structured activities for the students at lunch times that are physically active?

- Yes
- No

Research assistant checklists for school visits (N=12)

Do students…		Yes	No	Other (any notes)
1	have access to an oval? (either on school grounds or in a space nearby)	Yes		
2	have access to playground equipment such as monkey bars?	Yes		
3	have access to loose equipment such as balls?	Yes		

Student survey measures

Thinking about last week at school when answering the following questions:

How often did you play on the oval?

1	2	3	4	5
We don't have an oval	Never	Once or twice	A few times	Everyday

How often did you play on the playground equipment such as monkey bars?

1	2	3	4	5
We don't have playground equipment	Never	Once or twice	A few times	Everyday

How often did you play with equipment such as balls, provided by your school?

1	2	3	4	5
Teachers don't provide equipment	Never	Once or twice	A few times	Everyday

How often did you play organised games?

1	2	3	4	5
Teachers don't organise games	Never	Once or twice	A few times	Everyday

Further information:

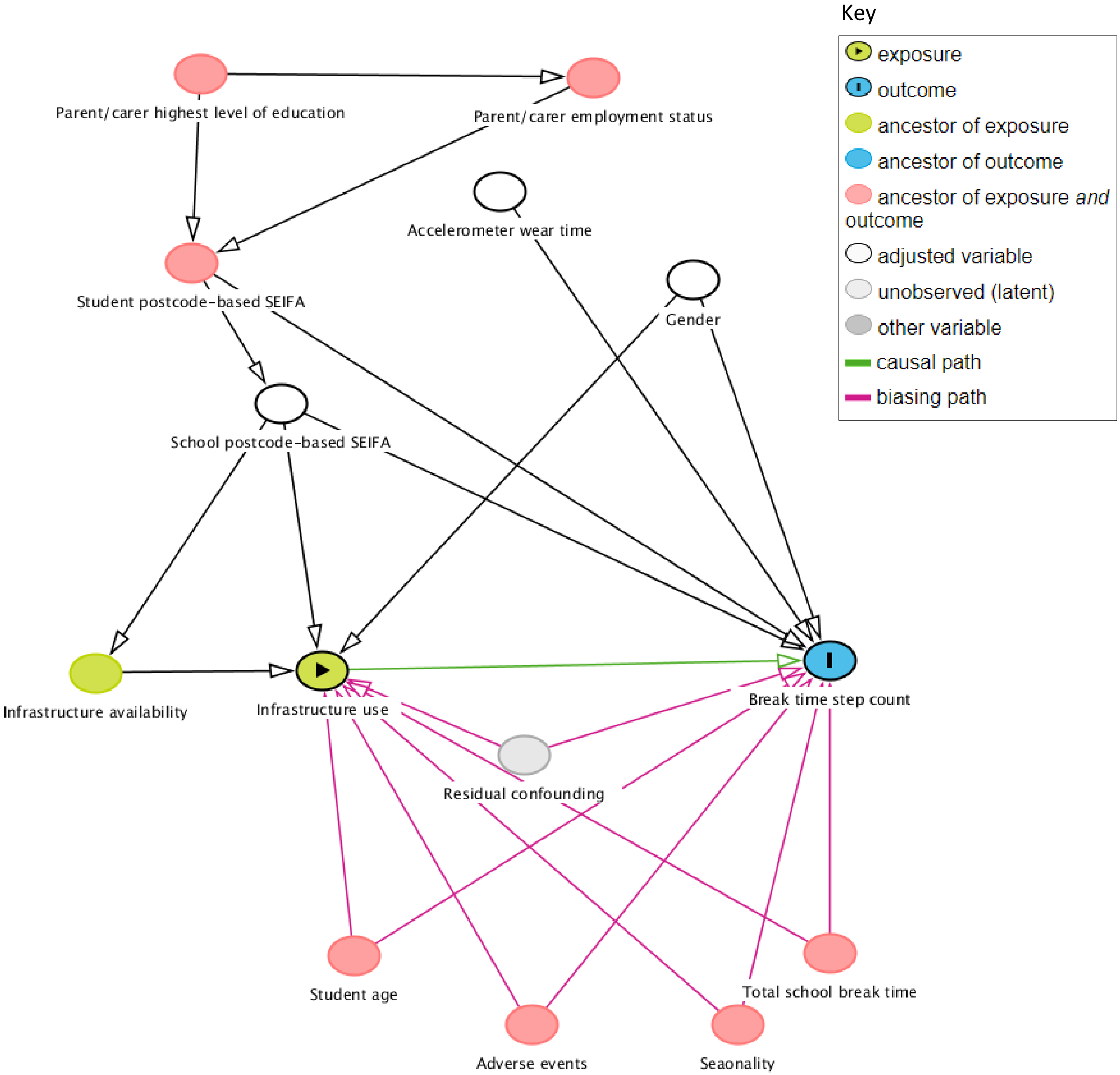
All principal and student survey items are included in Supplementary Materials of the trial protocol paper available at:

Nathan, N., McCarthy, N., Hall, A., Shoesmith, A., Lane, C., Jackson, R., ... & Wolfenden, L. (2022). Cluster randomised controlled trial to determine the impact of an activity enabling uniform on primary school student's fitness and physical activity: study protocol for the Active WeAR Everyday (AWARE) study. *BMJ open*, *12*(9), e064692.

Appendix 4.3. Direct Acyclic Graphs (DAGs) used to inform analyses

DAGs used to inform analyses, created using Daggity software[400]

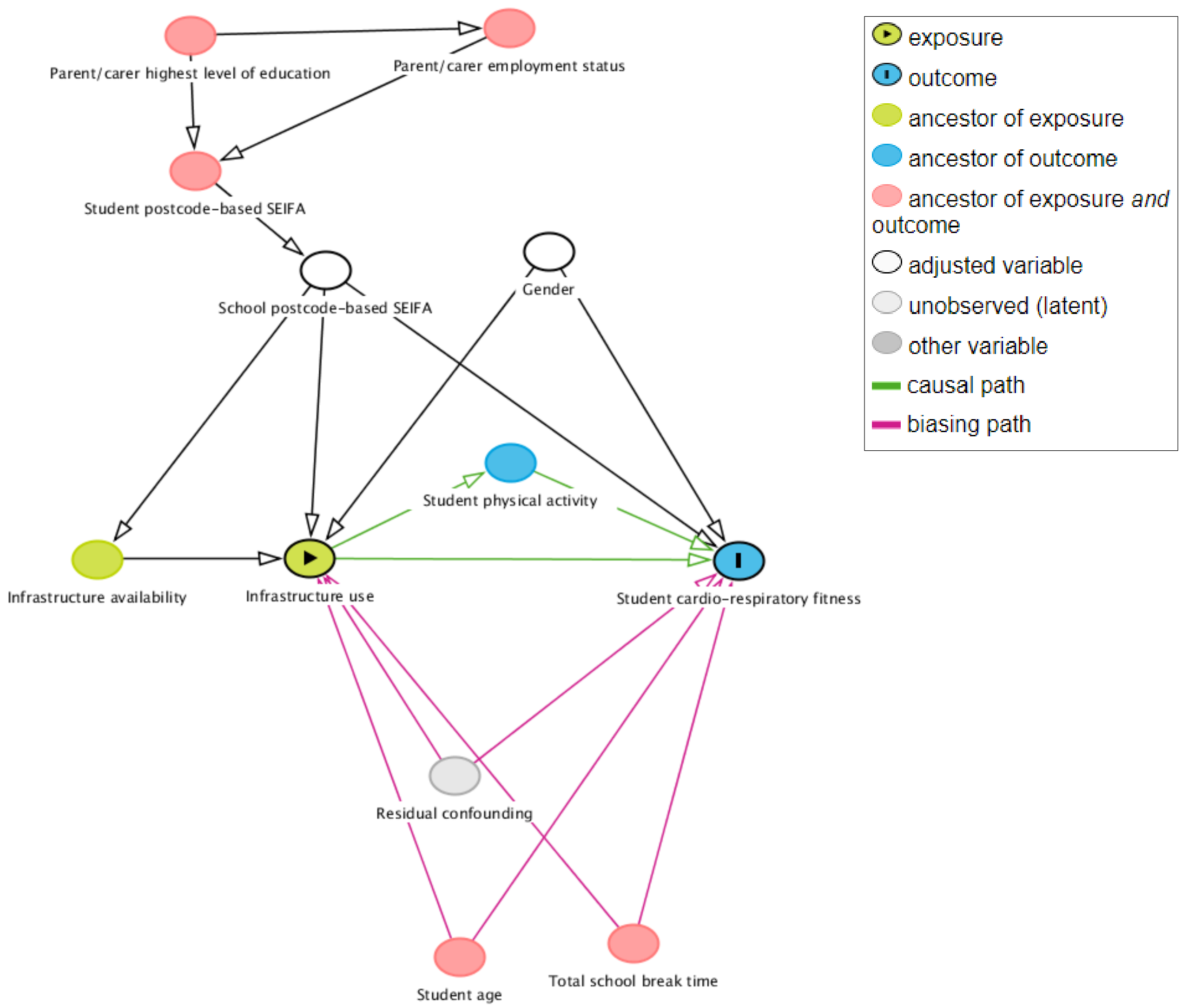
DAG used to inform analyses assessing the cross-sectional association between infrastructure use and break time step count



Adjusted for: gender, school postcode-based index of disadvantage classification (SEIFA), and accelerometer wear time

Based on the literature and the data, I adjusted for school postcode-based index of disadvantage classification (SEIFA), accelerometer wear-time, and gender.[40,401,402] I initially considered additional school and student-level confounders, including total school break time duration, seasonality, and adverse events, and student age.[403-406] However, I did not adjust for these to avoid potential separation issues. This was due to the narrow age range of participants, similar data collection months, absence of reported adverse events, and similar total break time across schools.

DAG used for analyses assessing the cross-sectional association between infrastructure use and cardio-respiratory fitness



Adjusted for: gender and school postcode-based index of disadvantage classification

Based on the literature and the data, I adjusted for gender and school postcode-based index of disadvantage classification.[403,407] I initially considered additional school and student-level confounders, including total school break time duration and student age.[403,408] However, I similarly did not adjust for these in analyses due to potential separation issues as a consequence of the narrow age range of participants included and similar total break time periods across schools. I did not adjust for student physical activity as it is affected by both the exposure and the outcome,[291] and on the hypothesised causal pathway between them. Adjusting for physical activity could therefore distort or reverse the association between playground infrastructure use and cardio-respiratory fitness.

Appendix 4.4. Associations between infrastructure use and break time step count by gender

Table 1. Students reported infrastructure use and mean break time steps by gender

	Boys			Girls		
Reported use[a]			**Break time steps**			**Break time steps**
Playing field	**n**	**%**	**Mean steps/min (SD)**[b]	**n**	**%**	**Mean steps/min (SD)**[b]
Daily use	119	39.9	38.63 (5.51)	97	32.6	33.15 (5.87)
Once or more	158	53.0	35.38 (6.86)	173	58.1	30.24 (5.46)
Never	21	7.0	32.97 (5.43)	28	9.4	28.07 (6.32)
Fixed equipment						
Daily use	14	5.1	37.86 (4.42)	18	7.0	28.80 (6.87)
Once or more	163	58.8	36.58 (6.80)	161	62.6	31.21 (5.95)
Never	100	36.1	36.39 (6.45)	78	30.4	30.65 (6.13)
Loose equipment						
Daily use	117	38.2	37.82 (5.91)	54	18.5	32.02 (5.14)
Once or more	166	54.2	35.66 (6.62)	209	71.6	30.94 (6.17)
Never	23	7.5	34.74 (7.64)	29	9.9	31.01 (5.21)
Teacher-organised games						
Daily use	60	19.5	37.50 (6.70)	35	12.0	29.69 (7.00)
Once or more	225	73.3	36.15 (6.38)	240	82.2	31.54 (5.66)
Never	22	7.2	36.08 (7.41)	17	5.8	27.67 (6.66)

[a] Students' self-reported use in the last week; [b] Assessed via accelerometer; *CI* Confidence Interval; *SD* Standard deviation

Do associations between students' infrastructure use and their step count differ by gender?

Table 2. Gender-based Difference in Difference (DID) estimates

	Estimate	95% CI	p-value
Reported use[a]			
Playing field			
Daily use vs Once or more	0.62	[-1.26, 2.49]	0.52
Daily use vs Never	0.51	[-2.96, 3.97]	0.77
Once or more vs Never	-0.11	[-3.46, 3.24]	0.95
Fixed equipment			
Daily use vs Once or more	2.58	[-1.48, 6.65]	0.21
Daily use vs Never	1.78	[-2.49, 6.05]	0.41
Once or more vs Never	-0.80	[-2.87, 1.27]	0.45
Loose equipment			
Daily use vs Once or more	1.18	[-0.94, 3.29]	0.27
Daily use vs Never	2.40	[-1.14, 5.93]	0.18
Once or more vs Never	1.22	[-2.03, 4.47]	0.46
Teacher-organised games			
Daily use vs Once or more	2.74	[0.19, 5.28]	0.04
Daily use vs Never	-1.73	[-5.98, 2.51]	0.42
Once or more vs Never	**-4.47**	**[-8.21, -0.73]**	**0.02**

[a] Students' self-reported use in the last week; Boys=1, Girls=2; *CI* Confidence Interval

Table 3. Comparison of associations between infrastructure use and break time step count by gender

	Boys			**Girls**		
	Estimate	95% CI	p-value	Estimate	95% CI	p-value
Reported use						
Playing field						
Daily use vs. Once or more	2.53	[1.19, 3.87]	0.00	1.92	[0.5, 3.34]	0.01
Daily use vs. Never	4.16	[1.56, 6.76]	0.00	3.65	[1.24, 6.06]	0.00
Once or more vs. Never	1.63	[-0.88, 4.14]	0.20	1.73	[-0.48, 3.95]	0.12
Fixed equipment						
Daily use vs. Once or more	0.70	[-2.33, 3.73]	0.65	-1.89	[-4.59, 0.81]	0.17
Daily use vs. Never	1.10	[-2.02, 4.21]	0.49	-0.69	[-3.63, 2.26]	0.65
Once or more vs. Never	0.40	[-1.02, 1.82]	0.58	1.20	[-0.45, 2.86]	0.15
Loose equipment						
Daily use vs. Once or more	1.99	[0.65, 3.34]	0.00	0.82	[-0.9, 2.54]	0.35
Daily use vs. Never	1.77	[-0.77, 4.31]	0.17	-0.63	[-3.19, 1.93]	0.63
Once or more vs. Never	-0.22	[-2.66, 2.21]	0.86	-1.44	[-3.61, 0.72]	0.19
Teacher-organised games						
Daily use vs. Once or more	1.58	[-0.01, 3.17]	0.05	-1.16	[-3.13, 0.81]	0.25
Daily use vs. Never	0.68	[-2.04, 3.39]	0.63	2.41	[-0.84, 5.66]	0.15
Once or more vs. Never	**-0.90**	**[-3.34, 1.53]**	0.47	**3.57**	**[0.75, 6.38]**	0.01

CI Confidence Interval

Appendix 4.5 Associations between infrastructure use and cardio-respiratory fitness by gender

Table 1. Students reported infrastructure use and mean fitness test score by gender

	Boys			Girls		
			Fitness test score[b]			**Fitness test score[b]**
Reported use[a]	**n**	**%**	**Mean result (SD)**	**n**	**%**	**Mean result (SD)**
Playing field						
Daily use	117	40.5	4.61 (1.74)	98	33.7	3.64 (1.41)
Once or more	152	52.6	3.75 (1.71)	166	57.0	3.14 (1.22)
Never	20	6.9	3.28 (1.57)	27	9.3	3.38 (1.38)
Fixed equipment						
Daily use	12	4.5	4.68 (2.08)	18	7.2	3.21 (1.54)
Once or more	161	59.9	4.20 (1.80)	157	62.8	3.35 (1.42)
Never	96	35.7	3.84 (1.77)	75	30.0	3.28 (1.14)
Loose equipment						
Daily use	114	38.5	4.24 (1.84)	55	19.3	3.57 (1.39)
Once or more	160	54.1	3.94 (1.74)	202	70.9	3.19 (1.25)
Never	22	7.4	3.36 (1.39)	28	9.8	3.67 (1.52)
Teacher-organised games						
Daily use	59	19.8	4.75 (1.70)	34	11.9	3.40 (1.45)
Once or more	219	73.5	3.95 (1.75)	235	82.5	3.29 (1.29)
Never	20	6.7	3.00 (1.28)	16	5.6	3.30 (1.44)

[a] Students' self-reported use in the last week; [b] Assessed using the validated 20-meter multi-stage fitness test (shuttle run test); *SD* Standard deviation

Do associations between students' infrastructure use and their fitness test score by gender?

Table 2. Gender-based Difference in Difference (DID) Estimates

	Estimate	**95% CI**	**p-value**
Reported use[a]			
Playing field			
Daily use vs Once or more	0.44	[-0.07, 0.95]	0.09
Daily use vs Never	**1.16**	**[0.21, 2.11]**	0.02
Once or more vs Never	0.72	[-0.2, 1.64]	0.13
Fixed equipment			
Daily use vs Once or more	0.74	[-0.46, 1.93]	0.23
Daily use vs Never	0.94	[-0.32, 2.19]	0.14
Once or more vs Never	0.20	[-0.39, 0.79]	0.50
Loose equipment			
Daily use vs Once or more	-0.06	[-0.64, 0.52]	0.84
Daily use vs Never	0.93	[-0.06, 1.91]	0.07
Once or more vs Never	0.98	[0.07, 1.9]	0.03
Teacher-organised games			
Daily use vs Once or more	0.68	[-0.02, 1.37]	0.06
Daily use vs Never	**1.45**	**[0.27, 2.63]**	0.02
Once or more vs Never	0.78	[-0.26, 1.82]	0.14

[a] Students' self-reported use in the last week; Boys=1, Girls=2; *CI* Confidence Interval

Table 3. Comparison of associations between infrastructure use and cardio-respiratory fitness by gender

	Boys			Girls		
	Estimate	**95% CI**	**p-value**	**Estimate**	**95% CI**	**p-value**
Reported use						
Playing field						
Daily use vs. Once or more	1.00	[0.64, 1.37]	<.0001	0.56	[0.18, 0.94]	0.00
Daily use vs. Never	**1.50**	**[0.79, 2.21]**	<.0001	**0.33**	**[-0.32, 0.99]**	0.32
Once or more vs. Never	0.49	[-0.2, 1.18]	0.16	-0.23	[-0.84, 0.38]	0.46
Fixed equipment						
Daily use vs. Once or more	0.63	[-0.28, 1.55]	0.17	-0.10	[-0.86, 0.65]	0.79
Daily use vs. Never	1.00	[0.06, 1.94]	0.04	0.06	[-0.77, 0.9]	0.88
Once or more vs. Never	0.37	[-0.03, 0.77]	0.07	0.17	[-0.3, 0.64]	0.49
Loose equipment						
Daily use vs. Once or more	0.40	[0.02, 0.77]	0.04	0.45	[-0.01, 0.92]	0.06
Daily use vs. Never	0.81	[0.1, 1.52]	0.03	-0.12	[-0.82, 0.59]	0.74
Once or more vs. Never	0.41	[-0.27, 1.1]	0.24	-0.57	[-1.18, 0.03]	0.06
Teacher-organised games						
Daily use vs. Once or more	0.84	[0.41, 1.28]	0.00	0.17	[-0.37, 0.7]	0.55
Daily use vs. Never	**1.66**	**[0.9, 2.43]**	<.0001	**0.21**	**[-0.69, 1.11]**	0.65
Once or more vs. Never	0.82	[0.13, 1.51]	0.02	0.04	[-0.74, 0.82]	0.91

CI Confidence Interval

Appendix D: Supplementary material for Chapter 5

Appendix 5.1. STROBE Statement

STROBE checklist of items that should be included in reports of cross-sectional studies[241]

Section	Item	Recommendation	Page	Appendix
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract		
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	N/A	
Introduction				
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	82	
Objectives	3	State specific objectives, including any pre-specified hypotheses	82	
Methods				
Study design	4	Present key elements of study design early in the paper	83	
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	83	
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	83	5.6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	83-85	5.4
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	83-85	
Bias	9	Describe any efforts to address potential sources of bias	83-85	
Study size	10	Explain how the study size was arrived at		
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	84-85	

Section	Item	Recommendation	Page	Appendix
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	85-86	
		(*b*) Describe any methods used to examine subgroups and interactions	85-86	
		(*c*) Explain how missing data were addressed	85-86	
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	85-86	
		(*e*) Describe any sensitivity analyses	85-86	
Results				
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	87	5.6
		(b) Give reasons for non-participation at each stage		5.4
		(c) Consider use of a flow diagram		5.6
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	87-89	5.7, 5.8 Table 5.1 Figures 5.2, 5.3
		(b) Indicate number of participants with missing data for each variable of interest	87-89	5.7 Table 5.1
Outcome data	15*	Report numbers of outcome events or summary measures	87-89	5.8 Tables 5.1, 5.2
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	89-91	Table 5.3
		(*b*) Report category boundaries when continuous variables were categorized	89-91	

Section	Item	Recommendation	Page	Appendix
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period		
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	89-91	
Discussion				
Key results	18	Summarise key results with reference to study objectives	92	
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	93-94	
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	93-94	
Generalisability	21	Discuss the generalisability (external validity) of the study results	93	
Other information				
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	iv	

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

1. Von Elm E, Altman DG, Egger M, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *Ann Intern Med* 2007; **147**(8): 573-7.

Appendix 5.2. Terminology and definitions adopted for the study

Term	Definition
Country/region	The terms 'country' or 'region' do not imply political independence but refer to any territory for which separate health statistics are reported.[330]
Gender	By gender, I refer to the social and cultural aspects associated with being a girl or a boy, including norms, behaviours, roles, and relationships within a given society. Gender is a social construct that varies across different societies and can evolve over time [409]. I note that most surveillance studies collected data on participants' sex but referred to sex disparities as gender differences.
Inequalities	Systematic, preventable and unjust disparities in health outcomes that can be observed between populations, between social groups within the same population or as a gradient across a population ranked by social position.[410]
Physical activity prevalence	The percentage of participants sampled reported to accumulate 'sufficient' physical activity, based on a stated threshold (e.g., at least 60 minutes per day, 7 days a week).
Primary school	Educational stages and definitions differ worldwide. By 'primary school' I refer to any formal setting that typically educates students aged 6-11 years.
School uniform	A consistent and standardised set of clothes that all students are required to wear during school hours.
Secondary school	By 'secondary school' I refer to any formal setting that typically educates students aged 12-18 years.
Study	A source reporting on physical activity with reference to a defined guideline/target among a defined group of participants.
Surveillance initiative	An evidence-gathering initiative aimed at surveying the amount of physical activity across multiple populations through primary or secondary data collection methods.

Appendix 5.3. Hierarchy used to prioritise physical activity study for selection

Colleagues and I used a hierarchy to prioritise selection of studies reporting on compliance with physical activity guidelines among children and adolescents aged 6-18 years at the country level.

For self-report data, we prioritised studies that reported on:

i) data collected between 2011-2022 (or the next most recent year),
ii) participants sampled from a national or regional population (over a local population),
iii) a larger sample of participants, and
iv) empirical data (i.e., 2016 projections from Guthold surveillance initiative[33] not selected for inclusion if empirical country-level data available from elsewhere (e.g.,[21]).

For device-measured data, studies were also prioritised that reported on

i) data collected between 2011–2022,
ii) participants sampled from a national population, and
iii) on a larger sample of participants.

For studies with repeated measures:

These criteria were also applied to inform prioritisation where selection was required for initiatives reporting repeated measures studies e.g.,[398] (i.e., if no waves from were collected between the 2011-2022 period, then the wave reporting on the largest sample of participants was selected for inclusion).

Appendix 5.4. Studies not selected for inclusion (N=304), with reasons

Country	Study name or abbreviation[a]	Data collection	Sample size	Age range[b]	Device measured[c]	Wave number[d]	Reason not selected
Albania	HBSC	2014-2014	4,924	11-15	No	n/a	Projection only
Armenia	HBSC	2014-2014	3,680	11-15	No	n/a	Projection only
Armenia	HBSC	2010-2010	2,833	11-15	No	n/a	Projection only
Australia	NNPAS	2012-2012	2,800	11-17	No	n/a	Sample size
Australia	NHS	2011-2011	1,686	12-17	No	n/a	Sample size
Australia	CLAN	2001-2001	718	6-11.99	Yes	1	Year of data collection
Australia	ACTPANS	2015-2015	1,353	11-12	No	n/a	Sample size
Australia	National Health Survey	2014-2014	863	15-17	No	n/a	Sample size
Australia	NaSSDA	2013-2013	8,888	12-17	No	n/a	Sample size
Australia	SPANS	2015-2015	3,217	5-16	No	n/a	Sample size
Australia	Victorian Student Health and Wellbeing Survey	2016-2016	11,421	10-16	No	n/a	Population sampled
Australia	CLAN	2004-2004	159	6-11.99	Yes	2	Year of data collection
Australia	CLAN	2006-2006	148	6-11.99	Yes	3	Year of data collection
Australia	HEAPS	2002-2003	650	6-11.99	Yes	1	Year of data collection
Australia	HEAPS	2006-2006	160	6-11.99	Yes	2	Year of data collection
Australia	CLAN	2001-2001	156	12-18.99	Yes	1	Sample size
Australia	CLAN	2006-2006	182	12-18.99	Yes	3	Sample size
Australia	HEAPS	2002-2003	76	12-18.99	Yes	1	Sample size
Australia	HEAPS	2006-2006	114	12-18.99	Yes	2	Sample size
Austria	HBSC	2014-2014	3,420	11-15	No	n/a	Projection only
Austria	HBSC	2010-2010	5,003	11-15	No	n/a	Projection only
Austria	HBSC	2005-2005	4,775	11-15	No	n/a	Projection only
Austria	HBSC	2001-2001	4,366	11-15	No	n/a	Projection only
Bangladesh	GSHS	2014-2014	2,881	12-17	No	n/a	Sample size
Bangladesh	GSHS	2014-2014	Not available	13-15	No	n/a	Sample size

Country	Study name or abbreviation[a]	Data collection	Sample size	Age range[b]	Device measured[c]	Wave number[d]	Reason not selected
Belgium	HBSC	2014-2014	10,240	11-15	No	n/a	Projection only
Belgium	HBSC	2010-2010	8,192	11-15	No	n/a	Projection only
Belgium	HBSC	2005-2005	8,787	11-15	No	n/a	Projection only
Belgium	HBSC	2001-2001	10,612	11-15	No	n/a	Projection only
Belgium	National survey	2014-2014	387	6-9	No	n/a	Sample size
Belgium	National survey	2014-2014	573	10-17	No	n/a	Sample size
Botswana	GSHS	2005-2005	2,087	12-16	No	n/a	Sample size
Brazil	PeNSE	2015-2015	16,600	13-17	No	n/a	Sample size
Brazil	PeNSE	2015-2015	102,072	14-14	No	n/a	Sample size
Brazil	PeNSE	2015-2015	16,556	13-17	No	n/a	Sample size
Bulgaria	HBSC	2014-2014	4,796	11-15	No	n/a	Projection only
Bulgaria	HBSC	2005-2005	4,854	11-15	No	n/a	Projection only
Bulgaria	National survey	2011-2011	Not available	14-18	No	n/a	Sample size
Canada	HBSC	2010-2011	15,710	11-15	No	n/a	Sample size
Canada	HBSC	2005-2005	5,787	11-15	No	n/a	Sample size
Canada	HBSC	2001-2001	4,361	11-15	No	n/a	Sample size
Canada	HBSC	2017-2017	22,115	10-17	No	n/a	Error identified
Chile	GSHS	2013-2013	1,871	12-17	No	n/a	Projection only
Chile	GSHS	2005-2005	3,577	12-16	No	n/a	Projection only
Chile	GSHS	2004-2004	8,002	12-16	No	n/a	Projection only
China	GSHS	2003-2003	8,791	11-16	No	n/a	Year of data collection
China	PAFCTYS	2016-2016	90,712	9-17	No	n/a	Sample size
China	PAFCTYS	2016-2016	31,472	13-13	No	n/a	Sample size
China	PAFCTYS	2016-2016	32,563	16-16	No	n/a	Sample size
Colombia	GSHS	2007-2007	9,524	12-16	No	n/a	Projection only
Colombia	ENSIN	2005-2005	7,490	13-17	No	n/a	Projection only
Colombia	ENSIN	2015-2015	Not available	6-12	No	n/a	Sample size
Croatia	HBSC	2014-2014	5,740	11-15	No	n/a	Projection only

Country	Study name or abbreviation[a]	Data collection	Sample size	Age range[b]	Device measured[c]	Wave number[d]	Reason not selected
Croatia	HBSC	2010-2010	6,252	11-15	No	n/a	Projection only
Croatia	HBSC	2005-2005	4,965	11-15	No	n/a	Projection only
Croatia	HBSC	2001-2001	4,366	11-15	No	n/a	Projection only
Czech Republic	HBSC	2014-2014	5,056	11-15	No	n/a	Projection only
Czech Republic	HBSC	2010-2010	4,404	11-15	No	n/a	Projection only
Czech Republic	HBSC	2005-2005	4,775	11-15	No	n/a	Projection only
Czech Republic	HBSC	2001-2001	5,012	11-15	No	n/a	Projection only
Czech Republic	HBSC	2018-2018	5,169	11-15	No	n/a	Sample size
Czech Republic	HBSC	2014-2014	Not available	12.5-14.5	No	n/a	Sample size
Czech Republic	HBSC	2014-2014	Not available	14.5-16.5	No	n/a	Sample size
Denmark	HBSC	2014-2014	3,846	11-15	No	n/a	Projection only
Denmark	HBSC	2010-2010	4,046	11-15	No	n/a	Projection only
Denmark	HBSC	2005-2005	5,682	11-15	No	n/a	Projection only
Denmark	HBSC	2001-2001	4,587	11-15	No	n/a	Projection only
Denmark	HBSC	2018-2018	1,807	13-15	No	n/a	Sample size
Denmark	CHAMPS study	2015-2015	Not available	12-16	Yes	n/a	Error identified
Denmark	Danish National Health Survey	2017-2017	4,634	16-17	No	n/a	Sample size
Denmark	HBSC	2014-2014	Not available	11-11	No	n/a	Sample size
Denmark	HBSC	2014-2014	3,891	11-15	No	n/a	Sample size
Denmark	HBSC	2014-2014	Not available	13-13	No	n/a	Sample size
Denmark	HBSC	2014-2014	Not available	15-15	No	n/a	Sample size
Denmark	CoSCIS	2001-2002	454	6-11.99	Yes	1	Year of data collection
Denmark	CoSCIS	2004-2005	423	6-11.99	Yes	2	Year of data collection
Denmark	EYHS Denmark	1997-1998	322	6-11.99	Yes	1	Year of data collection
Denmark	EYHS Denmark	2003-2004	390	6-11.99	Yes	2	Year of data collection
Denmark	CoSCIS	2008-2008	298	12-18.99	Yes	3	Year of data collection
Denmark	EYHS Denmark	1997-1998	186	12-18.99	Yes	1	Year of data collection
Denmark	EYHS Denmark	2003-2004	281	12-18.99	Yes	2	Year of data collection

Country	Study name or abbreviation[a]	Data collection	Sample size	Age range[b]	Device measured[c]	Wave number[d]	Reason not selected
Denmark	EYHS Denmark	2009-2010	271	12-18.99	Yes	3	Year of data collection
Ecuador	GSHS	2007-2007	5,264	11-16	No	n/a	Year of data collection
England	HBSC	2017-2018	1,568	11-15	No	n/a	Sample size
England	HBSC	2014-2014	2,116	11-11	No	n/a	Sample size
England	HBSC	2014-2014	1,593	13-13	No	n/a	Sample size
England	HBSC	2014-2014	1,608	15-15	No	n/a	Sample size
England	ALSPAC	2003-2003	4,254	6-11.99	Yes	1	Year of data collection
England	PEACH	2006-2006	687	6-11.99	Yes	1	Year of data collection
England	PEACH	2007-2007	199	6-11.99	Yes	2	Year of data collection
England	SPEEDY	2007-2007	1,576	6-11.99	Yes	1	Year of data collection
England	SPEEDY	2008-2008	671	6-11.99	Yes	2	Year of data collection
England	ALSPAC	2003-2003	832	12-18.99	Yes	1	Year of data collection
England	ALSPAC	2005-2005	3,383	12-18.99	Yes	2	Year of data collection
England	ALSPAC	2007-2007	1,875	12-18.99	Yes	3	Year of data collection
England	PEACH	2007-2007	210	12-18.99	Yes	2	Year of data collection
England	PEACH	2009-2009	267	12-18.99	Yes	3	Year of data collection
Estonia	HBSC	2014-2014	4,052	11-15	No	n/a	Projection only
Estonia	HBSC	2010-2010	4,224	11-15	No	n/a	Projection only
Estonia	HBSC	2005-2005	4,477	11-15	No	n/a	Projection only
Estonia	HBSC	2001-2001	3,976	11-15	No	n/a	Projection only
Estonia	HBSC	2018-2018	3,147	13-15	No	n/a	Sample size
Estonia	HBSC	2014-2014	Not available	11-11	No	n/a	Sample size
Estonia	HBSC	2014-2014	Not available	13-13	No	n/a	Sample size
Estonia	HBSC	2014-2014	Not available	15-15	No	n/a	Sample size
Finland	HBSC	2014-2014	5,838	11-15	No	n/a	Projection only
Finland	HBSC	2010-2010	6,607	11-15	No	n/a	Projection only
Finland	HBSC	2005-2005	5,193	11-15	No	n/a	Projection only
Finland	HBSC	2001-2001	5,348	11-15	No	n/a	Projection only

Country	Study name or abbreviation[a]	Data collection	Sample size	Age range[b]	Device measured[c]	Wave number[d]	Reason not selected
Finland	HBSC	2018-2018	2,194	13-15	No	n/a	Sample size
Finland	HBSC	2018-2018	946	11-11	No	n/a	Sample size
Finland	LITU study (survey)	2016-2016	7,321	9-9	No	n/a	Sample size
Finland	LITU study (survey)	2016-2016	Not available	11-11	No	n/a	Sample size
Finland	LITU study (survey)	2016-2016	Not available	13-13	No	n/a	Sample size
Finland	LITU study (survey)	2016-2016	Not available	15-15	No	n/a	Sample size
Finland	ISCOLE	2011-2013	528	6-11.99	Yes	n/a	Sample size
France	HBSC	2014-2014	5,636	11-15	No	n/a	Projection only
France	HBSC	2010-2010	6,128	11-15	No	n/a	Projection only
France	HBSC	2005-2005	7,141	11-15	No	n/a	Projection only
France	HBSC	2001-2001	8,185	11-15	No	n/a	Projection only
France	ESTEBAN	2015-2015	Not available	6-10	No	n/a	Sample size
France	ESTEBAN	2015-2015	Not available	11-14	No	n/a	Sample size
France	ESTEBAN	2015-2015	Not available	15-17	No	n/a	Sample size
France	INCA 3	2015-2015	1,291	11-17	No	n/a	Sample size
France	INCA 3	2015-2015	736	11-14	No	n/a	Sample size
France	INCA 3	2015-2015	555	15-17	No	n/a	Sample size
Germany	HBSC	2014-2014	5,910	11-15	No	n/a	Sample size
Germany	HBSC	2010-2010	4,955	11-15	No	n/a	Sample size
Germany	HBSC	2005-2005	7,224	11-15	No	n/a	Sample size
Germany	HBSC	2001-2001	5,635	11-15	No	n/a	Sample size
Germany	GINI+study and LISA+study	2014-2014	1,403	15.6-15.6	Yes	n/a	Sample size
Germany	HBSC	2014-2014	5,961	11-11	No	n/a	Sample size
Germany	HBSC	2010-2010	17,929	11-15	No	n/a	Year of data collection
Germany	HBSC	2014-2014	Not available	13-13	No	n/a	Sample size
Germany	HBSC	2014-2014	Not available	15-15	No	n/a	Sample size
Germany	KiGGs Study	2017-2017	Not available	3-6	No	n/a	Sample size
Germany	KiGGs Study	2017-2017	Not available	7-10	No	n/a	Sample size

Country	Study name or abbreviation[a]	Data collection	Sample size	Age range[b]	Device measured[c]	Wave number[d]	Reason not selected
Germany	KiGGs Study	2017-2017	Not available	11-13	No	n/a	Sample size
Germany	KiGGs Study	2017-2017	Not available	14-17	No	n/a	Sample size
Germany	IDEFICS	2007-2010	773	6-11.99	Yes	n/a	Year of data collection
Greece	HBSC	2014-2014	4,114	11-15	No	n/a	Projection only
Greece	HBSC	2010-2010	4,899	11-15	No	n/a	Projection only
Greece	HBSC	2005-2005	3,690	11-15	No	n/a	Projection only
Greece	HBSC	2001-2001	3,807	11-15	No	n/a	Projection only
Greenland	HBSC	2010-2010	1,205	11-15	No	n/a	Projection only
Greenland	HBSC	2005-2005	1,358	11-15	No	n/a	Projection only
Greenland	HBSC	2001-2001	873	11-15	No	n/a	Projection only
Hungary	HBSC	2014-2014	3,876	11-15	No	n/a	Projection only
Hungary	HBSC	2010-2010	4,787	11-15	No	n/a	Projection only
Hungary	HBSC	2005-2005	3,498	11-15	No	n/a	Projection only
Hungary	HBSC	2001-2001	4,057	11-15	No	n/a	Projection only
Iceland	HBSC	2014-2014	10,440	11-15	No	n/a	Projection only
Iceland	HBSC	2010-2010	11,049	11-15	No	n/a	Projection only
Iceland	HBSC	2005-2005	9,476	11-15	No	n/a	Projection only
India	GSHS	2007-2007	6,130	13-15	No	n/a	Year of data collection
India	Local research study	2009-2009	1,842	12-18	No	n/a	Year of data collection
Ireland	HBSC	2014-2014	4,078	11-15	No	n/a	Projection only
Ireland	HBSC	2010-2010	4,724	11-15	No	n/a	Projection only
Ireland	HBSC	2005-2005	4,840	11-15	No	n/a	Projection only
Ireland	HBSC	2001-2001	2,875	11-15	No	n/a	Projection only
Italy	HBSC	2014-2014	4,010	11-15	No	n/a	Projection only
Italy	HBSC	2010-2010	4,811	11-15	No	n/a	Projection only
Italy	HBSC	2005-2005	3,920	11-15	No	n/a	Projection only
Italy	HBSC	2001-2001	4,357	11-15	No	n/a	Projection only
Latvia	HBSC	2014-2014	5,536	11-15	No	n/a	Projection only

Country	Study name or abbreviation[a]	Data collection	Sample size	Age range[b]	Device measured[c]	Wave number[d]	Reason not selected
Latvia	HBSC	2010-2010	4,264	11-15	No	n/a	Projection only
Latvia	HBSC	2005-2005	4,221	11-15	No	n/a	Projection only
Latvia	HBSC	2001-2001	3,455	11-15	No	n/a	Projection only
Lebanon	GSHS	2016-2016	4,954	11-17	No	n/a	Sample size
Lebanon	GSHS	2011-2011	2,189	11-16	No	n/a	Sample size
Lebanon	GSHS	2017-2017	Not available	13-15	No	n/a	Sample size
Lebanon	GSHS	2017-2017	Not available	16-17	No	n/a	Sample size
Lithuania	HBSC	2014-2014	5,732	11-15	No	n/a	Projection only
Lithuania	HBSC	2010-2010	5,323	11-15	No	n/a	Projection only
Lithuania	HBSC	2005-2005	5,632	11-15	No	n/a	Projection only
Lithuania	HBSC	2001-2001	5,644	11-15	No	n/a	Projection only
Lithuania	HBSC	2014-2014	Not available	13-13	No	n/a	Sample size
Lithuania	HBSC	2014-2014	Not available	15-15	No	n/a	Sample size
Luxembourg	HBSC	2014-2014	3,112	11-15	No	n/a	Projection only
Luxembourg	HBSC	2010-2010	4,072	11-15	No	n/a	Projection only
Luxembourg	HBSC	2005-2005	4,300	11-15	No	n/a	Projection only
Malta	HBSC	2014-2014	2,258	11-15	No	n/a	Projection only
Malta	HBSC	2005-2005	1,389	11-15	No	n/a	Projection only
Malta	HBSC	2001-2001	1,945	11-15	No	n/a	Projection only
Mexico	ENSANUT	2016-2016	1,472	11-14	No	n/a	Sample size
Mexico	National Health and Nutrition Survey ENSANUT	2016-2016	1,440	15-19	No	n/a	Sample size
Moldova	HBSC	2014-2014	4,650	11-15	No	n/a	Projection only
Nepal	GSHS	2015-2015	6,167	11-17	No	n/a	Sample size
Nepal	GSHS	2015-2015	Not available	13-15	No	n/a	Sample size
Nepal	GSHS	2015-2015	Not available	16-17	No	n/a	Sample size
Netherlands	HBSC	2014-2014	4,236	11-15	No	n/a	Projection only
Netherlands	HBSC	2010-2010	4,520	11-15	No	n/a	Projection only
Netherlands	HBSC	2005-2005	4,228	11-15	No	n/a	Projection only

Country	Study name or abbreviation[a]	Data collection	Sample size	Age range[b]	Device measured[c]	Wave number[d]	Reason not selected
Netherlands	HBSC	2001-2001	4,268	11-15	No	n/a	Projection only
North Macedonia	HBSC	2014-2014	4,162	11-15	No	n/a	Projection only
North Macedonia	HBSC	2010-2010	3,897	11-15	No	n/a	Projection only
North Macedonia	GSHS	2007-2007	1,978	12-17	No	n/a	Projection only
North Macedonia	HBSC	2005-2005	5,271	11-15	No	n/a	Projection only
North Macedonia	HBSC	2001-2001	4,030	11-15	No	n/a	Projection only
Norway	HBSC	2014-2014	3,050	11-15	No	n/a	Projection only
Norway	HBSC	2010-2010	4,338	11-15	No	n/a	Projection only
Norway	HBSC	2005-2005	4,697	11-15	No	n/a	Projection only
Norway	HBSC	2001-2001	5,015	11-15	No	n/a	Projection only
Norway	EYHS Norway	missing	55	12-18.99	Yes	2	Sample size
Norway	EYHS Norway	1999-2000	356	6-11.99	Yes	1	Sample size
Poland	HBSC	2014-2014	4,518	11-15	No	n/a	Projection only
Poland	HBSC	2010-2010	4,241	11-15	No	n/a	Projection only
Poland	HBSC	2005-2005	5,489	11-15	No	n/a	Projection only
Poland	HBSC	2001-2001	6,310	11-15	No	n/a	Projection only
Poland	HBSC	2018-2018	3,507	13-15	No	n/a	Sample size
Poland	HBSC	2014-2014	Not available	11-11	No	n/a	Sample size
Poland	HBSC	2014-2014	Not available	13-13	No	n/a	Sample size
Poland	HBSC	2014-2014	Not available	15-15	No	n/a	Sample size
Poland	National survey	2013-2013	Not available	9-17	No	n/a	Sample size
Portugal	HBSC	2014-2014	4,990	11-15	No	n/a	Projection only
Portugal	HBSC	2010-2010	4,036	11-15	No	n/a	Projection only
Portugal	HBSC	2005-2005	3,919	11-15	No	n/a	Projection only
Portugal	HBSC	2001-2001	2,928	11-15	No	n/a	Projection only
Portugal	HBSC	2014-2014	Not available	11-11	No	n/a	Sample size
Portugal	HBSC	2014-2014	Not available	13-13	No	n/a	Sample size
Portugal	HBSC	2014-2014	Not available	15-15	No	n/a	Sample size

Country	Study name or abbreviation[a]	Data collection	Sample size	Age range[b]	Device measured[c]	Wave number[d]	Reason not selected
Portugal	IANAF survey	2016-2016	720	6-14	No	n/a	Sample size
Portugal	IANAF survey	2016-2016	Not available	6-9	No	n/a	Sample size
Portugal	IANAF survey	2016-2016	Not available	10-14	No	n/a	Sample size
Portugal	Observatório da Atividade Física e do Desporto	2007-2007	941	12-13	Yes	n/a	Year of data collection
Portugal	Observatório da Atividade Física e do Desporto	2007-2007	529	14-15	Yes	n/a	Year of data collection
Portugal	Observatório da Atividade Física e do Desporto	2007-2007	444	16-17	Yes	n/a	Year of data collection
Portugal	EYHS Portugal	1999-2000	182	12-18.99	Yes	1	Year of data collection
Portugal	EYHS Portugal	2007-2008	89	12-18.99	Yes	2	Year of data collection
Portugal	Observatório da Atividade Física e do Desporto	2007-2007	800	10-11	Yes	n/a	Year of data collection
Portugal	EYHS Portugal	1999-2000	313	6-11.99	Yes	1	Year of data collection
Portugal	EYHS Portugal	2007-2008	329	6-11.99	Yes	2	Year of data collection
Qatar	GSHS	2011-2011	1,829	11-16	No	n/a	Sample size
Romania	HBSC	2014-2014	3,942	11-15	No	n/a	Projection only
Romania	HBSC	2010-2010	5,352	11-15	No	n/a	Projection only
Romania	HBSC	2005-2005	4,684	11-15	No	n/a	Projection only
Russia	HBSC	2014-2014	4,576	11-15	No	n/a	Projection only
Russia	HBSC	2010-2010	5,174	11-15	No	n/a	Projection only
Russia	HBSC	2005-2005	8,231	11-15	No	n/a	Projection only
Russia	HBSC	2001-2001	8,032	11-15	No	n/a	Projection only
Scotland	HBSC	2014-2014	Not available	11-11	No	n/a	Sample size
Scotland	HBSC	2014-2014	Not available	13-13	No	n/a	Sample size
Scotland	HBSC	2014-2014	Not available	15-15	No	n/a	Sample size
Slovakia	HBSC	2014-2014	6,016	11-15	No	n/a	Projection only
Slovakia	HBSC	2010-2010	5,281	11-15	No	n/a	Projection only
Slovakia	HBSC	2005-2005	3,877	11-15	No	n/a	Projection only
Slovenia	HBSC	2014-2014	4,984	11-15	No	n/a	Projection only
Slovenia	HBSC	2010-2010	5,429	11-15	No	n/a	Projection only
Slovenia	HBSC	2005-2005	5,119	11-15	No	n/a	Projection only

Country	Study name or abbreviation[a]	Data collection	Sample size	Age range[b]	Device measured[c]	Wave number[d]	Reason not selected
Slovenia	HBSC	2001-2001	3,915	11-15	No	n/a	Projection only
South Korea	KYRBS	2013-2013	60,423	13-17	No	n/a	Projection only
South Korea	KYRBS	2012-2012	62,063	13-17	No	n/a	Projection only
Spain	HBSC	2014-2014	11,138	11-15	No	n/a	Projection only
Spain	HBSC	2010-2010	5,040	11-15	No	n/a	Projection only
Spain	HBSC	2005-2005	8,891	11-15	No	n/a	Projection only
Spain	HBSC	2001-2001	5,823	11-15	No	n/a	Projection only
Spain	HBSC	2018-2018	1,195	11-11	No	n/a	Sample size
Spain	ANIVA study	2014-2014	1,371	6-9	No	n/a	Population sampled
Spain	Local study	2015-2015	1,055	3-18	No	n/a	Population sampled
Sweden	HBSC	2014-2014	7,656	11-15	No	n/a	Projection only
Sweden	HBSC	2010-2010	6,645	11-15	No	n/a	Projection only
Sweden	HBSC	2005-2005	4,392	11-15	No	n/a	Projection only
Sweden	HBSC	2001-2001	3,896	11-15	No	n/a	Projection only
Sweden	HBSC	2014-2014	Not available	11-11	No	n/a	Sample size
Sweden	HBSC	2014-2014	Not available	13-13	No	n/a	Sample size
Sweden	HBSC	2014-2014	Not available	15-15	No	n/a	Sample size
Sweden	IDEFICS	2007-2010	399	6-11.99	Yes	n/a	Year of data collection
Sweden	Helena	2006-2007	224	12-18.99	Yes	n/a	Year of data collection
Switzerland	HBSC	2014-2014	6,530	11-15	No	n/a	Projection only
Switzerland	HBSC	2010-2010	6,611	11-15	No	n/a	Projection only
Switzerland	HBSC	2005-2005	4,579	11-15	No	n/a	Projection only
Switzerland	HBSC	2001-2001	4,528	11-15	No	n/a	Projection only
Switzerland	KISS	2005-2005	16	12-18.99	Yes	1	Sample size
Switzerland	KISS	2006-2006	64	12-18.99	Yes	2	Sample size
Switzerland	KISS	2005-2005	362	6-11.99	Yes	1	Sample size
Switzerland	KISS	2006-2006	302	6-11.99	Yes	2	Sample size
Switzerland	Ballabeina	2008-2008	26	6-11.99	Yes	1	Sample size

Country	Study name or abbreviation[a]	Data collection	Sample size	Age range[b]	Device measured[c]	Wave number[d]	Reason not selected
Switzerland	Ballabeina	2009-2009	153	6-11.99	Yes	2	Sample size
Taiwan	Nutrition and Health Survey	2010-2010	1,779	13-15	No	n/a	Population sampled
Taiwan	Nutrition and Health Survey	2011-2011	1,169	16-18	No	n/a	Population sampled
Thailand	Thailand Physical Activity Surveillance System	2016-2016	Not available	6-8	No	n/a	Sample size
Thailand	Thailand Physical Activity Surveillance System	2016-2016	Not available	9-11	No	n/a	Sample size
Thailand	Thailand Physical Activity Surveillance System	2016-2016	Not available	12-14	No	n/a	Sample size
Thailand	Thailand Physical Activity Surveillance System	2016-2016	Not available	15-17	No	n/a	Sample size
Ukraine	HBSC	2014-2014	4,552	11-15	No	n/a	Projection only
Ukraine	HBSC	2010-2010	5,890	11-15	No	n/a	Projection only
Ukraine	HBSC	2005-2005	5,069	11-15	No	n/a	Projection only
Ukraine	HBSC	2001-2001	4,090	11-15	No	n/a	Projection only
United Arab Emirates	GSHS	2016-2016	5,804	13-17	No	n/a	Sample size
United Arab Emirates	GSHS	2016-2016	Not available	13-15	No	n/a	Sample size
United Arab Emirates	GSHS	2016-2016	Not available	16-17	No	n/a	Sample size
United Arab Emirates	GSHS	2016-2016	Not available	13-17	No	n/a	Population sampled
United Arab Emirates	GSHS	2016-2016	Not available	13-17	No	n/a	Population sampled
Uruguay	GSHS	2012-2012	3,420	13-16	No	n/a	Projection only
Uruguay	GSHS	2006-2006	3,336	12-16	No	n/a	Projection only
USA	YRBSS	2017-2017	14,765	14-18	No	n/a	Sample size
USA	IBDS	2003-2005	16	12-18.99	Yes	3	Sample size
USA	IBDS	missing	291	12-18.99	Yes	5	Sample size
USA	IBDS	missing	263	12-18.99	Yes	6	Sample size
USA	IBDS	1998-2000	91	6-11.99	Yes	1	Sample size
USA	IBDS	2003-2005	445	6-11.99	Yes	3	Sample size
Wales	HBSC	2014-2014	Not available	13-13	No	n/a	Sample size
Wales	HBSC	2014-2014	Not available	15-15	No	n/a	Sample size
Zimbabwe	GSHS	2003-2003	5,368	11-16	No	n/a	Population sampled

[a] Study name/abbreviation; [b] Age range of participants where reported. Participants categorised as 6-11.99 or 12-18.99 respectively if primary or secondary school level reported only; [c] Physical activity measured using a device? (e.g., accelerometer) yes/no; [d] Study wave number (if applicable); [e] Reason study not selected for inclusion

Appendix 5.5. School uniform survey questions

University of Cambridge researchers are mapping the use of school uniforms worldwide to assess their potential impact on children and young people's activity behaviour.

Using a quick poll, they are collecting data to determine which countries use uniforms and which countries do not. They also want to know how this differs between primary and secondary school settings.

Can you help?

For which of the following countries or dependent territories can you say whether school uniforms* are used in the majority of educational settings? Please select one. You can add more later on.

*School uniforms are a consistent and standardised set of clothes that all pupils are required to wear during school hours.

Drop down menu shown

Do the majority (more than 50%) of primary schools in *(*country selected listed)* use uniforms?

*Educational stages and definitions differ worldwide. By 'primary school' we refer to any formal setting that typically educates students aged 6-11years

- o Yes
- o No
- o Don't know

Has this changed since 2011?

- o Yes (please provide details)

____

- o No
- o Don't know

Do the majority (more than 50%) of secondary schools in *(*country selected listed)* use uniforms?

* By 'secondary school' we refer to any formal setting that typically educates students aged 12-18 years

- o Yes
- o No
- o Don't know

Has this changed since 2011?

- o Yes (please provide details)

____

- o No
- o Don't know

Is there anything further that would like to add about the use of school uniforms in *(*country selected listed)*?

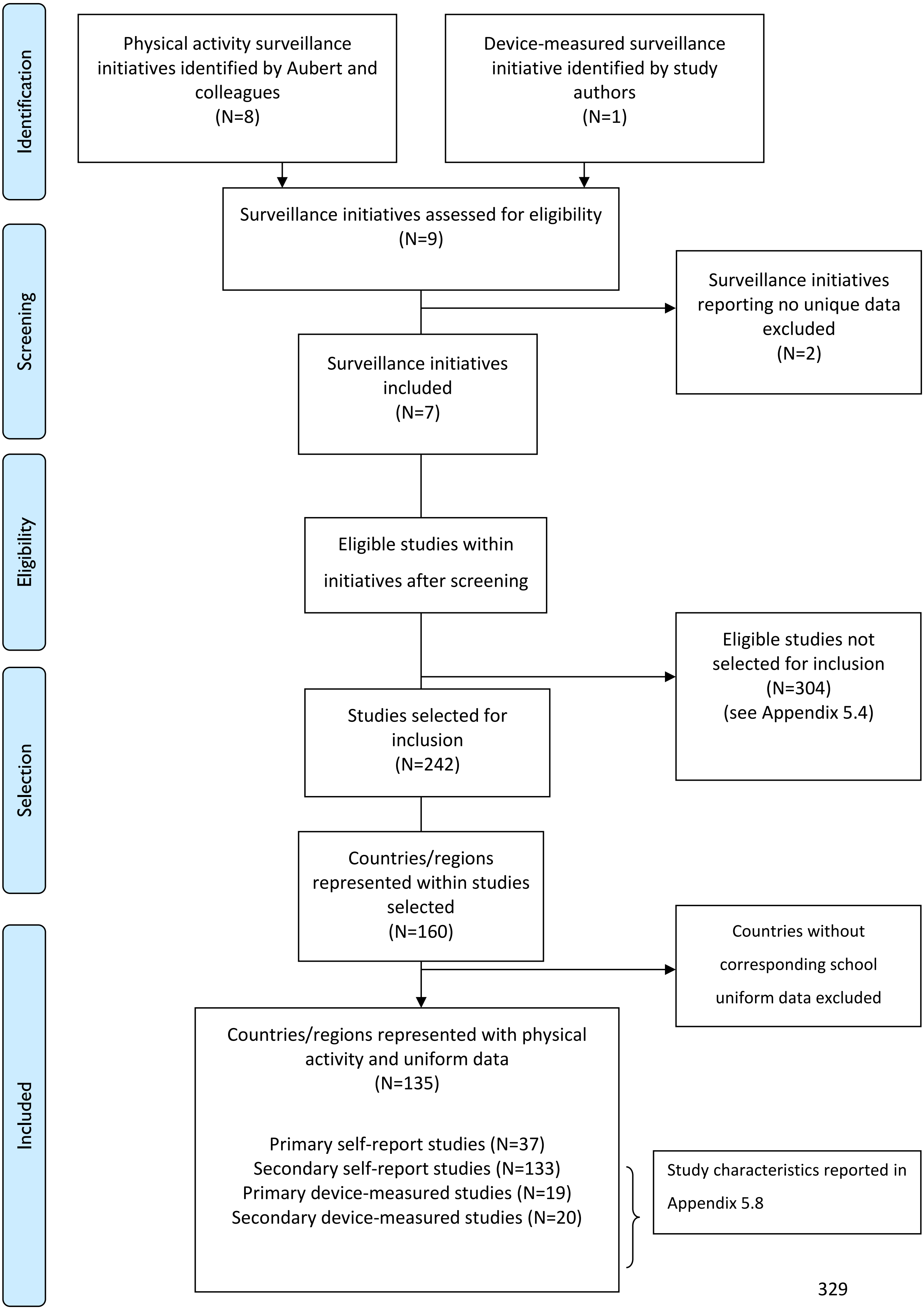
(optional)

Thank you for answering our questions about *(*country selected listed)*!

Are you able to confirm whether uniforms are widely used within schools in any other countries or dependent territories?

- o Yes
- o No

Appendix 5.6. Data availability, study selection and inclusion at each stage



Appendix 5.7. Survey responses received about school uniform practices (N=135 countries/regions; n=391 participants)

Country/region[a]	n[b]	Primary school settings[c]		Secondary school settings[f]	
		Uniforms used[d]	Change since 2011[e]	Uniforms used[d]	Change since 2011[e]
Afghanistan	1	Yes	No	Yes	No
Algeria	2	Yes	No	Yes	No
Anguilla	2	Yes	No	Yes	No
Antigua and Barbuda	3	Yes	No	Yes	No
Argentina	2	Yes	No	Yes	No
Australia	12	Yes	No	Yes	No
Austria	2	No	No	No	No
Bahamas	2	Yes	No	Yes	No
Bahrain	5	Yes	No	Yes	No
Bangladesh	2	Yes	No	Yes	No
Barbados	2	Yes	No	Yes	No
Belgium	2	No	No	No	No
Belize	2	Yes	Yes	Yes	Yes
Bhutan	2	Yes	No	Yes	No
Bolivia	1	Yes	No	Yes	No
Botswana	6	Yes	Yes	Yes	No
Brazil	2	Yes	No	Yes	No
British Virgin Islands	2	Yes	No	Yes	No
Brunei	2	Yes	No	Yes	No
Bulgaria	2	No	No	No	No
Cambodia	1	Yes	No	Yes	No
Canada	8	No	Yes	No	No
Cayman Islands	2	Yes	No	Yes	No
Chile	5	Yes	No	Yes	No
China	4	Yes	No	Yes	No
Colombia	3	Yes	Yes	Yes	Yes
Cook Islands	1	Yes	No	Yes	No
Costa Rica	2	Yes	No	Yes	No
Croatia	2	No	No	No	No
Curaçao	3	Yes	No	Yes	No
Czech Republic	4	No	No	No	No
Denmark	3	No	No	No	No
Djibouti	1	Yes	Yes	Yes	Yes
Dominica	1	Yes	No	Yes	No
Ecuador	2	Yes	No	Yes	No
Egypt	3	Yes	No	Yes	No
El Salvador	2	Yes	No	Yes	No
England	18	Yes	Yes	Yes	No

Country/region[a]	n[b]	Primary school settings[c]		Secondary school settings[f]	
Estonia	2	No	No	No	No
Fiji	4	Yes	No	Yes	No
Finland	2	No	No	No	No
France	5	No	No	No	No
Germany	8	No	No	No	No
Ghana	3	Yes	No	Yes	No
Greece	2	No	No	No	No
Greenland	2	No	No	No	No
Grenada	2	Yes	No	Yes	No
Guatemala	1	Yes	No	Yes	No
Guernsey	4	Yes	No	Yes	No
Guyana	1	Yes	No	Yes	No
Honduras	1	Yes	No	Yes	No
Hong Kong	2	Yes	No	Yes	No
Hungary	2	No	No	No	No
Iceland	2	No	No	No	No
India	5	Yes	No	Yes	No
Indonesia	2	Yes	No	Yes	No
Iraq	1	Yes	No	Yes	No
Ireland	19	Yes	No	Yes	No
Israel	3	Yes	Yes	Yes	Yes
Italy	3	No	No	No	No
Jamaica	1	Yes	No	Yes	No
Jordan	2	Yes	No	Yes	No
Kazakhstan	3	Yes	Yes	Yes	Yes
Kenya	2	Yes	No	Yes	No
Kuwait	2	Yes	No	Yes	No
Laos	2	Yes	No	Yes	No
Latvia	2	No	No	No	No
Lebanon	2	Yes	Yes	Yes	Yes
Liberia	2	Yes	No	Yes	No
Lithuania	3	Yes	Yes	Yes	No
Luxembourg	1	No	No	No	No
Malaysia	7	Yes	No	Yes	No
Malta	1	Yes	No	Yes	No
Mauritania	3	No	No	No	No
Mauritius	2	Yes	No	Yes	No
Mexico	9	Yes	No	Yes	No
Moldova	2	No	No	No	No
Montserrat	2	Yes	No	Yes	No
Morocco	3	Yes	No	Yes	No
Mozambique	3	Yes	No	Yes	No
Myanmar	3	Yes	No	Yes	No

Country/region[a]	n[b]	Primary school settings[c]		Secondary school settings[f]	
Namibia	5	Yes	No	Yes	No
Nauru	3	Yes	No	Yes	No
Nepal	3	Yes	No	Yes	No
Netherlands	4	No	No	No	No
New Zealand	2	Yes	No	Yes	No
Niue	2	Yes	No	Yes	No
North Macedonia	1	No	No	No	No
Norway	2	No	No	No	No
Oman	2	Yes	No	Yes	No
Pakistan	3	Yes	No	Yes	No
Panama	1	Yes	No	Yes	No
Peru	3	Yes	No	Yes	No
Philippines	2	Yes	No	Yes	No
Poland	3	No	No	No	No
Portugal	3	No	No	No	No
Qatar	1	Yes	No	Yes	No
Russia	1	Yes	No	Yes	No
Saint Kitts and Nevis	2	Yes	No	Yes	No
Saint Lucia	3	Yes	No	Yes	No
Samoa	3	Yes	No	Yes	No
Scotland	6	Yes	No	Yes	No
Senegal	2	Yes	No	Yes	No
Seychelles	1	Yes	No	Yes	No
Sierra Leone	2	Yes	Yes	Yes	Yes
Singapore	2	Yes	No	Yes	No
Slovakia	2	No	No	No	No
Slovenia	2	No	No	No	No
Solomon Islands	2	Yes	No	Yes	No
South Africa	4	Yes	No	Yes	No
Spain	2	No	No	No	No
Sri Lanka	2	Yes	No	Yes	No
Sudan	2	Yes	No	Yes	No
Suriname	1	Yes	No	Yes	No
Sweden	3	No	No	No	No
Switzerland	2	No	No	No	No
Syria	1	Yes	No	Yes	No
Taiwan	2	Yes	No	Yes	No
Tanzania	2	Yes	No	Yes	No
Thailand	4	Yes	No	Yes	No
Timor-Leste	1	Yes	No	Yes	No
Tonga	2	Yes	No	Yes	No
Trinidad and Tobago	2	Yes	No	Yes	No
Turkey	2	Yes	No	Yes	No

Country/region[a]	n[b]	Primary school settings[c]		Secondary school settings[f]	
Tuvalu	1	Yes	No	Yes	No
Uganda	2	Yes	No	Yes	No
United Arab Emirates	1	Yes	No	Yes	No
Uruguay	1	Yes	No	No	No
USA	10	No	No	No	No
Vanuatu	7	Yes	Yes	Yes	Yes
Venezuela	2	Yes	No	Yes	No
Vietnam	3	Yes	Yes	Yes	No
Wales	4	Yes	No	Yes	No
Zambia	3	Yes	No	Yes	No
Zimbabwe	3	Yes	No	Yes	No

[a] List of countries/regions for which survey data was received and consensus was achieved; [b] Number of participants per country/region; [c] Primary school refers to any formal setting that typically educates students aged 6-11 years; [d] Survey participants reported school uniforms are used by the majority (more than 50%) of primary/secondary schools in that country; [e] Any survey participants reporting a change to the common use of uniforms since 2011; [f] Secondary school refers to any formal setting that typically educates students aged 12-18 years

Additional data received about school uniform practices in countries/regions without corresponding physical activity data and excluded from study (N=7 countries/regions; n= 23 participants)

Country/region[a]	n[b]	Primary school settings[c]		Secondary school settings[f]	
		Uniforms use[d]	Change since 2011[e]	Uniforms use[d]	Change since 2011[e]
Belarus	1	No	No	No	No
Democratic Republic of the Congo	1	Yes	No	Yes	No
Ethiopia	2	Yes	Yes	Yes	Yes
Iran	3	Yes	No	Yes	No
Japan	8	No	No	Yes	No
Jersey	6	Yes	No	Yes	No
Northern Ireland	2	Yes	No	Yes	No

[a] List of countries/regions for which survey data was received and consensus was achieved; [b] Number of participants per country/region; [c] Primary school refers to any formal setting that typically educates students aged 6-11 years; [d] Survey participants reported school uniforms are used by the majority (more than 50%) of primary/secondary schools in that country; [e] Any survey participants reporting a change to the common use of uniforms since 2011; [f] Secondary school refers to any formal setting that typically educates students aged 12-18 years

Appendix 5.8. Characteristics of surveillance initiatives (N=7) and studies (N=213) included

Ref	Country/region	Study name/abbreviation	Year[a]	n[b]	School level[c]	Device-measured?	Guideline[d]	Wave[e]	Boys[f]	Girls[f]
[1]	Afghanistan	GSHS	2014-2014	2,155	Secondary	No	Daily		11.5	12.2
[1]	Algeria	GSHS	2011-2011	4,405	Secondary	No	Daily		23.6	8.7
[1]	Anguilla	GSHS	2016-2016	767	Secondary	No	Daily		21.4	14.9
[1]	Antigua and Barbuda	GSHS	2009-2009	1,178	Secondary	No	Daily		26.1	15.4
[1]	Argentina	GSHS	2012-2012	27,034	Secondary	No	Daily		20.1	10.1
[4]	Australia	ISCOLE	2011-2012	491	Primary	Yes	Average			
[5]	Australia	Queensland Preventive Health Survey	2018-2018	5,025	Primary	No	Daily		44.7	36.4
[6]	Australia	clan	2004-2004	275	Secondary	Yes	Average	2	56.4	19.5
[3]	Austria	HBSC	2018-2018	4,098	Secondary	No	Daily		26.0	15.0
[7]	Austria	Helena	2006-2007	217	Secondary	Yes	Average			
[1]	Bahamas	GSHS	2013-2013	1,298	Secondary	No	Daily		19.4	11.8
[1]	Bahrain	GSHS	2016-2016	7,017	Secondary	No	Daily		25.0	12.6
[5]	Bangladesh	GSHS	2014-2014	2,980	Secondary	No	Daily		42.0	40.2
[1]	Barbados	GSHS	2011-2011	1,550	Secondary	No	Daily		23.1	13.1
[3]	Belgium	HBSC	2018-2018	1,645	Primary	No	Daily		24.9	19.8
[3]	Belgium	HBSC	2018-2018	1,871	Secondary	No	Daily		18.2	11.7
[7]	Belgium	Belgium Pre-School Study	2006-2009	327	Primary	Yes	Average			
[7]	Belgium	The Belgian Environmental PA study in Youth	2008-2009	918	Secondary	Yes	Average			
[1]	Belize	GSHS	2011-2011	2,001	Secondary	No	Daily		23.6	15.8
[1]	Bhutan	GSHS	2016-2016	6,043	Secondary	No	Daily		17.2	14.6
[1]	Bolivia	GSHS	2012-2012	3,425	Secondary	No	Daily		17.6	11.4

Ref	Country/region	Study name/abbreviation	Year[a]	n[b]	School level[c]	Device-measured?	Guideline[d]	Wave[e]	Boys[f]	Girls[f]
[5]	Botswana	GSHS	2005-2005	2,178	Secondary	No	Daily		13.0	10.4
[1]	Brazil	N/A	missing	187	Primary	No	Daily		68.1	36.7
[1]	Brazil	1993 Pelotas (Brazil) Birth Cohort	2006-2007	457	Secondary	Yes	Daily		69.8	52.1
[1]	Brazil	PeNSE	2012-2012	102,072	Secondary	No	Daily		28.1	12.9
[1]	British Virgin Islands	GSHS	2009-2009	1,627	Secondary	No	Daily		22.5	13.1
[1]	Brunei	GSHS	2014-2014	2,490	Secondary	No	Daily		18.9	6.5
[3]	Bulgaria	HBSC	2018-2018	4,548	Secondary	No	Daily		25.1	20.9
[5]	Bulgaria	National survey	2011-2011	9,999	Primary	No	Daily		22.3	16.5
[1]	Cambodia	GSHS	2013-2013	2,892	Secondary	No	Daily		10.2	6.6
[3]	Canada	HBSC	2017-2018	3,621	Primary	No	Daily		37.2	30.2
[3]	Canada	HBSC	2017-2018	9,173	Secondary	No	Daily		30.0	17.3
[5]	Canada	CHMS	2012-2013	1,300	Primary	Yes	Daily		13.0	6.0
[1]	Cayman Islands	GSHS	2007-2007	1,218	Secondary	No	Daily		19.4	11.1
[5]	Chile	GSHS	2013-2013	1,888	Secondary	No	Daily		18.3	9.3
[5]	China	PAFCTYS	2016-2016	125,281	Secondary	No	Daily		14.5	11.7
[5]	China	PAFCTYS	2016-2016	26,650	Primary	No	Daily		34.1	33.0
[5]	Colombia	ENSIN	2015-2015	11,956	Primary	No	Average		35.8	26.0
[5]	Colombia	ENSIN	2015-2015	6,769	Secondary	No	Average		18.7	7.6
[1]	Cook Islands	GSHS	2015-2015	642	Secondary	No	Daily		22.3	12.3
[1]	Costa Rica	GSHS	2009-2009	2,637	Secondary	No	Daily		23.9	11.8
[3]	Croatia	HBSC	2018-2018	5,169	Secondary	No	Daily		26.1	19.1
[1]	Curaçao	GSHS	2015-2015	2,087	Secondary	No	Daily		16.5	9.7
[5]	Czech Republic	HBSC	2014-2014	5,750	Secondary	No	Daily		30.9	31.4
[5]	Czech Republic	HBSC	2014-2014	9,999	Primary	No	Daily		25.6	19.2

Ref	Country/region	Study name/abbreviation	Year[a]	n[b]	School level[c]	Device-measured?	Guideline[d]	Wave[e]	Boys[f]	Girls[f]
[3]	Denmark	HBSC	2018-2018	1,374	Primary	No	Daily		13.3	9.7
[5]	Denmark	The Youth Profile	2014-2014	40,022	Secondary	No	Daily		25.9	10.3
[7]	Denmark	COSCIS,OPUS,EYHS,SPACE	1997-2011	3,275	Primary	Yes	Average			
[7]	Denmark	EYHS,SPACE	1997-2010	1,632	Secondary	Yes	Average			
[1]	Djibouti	GSHS	2007-2007	1,706	Secondary	No	Daily		18.7	10.7
[1]	Dominica	GSHS	2009-2009	1,523	Secondary	No	Daily		17.9	14.0
[5]	Ecuador	ENSANUT	2012-2012	10,910	Secondary	No	Daily		34.5	21.4
[1]	Egypt	GSHS	2011-2011	2,445	Secondary	No	Daily		17.9	6.9
[1]	El Salvador	GSHS	2013-2013	1,845	Secondary	No	Daily		17.2	10.5
[5]	England	B-PROACT1V study	2016-2016	1,299	Primary	Yes	Daily		73.0	54.0
[5]	England	Health Survey for England	2015-2015	3,827	Primary	No	Average		23.0	20.0
[5]	England	HBSC	2013-2014	5,335	Secondary	No	Daily		22.0	14.3
[6]	England	speedy	2011-2011	324	Secondary	Yes	Average	3	24.2	11.7
[3]	Estonia	HBSC	2018-2018	1,559	Primary	No	Daily		19.7	18.2
[5]	Estonia	HBSC	2014-2014	4,057	Secondary	No	Daily		20.3	12.0
[7]	Estonia	EYHS(Estonia),IDEFICS	1998-2010	679	Primary	Yes	Average			
[7]	Estonia	EYHS(Estonia)	2007-2010	324	Secondary	Yes	Average			
[1]	Fiji	GSHS	2015-2015	2,916	Secondary	No	Daily		19.3	14.0
[5]	Finland	LITU study(accelerometer)	2016-2016	2,931	Primary	Yes	Average		65.0	41.0
[5]	Finland	National School Health Promotion Study	2017-2017	94,531	Primary	No	Daily		50.0	40.0
[5]	Finland	LITU study(accelerometer)	2016-2016	9,999	Secondary	Yes	Average		32.0	15.0

Ref	Country/region	Study name/abbreviation	Year[a]	n[b]	School level[c]	Device-measured?	Guideline[d]	Wave[e]	Boys[f]	Girls[f]
[5]	Finland	National School Health Promotion Study	2017-2017	71,695	Secondary	No	Daily		23.0	16.0
[3]	France	HBSC	2018-2018	9,106	Secondary	No	Daily		14.2	6.9
[5]	France	INCA3	2015-2015	644	Primary	No	Average		27.7	20.9
[7]	France	Helena	2006-2007	223	Secondary	Yes	Average			
[3]	Germany	HBSC	2018-2018	4,314	Secondary	No	Daily		16.6	9.7
[5]	Germany	IDEFICS Study	2011-2011	516	Primary	Yes	Daily		33.7	20.2
[5]	Germany	KiGGs Study	2017-2017	12,981	Primary	No	Daily		29.4	22.4
[7]	Germany	GINI, LISA, Helena	2006-2014	1,904	Secondary	Yes	Average			
[1]	Ghana	GSHS	2012-2012	2,378	Secondary	No	Daily		13.4	11.6
[3]	Greece	HBSC	2018-2018	1,227	Primary	No	Daily		24.2	18.3
[3]	Greece	HBSC	2018-2018	2,618	Secondary	No	Daily		18.3	10.0
[7]	Greece	Helena	2006-2007	382	Secondary	Yes	Average			
[3]	Greenland	HBSC	2018-2018	1,234	Secondary	No	Daily		22.1	19.0
[1]	Grenada	GSHS	2008-2008	1,431	Secondary	No	Daily		18.2	13.1
[1]	Guatemala	GSHS	2015-2015	4,070	Secondary	No	Daily		15.5	10.6
[5]	Guernsey	Guernsey Young People's Survey	2016-2016	9,999	Secondary	No	Daily		57.0	46.0
[1]	Guyana	GSHS	2010-2010	2,278	Secondary	No	Daily		18.3	13.7
[1]	Honduras	GSHS	2012-2012	1,695	Secondary	No	Daily		19.8	12.4
[5]	Hong Kong	National Physical Fitness Survey	2012-2012	2,723	Primary	No	Average		54.7	48.7
[5]	Hong Kong	National Physical Fitness Survey	2012-2012	2,517	Secondary	No	Average		50.1	34.2
[3]	Hungary	HBSC	2018-2018	3,772	Secondary	No	Daily		23.4	16.5
[7]	Hungary	IDEFICS	2007-2010	1,236	Primary	Yes	Average			

Ref	Country/region	Study name/abbreviation	Year[a]	n[b]	School level[c]	Device-measured?	Guideline[d]	Wave[e]	Boys[f]	Girls[f]
[7]	Hungary	Helena	2006-2007	347	Secondary	Yes	Average			
[3]	Iceland	HBSC	2018-2018	2,313	Primary	No	Daily		26.3	19.6
[3]	Iceland	HBSC	2018-2018	4,670	Secondary	No	Daily		23.3	15.4
[1]	India	GSHS	2007-2007	7,744	Secondary	No	Daily		28.2	23.7
[5]	India	Chronic Disease Risk Factor study	2012-2012	364	Primary	No	Daily		80.0	66.2
[1]	Indonesia	GSHS	2015-2015	10,706	Secondary	No	Daily		14.6	12.6
[1]	Iraq	GSHS	2012-2012	1,962	Secondary	No	Daily		20.1	9.5
[3]	Ireland	HBSC	2018-2018	1,266	Primary	No	Daily		43.7	33.5
[3]	Ireland	HBSC	2018-2018	2,539	Secondary	No	Daily		25.3	15.5
[1]	Israel	HBSC	2014-2014	6,194	Secondary	No	Daily		19.9	10.5
[3]	Italy	HBSC	2018-2018	4,122	Secondary	No	Daily		12.4	5.3
[7]	Italy	Helena	2006-2007	195	Secondary	Yes	Average			
[2]	Jamaica	GSHS	2017-2017	1,667	Secondary	No	Daily		23.8	22.6
[1]	Jordan	GSHS	2007-2007	2,133	Secondary	No	Daily		18.7	11.6
[3]	Kazakhstan	HBSC	2017-2017	4,849	Secondary	No	Daily		36.4	32.4
[1]	Kenya	GSHS	2003-2003	3,428	Secondary	No	Daily		15.1	11.1
[1]	Kuwait	GSHS	2015-2015	3,053	Secondary	No	Daily		20.6	10.0
[1]	Laos	GSHS	2015-2015	3,585	Secondary	No	Daily		22.0	9.0
[3]	Latvia	HBSC	2017-2018	1,535	Primary	No	Daily		23.3	20.4
[3]	Latvia	HBSC	2017-2018	2,861	Secondary	No	Daily		21.6	12.8
[5]	Lebanon	GSHS	2017-2017	5,700	Secondary	No	Daily		18.6	8.7
[2]	Liberia	GSHS	2017-2017	2,744	Secondary	No	Daily		12.9	8.5
[3]	Lithuania	HBSC	2018-2018	3,781	Secondary	No	Daily		20.5	16.1
[5]	Lithuania	HBSC	2014-2014	2,015	Primary	No	Daily		27.0	20.0
[3]	Luxembourg	HBSC	2018-2018	1,275	Primary	No	Daily		21.1	14.4
[3]	Luxembourg	HBSC	2018-2018	2,596	Secondary	No	Daily		17.4	8.1

Ref	Country/region	Study name/abbreviation	Year[a]	n[b]	School level[c]	Device-measured?	Guideline[d]	Wave[e]	Boys[f]	Girls[f]
[1]	Malaysia	GSHS	2012-2012	25,081	Secondary	No	Daily		19.4	8.6
[3]	Malta	HBSC	2018-2018	2,562	Secondary	No	Daily		22.9	13.7
[7]	Malta	MAL-TA	2012-2012	848	Primary	Yes	Average			
[1]	Mauritania	GSHS	2010-2010	1,951	Secondary	No	Daily		16.8	8.6
[1]	Mauritius	GSHS	2011-2011	2,147	Secondary	No	Daily		23.8	11.6
[5]	Mexico	National Health and Nutrition Survey ENSANUT	2016-2016	1,843	Secondary	No	Daily		21.8	12.7
[3]	Moldova	HBSC	2018-2018	4,686	Secondary	No	Daily		16.9	12.7
[1]	Montserrat	GSHS	2008-2008	197	Secondary	No	Daily		20.9	19.2
[1]	Morocco	GSHS	2016-2016	5,727	Secondary	No	Daily		15.4	9.9
[1]	Mozambique	GSHS	2015-2015	1,325	Secondary	No	Daily		17.0	8.7
[4]	Mozambique	ISCOLE	2017-2018	683	Primary	Yes	Average			
[1]	Myanmar	GSHS	2016-2016	2,752	Secondary	No	Daily		15.9	10.4
[1]	Namibia	GSHS	2014-2014	3,304	Secondary	No	Daily		13.5	11.6
[1]	Nauru	GSHS	2011-2011	485	Secondary	No	Daily		16.4	10.0
[5]	Nepal	GSHS	2015-2015	6,422	Secondary	No	Daily		17.4	13.4
[3]	Netherlands	HBSC	2017-2017	1,486	Primary	No	Daily		23.0	17.5
[3]	Netherlands	HBSC	2017-2017	3,205	Secondary	No	Daily		19.6	13.7
[1]	New Zealand	The Youth 12 survey	2012-2012	8,202	Secondary	No	Daily		15.1	7.3
[5]	New Zealand	Local study	2016-2016	1,085	Primary	Yes	Daily		53.0	24.0
[5]	New Zealand	Local study	2016-2016	314	Secondary	Yes	Daily		46.0	36.0
[1]	Niue	GSHS	2010-2010	106	Secondary	No	Daily		13.9	11.5
[3]	North Macedonia	HBSC	2018-2018	4,658	Secondary	No	Daily		36.8	25.9
[3]	Norway	HBSC	2018-2018	1,641	Primary	No	Daily		22.4	18.9
[3]	Norway	HBSC	2018-2018	1,472	Secondary	No	Daily		14.4	9.8

Ref	Country/region	Study name/abbreviation	Year[a]	n[b]	School level[c]	Device-measured?	Guideline[d]	Wave[e]	Boys[f]	Girls[f]
[7]	Norway	EYHS (Norway), PANCS	1999-2006	1,591	Primary	Yes	Average			
[7]	Norway	PANCS	2005-2006	795	Secondary	Yes	Average			
[1]	Oman	GSHS	2015-2015	3,090	Secondary	No	Daily		21.7	10.2
[1]	Pakistan	GSHS	2009-2009	5,112	Secondary	No	Daily		14.6	11.4
[2]	Panama	GSHS	2018-2018	2,948	Secondary	No	Daily		20.7	9.6
[1]	Peru	GSHS	2010-2010	2,827	Secondary	No	Daily		17.3	13.2
[1]	Philippines	GSHS	2015-2015	8,263	Secondary	No	Daily		7.2	5.9
[3]	Poland	HBSC	2017-2018	1,710	Primary	No	Daily		24.1	21.7
[5]	Poland	HBSC	2013-2014	4,545	Secondary	No	Daily		29.3	19.0
[3]	Portugal	HBSC	2018-2018	2,169	Primary	No	Daily		15.6	9.0
[3]	Portugal	HBSC	2018-2018	3,670	Secondary	No	Daily		12.8	5.9
[7]	Portugal	Prestyle, Portugal2008, Portugal 2010, EYHS (Portugal)	1999-2011	2,204	Primary	Yes	Average			
[7]	Portugal	Portugal 2008, Portugal2010, EYHS (Portugal)	1999-2011	2,375	Secondary	Yes	Average			
[5]	Qatar	Local study	2017-2017	1,499	Primary	No	Daily		39.6	18.5
[5]	Qatar	Qatar National School Survey	2016-2016	5,862	Secondary	No	Average		41.0	29.7
[3]	Romania	HBSC	2018-2019	4,520	Secondary	No	Daily		17.7	10.4
[3]	Russia	HBSC	2018-2018	4,281	Secondary	No	Daily		19.3	11.4
[1]	Saint Kitts and Nevis	GSHS	2011-2011	1,674	Secondary	No	Daily		21.5	13.9
[1]	Saint Lucia	GSHS	2007-2007	1,246	Secondary	No	Daily		17.2	14.1
[1]	Samoa	GSHS	2011-2011	2,114	Secondary	No	Daily		12.5	13.3
[3]	Scotland	HBSC	2018-2018	1,836	Primary	No	Daily		21.6	19.7
[3]	Scotland	HBSC	2018-2018	3,072	Secondary	No	Daily		17.7	13.0

Ref	Country/region	Study name/abbreviation	Year[a]	n[b]	School level[c]	Device-measured?	Guideline[d]	Wave[e]	Boys[f]	Girls[f]
[5]	Scotland	SPACES (Studying Physical Activity in Children's Environments across Scotland) study	2016-2016	774	Primary	Yes	Daily		12.5	9.8
[1]	Senegal	GSHS	2005-2005	3,059	Secondary	No	Daily		15.2	7.8
[1]	Seychelles	GSHS	2015-2015	2,439	Secondary	No	Daily		21.3	13.3
[2]	Sierra Leone	GSHS	2017-2017	2,798	Secondary	No	Daily		21.6	16.2
[1]	Singapore	Students' Health Survey	2015-2015	9,151	Secondary	No	Daily		30.3	16.9
[3]	Slovakia	HBSC	2018-2018	4,785	Secondary	No	Daily		27.3	18.6
[3]	Slovenia	HBSC	2018-2018	1,933	Primary	No	Daily		30.8	22.3
[3]	Slovenia	HBSC	2018-2018	3,728	Secondary	No	Daily		26.0	14.5
[1]	Solomon Islands	GSHS	2011-2011	1,296	Secondary	No	Daily		17.9	14.6
[5]	South Africa	Disease, Activity and School children's Health (DASH) study	2015-2015	832	Primary	No	Average		28.1	26.5
[5]	South Korea	Korea Youth Risk Behavior web-based Survey	2017-2017	57,884	Secondary	No	Daily		8.6	2.8
[3]	Spain	HBSC	2018-2018	3,125	Secondary	No	Daily		26.7	11.4
[5]	Spain	ESCA study	2016-2016	1,886	Primary	No	Daily		34.2	26.9
[7]	Spain	EYHS SPAIN,IDEFICS	2007-2010	1,111	Primary	Yes	Average			
[7]	Spain	Helena	2006-2007	362	Secondary	Yes	Average			
[1]	Sri Lanka	GSHS	2016-2016	3,192	Secondary	No	Daily		18.4	11.3
[1]	Sudan	GSHS	2012-2012	2,063	Secondary	No	Daily		10.4	9.0
[1]	Suriname	GSHS	2016-2016	1,867	Secondary	No	Daily		21.6	15.4
[3]	Sweden	HBSC	2017-2018	1,155	Primary	No	Daily		23.1	13.4

Ref	Country/region	Study name/abbreviation	Year[a]	n[b]	School level[c]	Device-measured?	Guideline[d]	Wave[e]	Boys[f]	Girls[f]
[3]	Sweden	HBSC	2017-2018	3,007	Secondary	No	Daily		14.0	10.9
[5]	Sweden	IDEFICS study	2014-2014	343	Primary	Yes	Daily		43.1	17.8
[5]	Sweden	Local study	2016-2016	91	Secondary	Yes	Daily		46.0	33.0
[3]	Switzerland	HBSC	2018-2018	2,476	Primary	No	Daily		23.3	14.6
[3]	Switzerland	HBSC	2018-2018	5,010	Secondary	No	Daily		14.6	9.5
[7]	Switzerland	Ballabeina Study, KISS	2005-2009	1,033	Primary	Yes	Average			
[7]	Switzerland	KISS	2005-2006	123	Secondary	Yes	Average			
[1]	Syria	GSHS	2010-2010	3,045	Secondary	No	Daily		15.9	8.9
[1]	Taiwan	GSHS	2012-2012	6,753	Secondary	No	Daily		20.9	10.2
[5]	Taiwan	Nutrition and Health Survey	2012-2012	1,260	Primary	No	Average		5.8	2.8
[1]	Tanzania	GSHS	2014-2014	3,561	Secondary	No	Daily		21.8	14.0
[1]	Thailand	Physical Activity Surveillance System	2016-2016	1,160	Secondary	No	Daily		29.8	15.0
[5]	Thailand	Thailand Physical Activity Surveillance System	2016-2016	1,287	Primary	No	Daily		39.0	9.7
[1]	Timor-Leste	GSHS	2015-2015	2,965	Secondary	No	Daily		14.5	6.6
[1]	Tonga	GSHS	2010-2010	2,157	Secondary	No	Daily		13.3	15.2
[1]	Trinidad and Tobago	GSHS	2011-2011	956	Secondary	No	Daily		21.2	14.4
[1]	Tunisia	GSHS	2008-2008	2,783	Secondary	No	Daily		25.1	11.6
[1]	Turkey	HBSC	2010-2010	5,574	Secondary	No	Daily		23.4	13.9
[1]	Tuvalu	GSHS	2012-2012	870	Secondary	No	Daily		14.7	11.1
[1]	Uganda	GSHS	2003-2003	2,986	Secondary	No	Daily		16.0	12.7
[3]	Ukraine	HBSC	2018-2018	6,660	Secondary	No	Daily		30.4	21.3
[1]	United Arab Emirates	GSHS	2016-2016	5,329	Secondary	No	Daily		22.1	13.1

Ref	Country/region	Study name/abbreviation	Year[a]	n[b]	School level[c]	Device-measured?	Guideline[d]	Wave[e]	Boys[f]	Girls[f]
[5]	Uruguay	GSHS	2012-2012	3,488	Secondary	No	Daily		42.6	17.1
[1]	USA	YRBSS	2015-2015	15,046	Secondary	No	Daily		36.0	19.5
[5]	USA	National Survey of Children's Health	2016-2016	34,952	Primary	No	Daily		28.0	20.2
[6]	USA	IBDS	2000-2004	477	Primary	Yes	Average	2	55.0	26.0
[6]	USA	IBDS	2005-2007	377	Secondary	Yes	Average	4	32.3	10.3
[1]	Vanuatu	GSHS	2011-2011	1,084	Secondary	No	Daily		13.8	11.0
[1]	Venezuela	GSHS	2003-2003	4,276	Secondary	No	Daily		15.2	7.1
[1]	Vietnam	GSHS	2013-2013	3,038	Secondary	No	Daily		17.7	9.4
[3]	Wales	HBSC	2017-2017	15,763	Secondary	No	Daily		23.2	14.0
[5]	Wales	HBSC	2013-2014	1,833	Primary	No	Daily		26.0	15.0
[1]	Zambia	GSHS	2004-2004	1,871	Secondary	No	Daily		10.6	10.9
[5]	Zimbabwe	GSHS	2015-2015	5,665	Secondary	No	Daily		64.1	55.0

[a] Year(s) of data collection; [b] Number of participants included; [c] School level assigned based on age of study participants; [d] Physical activity guideline indicator; [e] Study wave (if applicable); [f] Estimates of the percentage of boys and girls meeting physical activity guidelines; *Ref* References listed below

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Appendix E: Supplementary material for Chapter 6

Appendix 6.1 Copy of commentary published in Trials

Ryan *et al. Trials* (2023) 24:176
https://doi.org/10.1186/s13063-023-07215-1

Trials

COMMENTARY

Open Access

Incomplete reporting of complex interventions: a call to action for journal editors to review their submission guidelines

Mairead Ryan[1,2*], Tammy Hoffmann[3], Riikka Hofmann[2] and Esther van Sluijs[1]

Abstract

Reporting of intervention research has been inadequate for many years. The development and promotion of freely available checklists aims to address this problem by providing researchers with a list of items that require reporting to enable study interpretation and replication. In this commentary, we present evidence from a recent systematic review of 51 randomised controlled trials published 2015–2020 that inadequate intervention reporting remains a widespread issue and that checklists are not being used to describe all intervention components. In 2022, we assessed the submission guidelines of 33 journals that published articles included in our review and found that just one at the time encouraged the use of reporting checklists for all intervention components. To drive progress, we contacted the editors of the other 32 journals and requested that they update their submission guidelines in response. We conclude by highlighting the waste associated with current practices and encourage journals from all fields to urgently review their submission guidelines. Only through collective action can we build an evidence base that is fit for purpose.

Keywords Reporting checklists, Complex interventions, Journal editors, Reproducibility, Research integrity, Submission guidelines

Reporting guidelines in research

Randomised controlled trials and other forms of intervention evaluations constitute a considerable proportion of public health research activity. For many years, researchers have typically provided inadequate descriptions of the intervention(s) they tested [1], which has limited the scientific and applied value of this activity [2]. From the 1990s, in response to evidence of poor reporting and its costs, bodies such as the International Committee of Medical Journal Editors (ICMJE) and the Enhancing the QUAlity and Transparency Of health Research (EQUATOR) Network began supporting the development and promotion of evidence-based reporting guidelines [3]. There now exists a library of freely available reporting guidelines to support researchers in providing sufficient detail to enable study interpretation and replication [4]. The publication of the Template for Intervention Description and Replication (TIDieR) checklist in 2014 [5] aimed to improve reporting standards in intervention research specifically. The checklist outlines a minimum set of items considered essential for intervention description and replication. We present evidence in this commentary that the authors of complex interventions mostly use such checklists to describe only one part of the overall intervention. We draw on our experience of reviewing school-based physical activity research to present evidence of underreporting on interventions targeted at change agents.

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Successful implementation of school-based interventions is often dependent on behaviour change by key actors or 'change agents' in students' lives (e.g. teachers, parents/guardians, peers). For example, school staff may be required to change their teaching practices, and/or parents may be required to implement changes. Figure 1, adapted from the Medical Research Council guidance on the development and evaluation of complex interventions [6], illustrates that change agent-targeted interventions (sometimes referred to as 'implementation strategies' [7]) (e.g. staff training programmes, parent newsletters) play an important role in the logic model of the overall intervention. Nevertheless, they are frequently overlooked as behaviour change interventions in and of themselves [7] and their impact on process evaluation outcomes (e.g. percentage of intended educational sessions delivered) and trial effectiveness outcomes (e.g. students' behaviour) is poorly understood.

Evidence of inadequate reporting on change agent interventions in school-based research

We recently completed a systematic review of school-based physical activity interventions to study if specific features of staff training programmes were associated with intervention fidelity and students' study outcomes [8]. This was a significant research gap because the majority of children and adolescents worldwide are not sufficiently physically active [9, 10] and global intervention efforts, which largely focus on school settings, have mostly failed [11, 12]. Reasons for outcome failures were unknown as previous review efforts to address similar research questions were impeded by incomplete descriptions of interventions published 1999–2015 [13]. Given the greater availability and promotion of intervention reporting guidelines since 2015 (e.g. [5]), we solely reviewed interventions published since 2015, in anticipation that reporting quality had improved. We conducted a systematic, comprehensive and inclusive search for details on intervention descriptions of included randomised controlled trials, pooling information from multiple sources (e.g. protocols, process evaluations, outcome evaluations, trial registries, study websites; $n=183$ in total). See Additional file 1 for details about methods and sources included. We aimed to identify descriptions of staff training programmes based on items in the TIDieR checklist [5]. Where incomplete reporting was identified, we contacted lead authors for further information.

We included 51 trials, reporting on 53 training programmes [8]. We found that, prior to contacting authors, complete information was only available for one of the training programmes we reviewed (2%). Basic details (e.g. use of theory, location of the intervention) were missing from the majority of interventions (see Additional file 2 for breakdown by TIDieR item before and after author contact). Descriptions across all available study sources largely focused on the intervention(s) aimed at the student, and while some study authors reported using

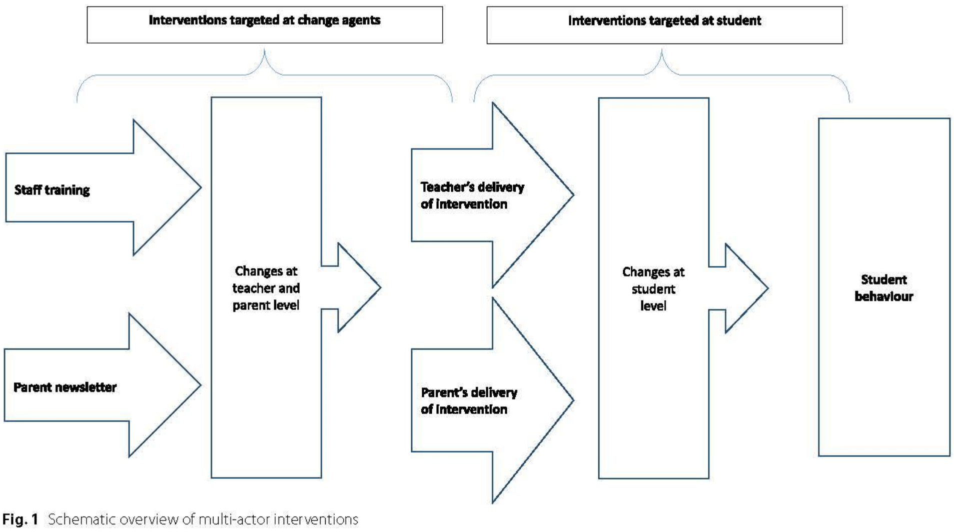

Fig. 1 Schematic overview of multi-actor interventions

checklists to describe student-targeted interventions, no checklists were reportedly used to describe change agent-targeted interventions.

At the time of writing this commentary, we checked the websites of all the journals that published articles included in our review ($n = 33$) and found that just one explicitly requested submission of reporting checklists for all intervention components. Our findings suggest that inadequate reporting remains a prevalent issue despite the availability of infrastructure (e.g. reporting checklists and online appendices/repositories to overcome manuscript word limits) and that current systems, including journal submission guidelines, are enabling wasteful practices to persist. Our findings are also particularly alarming given that adherence to reporting guidelines is reportedly better in larger and controlled studies [14]; the sample of publications we reviewed reported on medium-to-large-scale randomised controlled trials (median sample size: 779; interquartile range: 361–1397). While we found that the percentage of reported items improved considerably by contacting authors (see Additional file 2), this resource-intensive task is a poor replacement for Open Science practices. Moreover, readers of intervention outputs are not informed that they lack sufficient information to reliably replicate intervention(s) or interpret reported outcomes. As reliance upon change agents is common in many other intervention settings (e.g. hospitals, police custody suites, nursing homes [15–17]), our findings have wider relevance beyond school-based research.

Action taken

Current reporting practices are stifling learning opportunities within and beyond public health and limiting the types of knowledge that can be gained from costly evaluations. Without complete descriptions of all interventions under evaluation, the scientific community has no means of interpreting study outcomes or replicating effective interventions [5, 18]. This is resulting in poor outcomes for members of the public who have both funded and/or participated in intervention studies. Research communities must now move beyond describing poor reporting practices to taking action and pay equal attention to reporting of all change agent-targeted interventions. Although we urge authors of intervention papers to provide complete descriptions of all intervention components, we recognise the important gatekeeper role that journal editors play in setting research communication and reporting standards [14]. We contacted the editors of the other 32 journals (see Additional file 3), inviting them to update their submission guidelines in response to our findings. Specifically, we asked that they require intervention authors to submit separate reporting checklists for each of the interventions that have been delivered within a study, including interventions targeted at change agents. To date, we have received a reply from 27 journals, 26% of whom have updated their submission guidelines in response, including 'British Journal of Sports Medicine', 'Journal of Physical Activity and Health', 'Sport, Exercise, and Performance Psychology', 'Journal of Science and Medicine in Sport' and 'Journal of Experimental Social Psychology' (see Additional file 3 for a complete list).

Further action is needed

While we are pleased a number of journals have updated their guidelines, ongoing inaction from others will enable current practices to continue. The 2013 Declaration of Helsinki emphasises that journals have an ethical obligation to reject incomplete reports of research for publication [19]. We now call on all journals that publish intervention research, regardless of their field, to urgently review their submission policies. We also highlight the role that researchers, editorial teams, funders, and reviewers can all play in encouraging and supporting journals in this effort. Resources from the EQUATOR Network may be useful in guiding related discussion: https://www.equator-network.org/toolkits/using-guidelines-in-journals/creating-your-journals-reporting-guideline-policy/. As we approach the 10-year publication anniversary of the TIDieR intervention reporting guideline, we ask—how much more waste will be tolerated before action is taken?

Abbreviations

TIDieR	Template for Intervention Description and Replication
ICMJE	International Committee of Medical Journal Editors
EQUATOR	Enhancing the QUAlity and Transparency Of health Research

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13063-023-07215-1.

Additional file 1. Methods used to assess completeness of TIDieR checklist items in systematic review.

Additional file 2. List of TIDieR items reported before and after author contact.

Additional file 3. Complete list of journals contacted (n=32) and action taken (n=7).

Acknowledgements
Not applicable.

Authors' contributions
MR conceived the idea of the Commentary and contacted journal editors on behalf of all co-authors. MR and EvS drafted the main text. TH and RH reviewed and contributed additional content. All authors approved the final draft of the manuscript.

Funding
This work was supported by the Economic and Social Research Council [grant number ES/P000738/1], the University of Cambridge, and the Medical Research Council [grant number: MC_UU_00006/5]. The funders had no role in informing the content of the manuscript.

Availability of data and materials
A summary of reviewed studies and their outputs is available in Additional file 1.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
TH is the lead author of the TIDieR guideline and Co-Director of the Australasian EQUATOR Centre. EvS is a senior associate editor for the Journal of Physical Activity and Health. She played no role in the editor's decision to update the journal's submission guidelines. She is also a member of the Editorial Board at the International Journal of Behavioral Nutrition and Physical Activity.

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Publisher's Note

Additional file 1: Methods used to assess completeness of TIDieR checklist items in systematic review [376]

After full-text screening, we conducted forward and backward citation tracking and searched through articles and their supplementary materials for any peer-reviewed publications (e.g. protocols, process evaluations, outcome evaluations) and other outputs (e.g. trial registries, study websites) relevant to the trials eligible for inclusion. As a trial may have more than one output, all study publications and outputs were pooled for data extraction. A full list of trial publications and outputs is listed below[a].

The pooled publications and outputs were then searched to complete the Template for Intervention Description and Replication (TIDieR) checklist [155], a reporting guideline of the minimum set of items considered essential for intervention description and replication (e.g. use of theory, duration, mode of delivery). All data extraction was conducted by a single reviewer. Where multiple training programmes were delivered within a study (e.g. in the form of content, dose, material etc. beyond local adaptation or personalisation), and outcome data were reported for each arm, data was sought and extracted for each arm.

If TIDieR items were not identified and perceived as applicable, then lead authors of included articles were contacted. They were requested to check and complete a partially filled TIDieR-based form, and to add any relevant study publications not listed. Authors were given three weeks to respond with a reminder email.

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List of trial publications and outputs identified during data extraction period

Leading author of article included in review, name of intervention (or relevant acronym)

Study outputs identified

[a] Identical to those listed in Appendix 2.8 so not repeated here again

Additional file 2: List of TIDieR checklist-based items reported before and after author contact

TIDieR checklist-based item [155]	**Following data extraction (N=53)**			**Following author contact period (N=53)**		
	Available from majority?	**N**[a]	**%**	**Available from majority?**	**N**[a]	**%**
Name of the intervention	Yes	53	100.0	Yes	53	100.0
Describe any rationale/theory that underpinned the design of the teacher training provided (e.g. the Theory of Planned Behaviour).	No	14	28.3	Yes	43	81.1
Materials: Describe any physical or informational materials provided to teachers.	Yes	38	71.7	Yes	48	90.6
Procedures: Describe the procedures, activities, and/or processes used in the training, including any enabling or support activities.	Yes	53	100.0	Yes	53	100.0
Who provided the training?	Yes	43	81.1	Yes	49	92.5
Mode of delivery? (e.g. face-to-face, online, telephone, or multiple formats?)	Yes	46	86.8	Yes	51	96.2
Was the training delivered to staff **individually or in a group?**	No	21	39.6	Yes	43	81.1
Where was the training delivered? (describe the location and any necessary infrastructure)	No	20	37.7	Yes	44	83.0
Total mins/hours of training?	Yes	38	71.7	Yes	47	88.7
How many training **sessions** were provided?	Yes	42	79.2	Yes	50	94.3
Over what time period?	Yes	37	69.8	Yes	47	88.7
Was the training planned to be **personalised**? (e.g. was the training tailored based on teachers' skills?)	No	20	37.7	Yes	45	84.9
Was the training **modified** during the intervention? (i.e. any unforeseen modifications made to the overall training provided? e.g. teachers did not receive paper manuals as planned)	No	3	5.7	Yes	38	71.7

Was **adherence or fidelity** to the planned teacher training assessed? Were any strategies used to maintain training fidelity? If so, describe any strategies, and the extent to which the teacher training was delivered as planned.	No	3	5.7	Yes	40	75.5
Was **attendance of teachers monitored** at training? If so, describe any outcomes.	No	14	26.4	Yes	44	83.0

[a] Item was identified as present or not applicable

1. Hoffmann TC, Glasziou PP, Boutron I, Milne R, Perera R, Moher D, Altman DG, Barbour V, Macdonald H, Johnston M *et al*. Better reporting of interventions: template for intervention description and replication (TIDieR) checklist and guide. *BMJ* 2014, 348:g1687.

Additional file 3: Complete list of journals contacted (n=32) and action taken* (n=7)

1. American Journal of Preventive Medicine**
2. BMC Public Health
3. BMJ
4. BMJ Open
5. British Journal of Sports Medicine*
6. European Physical Education Review
7. Evaluation and Program Planning*
8. Health Education & Behavior
9. Health Education Research
10. Health Technology Assessment
11. International Journal of Child-Computer Interaction
12. International Journal of Environmental Research and Public Health
13. International Journal of Obesity
14. Irish Educational Studies
15. Journal of Experimental Social Psychology*
16. Journal of Paediatrics & Child Health
17. Journal of Physical Activity & Health*
18. The Journal of School Health
19. Journal of Science & Medicine in Sport*
20. Journal of Sports Sciences
21. Journal of Teaching in Physical Education
22. Medicine and Science in Sports and Exercise
23. Nutrients
24. Pediatric Exercise Science
25. Physical Education & Sport Pedagogy
26. PLoS ONE
27. Preventive Medicine
28. Preventive Medicine Reports
29. Psychology of Sport & Exercise*
30. Scandinavian Journal of Educational Research
31. Translational Journal of the American College of Sports Medicine
32. Sport, Exercise, and Performance Psychology*

* As of March 8th, 2023, journals marked with an asterisk (*) reported changes made to their submission guidelines. With the exception of 'Sport, Exercise, and Performance Psychology', who we contacted in July 2022, all other journals were initially contacted in May 2022.

** American Journal of Preventive Medicine reported changes were made to their submission guidelines in June 2023

Research Impact Statement form

Student name	Mairead Ryan
USN	304733369
Department	MRC Epidemiology Unit
Supervisor	Dr Esther van Sluijs
Thesis title	School-based health promotion: understanding the educational context to facilitate change

Research Impact Statement:

In October 2019, I began an interdisciplinary PhD studentship at the Medical Research Council Epidemiology Unit and the Faculty of Education to address research gaps in implementation science in school-based physical activity intervention research. The main focus of my PhD was originally an ethnography of an intervention, which involved fieldwork-based data collection. Between October 2019 and July 2020, I developed a protocol for the study, undertook courses in ethnography, identified a suitable intervention for evaluation, set up a collaboration with researchers in Bradford, England, secured funding for travel costs, and obtained necessary documentation for school-related fieldwork (e.g., a Disclosure and Barring Service check).

From March 2020 however, I encountered significant and ongoing disruptions in conducting this work as a consequence of school closures related to the Covid-19 pandemic. In March 2022, the UK went into a nationwide lockdown, which included school closures and population-wide stay-at-home initiatives. It was not possible to undertake the planned fieldwork remotely (e.g., via Zoom). All primary schools in England were closed to students except for vulnerable children and the children of key workers. Although students were allowed to return to school in autumn 2021, schools closed again in early January 2021 for a minimum period of two months.

I then decided to take a six-month break from my PhD studies, hoping that data collection activities would be feasible again in the latter half of the 2021/2022 school year. During this period (March-August 2021), I undertook an internship at the Government Office for Science. The internship involved revising the UK government's 'Code of Practice for Scientific Advisory Committees' and conducting a review that aimed to enhance the development and use of recommendations made by a scientific advisory council.

When I returned from the internship in September 2021, it became apparent that conducting the planned fieldwork would pose significant challenges. The Bradford study was experiencing issues with launching the intervention as intended, university support for student travel to other cities was limited, and research access to local schools was limited to allow teachers and their students a period of recovery from the pandemic. I, therefore, decided to make substantial revisions to my thesis questions and methods. The projects I subsequently developed (Chapters 3-5) intentionally required no physical attendance in schools, no engagement with students, and made greater use of existing datasets. Chapter 4 originated from an overseas visit that I initiated, in part, to gain practical experience in conducting research within a school setting.

I would like to express my thanks to Dr Andy Daly-Smith for his willingness to collaborate on the original ethnography study, his ongoing communication throughout the school closure period, and his support in facilitating other studies (e.g., contacting stakeholders to improve teacher recruitment in the PE Premium study). I would also like to thank the Economic and Social Research Council for granting a three-month funding extension to account for the disruptions caused by the Covid-19 pandemic.	
Student's signature	[Signature redacted]
Supervisor signature	[Signature redacted]