



## Review

# School-based physical activity and nutritional education interventions on body mass index: A meta-analysis of randomised community trials – Project PANE



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## ABSTRACT

**Objective.** To evaluate the effect of school-based physical activity (PA) and nutritional education (NE) interventions on children's and adolescents' body mass index.

**Methods.** We conducted a systematic search in fourteen databases until September 2012 for randomised controlled trials on PA and NE, conducted in the school setting, and delivered to children and adolescents. Additionally, we performed a cross-reference check in related papers. The title and abstract review and the quality assessment were performed by two independent researchers. The software EPPI-Reviewer3 was used to store, manage and analyse all data. The meta-analysis was conducted using the random-effects model, and the outcomes were reported as standardised mean difference (SMD). As a secondary analysis, we pooled together the interventions that considered PA or NE alone.

**Results.** Thirty-eight studies met the eligibility criteria. The main analysis showed a SMD between intervention and control groups of  $-0.03$  (95% CI:  $-0.09, 0.04$ ;  $n = 28,870$ ;  $I^2 = 83\%$ ). When we considered all 57 trials, there was no difference between the results of the primary analysis.

**Conclusion.** The synthesis of school-based PA and NE interventions showed no statistically significant mean reduction on children's and adolescents' body mass index. The high heterogeneity among studies requires caution in the generalisation of the results.

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## Introduction

Excessive weight gain in children and adolescents is due to a complex network of biological and environmental factors (Butland et al., 2007). The World Health Organization (WHO) reported that changes in the food intake pattern and physical inactivity are the most relevant factors associated with the fast progression of childhood overweight and obesity (WHO, 2010). Due to the failure of preventive strategies, the problem has extended to several ethnic groups and socioeconomic classes in the last four decades, although the incidence is still higher in highly industrialised countries (Wang and Lobstein, 2006; Wang et al., 2002).

Schools provide a particularly favourable setting for interventions focussing on the promotion of healthy lifestyles, as children and adolescents spend a large part of their time there and are exposed to various educational mechanisms.

The growing body of research on strategies to prevent and reduce childhood obesity has resulted in an exponential increase in publications on this topic and has led to the performance of eight meta-analyses with similar aims to the ones of the present study, but diverging as to methodological features. Such divergence is at the root of an ongoing controversy about the effectiveness of intervention programmes conducted in schools. Four studies have reported favourable effects of school-based interventions in terms of the reduction of the body mass index, three of which included non-randomised controlled clinical studies.

The main objective of this study was to assess the effect of school-based physical activity (PA) and nutritional education (NE) interventions by randomised controlled studies on the reduction of BMI among children and adolescents. As a secondary analysis, we added 19 studies considered in previous publications (Guerra et al., 2013; Silveira et al., 2013), which analysed the effect of PA or NE-only interventions on BMI (Ahamed et al., 2007; Amaro et al., 2006; Aquilani et al., 2007; Ask et al., 2010; Donnelly et al., 2009; Foster et al., 2008; Henaghan et al., 2008; James et al., 2004; Jiang et al., 2007; Kriemler et al., 2010; Lubans et al., 2010; Martinez Vizcaino et al., 2008; McManus et al., 2008; Muckelbauer et al., 2009; Sichieri et al., 2009; Simon et al., 2008; Thivel et al., 2011; Walther et al., 2009; Young et al., 2006).

## Methods

The present study is a part of “Physical Activity and Nutritional Education as School-based Interventions to Control Obesity in Children and Adolescents (Project PANE)”, which was registered at ClinicalTrials.gov (NCT00985972), and made in accordance with PRISMA statement (Liberati et al., 2009).

### Inclusion criteria

The research question and eligibility criteria were elaborated following the Population, Intervention, Comparison, Outcome, and Study design (PICOS) model (Centre for Reviews and Dissemination, 2009; Richardson et al., 1995).

We included only school-based randomised controlled community trials that 1) performed PA and NE interventions for children and adolescents aged 6 to 18 years old, independently of their anthropometric conditions, ethnicity, purchasing power, and gender; 2) included one control group for the purpose of comparison, which was followed up for the same period as the intervention

group; 3) described the BMI outcome in both intervention and control groups (means and variability); and 4) did not include samples representative of children and adolescents with physical or mental deficiency, eating disorders, anaemia, diabetes, or dyslipidaemias.

### Search for relevant articles

We searched for articles in 14 databases up to 30 September 2012: Applied Social Sciences Index and Abstracts (ASSIA); Cochrane CENTRAL; Cumulative Index to Nursing and Allied Health Literature CINAHL; EMBASE; Education Resources Information Center (ERIC); ISI Web of Knowledge; Latin American and Caribbean Literature on Health Science (Literatura Latinoamericana e do Caribe em Ciências da Saúde – LILACS); Physical Education Index; PsycINFO; PubMed/Medline; Social Care Online; Social Services Abstracts; Sociological Abstracts; and SPORTDiscus. No language limitations were established, except that we excluded languages that use logograms (e.g., Japanese and Chinese). Additionally, we performed a cross-reference check in related systematic reviews and in the selected trials for this meta-analysis.

The search strategy was based on the research question, using PubMed database as reference. Following careful keyword selection, these search terms were used: (school) AND (physical activity) OR (physical education) OR (exercise) OR (physical fitness) OR (sports) OR (nutrition) OR (nutritional science) OR (child nutrition sciences) OR (nutrition education) OR (diet) OR (energy intake) OR (energy density) OR (calories) OR (calorie) OR (food) OR (fruit) OR (vegetable) AND ((weight) OR (obese) OR (overweight) OR (weight reduction) OR (anthropometric) OR (anthropometry) OR (nutritional status) OR (nutrition assessment) OR (body mass index) OR (BMI) OR (body weights and measures) OR (waist circumference) OR (adipose tissue)) AND (randomised controlled trial[ptyp] AND (child[MeSH:noexp] OR adolescent[MeSH])). In addition, we performed a manual search in previous studies. Full description of 14 systematic searches is found in Appendix 1.

### Study selection

Two independent reviewers selected the studies in two different stages: based on the title and abstract, and based on the full text. In the case of duplicates (e.g., secondary analysis, subgroups) and studies with more than one intervention group, we selected the ones that best met the eligibility criteria. Instances of doubt or disagreement were solved by consensus, including the participation of two other experienced researchers (MN and JT).

### Quality assessment

The methodological quality of the studies was assessed using two tools: Quality Assessment Tool for Quantitative Studies of Effective Public Health Practice Project (EPHPP) (Thomas et al., 2004) and Grading of Recommendations Assessment, Development and Evaluation (GRADE) (Atkins et al., 2004), which include important domains of community-based randomised studies: selection, control of confounding factors, study stages in which blinding was used, data collection method, losses to follow up, integrity or contamination of intervention, unit for allocation and analysis, type of analysis, capacity of generalisation, and effect size. Based on the corresponding percentage of items that were appropriately met on a 21-point scale, the original studies were classified as to their methodological quality (high, average, or low). In the case of borderline results, the score in EPHPP was defining.

### Data extraction and synthesis

Following the assessment of methodological quality, two independent reviewers (PG and JS) extracted the data available in the selected studies related to the number of participants, number of involved schools, intervention protocol,

length of follow-up, investigated outcomes, statistical methods, and outcomes of the intervention and control groups. To retrieve important information not included in the articles, the first or corresponding author was contacted by e-mail.

Upon individual analysis of each study, the changes found in the intervention and control groups were calculated by subtracting the post-test results from the baseline values ( $\Delta$  group = post-test value – baseline value). Those results were used to calculate the difference in means ( $\Delta$  control group –  $\Delta$  treatment group) (Deeks et al., 2008). When the data were not reported in the original studies, the difference between means was calculated based on the sample size of each group and the p-value of the difference between means, or it was extracted from previous meta-analyses using similar statistical protocols. In the case of multiple comparisons (e.g., age range, gender), the difference between means was calculated separately in each group.

It is important to notice that the term “reduction” is used here to describe the negative difference in means within groups between the pre and post intervention period. It does not imply that in every trial children in the intervention group lost weight. In some cases, the negative difference can also be interpreted as “prevention”, when the control group gains more weight than expected and the intervention group stays within the normal range of weight gain.

In regard to the combination of included articles, Hedges' g statistic was used to obtain standardised mean differences (SMD) based on the goodness-of-fit to small-sample studies. The random-effects model was used to construct the summary effect due to the wide sampling and methodological variation among the included studies (DerSimonian and Laird, 1986). The  $I^2$  statistic was used to calculate the heterogeneity among the studies, which was classified as moderate when it was above 50% and high above 75% (Higgins et al., 2003). Publication bias was visually assessed in a funnel plot. Subgroups related to the primary outcome were established based on the length of the interventions, with a cut-off point of 8 months, which corresponds to one school year, to investigate possible differences among the interventions as a function of their length. All papers were assessed for their compliance with the eligibility criteria, selected and analysed in EPPI Reviewer 3 (Thomas, 2009). The primary analysis was carried out using school-based interventions combining PA and NE. To assess any possible impact on the primary analysis, we developed a secondary analysis involving other 19 school-based interventions, which considered any of these elements alone, reported in other publications (Guerra et al., 2013; Silveira et al., 2013).

## Results

### Literature search

The search strategy retrieved 5899 references among the 14 databases and seven from cross-references (Fig. 1). Among 211 articles whose full text was assessed, 60 were eligible for data extraction. From the latter, 38 met the inclusion criteria and were subjected to synthesis (Table 1).

### Characteristics of the included studies

Table 1 shows that 33 articles (87%) were published after 2000. The studies were conducted in 12 countries across four continents, with predominance of the United States (20.5%). Five studies included samples representative of overweight/obese schoolchildren (Grey et al., 2004; Johnston et al., 2007; Sahota et al., 2001; Vissers, 2008), and four included girls only (Bayne-Smith et al., 2004; Flores, 1995; Lubans et al., 2012; Neumark-Sztainer et al., 2003; Vissers, 2008). A total of 35 articles (92%) exhibited aggregated units of allocation and analysis, while in 12 (31%) the analysis involved all the participants included in the baseline sample in spite of eventual losses to follow-up. Seven of the highest methodological quality trials exhibited the intention-to-treat analysis (Eliakim et al., 2007; Grey et al., 2004; Jansen et al., 2011; Lubans et al., 2012; Robinson, 1999; Singh et al., 2009; Yin et al., 2005).

The included studies exhibited wide variations in the following variables: age range, which showed a greater number of interventions targeting schoolchildren aged 8 to 11 years, a lower number targeting adolescents older than 15 years, and one study involving youths aged 18 years; sample size, which varied from 41 (Grey et al., 2004) to 5106 (Luepker et al., 1996) participants at the baseline; and length of

intervention, which varied from 2 months (Killen et al., 1988) to 6 years (Manios et al., 2002) (Table 2).

The intervention aims and protocols also exhibited high variability among the included studies. Twenty-two studies based the efficacy of the intervention on the reduction of the rate of overweight/obesity in children. Only five studies prescribed unusual PA to the participants in the control group (Goran and Reynolds, 2005; Grey et al., 2004; Johnston et al., 2007; Neumark-Sztainer et al., 2003; Yin et al., 2005), and the participation of families in the study was not described in nine articles (Carrel et al., 2005; Flores, 1995; Killen et al., 1988; Kipping et al., 2008; Rosenbaum et al., 2007; Sahota et al., 2001; Singh et al., 2009; Vandongen et al., 1995; Yin et al., 2005). Finally, educational approaches based on Bandura's social-cognitive theory inspired the interventions performed in eight studies (Brandstetter et al., 2012; Caballero et al., 2003; Goran and Reynolds, 2005; Killen et al., 1988; Lubans et al., 2012; Neumark-Sztainer et al., 2003; Robinson, 1999; Vissers, 2008) (Appendix 2).

### Meta-analysis of the body mass index data

The primary result effect was  $-0.03$  (95% CI:  $-0.09$  to  $0.04$ ,  $p = 0.4$ ), which was calculated from the data of 28,870 children and adolescents participating in 38 original studies, of whom 15,627 were allocated to the intervention group and 13,603 to the control group. The  $I^2$  index was 83%, indicating high heterogeneity among the individual results (Fig. 2).

Subjective assessment of the distribution of the studies by funnel plot indicated publication bias in the primary synthesis (Fig. 3), due the presence of a high-precision study, which exhibited great efficacy in the reduction of BMI (Angelopoulos et al., 2009).

### Analysis stratified by length of intervention

Nineteen of 38 studies reported interventions longer than one school year (9 months). When two strata were analysed by length of intervention, the effect of both were not different from the overall estimate: interventions  $<1$  school year:  $-0.04$  (95% CI:  $-0.14$  to  $0.06$ ,  $n = 7604$ ,  $I^2 = 90\%$ ) and interventions  $>1$  school year:  $-0.02$  (95% CI:  $-0.10$  to  $0.07$ ,  $n = 21,266$ ,  $I^2 = 50\%$ ) (Fig. 2).

### Synthesis involving all included interventions

By clustering 57 studies included (Fig. 4), we obtained a synthesis based on the data corresponding to 41,634 schoolchildren, with an effect of  $-0.03$  (95% CI:  $-0.09$  to  $0.03$ ,  $p = 0.3$ ). The heterogeneity among the results was high ( $I^2 = 87\%$ ).

Subjective assessment of the funnel plot suggested the presence of publication bias, once again influenced by the wide effect of two high-precision studies, without correlates on the non-effect side (Angelopoulos et al., 2009; Jiang et al., 2007) (Fig. 5).

## Discussion

The aim of the present study was to assess the efficacy of school-based interventions that combined physical and nutritional education activities to reduce childhood overweight and obesity. Also, we conducted a secondary analysis involving data from two previous publications derived from the Project PANE (Guerra et al., 2013; Silveira et al., 2013).

In our primary analysis, we did not identify a positive effect regarding the combined interventions between treatment and control groups, different from what was found in recent meta-analyses (Friedrich et al., 2012; Lavelle et al., 2012), as well as in a systematic review focussing on the treatment of overweight and obesity (Sbruzzi et al., 2013). However, such comparisons require caution, because the data of these studies were obtained by different trials and meta-analytic protocols. Two

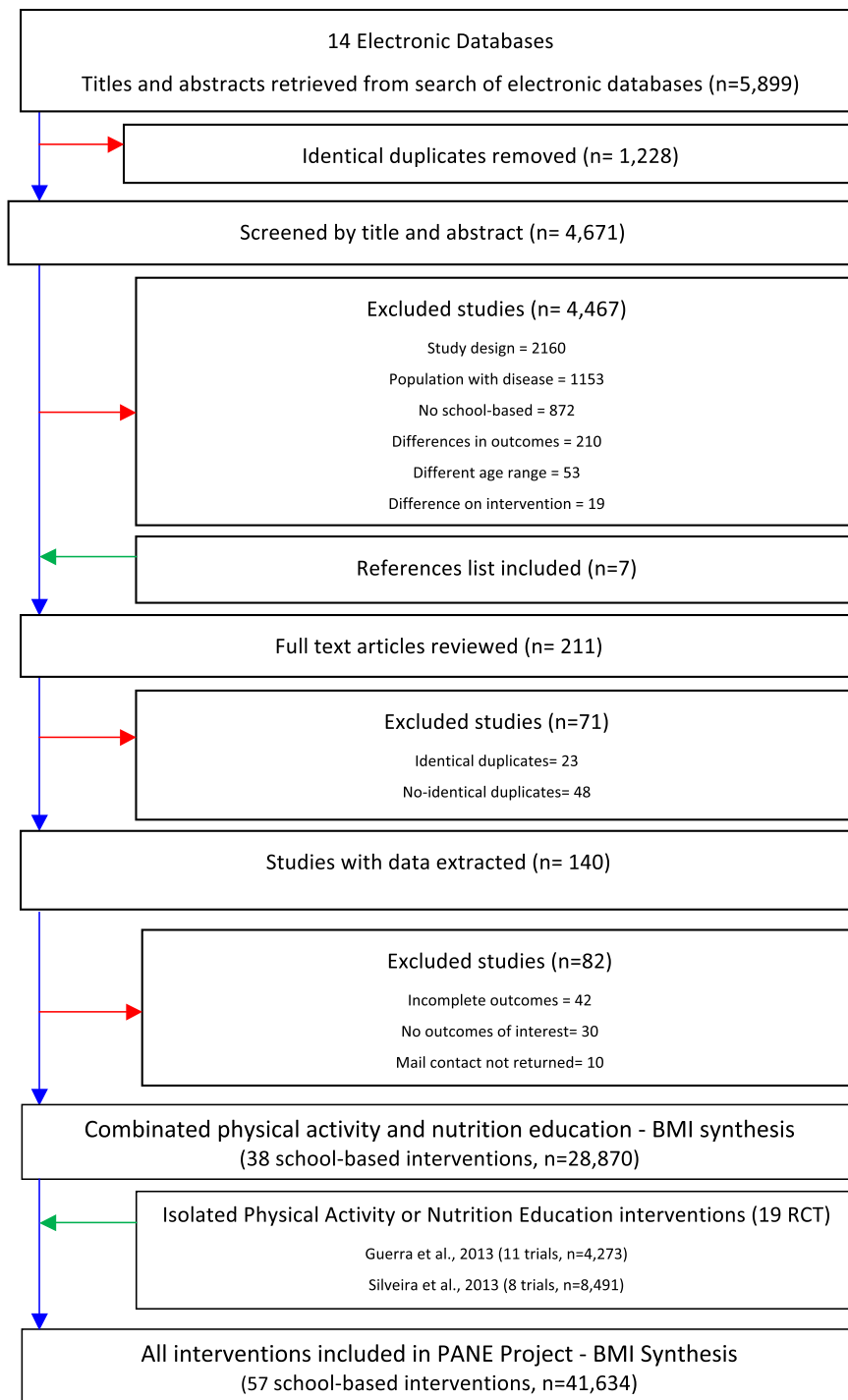


Fig. 1. Flowchart of study selection process.

other SR that included non-randomised trials also found results favourable to the intervention (Gonzalez-Suarez et al., 2009; Waters et al., 2011). Conversely, a subgroup analysis comprising only randomised trials found no effect of interventions on BMI (0.01 [95% CI: −0.14 to 0.14]) among 8381 participants (Harris et al., 2009). However, in this study, the authors did not provide the individual contribution of each school-based trial to the analysis, limiting the extent of the comparisons.

Also, in the primary synthesis we found wide positive effects in three of the included studies (Angelopoulos et al., 2009; Johnston et al., 2007; Vissers, 2008). After we elaborated a subgroup that excluded those trials, the heterogeneity decreased 31%, becoming moderate ( $I^2 = 52\%$ ).

From the analytic point of view, the effect of study exclusion was more intense in the subgroups by time of intervention, as the heterogeneity became almost non-existent ( $I^2 = 0\%$ ) after the exclusion of two studies with interventions shorter than one school year (Johnston et al., 2007; Vissers, 2008). The main reason behind the remarkable effect of the interventions in these studies may be their focus on samples with overweight/obese students. The group of interventions longer than one school year exhibited  $I^2 = 70\%$  after the exclusion of the super-positive study (Angelopoulos et al., 2009). The authors of this publication explained their findings as a result of the consolidation of healthy nutritional habits based on increased intake of fruits and reduced intake of fatty foods. Based on those data, we suggest that the heterogeneity found in the

**Table 1**  
Descriptive characteristics of the studies included in the meta-analysis (combined physical activity and nutrition education interventions).

References	Country	Age range	Gender (%F)	Random unit	Sch. no.	Int. length (m)	Curric. ins.	Rand. no.	ITT	Analysed no. (per group)		MQ
										TG	CG	
Angelopoulos et al. (2009)	GRE	9–11	57	CL	26	12	Y	646	N	321	325	B
Bayne-Smith et al. (2004)	USA	14–17	100	CL	1	12 w	N	442	Y	310	132	C
Brandstetter et al. (2012)	GER	7–8	46	CL	32	1 sy	Y	1119	N	450	495	B
Caballero et al. (2003)	USA	6–8	48	CL	41	36	Y	1704	N	727	682	A
Carrel et al. (2005) <sup>a</sup>	USA	11–13	47	IN	1	9	Y	53	N	27	23	B
Eliakim et al. (2007)	ISR	6	43	CL	1	14 w	Y	101	Y	54	47	A
Flores (1995)	USA	10–13	100	CL	1	12 w	Y	81	N	26	23	C
Gentile et al. (2009) <sup>b</sup>	USA	8–10	53	CL	10	7	Y	1323	N	582	619	A
Goran and Reynolds (2005)	USA	8–9	51	CL	4	8 w	Y	209	N	63	59	A
Graf et al. (2008)	GER	6–7	49	CL	17	48	Y	611	N	410	170	C
Grey et al. (2004) <sup>a</sup>	USA	11–13	63	CL	2	16 w <sup>g</sup>	N	41	Y	22	19	A
Haerens et al. (2006)	BEL	11–15	37	CL	15	24	Y	1985	N	971 <sup>d</sup>	591	B
Harrell et al. (1996)	USA	7–11	52	CL	12	8 w	Y	1274	N	588	686	B
Harrell et al. (2005) <sup>c</sup>	USA	10–12	43	CL	2	16 w	Y	205	N	102	84	B
Hopper et al. (2005)	USA	7–9	49	CL	6	20 w	Y	238	N	142	96	C
Jansen et al. (2011)	NETH	6–12	51	CL	20	1 sy	Y	2622	Y	1048	1168	A
Johnston et al. (2007) <sup>a</sup>	USA	10–14	52	IN	1	6	N	71	Y	46	25	B
Katz et al. (2011)	USA	7–10	51	CL	5	1 sy	Y	1180	Y	628	552	B
Killen et al. (1988)	USA	14–16	46	CL	4	2	Y	1447	N	622	508	B
Kipping et al. (2008) <sup>c</sup>	ENG	9–10	52	CL	19	5	Y	679	Y	249	223	B
Li et al. (2010) <sup>c</sup>	CHN	8–11	48	CL	20	12	Y	4700	N	2072	2115	A
Llargaes et al. (2011)	SPA	6	46	CL	16	24	Y	704	N	272	236	B
Lubans et al. (2012)	AUS	12–14	100	CL	12	12	N	357	Y	141	153	A
Luepker et al. (1996)	USA	8–9	48	CL	96	3 sy	Y	5106	N	2332	1627	B
Manios et al. (2002)	GRE	6	45	CL	40	6 y	Y	1046	N	356	285	B
McMurray et al. (2002)	USA	11–14	55	CL	5	8 w	Y	1140	Y	308 <sup>e</sup>	247	C
Neumark-Sztainer et al. (2003) <sup>b</sup>	USA	14–16	100	CL	6	16 w	Y	201	N	84	106	B
Robinson (1999)	USA	8–9	48	CL	2	6	Y	198	Y	92	100	A
Rosenbaum et al. (2007)	USA	13	42	CL	1	3.5	Y	79	N	49	24	A
Rush et al. (2012)	NZL	10–12	49	CL	124	24	Y	426	N	200	226	C
Sahota et al. (2001) <sup>a</sup>	ENG	7–11	45	CL	10	12	Y	613	N	54	53	B
Siegrist et al. (2011)	GER	7–9	48	CL	8	12	Y	826	N	427	297	B
Singh et al. (2009)	NETH	12–14	53	CL	18	20	Y	1108	Y	632	476	A
Singhal et al. (2010)	IND	15–17	40	CL	2	6	N	209	N	99	102	A
Spiegel and Foulk (2006)	USA	9–11	nd	CL	16	5	Y	1013	N	534	479	C
Vandongen et al. (1995)	AUS	6–7; 10–12	51	CL	30	9	Y	1240	N	149 <sup>f</sup>	126	C
Vissers (2008) <sup>a</sup>	BEL	16–18	68	IN	1	6	N	76	N	22	31	C
Yin et al. (2005)	USA	8–9	52	CL	18	8	Y	617	Y	182	265	A

Gender (%F): percentage of girls in the sample; Random unit: randomisation unit used – CL: cluster; IN: individual; Sch. no.: number of schools; Int. length: length of intervention in months – w: weeks; sy: scholar year; Curric. ins.: insertion of intervention in the school curriculum – Y: yes; N: no; Rand. no.: randomised number at baseline; ITT: intention-to-treat analysis – Y: yes/presence; N: no/absence; Analysed no.: analysed number per group; TG: treatment group (intervention); CG: comparison group; MQ: methodological quality – A: high quality; B: average quality; C: low quality. Countries: GER: Germany; AUS: Australia; BEL: Belgium; CHN: China; USA: United States; GRE: Greece; NETH: Netherlands; IND: India; ENG: England; ISR: Israel; NZL: New Zealand.

- <sup>a</sup> Samples of overweight and/or obese schoolchildren.
- <sup>b</sup> Data post-intervention.
- <sup>c</sup> Pilot study.
- <sup>d</sup> Data from group I.
- <sup>e</sup> Data from group EE.
- <sup>f</sup> Data from group FITNESS AND SCHOOL NUTRITION.
- <sup>g</sup> Data from assessment after 12 months.

primary analysis was due to the variation in the characteristics of the studies with interventions longer than 8 months. Nevertheless, the high heterogeneity found compels us to recommend caution in the generalisation of the results of the present study to other populations.

**Table 2**  
Specific description of combined interventions including physical activity and nutritional education.

Variables	Variability		Median
	Inferior	Superior	
Age range <sup>a</sup>	6	18	8–11
Number of schools	1	124	10
Length of intervention (months)	2	72	9
Sample size	41	5106	663

<sup>a</sup> Age range at baseline.

Specifically, in the set of all included studies, we analysed seven randomised trials whose samples are exclusively composed of overweight or obese children and adolescents (Carrel et al., 2005; Grey et al., 2004; Johnston et al., 2007; Sahota et al., 2001; Simon et al., 2008; Thivel et al., 2011; Vissers, 2008), and we obtained an effect of  $-0.21$  (95% CI:  $-0.54$  to  $0.13$ ,  $p = 0.2$ ,  $I^2 = 74\%$ ,  $n = 644$ ). After excluding those seven studies of Project PANE analysis, the summarised effect was not changed in the statistical perspective:  $-0.02$  (95% CI:  $-0.08$  to  $0.04$ ;  $p = 0.6$ ;  $I^2 = 88\%$ ), showing that these seven studies did not influence the estimated effect of our main outcome. However, despite the lack of statistical significance, the variation of effect size (from  $-0.21$  to  $-0.02$ ) suggests that the interventions produced better results among the overweight and obese children and adolescents.

Considering previous meta-analysis focussing on BMI reduction published by our group, we observed differences in terms of intervention efficacy. Among the three types of intervention evaluated in the project (PA-only, NE-only and PA and NE), we identified that solely NE-only



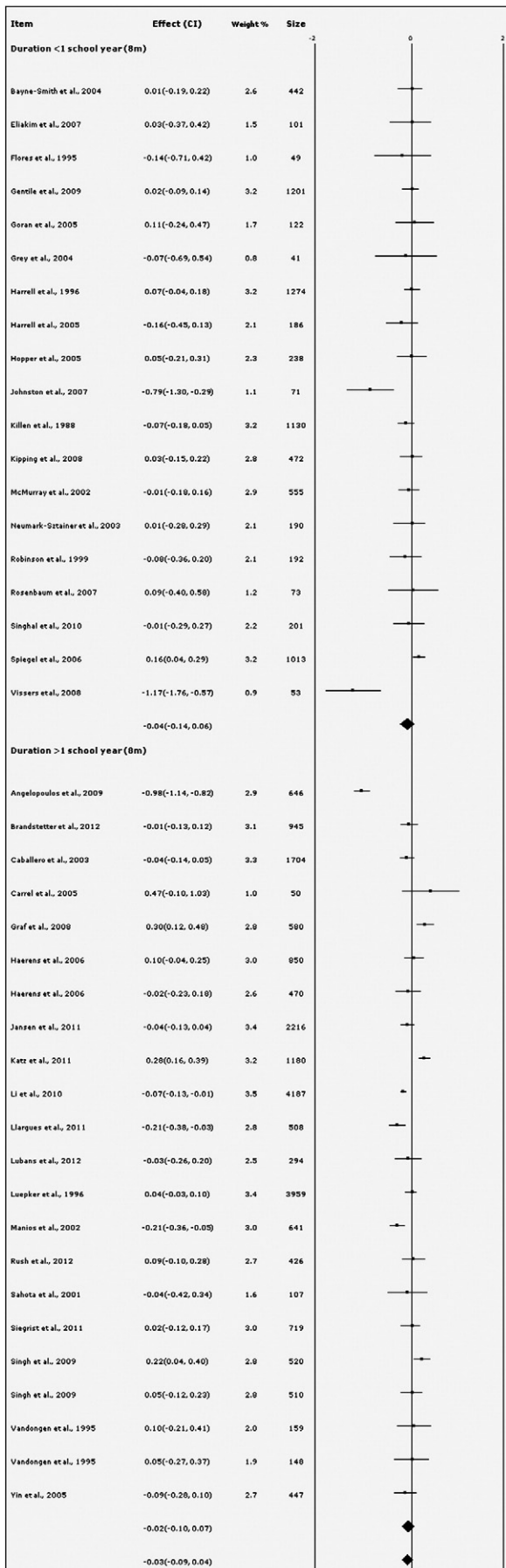


Fig. 2. Summary effect of the combined interventions on body mass index.

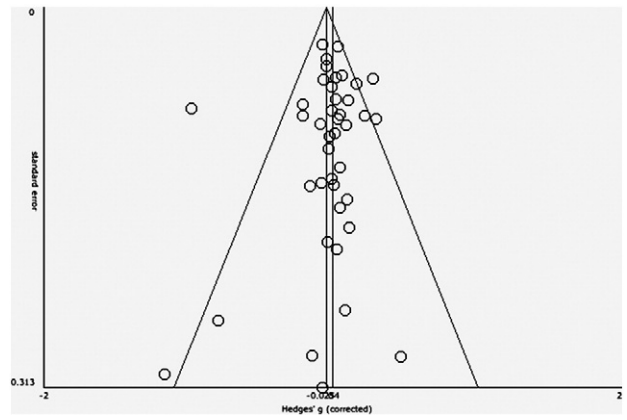


Fig. 3. Funnel plot of the combined studies. Outcome: body mass index.

intervention presented statistically significant results in favour of the intervention group ( $-0.33 \text{ kg/m}^2$  [95% CI:  $-0.55$  to  $-0.11$ ];  $n = 8722$ ), while PA-only ( $-0.02 \text{ SD}$  [95% CI:  $-0.13$  to  $0.17$ ];  $n = 4273$ ) and PA and NE interventions were not effective to reduce the mean BMI of the population (Silveira et al., 2013). As properly discussed in Silveira et al. (2013), there was one large-scale NE intervention (Jiang et al., 2007), which most influenced the result. It was conducted for three years and considered two important components for success of NE interventions: classroom activities and parental involvement (Silveira et al., 2011).

Despite the absence of statistical significance in interventions considering PA, the authors do not intend to support that such interventions are ineffective or even reduce the effect of NE on BMI of children and adolescents. There are other important underlying factors to which we attribute the lack of effect among PA interventions, such as the expected effect size and the differences between study protocols.

Since we were dealing with studies in a normal population, it was not expected to observe large effect sizes in the intervention group; thus, even with relative large sample size we were not able to show a statistically significant association in our meta-analysis. Regarding the study protocol, some factors are essential for the success of PA interventions: time and intensity of the activities – 300 min per week of moderate-to-vigorous PA – and adequacy to children's age, sex and social, cultural and economic background (WHO, 2010). Such factors are not clearly described across the studies analysed for this meta-analysis, and less information is provided regarding the amount of intervention that was actually delivered to the population and contamination between exposed and non-exposed groups. These limitations can be a reflex of the findings of Ridgers et al. (2006), who showed that physical education classes do not provide the recommended amount of PA to promote health, which is consistent with the lack of effect observed here.

Although physical education classes provide less PA than the recommended, Lonsdale et al. (2013) observed an increase of 24% in moderate-to-vigorous activities. Therefore, further research exploring the effectiveness of school-based PA interventions, with or without NE, should focus not only on increasing the amount of PA, but also on achieving/promoting the recommended level of 300 min of moderate-to-vigorous PA per week. Regarding NE, the effectiveness of an intervention can be attributed to its length (> 1 year) and its components, such as classroom activities and parental involvement (Lavelle et al., 2012; Silveira et al., 2011, 2013). We also recommend for future research that the intervention should be designed considering the feasibility to be implemented in a “real-world” situation, and the eligibility criteria to select the study population should avoid wide ranges of age, due to the issues related to sexual maturation and growth. Besides, it is important to present gender-specific analysis because girls tend to accumulate more fat than boys during mid-childhood and adolescence (Veldhuis et al., 2005).

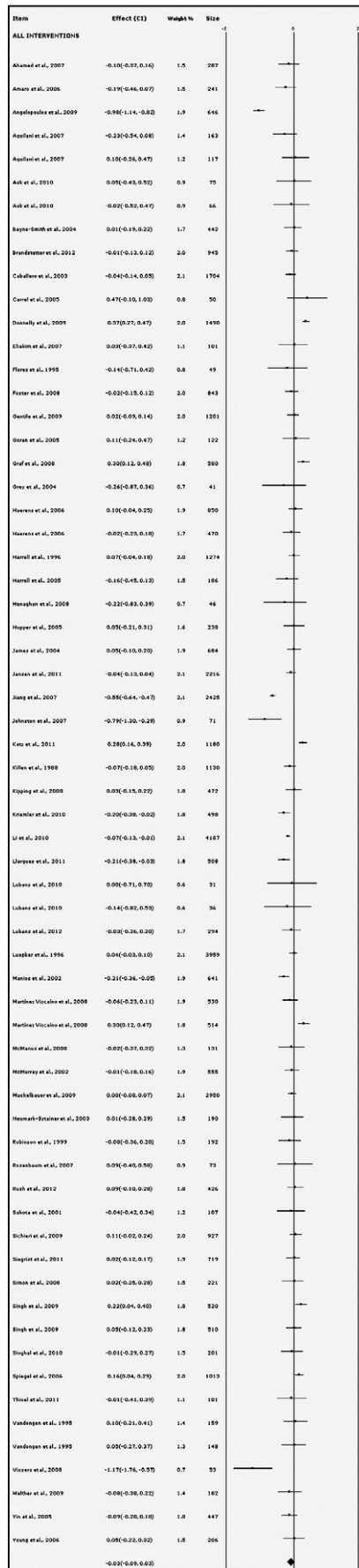


Fig. 4. Summary effect of all interventions included. Outcome: body mass index.

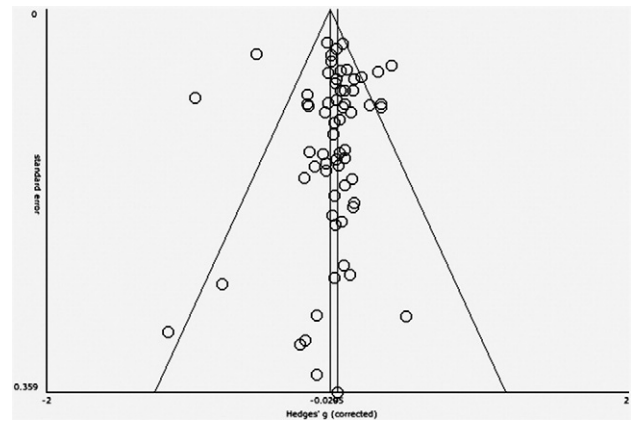


Fig. 5. Funnel plot of all interventions included. Outcome: body mass index.

Regarding the analysis, the authors should consider presenting data of changes in the prevalence of overweight/obesity and in the BMI's mean according to the children's and adolescents' nutritional status at baseline.

The present study included two relevant topics related to the research methods: the elaboration of more sensitive strategies for the systematic search, which resulted in a large number of randomised studies for primary analysis, in particular, recovering 10 studies that are not present in the previous meta-analyses (Brandstetter et al., 2012; Goran and Reynolds, 2005; Katz et al., 2011; Killen et al., 1988; Llurgues et al., 2011; Lubans et al., 2012; McMurray et al., 2002; Rosenbaum et al., 2007; Rush et al., 2012; Vissers, 2008), and the combined use of EPHPP and GRADE to perform a thorough assessment of the main features of the original studies. Other positive aspect of our meta-analysis was the use of the standardised mean differences and the random effects model, in order to control the positivity bias of the small-sample studies in analysis and the wide variability of the research protocols of included studies. These techniques are also observed in four other previous meta-analyses (Friedrich et al., 2012; Kanekar and Sharma, 2008; Katz et al., 2008; Waters et al., 2011).

Despite the strengths, our meta-analysis presents two limitations. The first was the exclusion of studies published in Asian languages, because of difficulties in their identification, retrieval, and translation. Nevertheless, the authors of a correlated systematic review of Chinese interventions indicated a high number of studies with low methodological quality (Li et al., 2008). Moher et al. observed that in spite of the strengths of studies published in French and German, language restrictions are not a source of bias in the estimation of the effectiveness of conventional interventions (Moher et al., 2003). The second limitation was the exclusion of ten studies due to incomplete data to perform the meta-analysis (Appendix 3). Emails were sent to the corresponding authors requesting additional information, but no answer was provided.

The evidence regarding the effectiveness of school-based PA and NE interventions to reduce the BMI in children and adolescent is still mixed. More studies are needed in order to provide an effective framework to be implemented in the school setting. Based on our synthesis of evidence, none of the meta-analyses performed showed statistically significant reduction in the SMD between exposed and non-exposed groups. The high heterogeneity among studies requires caution in the generalisation of our results.

**Conflict of interest statement**

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### Authorship statement

All authors support and agree with the information presented in this study.

### Contributorship statement

All authors truly contributed to the development of this study.

PG: participated in assessment and data extraction of original studies, statistical analysis and the writing of this manuscript.

MN: senior researcher of this project, participated in research protocol development, analysis and the writing of this manuscript.

JT: senior researcher of this project, participated in research protocol development, analysis and the data extraction of original studies.

JS: participated in assessment, data extraction of original studies and reviewing the final draft.

### Appendix A. Supplementary data

Supplementary data to this article can be found online at <http://dx.doi.org/10.1016/j.ypmed.2014.01.005>.

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