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REVIEW ARTICLE

Evaluation of school-based interventions including homework to promote healthy lifestyles: a systematic review with meta-analysis

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Abstract

Aim It is important to promote healthy lifestyles in youth through initiatives in school, which is a preferred setting to implement health-related interventions also targeted at families to be more effective. This study aimed to synthesise school-based interventions including homework and extracurricular activities for the promotion of healthy lifestyles, especially healthy nutrition and physical activity, in children and adolescents.

Methods This systematic review was conducted according to the PRISMA guidelines. Quality assessment was performed using the Cochrane Tool for Quality Assessment for randomized and non-randomized control trials, while the STROBE (Strengthening the Reporting of Observational studies in Epidemiology) guidelines were used for observational studies.

Results From the 1356 studies identified, eight were included. Across studies, a significant effect was found in increasing fruit and vegetable consumption and reducing snack and sugar intake, while no effect was found for moderate to vigorous physical activity (MVPA) unless for light PA (LPA) and step counts. The results of BMI and waist circumference are still unclear after performing a meta-analysis of three studies.

Conclusion School-based interventions including homework and extracurricular activities were shown to improve nutritional behaviour, step counts, and LPA. Despite some statistically significant results, the effects of BMI and waist circumference are still unclear. Further studies are needed to demonstrate that these intervention s can represent an effective strategy for obesity prevention.

Keywords Extracurricular activity · Homework · Nutrition · Physical activity · Children · Adolescents

Background

Physical activity (PA) combined with healthy eating and sleeping habits are essential for many aspects of child health and development, including the prevention of chronic health conditions, such as overweight and obesity (Bull et al. 2020; Matricciani et al. 2019). To obtain these beneficial health outcomes, children and adolescents should practise at least an average of 60 min per day of moderate-to-vigorous intensity PA (MVPA) across the week, mostly aerobic, and incorporate 3 days a week of vigorous-intensity aerobic activities, as well as those that strengthen muscles and bones (Bull et al. 2020). Alongside this, sedentary behaviours, defined as activities performed in a sitting and/or reclining position with an energy expenditure lower than 1.5 MET, are more and more frequent, and new evidence suggests that higher time spent in sedentary behaviour, particularly screen time, is associated with poorer physical health outcomes such as lower fitness and poorer cardio-metabolic health (Carson et al. 2016; Katzmarzyk et al. 2019), and may increase obesity (Matusitz and McCormick 2012).

Good nutrition (defined as the intake of an adequate, well-balanced diet) is fundamental for good health throughout life

Aurelia Salussolia and Alessandra Anastasia contributed equally to this article.

Sofia Marini and Laura Dallolio, Both authors jointly directed this research.

Please note that the word 'homework' when used in this paper refers to the assignment of PA-related tasks for school pupils to perform at home, not to academic activity

Extended author information available on the last page of the article

(WHO 2014; Haines et al. 2019). The Food and Agriculture Organization (FAO) and World Health Organisation (WHO) emphasise the importance of increasing plant foods intake (fruits, vegetables, legumes, nuts, and whole grains) and limiting the intake of fats (especially saturated and trans-fats), salt and energy from free sugars (such as those added to foods and drinks) (FAO and WHO 2019). Good habits in the consumption of fruit and vegetables during childhood are related to lower adiposity, lower cardiometabolic risk factors, and higher academic performance (Janssen and Leblanc 2010; Ness et al. 2007; Ekelund et al. 2012).

In this scenario, it is increasingly essential to promote healthy lifestyle projects and initiatives, particularly in school, which is a preferred setting to promote health and implement health-related interventions (Pulimeno et al. 2020). The school setting has indeed been identified as an ideal environment for health promotion interventions because it is an inclusive place where it is possible to avoid socio-economic inequalities which can occur in the community and in other facilities such as sports clubs.

Furthermore, children and adolescents spend a significant amount of time in school, where they are also exposed to supportive environments such as school health policies, physical and nutrition education, and PA during school hours (Story et al. 2009).

Growing evidence from systematic reviews shows that school-based interventions are effective in improving healthy lifestyles in youth (Wolfenden et al. 2022; Brown et al. 2019; Dobbins et al. 2013). The majority of the literature has investigated the effectiveness of school-based intervention on multidisciplinary curricular activities (i.e., active breaks, physically active lessons, physical education classes, and nutritional intervention) (Masini et al. 2020a, b; Masini et al. 2020a, b). However, school-based interventions to promote healthy lifestyles are not always possible due to the demands of the curriculum.

Furthermore, some reviews have found that interventions not only focused on schools but also targeted on extracurricular time are likely to be most effective (Dobbins et al. 2013; Wang et al. 2015). Therefore, long-term behavioural change may be more achievable when the environment outside the school context (i.e., the family and community settings) is considered and reinforces key contents delivered during school time. Thus, school-based interventions with extracurricular activities (i.e., healthy homework such as creating a healthy plate, biking for 10 km during week-end) and with challenges' components (i.e., being in competition with other students on healthy homework such as "Who is the first student who performed 10 km on foot today?"), could maximise and potentially improve the success of this type of intervention. Therefore, the concepts of extracurricular activities, challenges, and homework promoting health would be taken into account in school-based interventions (Centers for Disease Control and Prevention 2013).

There is not much evidence on this type of interventions, and therefore there is a need for more investigations and analysis on this topic. In this scenario, the present systematic review aims to evaluate and synthesise school-based interventions, which include extracurricular activities and homework promoting healthy lifestyles (PA, healthy diet, and sleep hygiene) in children and adolescents, focusing on efficacy over time. To our knowledge, this is the first systematic review focused on interventions organised from the school setting and translated to the out-of-school environment.

Methods

Search strategy and data sources

The present systematic review was conducted following the PRISMA recommendations and the criteria of the reporting of meta-analysis guidelines (Page et al. 2021). The protocol of the systematic review was previously documented in the International Prospective Register of Systematic Reviews (PROSPERO; registration no. CRD42021281011). We developed a PICOS (patients, interventions, comparators, outcomes and study design) using the following search terms to address the primary search objective: (P) Healthy school children and school adolescents aged 6–18, (I) Primary and secondary school-based healthy lifestyle intervention involving homework and challenges in extracurricular time, (C) Usual lessons or no intervention, (O) PA related behaviours, sedentary related behaviours, nutrition-related behaviours, sleep-related behaviours, anthropometric outcomes, physical fitness, well-being, quality of life, health status, and (S) randomized controlled trial (RCT), clinical trial, clinical study, case report, and observational study (i.e., cohort studies, longitudinal studies) with original primary data. A systematic search of the following scientific databases: Medline (PubMed), Cochrane Central Register of Controlled Trials (Central), CINAHL (EBSCO), Psycinfo (EBSCO) was performed to identify all published articles about school-based interventions, which included extracurricular activities and homework, to promote healthy lifestyle in children and adolescents. We searched electronic databases, with no time restriction and up to July 2020.

Search strategy was created and adapted, when necessary to the different databases, using the following boolean expression: [(Homework* OR Extra-curricul* OR Extracurricul* OR After-school) AND (Child* OR Adolescent* OR Teen*) AND (Exercises OR "Physical Activit*", Physical OR "Activity Physical" OR "Physical Activities" OR "Exercise Physical" OR "Exercises Physical" OR "Physical Exercise" OR "Physical Exercises" OR "Acute Exercise" OR "Acute Exercises" OR "Exercise Acute" OR "Exercises Acute" OR "Exercise Aerobic" OR "Aerobic Exercise" OR "Aerobic Exercises" OR Exercises Aerobic OR Exercise Training OR Exercise

Trainings OR Training Exercise OR Trainings Exercise) AND ("Lifestyle Healthy" OR "Lifestyles Healthy" OR "Healthy Life Styles" OR "Healthy Lifestyles" OR "Healthy Life Style" OR Life Style Healthy OR Life Styles Healthy OR "healthy behavio*" OR "healthy habit*" OR "Sedentary Behavio*" OR "Behavior Sedentary" OR "Sedentary Behaviors" OR "Sedentary Lifestyle" OR "Lifestyle Sedentary" OR "Physical Inactivity" OR "Inactivity Physical" OR "Lack of Physical Activity" OR "Sedentary Time" OR "Sedentary Times" OR "Time Sedentary" OR "Eating Habit*" OR "Eating Habits" OR "Eating Habit" OR "Habit Eating" OR "Dietary Habits" OR "Dietary Habit" OR "Habit Dietary" OR nutrition* OR diet* OR "Sleeping Habit*" OR "Sleeping Habits" OR "Sleep Habits" OR "Habit Sleep" OR "Habits Sleep" OR "Sleep Habit" OR "Sleeping Habit" OR "Habit Sleeping" OR "Habits Sleeping" OR "Sleep Hygiene")].

Furthermore, a grey literature search and hand search were performed to retrieve other eligible papers; we examined references cited in the primary papers to identify additional papers, in accordance with the snowball technique (Greenhalgh and Peacock 2005).

The PICOS inclusion and exclusion criteria used to collect papers are summarised in Table 1.

Data extraction and quality assessments

Screening and checking phases followed different steps. First of all, the reviewers independently and blindly screened eligible papers, after the removal of duplicates, reading titles, and abstracts in order to select pertinent papers. After the first screening, the reviewers retrieved and read the full text of all potentially eligible studies. Disagreements regarding the eligibility of the studies for inclusion were resolved by discussion among all the researchers' groups, and if more information was necessary the study authors were contacted. Finally, the investigators independently — following the standardised rules for literature collection provided by the Cochrane Reviewers handbook (Higgins 2008) — extracted the data of the included studies, focusing on the following characteristics: author, country, study design, population, intervention, outcomes, and results were tabulated as mean ± SD where possible.

The studies included in the final step were blindly and independently assessed for the risk of bias separately by researchers (AA, AS, GS, GZ) using the "Cochrane risk-of-bias tool for randomized trials (RoB-2)" (Sterne et al. 2019), the "Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) tool for observational studies" (Cuschieri 2019) and "The Risk Of Bias In Non-randomized Studies – of Interventions (ROBINS-I) assessment tool" (Sterne et al. 2016). Any disagreement between reviewers was solved through discussion with tiebreakers (AM, SM). This methodological choice was supported by the PRISMA guidelines (Moher et al. 2009).

The RoB-2 tool analyses different bias domains: bias arising from the randomization process; bias due to deviations from intended interventions, bias due to missing outcome data, bias in the measurement of the outcome, and bias in the selection of the reported result. The response options for the signaling questions in each domain are yes/probably yes/probably no/no; no information.

Table 1 PICOS Eligibility criteria

Parameter	Inclusion criteria	Exclusion criteria
Population	School-children and school-adolescents aged 6–18	Preschool children aged 3–6, adult, workers
Intervention	Primary and secondary school-based healthy lifestyle intervention involving homework and challenges	Intervention not carried out during curricular hours involving recess /PE lessons/ active breaks/ physically active lessons/ Intervention set only during extracurricular time not involving school setting Intervention targeting families only
Comparator	No school-based healthy lifestyle intervention/any other type of intervention	
Outcome	PA-related behaviours Sedentary-related behaviours Nutrition-related behaviours Sleep-related behaviours Anthropometric outcomes Physical fitness Well-being Quality of life Health status	Other outcomes
Study design	Experimental (i.e., RCT, quasi-experimental studies, pilot studies) or observational study (i.e.,cohort studies, longitudinal studies) with original primary data and full-text studies written in English, Spanish, Portuguese; French, Italian	Study protocol or other papers without original data (i.e., reviews, letters to editors, trial registrations, proposals for protocols, editorials, book chapters, conference abstracts)

These categories provide the basis for an overall risk-of-bias judgement for the specific trial result being assessed in low risk of bias, some concerns, and high risk of bias.

The ROBINS-I scale uses seven different domains: bias due to confounding; bias in the selection of participants in the study, bias in classification of interventions, bias due to deviations from intended interventions, bias due to missing data, bias in the measurement of outcomes, and bias in the selection of the reported result. The response options for each domain level were the same as RoB-2, but the overall risk of bias judgment was divided into low risk, moderate risk, serious risk, and critical risk of bias.

The STROBE statement is a 22-item tool divided into three different checklists: cohort study, cross-sectional and case report studies. In line with the previous study, we adopted a cut-off for three levels of scores: 0–14 poor quality (high risk of bias), 15–25 intermediate qualities (some concerns), and 26–33 good quality (low risk of bias).

Meta-analysis

We performed separate meta-analyses for the different variables. Only comparable studies for measurement and statistical methods were included. If possible, pre-post intervention values were compared between experimental groups (EG) and control groups (CG). We analysed statistical heterogeneity to test the strength of matching the studies for meta-analysis, evaluating heterogeneity by the use of graphic forest plots and by calculating the I2 statistic. I2 statistic ≥ 50% was considered as a threshold for substantial heterogeneity. We used a random-effect model when studies were heterogeneous and lower than five, in accordance with the Cochrane Handbook for Systematic Reviews of Interventions, following the method of DerSimonian and Laird to compute the random effects estimates for the corresponding statistics (Higgins et al. 2003; DerSimonian and Laird 1986). Rev-Man Program (Version 5.3. Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2014) was used to perform meta-analyses and forest plots to show graphically effect estimates with 95% CIs for the single trials selected for meta-analysis and pooled results.

Results

Study selection and characteristics

Through database browsing and hand-searching a total of 1356 articles were identified (Fig. 1). Papers were published from 1999 to 2021. Considering articles identified from databases, 585 were excluded because they were duplicated, and 625 were excluded following abstract reading. Of the 142 articles deemed eligible, two were excluded because no full text was found, and therefore the full text of 140 articles was read. Eventually, 132 were excluded because they matched the exclusion criteria, and only eight were considered relevant (Fairclough et al. 2013; Kipping et al. 2014, 2012; Anderson et al. 2016; Lloyd et al. 2018; Duncan et al. 2011, 2019; Friel et al. 1999). All the records identified from hand-searching were excluded after reading the full text.

The main reasons for exclusion in the first step (abstract reading) were: no intervention present in the study (36%) and not school-based (25%). After the full-text reading (considering both reports from databases and hand-searching), the main cause of exclusion was the implementation of other types of interventions (42%).

Risk of bias

Each study was evaluated for quality assessment, differentiating RCTs from quasi-experimental and observational studies. In accordance with the revised Cochrane Tool for Quality Assessment, the six studies categorised as RCTs scored a risk of bias from low to some concern. Four studies resulted in low risk of bias (Fairclough et al. 2013; Kipping et al. 2014; Anderson et al. 2016; Lloyd et al. 2018) and two with some concerns (Duncan et al. 2011, 2019) (Table 2). In particular, the first study performed by Duncan et al. in 2011 presented some concerns regarding the first domain of the randomization process, and the second focused on deviations from intended interventions (Duncan et al. 2011). Even the study conducted by Duncan et al. presented some concerns, particularly regarding the outcome measurements' evaluators, who were not blinded, and the randomization process, which was not clear (Duncan et al. 2011). Considering the quasi-experimental study performed by Friel et al., we assessed a serious risk of bias mainly due to confounding and missing data bias (Friel et al. 1999). Finally, the observational study by Kipping et al. was assessed with intermediate quality, mainly due to gaps both in statistical analysis and in data description (Kipping et al. 2012).

Data extraction

The geographic origins of the studies were: five out of eight from the UK (Fairclough et al. 2013; Kipping et al. 2014, 2012; Anderson et al. 2016; Lloyd et al. 2018), two from New Zealand (Duncan et al. 2011, 2019) and one from Ireland (Friel et al. 1999) (Table 3).

Amongst the selected ones, six out of eight studies were classified as RCTs (Fairclough et al. 2013; Kipping et al. 2014; Anderson et al. 2016; Lloyd et al. 2018; Duncan et al. 2011, 2019), one as qualitative study (Kipping et al. 2012), and one as quasi-experimental study (Friel et al. 1999); the oldest one was published in 1999, while most of them in the second decade of the 2000s.

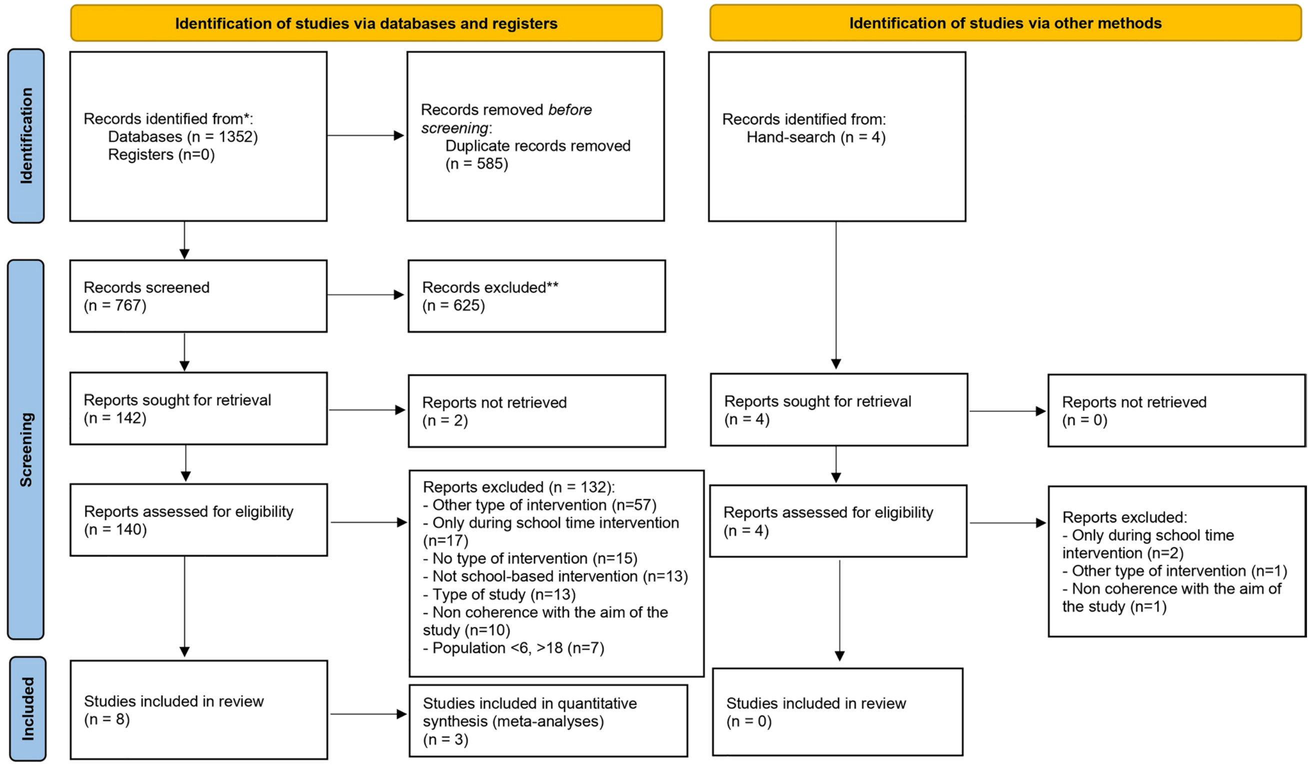


Fig. 1 PRISMA 2020 flow diagram of the study selection

Table 2 Quality assessment of RCTs and observational studies

Authors	Study design	Tool for assessment	Quality
Duncan et al. 2011	RCT	Cochrane ROB2 Tool	Some concerns
Fairclough et al. 2013	RCT	Cochrane ROB2 Tool	Low risk
Kipping et al. 2014	RCT	Cochrane ROB2 Tool	Low risk
Anderson et al. 2016	RCT	Cochrane ROB2 Tool	Low risk
Lloyd et al. 2018	RCT	Cochrane ROB2 Tool	Low risk
Duncan et al. 2019	RCT	Cochrane ROB2 Tool	Some concerns
Friel et al. 1999	Quasi-experimental	ROBBINS	Serious risk
Kipping et al. 2012	Observational	STROBE	Intermediate

RCT, randomized control trial; *ROB2*, Cochrane risk-of-bias tool for randomized trials. *ROBBINS-I*, the Risk Of Bias In Non-randomized Studies – of Interventions. *STROBE*, Strengthening the Reporting of Observational Studies in Epidemiology

The sample size varied from 32 (Kipping et al. 2012) to 2221 (Kipping et al. 2014; Anderson et al. 2016). While in our inclusion the age criteria were 6–18, the age range in the selected articles was between 7 and 11 years old.

Data regarding the intervention characteristics were extracted adopting the "F.I.T.T." classification (Frequency, Intensity, Time, Type) mainly used in exercise prescription (Burnet et al. 2019). The "Type" of intervention in all the included studies was school-based healthy lifestyle intervention involving homework and challenges. Homework and challenges were a curriculum-based schedule, complemented by an in-class teaching resource, designed to promote physical activity and healthy eating. Education lessons are delivered by the class teacher then short homework tasks

Table 3 Summary of main findings of studies of school-based interventions including homework

Study	Study design	Population	Intervention	Nutrition-related behaviours		PA and sedentary behaviours		Anthropometric outcomes	
				Experimental	Control	Experimental	Control	Experimental	Control
Friel et al. 1999 (Ireland)	Quasi-experimental	*N*: 821 *Age*: 8–10 *EG*: 453 *CG*: 368	*Type:* "Hearty Heart and Friends" lesson plans, activity worksheets for pupils, a home team pack to involve parents and the food diaries *Frequency:* every school day × 20–30'' *Time:* 10 weeks	*Behaviour* (scores) *P < 0.01* Pre: 25.4 ± 3.6 Post: 24.2 ± 3.7	 *P* = NS Pre: 26.5 ± 3.3 Post: 26.8 ± 3.5	NA		NA	
				Preference (scores) *P < 0.01* Pre: 27.4 ± 4.2 Post: 26.2 ± 4.0	 *P* = NS Pre: 29.4 ± 3.8 Post: 30.0 ± 3.6				
				Knowledge (scores) *P* = NS Pre: 20.5 ± 2.4 Post: 19.7 ± 2.1	 *P* = NS Pre: 19.7 ± 1.6 Post: 19.3 ± 1.7				
Kipping et al. 2012) (UK)	Observational	*N*: 32 *Age*: 9–10	*Type:* AFLY5 *Frequency:* 16 lessons *Time:* 6-7 months	Qualitative study, descriptive results in the text		NA		NA	
Duncan et al. 2011 (New Zealand)	RCT	*N*: 97 *Age*: 9–11 *EG*: 57 *CG*: 40	*Type*: Healthy Homework schedule and complementary teaching resource, homework booklet with PA and nutrition tasks, website pedometer/sports/food diaries *Frequency*:18 lessons × 1.5 h *Time*: 6 weeks	*Fruits* (servings/day) *P* = NS Pre: 1.07 (0.70;1.75) Post: 1.43 (0.86–2.11)	 *P* = NS Pre: 1.06 (0.58;1.43) Post: 1.14 (0.69–1.66)	*Overall PA* (steps/day) *P < 0.05* Pre: 10,790 (8,200–12,160) Post:11,790 (9,670–15,680)	 *P* = NS Pre: 11,240 (9,420–12,860) Post: 9,910 (7,500–12,700)	NA	
				Vegetables (servings/day) *P* = NS Pre: 0.79 (0.36–1.68) Post: 1.43 (0.83–1.93)	 *P* = NS Pre: 1.13 (0.47–1.81) Post: 0.93 (0.36–1.57)	*Overall Screen time* (h/day) *P* = NS Pre: 1.25 (0.36–1.93) Post: 1.05 (0.63–1.52)	 *P* = NS Pre: 1.09 (0.59–2.04) Post: 1.25 (0.39–2.64)		
				Unhealthy food (servings/day) *P < 0.01* Pre: 2.07 (1.43–3.00) Post: 1.21 (0.68–2.43)	 *P* = NS Pre: 1.90 (1.27–3.43) Post: 1.68 (1.24–2.63)	*Overall Sports participation* (h/day) *P* = NS Pre: 0.64 (0.14–1.01) Post: 0.71 (0.46–1.28)	 *P* = NS Pre: 0.52 (0.14–0.90) Post: 0.81 (0.41–1.14)		
				Unhealthy drink (servings/day) *P < 0.05*	 *P* = NS	*Weekdays active transport* (h/day) *P* = NS	 *P < 0.05*		

Table 3 (continued)

Study	Study design	Population	Intervention	Nutrition-related behaviours		PA and sedentary behaviours		Anthropometric outcomes	
				Experimental	Control	Experimental	Control	Experimental	Control
				Pre: 0.93 (0.07–1.79) Post: 0.29 (0.00–0.79)	Pre: 0.29 (0.00–0.88) Post: 0.29 (0.00–0.79)	Pre: 0.17 (0.00–0.33) Post: 0.13 (0.00–0.44)	Pre: 0.15 (0.00–0.46) Post: 0.00 (0.00–0.29)		
Fairclough et al. 2013 (UK)	RCT	*N*: 318 *Age*: 10–11 *EG*: 152 *CG*: 166	*Type:* Worksheets, homework, lesson resources *Frequency:*20 lessons × 60 min *Time*: 20 weeks	*Breakfast* (%) *P* = NS *Fruit* (%) *P* = NS *Vegetables* (%) *P* = NS		*Sedentary time P* = NS *LPA* (min/day) *P = 0.01** *MPA* (min/day) *P* = NS *VPA* (min/day) *P* = NS		*BMI* (kg/m^2) *P* = NS *BMI* (z score) *P = 0.04** *WC* (cm) *P* = NS	
Kipping et al. 2014 (UK)	RCT	*N*: 2221 *Age*: 8–9 *EG*: 1064 *CG*: 1157	*Type:* "Active for Life Year 5 (AFLY5)": Teacher's training, provision of lesson and child-parent interactive homework plans *Frequency:* 16 lessons *Time:* 6–7 months	*Fruits or vegetables* (servings/day) *P* = NS		*MVPA* (min/day) *P* = NS		*BMI* (z score) *P* = NS	
				Pre: 1 [0–2] Post: 1.89 ± 1.70	Pre: 1 [0–2] Post: 1.81 ± 1.55	Pre: 59 ± 23 Post: 55.25 ± 22.33	Pre: 56 ± 21 Post: 56.65 ± 23.42	Pre: –0.06 ± 0.94 Post: –0.05 ± 0.95	Pre: 0.05 ± 1.04 Post: 0.05 ± 1.03
				Snacks (servings/day) *P = 0.01*		*Sedentary behaviour* (min/day) *P* = NS		*Waist circumference* (z score) *P = 0.03*	
				Pre: 2 [1–3] Post: 2.24 ± 1.49	Pre: 2 [1–3] Post: 2.46 ± 1.59	Pre: 422 ± 72 Post: 454.08 ± 66.78	Pre: 416 ± 68 Post: 451.84 ± 65.40	Pre: –0.03 ± 0.97 Post: –0.08 ± 0.94	Pre: 0.03 ± 1.02 Post: 0.08 ± 1.04
				High energy drinks (servings/day) *P = 0.002*		*Screen Time Weekdays* (min/day) *P* = NS		*Overweight/obesity* (%) P = NS	
				Pre: 2 [1–3] Post: 2.21 ± 1.44	Pre: 2 [1–3] Post: 2.45 ± 1.61	Pre: 105 [45–240] Post:132.52 ± 125.37	Pre:105 [45–225] Post: 145.45 ± 133.95	Pre: 19% Post: 18.9%	Pre: 22% Post: 21.05%
				High-fat foods (servings/day) *P* = NS		*Screen Time Weekend* (min/day) *P = 0.01*		*Central overweight/obesity* (%) *P* = NS	
				Pre: 0 [0–1] Post: 0.79 ± 0.97	Pre: 1 [0–1] Post: 0.88 ± 0.96	Pre: 90 [30–240] Post: 155.33 ± 154.43	Pre:105 [30–240] Post: 175.64 ± 171.79	Pre: 36% Post: 43.6%	Pre: 39% Post: 49.7%

Table 3 (continued)

Study	Study design	Population	Intervention	Nutrition-related behaviours		PA and sedentary behaviours		Anthropometric outcomes	
				Experimental	Control	Experimental	Control	Experimental	Control
Anderson et al. 2016 (UK)	RCT	*N*: 2221 *Age*: 8–9 *EG*: 1064 *CG*:1157	*Type:* "Active for Life Year 5 (AFLY5)": Teacher's training, provision of lesson and child-parent interactive homework plans *Frequency:* 16 lessons *Time:* 6–7 months	*Fruit or vegetables* (servings/day) $P = \text{NS}$		*MVPA* (min/day) $P = \text{NS}$		*BMI* (z-score) $P = \text{NS}$	
				Pre: 1 [0–2] Post: 1.80 ± 1.55	Pre: 1 [0–2] Post: 1.82 ± 1.59	Pre: 56 ± 21.00 Post: 52.56 ± 20.67	Pre: 59 ± 23 Post: 54.37 ± 22.23	Pre: − 0.06 ± 0.94 Post: − 0.03 ± 0.97	Pre: 0.05 ± 1.04 Post: 0.03 ± 1.02
				Snacks (servings/day) $P = \text{NS}$		*Sedentary behaviour* (min/day) $P = \text{NS}$		*Waist circumference* (z score) $P = \text{NS}$	
				Pre: 2 [1–3] Post: 2.11 ± 1.55	Pre: 2 [1–3] Post: 1.99 ± 1.47	Pre: 461.78 ± 68 Post: 61.78 ± 66.33	Pre: 422 ± 72 Post: 65.46 ± 70.61	Pre: 0.03 ± 1.02 Post:0.03 ± 1.04	Pre: − 0.03 ± 0.97 Post: − 0.03 ± 0.95
				High-energy drinks (servings/day) *$P = 0.04$*		*Screen Time Weekday* (min/day) $P = \text{NS}$		*Overweight/obesity* (%) $P = \text{NS}$	
				Pre: 2 [1–3] Post: 2.38 ± 1.58	Pre: 2 [1–3] Post: 2.19 ± 1.45	Pre:105 [45–225] Post:148.01 ± 126.39	Pre:105 [45–240] Post:138.88 ± 125.00	Pre: 22% Post: 21.02%	Pre: 19% Post: 20.11%
				High-fat foods (servings/day) *$P = 0.05$*		*Screen Time Weekend* (min/day) *$P = 0.06$*		*Central overweight/obesity* (%) $P = \text{NS}$	
				Pre: 1 [0–1] Post: 0.86 ± 0.94	Pre: 0 [0–1] Post: 0.74 ± 1.07	Pre: 105 [30–240] Post:180.52 ± 164.82	Pre: 90 [30–240] Post:167.71 ± 156.28	Pre: 39% Post: 42.40%	Pre: 36% Post: 42.14%
Lloyd et al. 2017 (UK)	RCT	*N*: 1244 *Age:* 9–10 *EG*: 676 *CG*: 648	*Type:* Healthy Lifestyles Programme (HeLP) Dynamic and interactive activities eg. physical activity workshops, education sessions delivered by teachers with short homework tasks, drama sessions, setting goals to modify behaviour *Frequency:* during normal classes *Time:* 1 year	*Energy-dense snacks* (score) *Overall : $P = 0.017$*		*Weekly acceleration* (mg) $P = \text{NS}$		*BMI* (SDS) $P = \text{NS}$	

Table 3 (continued)

Study	Study design	Population	Intervention	Nutrition-related behaviours		PA and sedentary behaviours		Anthropometric outcomes	
				Experimental	Control	Experimental	Control	Experimental	Control
				Pre: 4.2 ± 2.2 Post: 3.72 ± 1.86	Pre: 4.1 ± 2.2 Post: 4.06 ± 2.07	Pre: 49.0 ± 11.3 Post: 52.14 ± 13.95	Pre: 49.6 ± 10.9 Post: 51.47 ± 12.95	Pre: 0.32 ± 1.16 Post: 0.35 ± 1.25	Pre: 0.18 ± 1.14 Post: 0.22 ± 1.22
				Weekdays: P = 0.013		*Total MVPA* (min/day) *P* = NS		*Waist circumference* (SDS) *P* = NS	
				Pre: 4.0 ± 2.4 Post: 3.54 ± 2.03	Pre: 4.0 ± 2.4 Post: 3.99 ± 2.27	Pre: 182.7 ± 36.7 Post: 199.71 ± 43.94	Pre: 185.0 ± 34.7 Post: 198.05 ± 40.20	Pre: 0.72 ± 1.11 Post: 0.63 ± 1.24	Pre: 0.55 ± 1.15 Post: 0.54 ± 1.21
				Weekend:: *P* = NS		*LPA* (min/day) *P* = NS		*Body fat %* (SDS) *P* = NS	
				Pre: 4.6 ± 2.5 Post: 4.17 ± 2.21	Pre: 4.4 ± 2.4 Post: 4.26 ± 2.35	Pre: 129.4 ± 24.7 Post: 141.72 ± 27.80	Pre: 131.1 ± 24.2 Post: 141.07 ± 27.09	Pre: –0.61 ± 2.18 Post: –0.78 ± 2.16	Pre: –0.63 ± 2.38 Post: –0.78 ± 1.89
				Healthy snacks (score) *Overall*: *P* = NS		*MPA* (min/day) *P* = NS		*Body fat %*, minus extreme cases (SDS) *P* = NS	
				Pre: 3.3 ± 1.6 Post: 3.61 ± 1.63	Pre: 3.1 ± 1.6 Post: 3.30 ± 1.50	Pre: 40.0 ± 12.1 Post:44.26 ± 16.24	Pre: 40.4 ± 11.4 Post:43.46 ± 13.43	Pre: –0.39 ± 1.62 Post: –0.59 ± 1.84	Pre: –0.46 ± 1.52 Post: –0.65 ± 1.69
				Weekdays: P = NS		*MVPA* (min/day) *P* = NS		*Underweight/normal weight* (%) *P* = NA	
				Pre: 3.4 ± 1.8 Post: 3.69 ± 1.77	Pre: 3.2 ± 1.7 Post: 3.38 ± 1.64	Pre: 53.3 ± 16.8 Post: 57.99 ± 22.34	Pre: 53.9 ± 16.2 Post: 56.98 ± 19.39	Pre: 74% Post: 69%	Pre: 77% Post: 73%
				Weekend: *P* = NS		*VPA* (min/day) *P* = NS		*Overweight* (%) *P* = NA	
				Pre: 3.2 ± 1.9 Post: 3.42 ± 1.83	Pre: 2.9 ± 1.8 Post: 3.12 ± 1.73	Pre: 13.3 ± 6.2 Post: 13.73 ± 7.66	Pre: 13.5 ± 6.2 Post: 13.52 ± 7.38	Pre: 12% Post: 14%	Pre: 11% Post: 14%
				Positive food markers (score) *Overall* :*P* = NS		*Sedentary behaviour* (min/day) *P* = NS		*Obesity* (%) *P* = NA	
				Pre: 6.0 ± 2.7 Post: 6.20 ± 2.36	Pre: 5.7 ± 2.5 Post: 5.77 ± 2.31	Pre: 780.4 ± 36.1 Post: 764.50 ± 43.29	Pre: 778.2 ± 34.0 Post: 766.36 ± 39.88	Pre: 15% Post: 17%	Pre: 13% Post: 13%
				Weekdays: *P* = NS				*Overweight and obesity* (%) *P* = NS	
				Pre: 6.1 ± 2.9 Post: 6.28 ± 2.55	Pre: 5.7 ± 2.8 Post: 5.87 ± 2.52			Pre: 27% Post: 31%	Pre: 24% Post: 27%
				Weekend: *P* = NS					
				Pre: 6.0 ± 3.1 Post: 6.00 ± 2.66	Pre: 5.5 ± 2.9 Post: 5.52 ± 2.64				
				Negative food markers (score) *Overall : P = 0.041*					

Table 3 (continued)

Study	Study design	Population	Intervention	Nutrition-related behaviours: Experimental	Nutrition-related behaviours: Control	PA and sedentary behaviours: Experimental	PA and sedentary behaviours: Control	Anthropometric outcomes: Experimental	Anthropometric outcomes: Control
				Pre: 6.8 ± 3.4 Post: 5.90 ± 2.73	Pre: 6.8 ± 3.3 Post: 6.38 ± 3.00				
				Weekdays: P = *0.02*					
				Pre: 6.5 ± 3.7 Post: 5.54 ± 2.94	Pre: 6.7 ± 3.8 Post: 6.21 ± 3.28				
				Weekend: P = NS					
				Pre: 7.7 ± 4.0 Post: 6.79 ± 3.24	Pre: 7.1 ± 3.6 Post: 6.82 ± 3.36				
Duncan et al. 2019 (New Zealand)	RCT	*N*: 675 *Age*: 7–10 *EG*: 346 *CG*: 329	*Type*: Healthy Homework *Frequency*: 24 lessons × 1.5 h *Time*: 8 weeks	Experimental vs control *Fruit Consumption: P* = *0.036*		Experimental vs control *Weekday PA* (step/days) *P* < *0.001* *Weekend PA* (step/days) *P* < *0.001*		Experimental vs control *BMI* : *P* = *0.020* *WtHR*: *P* = NS	

are given at the end of each session related to a specific school challenge.

The "Frequency" and "Time" of the intervention varied from 3–5 times per week for 6–10 weeks of intervention (Duncan et al. 2011, 2019; Friel et al. 1999) to 16 lessons for 6–7 months (Fairclough et al. 2013; Kipping et al. 2014, 2012). The study by Lloyd et al. structured the intervention for an entire school year, but the frequency was not reported (Lloyd et al. 2018). Only four studies described the "Intensity" of the intervention, which varied between 20/30 min per lesson (Friel et al. 1999) and 1/1.5 hours (Duncan et al. 2011, 2019). Many studies analysed multiple outcomes and were thus included in several of the following three primary outcomes:

1. Nutrition-related behaviors: eight studies (100%)
2. Physical activity and sedentary-related behaviours: six studies (75%)
3. Anthropometric outcomes: five studies (62.5%).

Nutrition-related behavior

Overall, eight studies analysed nutrition-related behaviour outcomes. The tools used to assess these outcomes were mainly based on food diaries (Duncan et al. 2011; Friel et al. 1999) and/or self-reported or food-pairing questionnaires (Fairclough et al. 2013; Kipping et al. 2014, 2012; Anderson et al. 2016; Lloyd et al. 2018; Duncan et al. 2019; Friel et al. 1999). In the study by Friel et al., the nutrition-related behaviour was analysed using both a food-pairing questionnaire and a food diary (Friel et al. 1999). The food-pairing questionnaire comprised three sections: knowledge, preference, and behaviour (Friel et al. 1999). The analysis of the effects of the intervention resulted in a statistically significant improvement in the post-intervention questionnaire score in the areas of behaviour and preference, while no significant changes were found in the control group. With regard to post-intervention diaries, beneficial patterns compared with controls were retained in reported consumption of dairy products and cereals, and improved intake of fruit, vegetables, and salty snacks.

Both Fairclough et al. and Lloyd et al. used food intake questionnaires (Fairclough et al. 2013; Lloyd et al. 2018). Fairclough et al. found no significant intervention effects in the areas of fruit and vegetable intake and breakfast consumption (Fairclough et al. 2013). According to Fairclough et al., a healthy diet includes breakfast consumption and at least five portions of a variety of fruits and vegetable per day. Lloyd instead reported a significant decrease in the consumption of unhealthy foods and unhealthy snacks (defined as energy-dense snacks), both weekly and weekday in the intervention group when compared to the control group (Lloyd et al. 2018). In the study by Anderson et al., when analysing the difference among the self-reported food habits, the statistically significant result was the lower consumption of high-fat foods and high-energy drinks in the intervention group compared to the control group (Anderson et al. 2016).

Kipping et al. reported a significant post-intervention reduction in self-reported snacks and high-energy drink consumption (measured with a validated questionnaire) in the intervention group compared to the control group (Kipping et al. 2014).

In the study by Duncan et al. in 2011, evaluating the food diary in the intervention group, a significant decrease was observed in the overall consumption of unhealthy food ($P=0.001$) and drink ($P=0.010$), while significant increases at follow-up were observed for weekend vegetable consumption ($P<0.001$) (Duncan et al. 2011).

Duncan et al. defined unhealthy foods and drinks that are energy-dense and nutrient-poor, such as confectionery and chocolate, deep-fried food, full-sugar soft drinks, and high-fat pastry products. Between groups, statistically significant differences were found in unhealthy drink consumption at baseline ($P=0.037$). At the multiple analysis, significant effects were detected for vegetable consumption on weekends (an increase of 0.83 servings.day-1, $P=0.007$) and for unhealthy food consumption (decrease of 0.56 servings.day-1 on weekends, $P=0.027$, and of 0.48 servings.day-1 overall, $P=0.042$).

In the study by Duncan et al. (Duncan et al. 2019), dietary behaviours were estimated using items extracted from the Children's Dietary Questionnaire (CDQ) (Magarey et al. 2009). The only significant effect was observed for fruit consumption immediately post-intervention ($P=0.036$) — although the effect was limited — and 6 months post-intervention; the difference between the intervention group and the control group did not reach statistical significance.

In the 2012 study by Kipping et al., according to the results of focus groups with children, the intervention was shown to be effective in changing nutrition habits, especially in increasing vegetable and fruit consumption, decreasing sugar consumption, and moderating food intake (Kipping et al. 2012). In addition, consistent with the results of the questionnaire administered to parents, the intervention was established to improve children's awareness about healthy nutrition, although nutrition habits changed to a small extent.

Anthropometric outcomes

Overall, the anthropometric outcomes that were analysed are: body mass index (BMI) z-score (Fairclough et al. 2013; Kipping et al. 2014; Anderson et al. 2016; Duncan et al. 2019) and BMI SDS (Lloyd et al. 2018), waist circumference (WC) (Fairclough et al. 2013; Kipping et al. 2014; Anderson et al. 2016; Lloyd et al. 2018) in most cases, and general overweight/obesity and central overweight/obesity (Anderson et al. 2016; Lloyd et al. 2018), waist-to-height ratio (WtHR) and percentage of body fat (Lloyd et al. 2018) in few cases.

BMI was assessed in all these studies. A significant difference between baseline and follow-up was found in Fairclough et al. after 30 weeks of intervention ($P=0.04$) (Fairclough et al. 2013), and in Duncan et al. 6 months post-intervention (Duncan et al. 2019) ($P=0.02$), while no significant differences were proven in the studies by Anderson et al., Kipping et al. in 2014, and Lloyd et al. (Anderson et al. 2016; Kipping et al. 2014; Lloyd et al. 2018).

With regard to WC, a statistically significant difference was shown in Fairclough et al. ($P<0.001$) in the post-intervention, but this result was not confirmed at follow-up after 30 weeks (Fairclough et al. 2013). The study by Kipping et al. 2014 obtained the same positive results ($P=0.03$). The studies by Anderson et al. and Lloyd et al. reported no statistically significant results (Anderson et al. 2016; Lloyd et al. 2018).

General overweight/obesity and central overweight/obesity, as binary outcomes, were assessed, and no significant differences were found between groups in Anderson et al. 2016 and Kipping et al. 2014 .

WtHR was studied only by Duncan et al. (2019) but no significant differences were observed before and after the intervention.

Eventually, the percentage of body fat was investigated by Lloyd et al. both after 18 and 24 months (6 and 12 months after the intervention), and no significant differences were reported (Lloyd et al. 2018).

Physical activity and sedentary-related behaviors

A total of six studies analysed PA and sedentary-related behaviours as outcomes (Fairclough et al. 2013; Kipping et al. 2014; Anderson et al. 2016; Lloyd et al. 2018; Duncan et al. 2011, 2019). PA assessment was performed using different objective tools: accelerometers (Fairclough et al. 2013; Kipping et al. 2014; Anderson et al. 2016; Lloyd et al. 2018) and pedometers (Duncan et al. 2011, 2019). Both studies performed by Duncan et al. found significant intervention effects in the total step count during weekdays and weekends (Duncan et al. 2011, 2019).

With regard to the effects of accelerometry-based studies, in terms of MVPA, light physical activity (LPA), moderate physical activity (MPA), and vigorous physical activity (VPA), only the study by Fairclough et al. reported a significant improvement in LPA, using a multilevel analysis of the effectiveness of the intervention between baseline and follow-up (B: -0.24c; $P<0.04$) (Fairclough et al. 2013). The other three studies that used accelerometers reported no statistically significant results (Kipping et al. 2014; Anderson et al. 2016; Lloyd et al. 2018).

With regard to sedentary-related behaviours, four studies (Fairclough et al. 2013; Kipping et al. 2014; Anderson et al. 2016; Lloyd et al. 2018) used accelerometers to calculate time spent in sedentary activity. No statistically significant differences between groups were shown in the time spent in sedentary behaviour after the intervention.

Screen time and television-related sedentary behaviours were analysed using different questionnaires in four studies

(Fairclough et al. 2013; Kipping et al. 2014; Duncan et al. 2011, 2019). Both the studies by Duncan et al. (Duncan et al. 2011, 2019) used an "ad hoc questionnaire" reporting (Robinson 1999) no differences between groups after the intervention.

A self-reported validated questionnaire about the "mean time spent screen viewing on a typical weekday and weekend day" was used by the studies by Anderson et al. and Kipping et al. (Kipping et al. 2014; Anderson et al. 2016; Kipping et al. 2012).

The study by Kipping et al. 2014 reported a statistically significant beneficial effect on self-reported screen viewing on Saturdays ($P < 0.01$) (Kipping et al. 2014). The same improvement trend is highlighted n the study by Anderson et al. ($P < 0.06$) (Anderson et al. 2016).

Meta-analysis results

Due to the heterogeneity in the outcomes measurements, three studies were quantitatively compared in a meta-analysis regarding anthropometric outcomes (Kipping et al. 2014; Anderson et al. 2016; Lloyd et al. 2018). Two different meta-analyses were conducted focusing on BMI (z-score) and WC, using pre–post change results.

With regard to BMI, a non-statistically significant trend between EG and CG ($P = 0.29$, 95% C.I. −0.01, 0.05, random model I2 = 100%) (Fig. 2) was shown by the meta-analysis. However, an average, but not statistically significant, reduction in EG compared with CG from baseline to follow-up ($P = 0.14$, 95% C .I. −03.66, 0.51, random model I2 = 38%) was evidenced by the WC analysis.

While the quality of RCT studies was deemed good, meta-analysis results should be approached with caution due to the limited number of included studies (Fig. 2).

Discussion

The purpose of this systematic review was to assess the effectiveness over time of school-based interventions that included extracurricular activities and homework aimed at the promotion of healthy lifestyles. Most of the excluded studies were focused on PA intervention not school-based or multiple interventions with PA, PE, and organised sports activities (Ludyga et al. 2019; Muzaffar et al. 2019; Moore et al. 2010). Although the included age criteria were 6–18 years, the age range of the studies analysed in this systematic review was limited (7–11 years), given that studies with secondary school students (12–18) were not found. This result might underline the necessity of the development of school-based health promotion interventions in secondary school settings (Frech 2012). The age of adolescence is indeed a key period to develop and stabilise healthy behaviours, which risk declining drastically during the transition to young adulthood if no proper social support is given (Bonell et al. 2019). In connection with this, a recent longitudinal study evaluating the effects of school environments on student risk behaviours suggests that there is a need for school-based intervention promoting health among secondary school children (Althubaiti et al. 2016). Due to our strict inclusion criteria, we finally included only eight studies in our review.

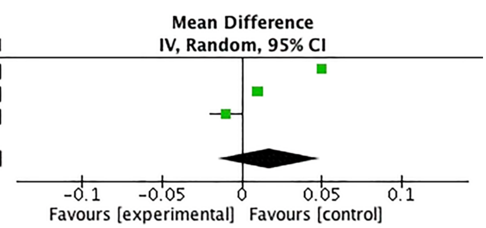
The school-based interventions with healthy homework and extracurricular activities investigated in the included studies were structured in a very similar way in terms of content. The main intervention differences between the eight studies were observed in the total duration of the intervention and the weekly frequency.

Nutritional and anthropometric outcomes and assessment tools

All eight included studies analysed nutrition-related outcomes.

	Experimental			Control				Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Anderson et al. 2016	0.03	0.03	870	−0.02	0.02	923	33.6%	0.05 [0.05, 0.05]
Kipping et al. 2014	0.01	0.01	880	0	0.01	945	33.7%	0.01 [0.01, 0.01]
Lloyd et al. 2017	0.03	0.09	630	0.04	0.08	620	32.7%	−0.01 [−0.02, −0.00]
Total (95% CI)			**2380**			**2488**	**100.0%**	**0.02 [−0.01, 0.05]**

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 975.43$, df = 2 ($P < 0.00001$); $I^2 = 100\%$
Test for overall effect: Z = 1.05 (P = 0.29)



	Experimental			Control				Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Anderson et al. 2016	0	0.02	935	0	0.02	993	33.4%	0.00 [−0.09, 0.09]
Kipping et al. 2014	−0.05	0.03	954	0.05	0.02	1027	33.3%	−3.95 [−4.10, −3.80]
Lloyd et al. 2017	−0.09	0.13	629	−0.01	0.06	618	33.3%	−0.79 [−0.90, −0.67]
Total (95% CI)			**2518**			**2638**	**100.0%**	**−1.58 [−3.67, 0.51]**

Heterogeneity: $Tau^2 = 3.40$; $Chi^2 = 1949.81$, df = 2 ($P < 0.00001$); $I^2 = 100\%$
Test for overall effect: Z = 1.48 (P = 0.14)

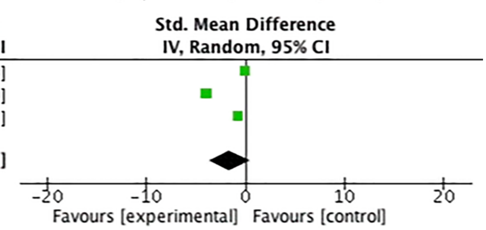


Fig. 2 Meta-analysis results: BMI (*above*) and waist circumference (*below*)

With the exception of Fairclough et al., who reported no significant differences in food intake (Fairclough et al. 2013) all other studies found significant variations in nutritional outcomes, although with different assessment tools (Kipping et al. 2014, 2012; Anderson et al. 2016; Lloyd et al. 2018; Duncan et al. 2011, 2019; Friel et al. 1999). Overall, we can establish that the use of healthy tasks, challenges, and educational lessons focusing on healthy lifestyles could have a positive impact on children's eating habits. These positive results were evident both after a few weeks of intervention (short studies) and after several months of intervention (long studies).

For the studies using questionnaires to assess an outcome, it is important to consider that all questionnaires used differ from each other in various ways and therefore it is difficult to compare the studies.

Furthermore, a tool such as a questionnaire—which is filled out by the participants themselves—is less objective than others used to measure the other outcomes in these studies (BMI, PA, etc.). In particular, it has to be considered that these questionnaires were answered after following specific classes where children were taught how to follow a healthy diet. This could have led to a potential error, also known as "social desirability bias". Unfortunately, the authors do not describe in detail the administered questionnaires. This is why it was not possible to assess them for any self-reported bias (Neil-Sztramko et al. 2021).

With regard to anthropometric outcomes, the results are still unclear. The intervention appears to have limited effects both for BMI and WC measures in the short term, since they are not maintained over a longer period. The systematic review by Wang et al. confirmed that multi-setting and multi-component interventions, especially focused on diet, are more beneficial and have more favourable impacts on adiposity-related outcomes when compared with single-setting interventions (Wang et al. 2015). The meta-analysis highlights a positive trend in terms of the effect of the intervention on the WC, albeit not significant, while there is no clear trend withe regard to BMI in the included studies. However, it is imperative to be cautious when interpreting the outcomes of the meta-analysis, given the limited number of studies and their inherent heterogeneity.

PA and sedentary-behaviors outcomes

With regard to PA outcomes, all the studies used objective and valid tools. Both the studies by Duncan et al. used pedometers and found an increase in the number of steps (Duncan et al. 2011, 2019). Using accelerometers instead, only Fairclough et al. found an improvement in the LPA parameter (Fairclough et al. 2013). The other studies reported no effect on PA. These results underline that probably school-based interventions with extracurricular activity, independent of intensity and duration, do not have great effects on improving MVPA. An effect is evident only in low and light intense activity registered in the number of steps. Sedentary behaviours were assessed using both objective tools and questionnaires (screen-time-related behaviour). No effects were found when sedentary times were calculated with ActiGraph accelerometers. In terms of screen time, the studies by Duncan et al. (Duncan et al. 2011, 2019) reported no differences, while Anderson et al. and Kipping et al. (Anderson et al. 2016: Kipping et al. 2014) found a reduction in the time spent with devices at the weekend.

These findings were in line with a recent review protocol suggesting that school-based PA interventions probably have little to no impact on either time spent in MVPA or on time spent in sedentary behaviour objectively measured (Doustmohammadian et al. 2020). However, the effect on steps counts and LPA in our review suggests that school-based intervention with extracurricular homework and challenges, focused on PA to be practised outside the school environment, could help to increase low-intensive physical activity such as walking over the short to medium term (Duncan et al. 2011, 2019; Fairclough et al. 2013).

Students' and teachers' feedback

No studies included in this review reported negative feedback from teachers and pupils involved in the intervention, even the study by Kipping et al. in 2012 measured children's satisfaction and reported generally positive feedback (Kipping et al. 2012). Children enjoyed doing homework, especially the activities carried out with their parents. In conclusion, the use of this school-based intervention including healthy homework, challenges, and educational lessons focusing on healthy lifestyles could have a positive impact on children's eating habits, both after a few weeks of intervention or after several months, and could be a good strategy for enhancing LPA and step counts. An imperative exists for a more rigorous investigation of this type of intervention. There is a need for better investigation of this type of intervention, which might facilitate lifestyle modifications involving both children and their families which stimulate a change in lifestyle. Such an approach holds significant promise as a solution, and could represent an integrative strategy targeting the prevention of obesity and overweight.

Study limitations

The present systematic review shows some limitations due to the study design of included studies. Generally, the quality of the included studies is good; the majority of the RCTs are well conducted, with a low risk of bias. However, both studies performed by Duncan et al. produced some concerns about the randomization process and the blindness of evaluators (Duncan et al. 2011, 2019). The only quasi-experimental study presents a serious risk of bias due to confounding and missing data (Friel et al. 1999). Finally, considerable heterogeneity, which limits our review, exists in the type of intervention, outcomes assessed, and statistical analysis of the results. Taking into account all of these issues, only three studies were eligible to be included in meta-analyses, implying the need for cautious interpretation.

Conclusions

Recently, a growing interest has been shown in investigating and evaluating school-based interventions that promote healthy lifestyles in various age groups of young people (de Medeiros et al. 2019; Nury et al. 2021; Masini et al. 2020a, b). We found many studies focused on health promotion programs, but most school-based interventions promoting healthy lifestyles in youth focused solely on the school setting (Dallolio et al. 2016; Calella et al. 2020; Grao-Cruces et al. 2020; Masini et al. 2020a, b). Nowadays, only school-based PA interventions, especially using active breaks or physical active lessons, have been extensively studied and have proven effects on several health outcomes (Frech 2012; Daly-Smith et al. 2018; Norris et al. 2020; Infantes-Paniagua et al. 2021). Some evidence suggests that incorporating PA throughout the school day (e.g., PA lessons, PA breaks) may have the strongest impact on time spent in MVPA (Doustmohammadian 2020).

This review provides evidence that school-based interventions including homework can improve nutritional behaviour, step counts, and LPA. Despite some statistically significant results, the effects on anthropometric outcomes are still unclear. Further studies are needed to demonstrate that these interventions can represent a strategy for obesity prevention.

Author's contribution Alice Masini, Andrea Ceciliani, Sofia Marini, and Laura Dallolio designed the systematic review. Alice Masini and Sofia Marini designed the methodology and coordinated the activity planning.

Alice Masini, Sofia Marini, Alessandra Anastasia, Aurelia Salussolia, Giorgia Soldà, Giorgia Zanutto, Andrea Ceciliani, and Laura Dallolio independently reviewed abstracts and papers, and disagreements were resolved by consensus with Alice Masini and Sofia Marini.

Alessandra Anastasia, Aurelia Salussolia, Giorgia Soldà, Giorgia Zanutto, and Laura Dallolio performed the qualitative assessment, and disagreements were resolved by Alice Masini and Sofia Marini. Alice Masini, Alessandra Anastasia, Aurelia Salussolia, Giorgia Soldà, Giorgia Zanutto, and Sofia Marini acquired, analysed, and interpreted the data. Alice Masini performed the statistical analysis. Laura Dallolio checked data extractions. Alice Masini drafted the manuscript, which was critically revised for important intellectual content by all authors. Alessandra Anastasia, Aurelia Salussolia, Giorgia Soldà, and Giorgia Zanutto wrote sections of the manuscript. Alberto Grao-Cruces and David Sanchez-Oliva revised the manuscript and.

contributed with intellectual ideas. Andrea Ceciliani and Laura Dallolio supervised the study. Stephan Riegger and Raffaela Mulato edited the manuscript's language.

All authors have read and approved the final manuscript, including figures and tables.

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Data availability Available from the corresponding author upon request.

Code availability Not applicable.

Declarations

Ethical statement This systematic review adheres to the highest ethical standards. The study protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO; registration no. CRD42021281011). Informed consent was not required as the review involved secondary data analysis. The search and selection process followed predefined criteria to minimize bias. Data extraction and synthesis were conducted rigorously, with transparency regarding potential conflicts of interest among authors. Reporting complies with PRISMA reporting guidelines.

Ethics approval Not applicable.

Consent to participate Not applicable.

Consent to publication Not applicable.

Competing interests The authors have no competing interests to declare that are relevant to the content of this article.

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