

The effect of school-based physical activity interventions on body mass index: a meta-analysis of randomized trials

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This study reviewed the effectiveness of school-based physical activity interventions aimed at reducing overweight, obesity and hypertension in children. We searched 14 databases and analyzed studies published between April 2009 and September 2012. Only randomized controlled trials performed at the school level that included elements of physical activity but did not include nutritional co-interventions were analyzed. Studies were assessed by two recommended tools (EPHPP and GRADE), and the standardized mean differences with 95% confidence intervals were collected for a random-effect meta-analysis. A total of 12 papers were included in the meta-analysis, and these were divided according to three outcomes: body mass index (11 trials, $n = 4,273$, -0.02 , 95% CI: -0.13 to 0.17 , $p = 0.8$); body weight (5 trials, $n = 1,330$, -0.07 , 95% CI: -0.18 to 0.04 , $p = 0.2$); and blood pressure (6 trials, $n = 1,549$), including systolic (0.11 , 95% CI: -0.10 to 0.31 , $p = 0.3$) and diastolic pressure (-0.00 , 95% CI: -0.10 to 0.10 , $p = 0.9$). This meta-analysis of data from 11 randomized, school-based physical activity interventions suggests that, regardless of the potential benefits of physical activity in the school environment, the interventions did not have a statistically significant effect. However, it is difficult to generalize from these results because the duration, intensity and type of physical activity used in the interventions varied greatly.

KEYWORDS: Children; Schools; Physical Education and Training; Obesity; Randomized Controlled Trials; Review.

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INTRODUCTION

The increasing prevalence of overweight and obesity in children and adolescents is an important issue in public health. Overweight and obesity affect countries across the globe and involve different ethnic and socioeconomic groups (1,2). The situation has worsened since the 1970s (3). Brazil has a high prevalence of overweight and obesity (1), and adolescents in industrialized regions of the country have a higher risk for overweight and obesity than adolescents in less-developed regions (4).

According to the literature, 35% of children transition from a normal weight range during childhood to overweight in adolescence, and 62% of children in the highest body mass index (BMI) quartile remain in this range when they become young adults (5). Moreover, this association between high BMI values in childhood and high values in adulthood has been reported by other authors (6,7). Four cohort studies involving 6,328 individuals showed that overweight or obese children who became obese adults had an increased risk of developing type 2 diabetes, hypertension, dyslipidemia and carotid artery atherosclerosis. Additionally, these studies showed that the risk of these outcomes among overweight and obese children who became nonobese adults was similar to the risk of individuals who had never been overweight (8).

In addition to childhood obesity, which some authors consider an independent risk factor for increased blood pressure (BP) in adulthood (9), stress and increased salt consumption contribute to the development of hypertension.

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Other authors have suggested that high BP may be a more important predictor of morbidity than increased BMI and cholesterol levels (5).

Because children and adolescents spend much of their time in school, this environment should be conducive to the implementation of interventions aimed at promoting healthy lifestyles and practices that prevent illness (10). Expanding physical education programs in schools should be considered an effective means of overweight prevention among children, especially girls (11,12). One study (13) indicated that earlier involvement in physical activity was associated with greater effectiveness in preventing increased BMI. Additionally, a 2-year intervention program that combined physical activity and nutritional education was effective in reducing weight gain in nonobese students (14).

The growing importance of this issue has resulted in a remarkable increase in the number of studies on interventions aimed at preventing and reducing overweight and obesity among children and adolescents. Moreover, there have been 7 meta-analyses of these studies (15–21).

One meta-analysis of 15 original studies involving randomized and nonrandomized trials with 13,003 children found a lack of favorable BMI outcomes for physical activity-based school interventions. In this meta-analysis, the weighted average difference between groups was 0.05 kg/m² (95% CI: -0.19 to 0.10) (18). In contrast, another meta-analysis that reviewed randomized and nonrandomized trials and included interventions based on physical activity along with nutritional counseling showed beneficial effects on the control of childhood obesity based on BMI measurement. This type of intervention was particularly effective for programs aimed at children aged 6–12 years. For this age group, the weighted average difference between groups was -0.15 kg/m² (95% CI: -0.21, -0.09). However, the data are questionable because of their high heterogeneity ($I^2 = 82%$) (19).

The controversy in the literature is primarily attributed to the use of multiple concurrent interventions and the inclusion of studies with different study designs. The aims of the present study were to expand the number of screened databases and focus on studies that proposed randomized interventions of school-based physical activities.

Therefore, our primary goal was to evaluate the effectiveness of interventions that promoted physical activity in the school environment and reduced overweight and obesity in children and adolescents. The secondary goal was to evaluate the outcome of these interventions on high BP.

■ METHODS

We searched the following 14 databases: ASSIA, Cochrane CENTRAL, CINAHL, EMBASE, ERIC, Thomson Reuters Web of Knowledge, LILACS, Physical Education Index, PsycINFO, PubMed/MEDLINE, Social Care Online, Social Services Abstracts, Sociological Abstracts and SPORTDiscus. The search started in April 2009 and updates were included through September 30, 2012. For each database, we used descriptors that corresponded to physical activity, school environment, age, overweight and obesity, BMI, anthropometry and randomized trial as the study design. The strategies for the electronic searches are included in the Appendix. Moreover, we performed a supplementary search based on previous reviews. All of the

retrieved papers were allocated, evaluated for eligibility criteria and selected using the Internet access platform of Eppi Reviewer 3.0 software (23). This study is registered on clinicaltrials.gov under number NCT00985972.

Two independent reviewers (P.G. and J.S.) selected the studies in two distinct phases: The studies were selected based on the title and abstract, and the assessment was performed on the full text of the articles. In case of disagreement between the reviewers, consensus was reached with the participation of another researcher (M.N.). Randomized trials that met the following eligibility criteria were selected: interventions that used physical activity involving the whole school population between the ages of 6 to 18 years, according to the structure of the Brazilian educational system for elementary and secondary schools. Studies that were excluded were nonrandomized trials, trials restricted to clinical populations outside the school environment and studies that included an associated medication or other nonpharmacological interventions. Among publications with duplicate data, the publication that best met the eligibility criteria was selected. The primary outcome was BMI, with body weight and BP as secondary outcomes. In three studies including more than one intervention group, the group that best fulfilled the eligibility criteria was selected.

We assessed the methodological quality of individual papers using two tools: EPHPP (24) and GRADE (25). The percentage of items properly completed from the selected papers, as assessed by the two tools, was distributed on a 21-point scale. The scale was subsequently converted into three rankings of methodological quality: high (A), medium (B) and low (C). In cases of discrepancy between the two tools, priority was given to the EPHPP score. We extracted the data including the number of individuals in the intervention and control groups and the respective means and standard deviations of BMI, body weight and systolic and diastolic pressure. The authors of the papers reviewed were contacted to recover missing information.

Meta-analytic syntheses were calculated by the random-effects approach (26) with Hedges' *g* corrected to show summary effect sizes. We used Cochran's *Q* test and I^2 statistics to analyze the heterogeneity of the results, assuming that a percentage above 75 indicated high heterogeneity (27). Literature bias was tested using a funnel plot graph. Two subgroup analyses were also conducted: duration of the intervention, with a cut-off point of six months, and methodological quality of the studies, involving only trials with high and medium scores.

■ RESULTS

The flow chart describes how references retrieved in the database searches were distributed throughout the review (Figure 1). The full text of 4.5% of the papers initially retrieved was examined. Of the 32 randomized controlled trials from which data were extracted, 12 met all inclusion criteria and were included in this meta-analysis (28–39).

The major features of the 12 trials included in this meta-analysis are as follows: the earliest publication date was 2006 and there were reports of interventions in ten countries designated by the World Bank as having high-income economies (>\$12,276); 7 (58%) of these studies were located on the European continent. In all of the papers, the 9–11 years age group was the most prevalent (83%), and trials with populations older than 17 years were not included. Two studies comprised samples of obese individuals (33,36)

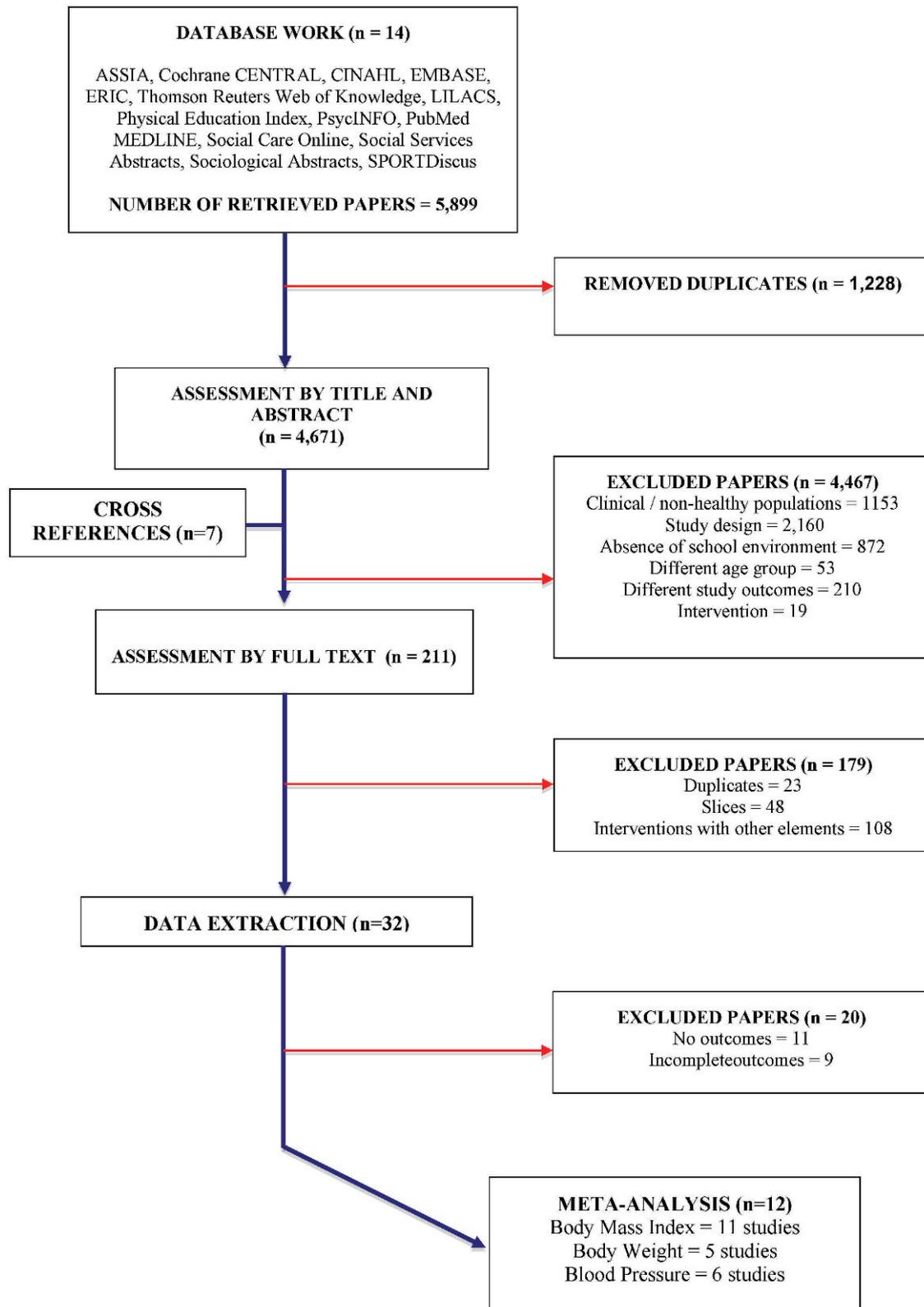


Figure 1 - Meta-analysis flow chart.

and one study comprised exclusively females (39). The duration of the intervention ranged from 2 weeks to 48 months, and the schools involved ranged in number from 1

to 26. In nine studies, the intervention was incorporated into the school curriculum. The randomization and analysis units were clustered in ten studies and on an individual



basis in two studies (Table 1). Most school-based interventions in this review ($n=11$) were designed to increase the level of physical activity relative to sedentary behavior; moreover, the interventions were designed to reduce overweight, obesity and the risk of cardiovascular disease. In three studies, co-interventions with health education guidelines were presented, and in one study, family support was included. The length of the intervention ranged from 75 to 270 minutes/week. In ten research protocols, exercises with moderate intensity were prescribed.

The sum of scores assessed by the EPHPP and GRADE instruments resulted in three quality rankings. The papers that obtained the top ranking had scores ranging from 77–85% of the maximum score, the middle-ranking papers scored 46–69% and the third rank of papers had scores of 31–39% (Table 1). Priority was given to the ranking provided by EPHPP in 2 cases, in which there was a discrepancy from the ranking provided by the GRADE tool. In the 7 papers with high and medium methodological quality, cluster randomization, an intervention duration >6 months, a higher number of schools involved, and increased integration of the intervention in the school curriculum were more prevalent. In 3 studies with an A ranking (75%), the final data analysis was performed as an intention-to-treat analysis.

Primary outcome: BMI

This pooled analysis was generated from the data of 4,273 individuals in 11 studies (2,267 individuals were in intervention groups and 2,006 were in control groups), with 50.7% of the meta-analysis weight coming from papers with a high methodological quality (29,31,33,35). The random effects summary estimate is as follows: -0.02 , 95% CI: -0.13 to 0.17 , $p = 0.8$ (Figure 2). Heterogeneity tests showed $I^2 = 77\%$. A subjective evaluation of the funnel plot showed no publication bias (Figure 3).

In parallel, we developed two analyses stratified by the methodological quality of the studies, corresponding to data from high quality (A) and medium quality (B) papers (28–31,33,35,36,38). The results of these studies were as follows: -0.03 kg/m² (95% CI: -0.15 to 0.21 , $p = 0.7$, $n = 3,869$, $I^2 = 84\%$). Another synthesis included interventions with a duration equal to or exceeding 9 months, which corresponds to a school year (28,29,31,32,35,38). The results of these studies were as follows: -0.00 kg/m² (95% CI: -0.25 to 0.24 , $p = 0.9$, $n = 2,745$, $I^2 = 85\%$). In both subgroup analyses, no publication bias was present.

Secondary outcome: Body weight

In total, 1,330 individuals were included in this synthesis. They were distributed across five trials, with 87.5% of the meta-analysis weight coming from papers with a medium methodological quality (28,30,36,37). Figure 4 shows the following random effects summary estimate: -0.07 (95% CI: -0.18 to 0.04 , $p = 0.2$). For this outcome, the funnel plot shows publication bias, with two precise and positive standard errors positioned far from the no-effect line (28,37). The heterogeneity test revealed $I^2 = 0\%$, indicating that any variability in the results was random.

Secondary outcome: BP

This outcome was subdivided into systolic and diastolic blood pressure. The six papers examined (30,31,34,35,38,39) included data from 1,549 individuals (Table 2). In total, 64%

of these individuals participated in studies with a high methodological quality, and 22% participated in low-quality trials. The pooled effect was not statistically significant for any of the outcomes.

DISCUSSION

This meta-analysis of a group of randomized trials found that school-based physical activity interventions did not lead to statistically significant effects in all outcomes. The data used to analyze the body weight outcome are derived from one of the five retrieved trials, which accounted for more than half of the children and adolescents included in this meta-analysis.

In particular, the preliminary findings of this work correspond to those of other studies that used similar inclusion criteria. For example, a subgroup analysis by Harris et al. (18) identified a result of -0.05 (95% CI: -0.19 to 0.10 , $n = 8381$). An analysis of physical activity by Friedrich et al. (21) identified a result of -0.02 (95% CI: -0.08 to 0.04 , $n = 4,172$, $I^2 = 0\%$). However, caution should be used when comparing the current analysis to others. The analysis by Harris et al. does not include all the studies analyzed in our summary and does not consider the contribution of each study to the pooled effect. Of the five experiments included in the analysis by Friedrich et al., two represent interventions combining physical activity and nutritional education (40,41), and two report data on the same intervention, named “MOVI” (33,42). Finally, we found that two studies (29,33) shared our preliminary synthesis.

Primary analysis showed high variability in the intervention period, from a 2-week trial that had the main purpose of promoting physical activity (34), to the ICAPS intervention (35) that was developed over 4 school years and focused on the prevention of overweight and obesity. These interventions focus on inspiring young people to develop lifelong healthy habits, and a shorter intervention may not be an ideal means for the permanent establishment of these practices. However, when the shortest initiative was removed from the primary analysis, the null result was maintained (0.00; 95% CI: -0.13 to 0.18 , $p = 0.7$, $I^2 = 78\%$).

Only two studies reported more than 300 minutes per week of physical activity (60 minutes per day) when the amounts of intervention and the regular classes of physical education were totaled (33,38). This amount of activity was originally proposed by Strong et al. (43) and in 2008 was recommended by the World Health Organization (WHO) as the minimum cut-off point for sufficient physical activity for children and teenagers (44). The insufficient amount of physical activity prescribed in the included study protocols can also be seen in the only intervention (30) that involved high intensity exercises. At 120 minutes/week, this intervention was far from meeting global requirements.

Conversely, the subgroup presented in a paper published in the Cochrane Review (19) suggests a favorable result of specific physical activity interventions. This review identified an effect of -0.11 (95% CI: -0.19 to -0.02 , $n = 9,242$, $I^2 = 66\%$). In this case, the statistical significance can be attributed to the presence and influence of nonrandomized trials; in the two analyses that involve only randomized interventions, the results were not statistically significant (18,21). Aside from the conflicting evidence, physical activity should be recommended as it provides physiological, psychological and social benefits (43).



Table 1 - Descriptive characteristics of selected studies according to outcomes chosen for meta-analysis.

	Country	BMI	BW	BP	Age (years)	Gender (%F)	Number of schools	Duration of intervention (months)	Weekly amount of intervention (sessions per week x minutes)	Weekly amount of physical education classes	Type of physical activity performed	Intensity	Randomized by group		Quality ranking
													Intervention	Control	
Ahamed et al., 2007 (28)	CAN	x	x	x	9-11	50	10	16	75' (5x15')	80'	skipping, dance, and resistance training	nd	311	84	B
Donnelly et al., 2009 (29)	USA	x	x	x	7-10	52	26	36	90'	60'	nd	moderate	814	713	A
Henaghan et al., 2008 (30)	ENG	x	x	x	10-11	41	3	9 weeks	120' (2x60')	nd	circuits, dance, and games	high	16 ^{*3}	30	B
Kriemler et al., 2010 (31)	SWI	x	x	x	6-11	51	15	9	90' (2x45')	135'	recreational athletics	moderate to high	297	205	A
Lubans et al., 2010 (32)	AUS	x	x	x	14-16	48	1	11	90' (2x45')	nd	endurance and resistance training	moderate to high	37 ^{*4}	30	C
Martinez Vizcaino et al., 2008 (33)	SPA	x	x	x	7-10	49	20	24 weeks	270' (3x90')	180'	sports, games, dance and recreational athletics	moderate	691	718	A
McManus et al., 2008 (34)	CHN†	x	x	x	8-11	50	3	2 weeks ^{*2}	nd	nd	games	moderate	64 ^{*5}	68 ^{*6}	C
Simon et al., 2008 (35)	FRA	x	x	x	11-16	50	8	48	nd	150'	sports, games and recreational athletics	moderate	475	479	A
Thivel et al., 2011 ^{*1} (36)	FRA	x	x	x	6-10	51	19	6	120' (2x60')	120'	endurance, resistance training and recreational athletics	moderate	60	41	B
Verstraete et al., 2007 (37)	BEL	x	x	x	9-11	51	16	2 school years	90' (3x30')	nd	recreational athletics	moderate to high	nd	nd	B
Walther et al., 2009 (38)	GER	x	x	x	11-12	44	3	12	225' (5x245')	90'	recreational athletics and endurance training	moderate to high	109	73	B
Young et al., 2006 (39)	USA	x	x	x	14-15	100	1	8	nd (5x)	nd	sports	moderate to high	310	132	C

BMI: body mass index, BW: body weight, BP: blood pressure, gender (% F): percentage of girls in sample, CAN: Canada, USA: United States of America, ENG: England, SWI: Switzerland, AUS: Australia, SPA: Spain, CHN: China (†Hong Kong SAR), FRA: France, BEL: Belgium, GER: Germany, ^{*1}: Obese population, ^{*2}: Data of 6-month follow-up, ^{*3}: STEX Group, ^{*4}: Free weights group, ^{*5}: EG (Int), ^{*6}: CG (Con), and: not described.

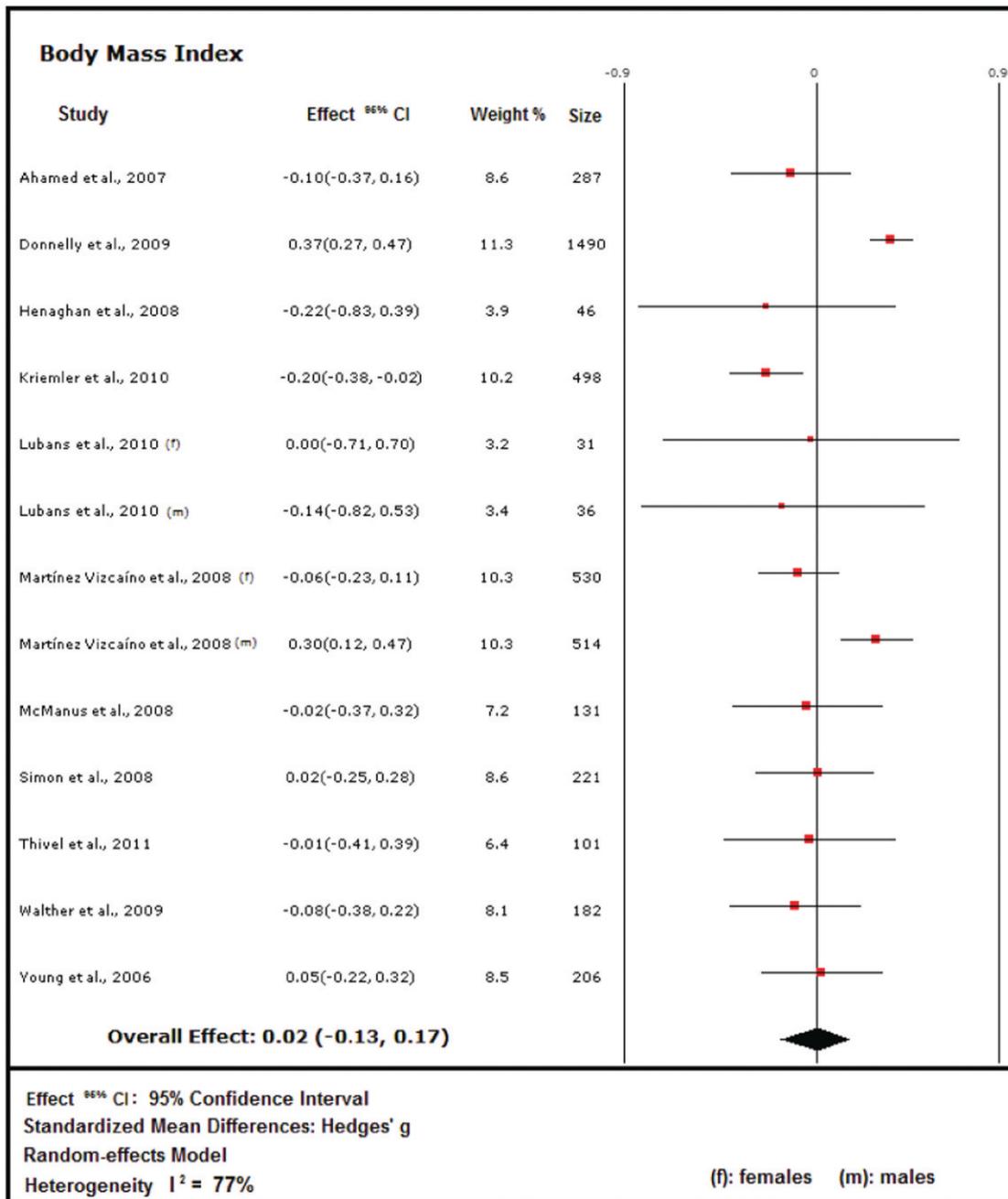


Figure 2 - Comparison of the effects of school-based interventions on the change in body mass index compared with controls.

In our review, the favorable effect on body weight was primarily influenced by the results of one of the included studies (37); this study included more than 50% of the subjects analyzed. In a sensitivity analysis, the summary effect lost statistical significance when this study was not included; this finding suggests that the intervention may be effective in children aged 9–11 years, or before the pubertal growth spurt. It was not possible to exclude publication bias in the synthesis of this outcome, although we believe this bias was unlikely.

Our review includes seven original research papers (28,30,32,34,36,37,39) that were not included in any of the seven previous systematic reviews. One of the papers (36) analyzes the same population, intervention and outcome

reported in another paper (45) published in the Cochrane Review (19), despite the fact that our search strategy was recommended after previous testing by researchers (46).

The high amount of heterogeneity was due to the large amount of variation among the study protocols; variations were common in the research rationale, the nature and objectives of physical activity protocols, the age ranges of the targeted children and the follow-up times. Because of this variability, all analyses were performed under the random effects model (47). Previous meta-analyses of combined interventions (physical activity plus nutrition education) also showed moderate to high heterogeneity in BMI synthesis, with the I² value ranging from 54% to 98%.

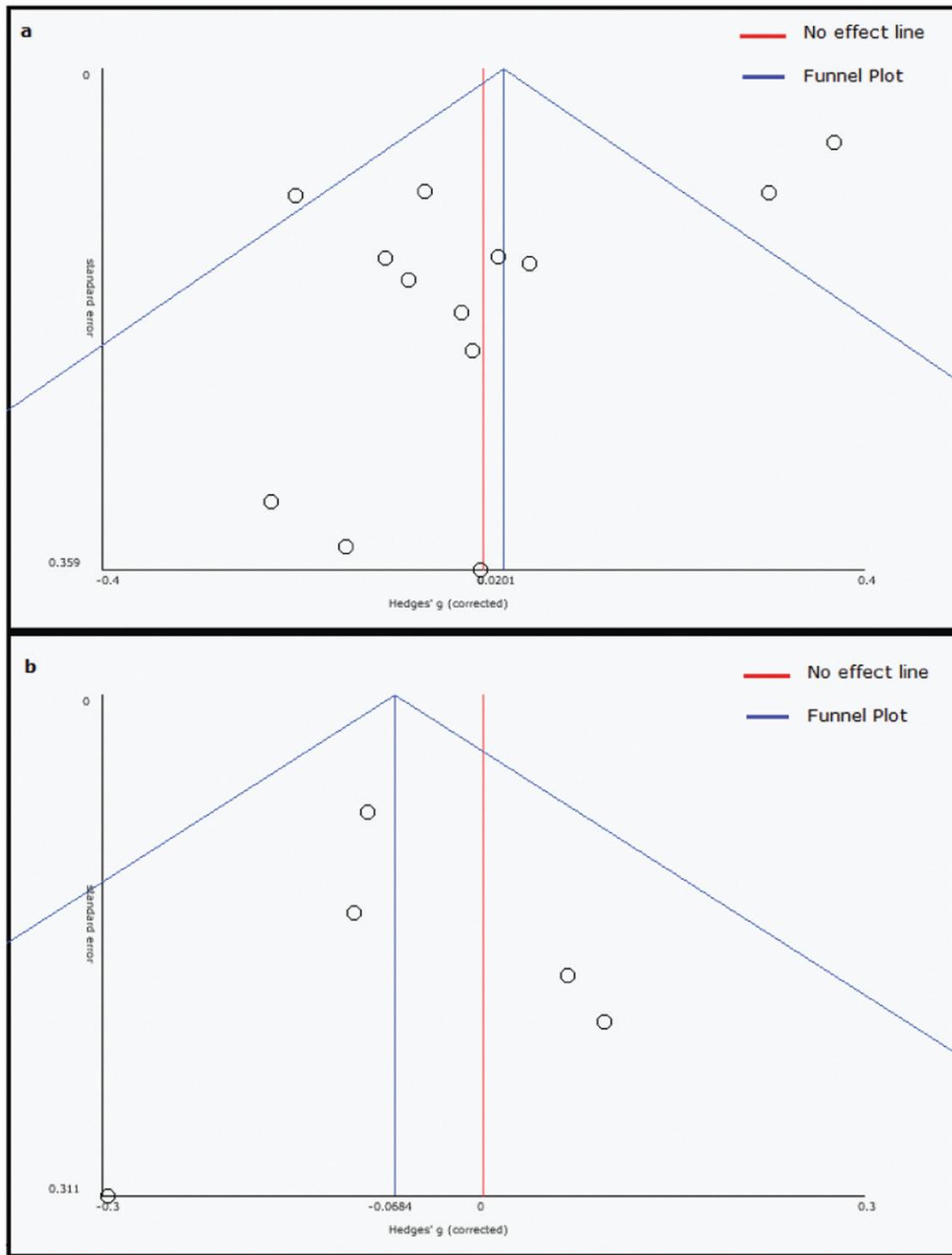


Figure 3 - Funnel plots of papers included in the body mass index synthesis (a) and body weight synthesis (b).

One of the limitations of this study is that BP outcomes were not included in the initial goals. In the process of paper selection and extraction we found these outcomes were frequently included in reports. We sought to correct possible selection bias by expanding our search strategy in PubMed and ISI. Another limitation of this review was the constraint on publication languages. However, this limitation does not usually represent a significant bias in terms of

estimating the effects of conventional interventions (48). A systematic review of trials involving Chinese school students, published in English (49), included 22 studies and showed no evidence of the prevention of obesity in children and adolescents. None of the nine studies with BMI as an outcome were indexed in the 14 databases that were screened. Instead, the authors of this review indicate the low methodological quality of the included studies.

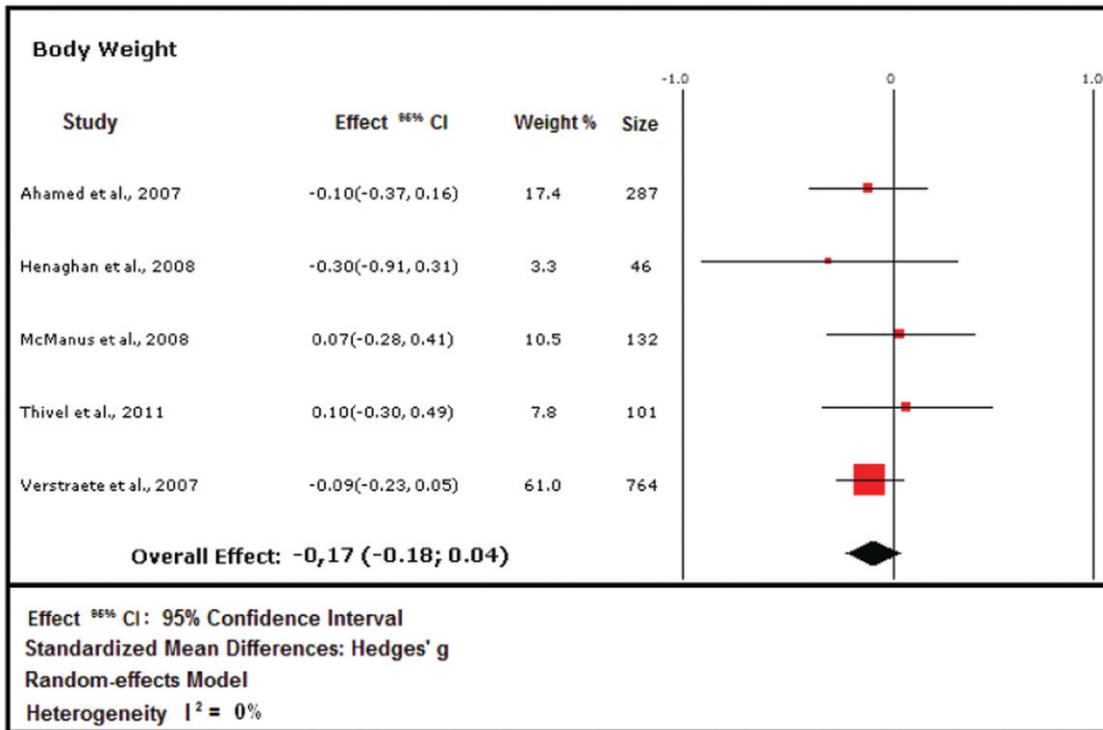


Figure 4 - Comparison of the effects of school-based interventions on changes in body weight compared with controls.

In this paper, we performed a meta-analysis of initiatives in countries with different socio-cultural values where excess body weight and engagement in physical activity are rewarded. Our expectations of positive results that could be attributed to educational interventions based on a single intervention model were therefore reduced. Nevertheless, none of the selected papers showed an unequivocally effective result; this finding suggests that the process of change must involve more comprehensive educational interventions and a broader conceptual basis. This need is especially strong given the exposure of individuals to the demands of consumerism.

Based on our results, we suggest that future research use the cluster random allocation method to select students, choose the school as the allocation unit and include a sufficiently large number of participants of both sexes aged 6–11 years from different body composition strata and with different frequencies of school attendance. In addition, the time period for curriculum intervention should be at least one school year, and moderate-to-vigorous physical activity should be monitored for at least 60 minutes per day, as specified by WHO (44). Finally, any analysis of individual results needs to be adjusted by cluster distribution.

This meta-analysis of data from 11 randomized, school-based physical activity interventions suggests that, regardless of the potential benefits of physical activity in the school environment, the interventions did not have a statistically significant effect. However, it is difficult to generalize from these results because of great variability in the duration, intensity and type of physical activity used in the interventions.

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■ AUTHOR CONTRIBUTIONS

All of the authors developed the study concept, design and study selection and conducted the meta-analysis. Nobre MR and Guerra PH developed the idea for the study and drafted the manuscript. Guerra PH and Silveira JA were responsible for conducting the search, data collection, study quality assessment, data extraction and interpretation of data. Nobre MR and Taddei JA were responsible for critical revisions and study supervision. All of the authors read and approved the final version of the manuscript.

Table 2 - Analysis of blood pressure outcome.

Stratum	Studies (n)	Participants (n)	CE	95% CI	p	I ²	PB	Weight %		
								A	B	C
Systolic	6	1,549	0.11	-0.10 a 0.31	0.3	70%	N	44	24	32
Diastolic			-0.00	-0.10 a 0.10	0.9	0%	N	64	14	22

CE: Central estimate of summary effect; PB: presence (Y) or absence (N) of publication bias via funnel plot; weight %: percentage weight of studies in each stratum in the composition of the forest plot.



■ REFERENCES

- Wang Y, Monteiro C, Popkin BM. Trends of obesity and underweight in older children and adolescents in the United States, Brazil, China, and Russia. *Am J Clin Nutr*. 2002;75(6):971-7.
- Ogden CL, Carroll MD, Curtin LR, McDowell MA, Tabak CJ, Flegal KM. Prevalence of overweight and obesity in the United States, 1999-2004. *JAMA*. 2006;295(13):1549-55. <http://dx.doi.org/10.1001/jama.295.13.1549>.
- Flegal KM, Carroll MD, Kuczmarski RJ, Johnson CL. Overweight and obesity in the United States: prevalence and trends, 1960-1994. *Int J Surg Pathol*. 2000;8(1):39-47.
- Neutzling MB, Taddei JA, Rodrigues EM, Sigulem DM. Overweight and obesity in Brazilian adolescents. *Int J Obes Relat Metab Disord*. 2000;24(7):869-74. <http://dx.doi.org/10.1038/sj.ijo.0801245>.
- Myers L, Coughlin SS, Webber LS, Srinivasan SR, Berenson GS. Prediction of adult cardiovascular multifactorial risk status from childhood risk factor levels. The Bogalusa Heart Study. *Am J Epidemiol*. 1995;142(9):918-24.
- Deshmukh-Taskar P, Nicklas TA, Morales M, Yang SJ, Zakeri I, Berenson GS. Tracking of overweight status from childhood to young adulthood: the Bogalusa Heart Study. *Eur J Clin Nutr*. 2006;60(1):48-57.
- Freedman DS, Khan LK, Serdula MK, Dietz WH, Srinivasan SR, Berenson GS. The relation of childhood BMI to adult adiposity: The Bogalusa Heart Study. *Pediatrics*. 2005;115(1):22-7.
- Juonala M, Magnussen CG, Berenson GS, Venn A, Burns TL, Sabin MA, et al. Childhood adiposity, adult adiposity, and cardiovascular risk factors. *N Engl J Med*. 2011;365(20):1876-85.
- Lloyd LJ, Langley-Evans SC, McMullen S. Childhood obesity and adult cardiovascular disease risk: a systematic review. *Int J Obes (Lond)*. 2010;34(1):18-28.
- Nobre MRC, Zanetta R, Cols. Multiplicadores do Estilo de Vida Saudável - Prevenção de doença cardiovascular na adolescência. Porto Alegre: Artmed; 2011.
- Datar A, Sturm R. Physical education in elementary school and body mass index: evidence from the early childhood longitudinal study. *Am J Public Health*. 2004;94(9):1501-6.
- Scheffler C, Ketelhut K, Mohasseb I. Does physical education modify the body composition? -results of a longitudinal study of pre-school children. *Anthropol Anz*. 2007;65(2):193-201.
- Sollerhed AC, Ejlertsson G. Physical benefits of expanded physical education in primary school: findings from a 3-year intervention study in Sweden. *Scand J Med Sci Sports*. 2008;18(1):102-7.
- Taylor RW, McAuley KA, Barbezat W, Farmer VL, Williams SM, Mann JJ, et al. Two-year follow-up of an obesity prevention initiative in children: the APPLE project. *Am J Clin Nutr*. 2008;88(5):1371-7.
- Kanekar A, Sharma M. Meta-analysis of school-based childhood obesity interventions in the U.K. and U.S. *Int J Community Health Educ*. 2008;29(3):241-56. <http://dx.doi.org/10.2190/IQ.29.3.d>.
- Katz DL, O'Connell M, Njike VY, Yeh MC, Nawaz H. Strategies for the prevention and control of obesity in the school setting: systematic review and meta-analysis. *Int J Obes (Lond)*. 2008;32(12):1780-9.
- Gonzalez-Suarez C, Worley A, Grimmer-Somers K, Dones V. School-based interventions on childhood obesity: a meta-analysis. *Am J Prev Med*. 2009;37(5):418-27.
- Harris KC, Kuramoto LK, Schulzer M, Retallack JE. Effect of school-based physical activity interventions on body mass index in children: a meta-analysis. *CMAJ*. 2009;180(7):719-26.
- Waters E, de Silva-Sanigorski A, Hall BJ, Brown T, Campbell KJ, Gao Y, et al. Interventions for preventing obesity in children. *Cochrane Database Syst Rev*. 2011(12):CD001871.
- Lavelle HV, Mackay DF, Pell JP. Systematic review and meta-analysis of school-based interventions to reduce body mass index. *J Public Health (Oxf)*. 2012;34(3):360-9. <http://dx.doi.org/10.1093/pubmed/fdr116>.
- Friedrich RR, Schuch I, Wagner MB. Effect of interventions on the body mass index of school-age students. *Rev Saude Publica*. 2012;46(3):551-60.
- Atlantis E, Barnes EH, Singh MA. Efficacy of exercise for treating overweight in children and adolescents: a systematic review. *Int J Obes (Lond)*. 2006;30(7):1027-40.
- Thomas J. EPPI-Reviewer 3.0: analysis and management of data for research synthesis. In: Brunton J, editor. EPPI-Centre Software: London: Social Science Research Unit, Institute of Education, London; 2009.
- Thomas BH, Ciliska D, Dobbins M, Micucci S. A process for systematically reviewing the literature: providing the research evidence for public health nursing interventions. *Worldviews Evid Based Nurs*. 2004;1(3):176-84. <http://dx.doi.org/10.1111/j.1524-475X.2004.04006.x>.
- Atkins D, Best D, Briss PA, Eccles M, Falck-Ytter Y, Flottorp S, et al. Grading quality of evidence and strength of recommendations. *BMJ*. 2004;328(7454):1490-4.
- DerSimonian R, Laird N. Meta-Analysis in Clinical Trials. *Control Clin Trials*. 1986;7(3):177-88. [http://dx.doi.org/10.1016/0197-2456\(86\)90046-2](http://dx.doi.org/10.1016/0197-2456(86)90046-2).
- Hatala R, Keitz S, Wyer P, Guyatt G. Evidence-Based Med Teaching T. Tips for learners of evidence-based medicine: 4. Assessing heterogeneity of primary studies in systematic reviews and whether to combine their results. *CMAJ*. 2005;172(5):661-5.
- Ahamed Y, MacDonald H, Reed K, Naylor PJ, Liu-Ambrose T, McKay H. School-based physical activity does not compromise children's academic performance. *Med Sci Sports Exerc*. 2007;39(2):371-6.
- Donnelly JE, Greene JL, Gibson CA, Smith BK, Washburn RA, Sullivan DK, et al. Physical Activity Across the Curriculum (PAAC): A randomized controlled trial to promote physical activity and diminish overweight and obesity in elementary school children. *Prev Med*. 2009;49(4):336-41. <http://dx.doi.org/10.1016/j.ypmed.2009.07.022>.
- Henaghan J, McWhannell N, Foweather L, Cable NT, Batterham AM, Stratton G, et al. The effect of structured exercise classes and a lifestyle intervention on cardiovascular risk factors in primary schoolchildren: An exploratory trial (the A-CLASS project). *Pediatr Exerc Sci*. 2008;20(2):169-80.
- Kriemler S, Zahner L, Schindler C, Meyer U, Hartmann T, Hebestreit H, et al. Effect of school based physical activity programme (KISS) on fitness and adiposity in primary schoolchildren: cluster randomised controlled trial. *BMJ*. 2010;340:c785. <http://dx.doi.org/10.1136/bmj.c785>.
- Lubans DR, Sheaman C, Callister R. Exercise adherence and intervention effects of two school-based resistance training programs for adolescents. *Prev Med*. 2010;50(1-2):56-62. <http://dx.doi.org/10.1016/j.ypmed.2009.12.003>.
- Martinez Vizcaino V, Salcedo Aguilar F, Franquelo Gutierrez R, Solera Martinez M, Sanchez Lopez M, Serrano Martinez S, et al. Assessment of an after-school physical activity program to prevent obesity among 9- to 10-year-old children: a cluster randomized trial. *Int J Obes (Lond)*. 2008;32(1):12-22.
- McManus AM, Masters RSW, Laukkanen RMT, Yu CCW, Sit CHP, Ling FCM. Using heart-rate feedback to increase physical activity in children. *Prev Med*. 2008;47(4):402-8. <http://dx.doi.org/10.1016/j.ypmed.2008.06.001>.
- Simon C, Schweitzer B, Oujaa M, Wagner A, Arveiler D, Tribey E, et al. Successful overweight prevention in adolescents by increasing physical activity: a 4-year randomized controlled intervention. *Int J Obes (Lond)*. 2008;32(10):1489-98.
- Thivel D, Isacco L, Lazaar N, Aucouturier J, Ratel S, Dore E, et al. Effect of a 6-month school-based physical activity program on body composition and physical fitness in lean and obese schoolchildren. *Eur J Pediatr*. 2011;170(11):1435-43.
- Verstraete SJM, Cardon GM, De Clercq DLR, De Bourdeaudhuij IMM. A comprehensive physical activity promotion programme at elementary school: the effects on physical activity physical fitness and psychosocial correlates of physical activity. *Public Health Nutr*. 2007;10(5):477-84.
- Walther C, Gaede L, Adams V, Gelbrich G, Leichtle A, Erbs S, et al. Effect of Increased Exercise in School Children on Physical Fitness and Endothelial Progenitor Cells A Prospective Randomized Trial. *Circulation*. 2009;120(22):2251-9. <http://dx.doi.org/10.1161/CIRCULATIONAHA.109.865808>.
- Young DR, Phillips JA, Yu T, Haythornthwaite JA. Effects of a life skills intervention for increasing physical activity in adolescent girls. *Arch Pediatr Adolesc Med*. 2006;160(12):1255-61. <http://dx.doi.org/10.1001/archpedi.160.12.1255>.
- Robinson TN. Reducing children's television viewing to prevent obesity: a randomized controlled trial. *JAMA*. 282. United States. 1999. p. 1561-7.
- Yin Z, Gutin B, Johnson MH, Hanes Jr J, Moore JB, Cavnar M, Thornburg J, et al. An environmental approach to obesity prevention in children: Medical College of Georgia FitKid Project year 1 results. *Obes Res*. 2005;13(12):2153-61. <http://dx.doi.org/10.1038/oby.2005.267>.
- Salcedo Aguilar F, Martinez-Vizcaino V, Sanchez Lopez M, Solera Martinez M, Franquelo Gutierrez R, Serrano Martinez S, et al. Impact of an after-school physical activity program on obesity in children. *J Pediatr*. 2010;157(1):36-42 e3. <http://dx.doi.org/10.1016/j.jpeds.2009.12.046>.
- Strong WB, Malina RM, Blimkie CJ, Daniels SR, Dishman RK, Gutin B, et al. Evidencebased physical activity for school-age youth. *J Pediatr*. 2005;146(6):732-7. <http://dx.doi.org/10.1016/j.jpeds.2005.01.055>.
- WHO. World Health Organization. Global strategy on diet, physical activity and health website. Physical activity and young people. In: Geneva; 2008.
- Lazaar N, Aucouturier J, Ratel S, Rance M, Meyer M, Duche P. Effect of physical activity intervention on body composition in young children: influence of body mass index status and gender. *Acta Paediatr*. 2007;96(9):1315-20.
- Woodman J, Lorenc T, Harden A, Oakley A. Social and environmental interventions to reduce childhood obesity: a systematic map of reviews London: EPPI-Centre Technical Report no. 1610 (2008). EPPI-Centre, Social Science Research Unit, Institute of Education, University of London, September.
- Riley RD, Higgins JP, Deeks JJ. Interpretation of random effects meta-analyses. *BMJ*. 2011;342:d549. <http://dx.doi.org/10.1136/bmj.d549>.
- Moher D, Pham B, Lawson ML, Klassen TP. The inclusion of reports of randomised trials published in languages other than English in systematic reviews. *Health Technol Assess*. 2003;7(41):1-90.



49. Li M, Li S, Baur LA, Huxley RR. A systematic review of school-based intervention studies for the prevention or reduction of excess weight among Chinese children and adolescents. *Obes Rev.* 2008;9(6):548-59. <http://dx.doi.org/10.1111/j.1467-789X.2008.00495.x>.

■ APPENDIX

Search strategies

ASSIA: ((school) and ((physical activity) or (physical education) or (exercise) or (physical fitness) or (sport) or (nutrition) or (nutrition education) or (diet) or (energy intake) or (energy consumption) or (calorie) or (food) or (fruit) or (vegetable)) and ((weight) or (overweight) or (obesity) or (obese) or (weight loss) or (weight reduction) or (anthropometry) or (anthropometric) or (body mass index) or (bmi) or (waist circumference) or (skinfold thickness) or (adipose tissue)) and (random*))

CINAHL:[http://search.ebscohost.com/login.aspx?direct=true&db=c8h&bquery=\(\(TX+\(school\)\)+AND+\(\(\(TX+\(Weight\)\)\)+OR+\(\(TX+\(obese\)\)\)+OR+\(\(TX+\(Overweight\)\)\)+OR+\(\(TX+\(Weight+loss\)\)\)+OR+\(\(TX+\(Anthropometry\)\)\)+OR+\(\(TX+\(Anthropometrics\)\)\)+OR+\(\(TX+\(nutritional+status\)\)\)+OR+\(\(TX+\(nutrition+assessment\)\)\)+OR+\(\(TX+\(Body+mass+index\)\)\)+OR+\(\(TX+\(bmi\)\)\)+OR+\(\(TX+\(waist+circumference\)\)\)+OR+\(\(TX+\(body+measures\)\)\)+OR+\(\(TX+\(waist+circumference\)\)\)+OR+lp;TX+\(adipose+tissue\)\)\)&AND+\(\(\(TX+\(Physical+activity\)\)\)+OR+\(\(TX+\(Physical+education\)\)\)+OR+\(\(TX+\(Exercise\)\)\)+OR+\(\(TX+\(Physical+fitness\)\)\)+OR+\(\(TX+\(Sports\)\)\)\)\)+OR+\(\(\(TX+\(Nutrition\)\)\)+OR+\(\(TX+\(nutrition+education\)\)\)+OR+\(\(TX+\(diet\)\)\)+OR+\(\(TX+\(Energy+consumption\)\)\)+OR+\(\(TX+\(Calories\)\)\)+OR+\(\(TX+\(food\)\)\)+OR+\(\(TX+\(fruit\)\)\)+OR+\(\(TX+\(Vegetable\)\)\)\)\)\)\)+and+TX+\(random*\)&cli0=PT12&clv0=Clinical+Trial&cli1=AG3&clv1=Child%2c+6-12+years%7eAdolescence&type=1&site=ehost-live](http://search.ebscohost.com/login.aspx?direct=true&db=c8h&bquery=((TX+(school))+AND+(((TX+(Weight)))+OR+((TX+(obese)))+OR+((TX+(Overweight)))+OR+((TX+(Weight+loss)))+OR+((TX+(Anthropometry)))+OR+((TX+(Anthropometrics)))+OR+((TX+(nutritional+status)))+OR+((TX+(nutrition+assessment)))+OR+((TX+(Body+mass+index)))+OR+((TX+(bmi)))+OR+((TX+(waist+circumference)))+OR+((TX+(body+measures)))+OR+((TX+(waist+circumference)))+OR+lp;TX+(adipose+tissue)))&AND+(((TX+(Physical+activity)))+OR+((TX+(Physical+education)))+OR+((TX+(Exercise)))+OR+((TX+(Physical+fitness)))+OR+((TX+(Sports)))))+OR+(((TX+(Nutrition)))+OR+((TX+(nutrition+education)))+OR+((TX+(diet)))+OR+((TX+(Energy+consumption)))+OR+((TX+(Calories)))+OR+((TX+(food)))+OR+((TX+(fruit)))+OR+((TX+(Vegetable)))))))+and+TX+(random*)&cli0=PT12&clv0=Clinical+Trial&cli1=AG3&clv1=Child%2c+6-12+years%7eAdolescence&type=1&site=ehost-live)

Cochrane CENTRAL: ((school OR student OR students) AND (adolescent* OR child*)) 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 (random*)) not drug in Keywords in Cochrane Central Register of Controlled Trials"

EMBASE: school/exp OR school AND ('adipose tissue' OR weight OR obese OR 'obesity'/exp OR obesity OR overweight OR ('weight'/exp OR weight AND ('reduction'/exp OR reduction)) OR anthropometric OR 'nutritional status'/exp OR 'nutritional status' OR 'nutrition assessment'/exp OR 'nutrition assessment' OR (body AND ('mass'/exp OR mass)) OR (body AND ('fat'/exp OR fat)) OR bmi OR (waist AND ('hip'/exp OR hip) AND ratio) OR (weight, AND ('mass'/exp OR mass) AND size) OR ('arm'/exp OR arm AND circumference) OR (body AND weights AND measures) OR (waist AND circumference) OR 'anthropometry'/exp OR anthropometry) AND (physical AND activity OR (physical AND ('education'/exp OR education)) OR 'exercise'/exp OR exercise OR 'training'/exp OR training OR 'sport'/exp OR sport OR sports OR (physical AND fitness) OR 'fitness'/exp OR fitness OR 'nutrition'/exp OR nutrition OR (energy AND intake) OR (energy AND density) OR calorie OR calories OR 'fruit'/exp

OR fruit OR 'vegetable'/exp OR vegetable) NOT 'drug'/exp AND [randomized controlled trial]/lim AND ([article]/lim OR [article in press]/lim) AND ([school]/lim OR [adolescent]/lim) AND [humans]/lim AND [embase]/lim

ERIC: ((Keywords:school) and ((Keywords:physical and Keywords:activity) OR (Keywords:physical and Keywords:education) OR (Keywords:exercise) OR (Keywords:physical and Keywords:fitness) OR Keywords:sports OR (Keywords:nutrition) OR (Keywords:nutritional and Keywords:science) OR (Keywords:child and Keywords:nutrition and Keywords:sciences) OR (Keywords:nutrition and Keywords:education) OR (Keywords:diet) OR (Keywords:energy and Keywords:intake) OR (Keywords:energy and Keywords:density) OR (Keywords:calories) OR (Keywords:calorie) OR (Keywords:food) OR (Keywords:fruit) OR (Keywords:vegetable)) and ((Keywords:weight) OR (Keywords:obese) OR (Keywords:overweight) OR (Keywords:weight and Keywords:reduction) OR (Keywords:anthropometric) OR (Keywords:anthropometry) OR (Keywords:nutritional and Keywords:status) OR (Keywords:nutrition and Keywords:assessment) OR (Keywords:body and Keywords:mass and Keywords:index) OR (Keywords:BMI) OR (Keywords:Body and Keywords:Weights and Keywords:Measures) OR (Keywords:waist and Keywords:circumference) OR (Keywords:adipose and Keywords:tissue)))

LILACS: ((school\$) and (((((physical and activity) or ((physical and education) or ((exercise\$ or ((exercise) or ((exercises)))) or ((physical and fitness) or ((sport\$)))) or (((nutrition) or ((nutritional and science\$) or ((child and nutrition and science\$) or ((nutrition and education) or ((diet) or ((energy and intake) or ((energy and density) or ((calorie\$) or ((food\$) or ((fruit\$) or ((vegetable\$)))))) and (((weight) or ((obes\$) or ((overweight) or ((weight and reduction) or ((anthropometr\$) or ((nutritional and status) or ((nutrition and assessment) or ((body and mass and index) or ((bmi) or ((measure\$) or ((waist and circumference) or ((waist and hip) or ((adipose and tissue) or ((dxa) or ((densitometry) or ((magnetic and resonance) or ((body and fat)))))) and random\$ AND Faixaetária = Criança (6-12 anos) OR Adolescente (13-18 anos) AND Espécie = Humanos AND Tipo de publicação = Artigo de revista OR Ensaio clínico OR Ensaio clínico controlado

Physical Education Index: ((school) and ((physical activity) or (physical education) or (exercise) or (physical fitness) or (sport) or (nutrition) or (nutrition education) or (diet) or (energy intake) or (energy consumption) or (calorie) or (food) or (fruit) or (vegetable)) and ((weight) or (overweight) or (obesity) or (obese) or (weight loss) or (weight reduction) or (anthropometry) or (anthropometric) or (body mass index) or (bmi) or (waist circumference) or (skinfold thickness) or (adipose tissue)) and (random*))

PsycInfo: (AnyField:(school) AND (AnyField:(body weight) OR (AnyField:(overweight) OR (AnyField:(obesity) OR (AnyField:(weight loss) OR (AnyField:(anthropometry) OR (AnyField:(body mass index)) AND ((AnyField:(physical activity)) OR (AnyField:(physical education) OR (AnyField:(exercise) OR (AnyField:(physical fitness) OR (AnyField:(sports))) OR ((AnyField:(nutrition) OR (AnyField:(nutrition education) OR (AnyField:(diets) OR (AnyField:(nutritional science) OR (AnyField:(food))) AND random*):Any Field (School Age (6 to 12 yrs) OR Adolescence (13 to 17 yrs)):Age Group AND Human: Population Group



PubMed: (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 (Randomized Controlled Trial[ptyp] AND (child[MeSH:noexp] OR adolescent[MeSH]))

Social Care Online: school and physical activity or physical education or physical fitness or exercise or nutrition or food or energy intake or calorie and overweight or obesity or anthropometry or body mass index and random

Social Services Abstracts: ((school) and((physical activity) or(physical education) or(exercise) or(physical fitness) or(sport) or(nutrition) or(nutrition education) or(diet) or(energy intake) or(energy consumption) or(calorie) or(food) or(fruit) or(vegetable)) and((weight) or(overweight) or(obesity) or(obese) or(weight loss) or(weight reduction) or(anthropometry) or(anthropometric) or(body mass index) or(bmi) or(waist circumference) or(skinfold thickness) or(adipose tissue))) and(random*)

Sociological Abstracts: ((school) and((physical activity) or(physical education) or(exercise) or(physical fitness) or(sport) or(nutrition) or(nutrition education) or(diet) or(energy intake) or(energy consumption) or(calorie) or(food) or(fruit) or(vegetable)) and((weight) or(overweight) or(obesity) or(obese) or(weight loss) or(weight reduction) or(anthropometry) or(anthropometric) or(body mass index)

or(bmi) or(waist circumference) or(skinfold thickness) or(adipose tissue))) and(random*)

SPORTDiscus: (((TX (SCHOOL))) AND (((TX (weight))) OR ((TX (obese))) OR ((TX (obesity))) OR ((TX (overweight))) OR ((TX (weight loss))) OR ((TX (Anthropometry))) OR ((TX (Anthropometrics))) OR ((TX (nutritional status))) OR ((TX (nutrition assessment))) OR ((TX (Body mass index))) OR ((TX (bmi))) OR ((TX (body measures))) OR ((TX (waist circumference))) OR ((TX (adipose tissue)))))) AND (((((TX (Physical activity))) OR ((TX (Physical education))) OR ((TX (exercise))) OR ((TX (physical fitness))) OR ((TX (sports)))))) OR (((TX (Nutrition))) OR ((TX (nutritional sciences))) OR ((TX (nutrition education))) OR ((TX (Diet))) OR ((TX (Energy consumption))) OR ((TX (Energy density))) OR ((TX (Calories))) OR ((TX (Food))) OR ((TX (fruit))) OR ((TX (Vegetable))))))))) and (TX (random* control* trial OR clinical trial)) and (TX (child* OR adolescent* OR teenager*)) not (TX (review))

Web of Knowledge - ISI: Topic=(school*) AND Topic=((physical activity) OR (physical fitness) OR (physical education) OR exercise* OR exercise OR exercises OR sport* OR sport OR sports OR nutrition OR (nutrition education) OR (nutritional science*) OR (child nutrition science*) OR (energy intake) OR (energy density) OR calorie* OR food OR fruit* OR vegetable*) AND Topic=(weight OR obes* OR overweight OR anthropometr* OR (body mass index) OR (BMI) OR measure* OR (waist circumference) OR adipose OR adiposity OR (magnetic resonance) OR (body fat) OR densitometry) AND Topic=(random*) AND Topic=(child* OR adolescent*) AND Document Type=(Article) - Databases = SCI-EXPANDED, SSCI Timespan = All Years