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Review Article

Effectiveness of school-based nutrition education interventions to prevent and reduce excessive weight gain in children and adolescents: a systematic review

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Abstract

Objective: To evaluate the effectiveness of school-based nutrition education in reducing or preventing overweight and obesity in children and adolescents.

Sources: Systematic search in 14 databases and five systematic reviews for randomized controlled trials conducted in schools to reduce or prevent overweight in children and adolescents. Body mass index and fruit and vegetable intake were used as primary and secondary measures of outcome, respectively. There was no restriction by date of publication or language, except for languages with structured logograms. We excluded studies on specific populations presenting eating disorders, dyslipidemia, diabetes, and physical or mental disabilities, as well as studies that used drugs or food supplements as components of the intervention. The assessment by title and abstract and the quality assessment were performed independently by two researchers. We used the Centre for Reviews and Dissemination's guidance for undertaking reviews in health care and the software EPPI-Reviewer 3.

Summary of the findings: From the initially retrieved 4,809 references, 24 articles met the inclusion criteria. The extracted data show that there is evidence of positive effects on anthropometry and of increase in fruit and vegetable consumption. Characteristics of the interventions that demonstrated effectiveness are: duration > 1 year, introduction into the regular activities of the school, parental involvement, introduction of nutrition education into the regular curriculum, and provision of fruits and vegetables by school food services.

Conclusion: Interventions in schools to reduce overweight and obesity, as well as to increase fruits and vegetable consumption, have demonstrated effectiveness in the best-conducted studies.

J Pediatr (Rio J). 2011;87(5):382-92: Review, children, adolescent, nutrition policy, education, randomized controlled trials, body mass index, fruit, vegetables, school.

Introduction

The increasing prevalence of overweight dates from the 1970s.[1] Overweight and obesity are, together, the fifth leading global risk factor for mortality.[2] Although the prevalence of overweight and obesity is high in both developed and developing countries, prevalence in the former is roughly twice that observed in less privileged populations. Nonetheless, in absolute numbers, developing countries have four times more overweight and obese children when compared with developed nations.[1,2] It is estimated that, by 2020, the prevalence of overweight and obesity in the

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under 5 year-old world population will be 9.1%, varying from 14.1% in developed countries to 8.6% in developing countries.[3]

The consequences associated with overweight are increased risk for cardiovascular disease, hypertension, diabetes mellitus type II, and, as more recently observed, hepatic steatosis and psychosocial disturbances resulting from social stigmatization.[4,5] As overweight children are more likely to become obese in adulthood,[6] it is essential to develop public policies aimed at preventing obesity and reducing obesity rates in the pediatric population. Schools are the preferred setting for the implementation of these policies because most children spend the greatest part of their time in school.

In addition, the school environment influences health because schools give their students the tools needed to understand the health messages disseminated by various media. School also plays a major role in children's psychological and emotional development and can incorporate the most current health information into the traditional curriculum or into specific disciplines (such as physical or nutrition education) aimed at promoting health.[7]

Several systematic reviews (SRs) addressing school-based interventions to control obesity have been published along the years. A 2006 SR including publications up to April 2004[8] focused on nutrition education interventions; the authors found 15 papers for inclusion in the review. Six years later, the number of relevant papers has more than doubled. Most recent SRs do not address randomized controlled trials (RCTs) alone and include other interventions besides the school-based ones, making it difficult to assess the impact of individual interventions on childhood and adolescent obesity.[9,10] This SR is part of a larger project called "Physical Activity and Nutrition Education Systematic Review Project"; its design is based on the Centre for Reviews and Dissemination's guidance for undertaking reviews in health care[11] and was registered at ClinicalTrials.gov (NCT00985972). For the purpose of this paper, i.e., to provide an up-to-date assessment of existing knowledge on school-based interventions, we describe the effectiveness of those with a nutrition education only (NE-O) components in the prevention or reduction of overweight and in the promotion of changes in fruit and vegetable consumption in children and adolescents. To our knowledge, this is the first SR of RCTs focused on school-based nutrition education interventions in children and adolescents covering the scientific literature without limit of time.

Methods

The research question, protocol, search strategy, and selection criteria were organized by an expanded version of the "Population, Intervention, Comparison, Outcome" (PICO) model used in evidence-based medicine: the PICOCS model, which considers "Context" and "Study design" as well and is recommended for use in SRs in public health.[11]

Search strategy

A broad, systematic literature search was performed in 14 electronic databases (PubMed, EMBASE, ISI Web of Knowledge, Cochrane Central Register of Controlled Trials [CENTRAL], Educational Resources Information Center [ERIC], Cumulative Index to Nursing and Allied Health Literature [CINAHL], LILACS, PsycINFO, SPORTDiscuss, Applied Social Sciences Index and Abstracts [ASSIA], Physical Education Index, Social Care Online, Social Services Abstracts, and Sociological Abstracts) for articles published up to May 5, 2010. No date of publication or language filter was used, except to filter out languages based on logograms (e.g., Japanese and Chinese). The only filters used were age group and type of article.

The search strategy was developed with PubMed as a reference. After careful selection of keywords, the search was organized as follows: (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])). When required, the strategy was adapted to each database.

Additionally, the references in five previously published SRs[8-10,12,13] on the same topic were checked to find any article missed by the search in the databases.

Eligibility criteria

Studies were eligible if they met the following criteria: 1) the design was a RCT; 2) participants were aged 5 to 18 years, independently of anthropometric classification, country, ethnic group, socioeconomic status, and gender; 3) the study reported at least one anthropometric (absolute or standardized measure of body mass index [BMI], skin folds, circumferences and percentage of body fat or lean mass) or dietary outcome (measured with a food recall or food frequency questionnaire); 4) interventions were school-based, consisting of behavioral lifestyle changes recommended by health professionals or school teachers; 5) there were no representative samples of children with eating disorders, dyslipidemia, mental or physical disabilities, diabetes, or anemia; and 6) the intervention and control groups were contemporaneous and received the same cumulative duration of treatment or non-treatment.

After-school interventions and data from articles addressing impacts at different follow-up periods were not considered.

Selection of articles

We used the web-based software EPPI-Reviewer 3.0 (Social Sciences Research Unit, Institute of Education, University of London) to manage this SR. All reference files retrieved from each database were uploaded to the software and then checked for internal (intra-database) and external (inter-database) duplicates.

Independently, two authors (J.S. and P.G.) evaluated all references by title and abstract, using the predefined inclusion criteria. In case of discordance or doubt, a senior researcher (M.N. or J.T.) was consulted.

Articles were downloaded from Portal de Periódicos CAPES*,* a Brazilian virtual library supported by the Ministry of Education. Those unavailable for download were requested to the Cooperative Service for Accessing Documents (Serviço Cooperativo de Acesso a Documentos, SCAD) – Virtual Health Library – BIREME/PAHO/WHO.

Quality assessment

The article methods were evaluated independently by two authors (J.S. and P.G.) using two quality assessment tools: a modified version of the Quality Assessment Tool for Quantitative Studies, developed by the Effective Public Health Practice Project (EPHPP)[14] and the Grading of Recommendations Assessment, Development and Evaluation (GRADE) system.[15]

The EPHPP tool covers eight areas: "selection bias," "study design," "confounders," "blinding," "data collection method," "withdrawals and dropouts," "intervention integrity," and "analysis." Each area can be classified as "strong," "moderate," or "weak," and, at the end of evaluation, an overall rating is given. Our modified EPHPP tool attributes points instead of designating classifications, ranging from -1 (weak) to 1 (strong), resulting in an overall score between -5 and 7. As we are evaluating educational interventions, "blinding" was not considered.

The GRADE system covers five areas: "type of evidence," "quality," "consistency," "directness," and "effect size." Points are allotted according to the type of evidence and effect size and deducted from quality, consistency and directness. To establish an overall score, we used the score system detailed by the British Medical Journal,[16] which ranges from -2 to 7.

According to the combination of classifications of the two assessment tools, papers were classified as follows: A, high quality (EPHPP ≥ 4 and GRADE ≥ 3); B, regular quality (EPHPP ≥ 4 and GRADE = 2); or C, low quality (EPHPP ≤ 3 or GRADE ≤ 1).

Data extraction and effect size

Data were extracted by one researcher (J.S.) and included the following: total number of participants, study length, theoretical framework, intervention components, anthropometric and dietary outcomes, and characteristics of randomization and data analysis. A meta-analysis to estimate the pooled effect size could not be performed because of the heterogeneity of interventions, outcomes and measures observed in the included studies.[17] The data shown in the qualitative synthesis are the effect size as calculated by pre- and post-intervention differences, both within and between groups. For those articles that did not present these calculations, the differences were calculated following these equations:

(1) Differences within groups = Post $\text{Assessment}_{(\text{Intervention})}$ - Pre $\text{Assessment}_{(\text{Intervention})}$

(2) Differences between groups = (Post $\text{Assessment}_{(\text{Intervention})}$ - Pre $\text{Assessment}_{(\text{Intervention})}$) - (Post $\text{Assessment}_{(\text{Control})}$ - Pre $\text{Assessment}_{(\text{Control})}$)

Results

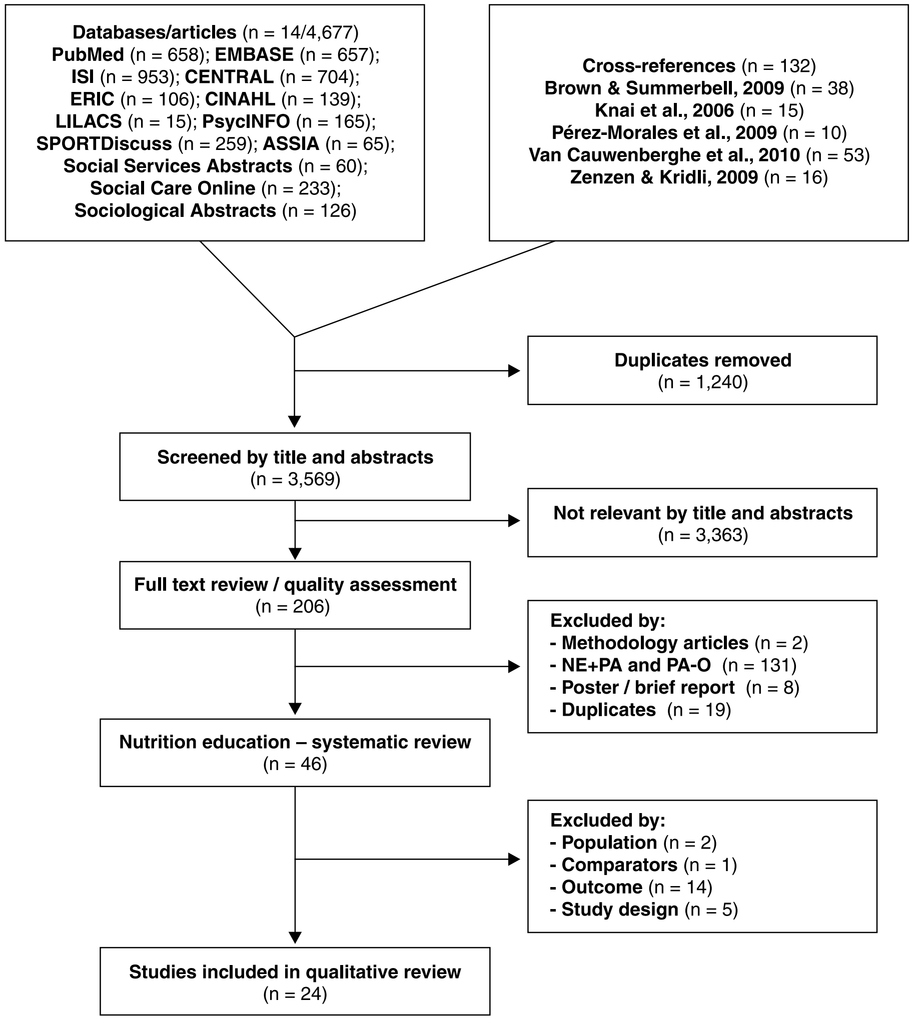
Literature search

The search, which was performed in 14 databases, along with reference checks in five SRs, retrieved 4,809 references; after a duplicate check, 3,569 references remained. Of these references, 206 abstracts met the selection criteria and were submitted to full-text review. These articles were separated into three intervention groups: NE-O, PA-O (physical activity only*)* and NE + PA (nutrition education and physical activity combined). For this SR, only the first group (46 articles) was considered. After a detailed review, 24 articles were included in the qualitative synthesis (Figure 1).

General characteristics of the studies

Despite the fact that no language filter was applied, all detected papers were published in English. None of the selected studies was conducted with a single gender or in a sample with only overweight/obese children, and all of them used BMI as the sole anthropometric indicator. Only two studies were conducted in developing countries; both were classified in the highest quality level.[19,20] The general characteristics of the 24 included studies were organized in relation to their methodological quality and are shown in Table 1.

Among the nine articles at quality level A, seven analyzed their data using the same unit of randomization. Of these, six were randomized at the school level,[20,22-26] and one was randomized at the classroom level.[27] Only two articles were randomized at the school level but analyzed the data at the student level.[19,28]



ASSIA = Applied Social Sciences Index and Abstracts; CENTRAL = Cochrane Central Register of Controlled Trials; CINAHL = Cumulative Index to Nursing and Allied Health Literature; ERIC = Educational Resources Information Center; NE + PA = nutrition education and physical activity combined; PA-O = physical activity only; PRISMA = Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

Figure 1 - Flowchart of PRISMA qualifications[18]

From the nine articles at quality level B, six were randomized and analyzed at the school level.[21,29-33]. Three others were randomized at the school level but analyzed their data at the student level.[34-36]

At quality level C, three articles used the same unit to randomize and analyze their data: one at the school level[37] and two at the classroom level.[38,39] The other three level C articles were analyzed at the student level, with two randomized at classroom level[40,41] and one at the school level.[42]

Seven of the 24 articles included intent-to-treat analysis, of which two,[20,23] four[30,31,33,35] and one[39] were at quality levels A, B and C, respectively.

Regarding the intervention components, 40% of interventions had only one; no one component was predominant among them. Table 2 features all intervention components of each study, along with the studies' respective levels of quality.

Ten articles described the theoretical framework adopted to guide the intervention. All used behavioral change theories (BCTs). Articles of quality level C described the theoretical framework most frequently, followed by articles of level B and A.

Among the articles that adopted BCTs, the social cognitive theory was used most.[21,22,25,29,36,37] Only Anderson et al.[42] and Muckelbauer et al.[24] adopted the theory of planned

Table 1 - General characteristics of the included studies, organized by quality level

Quality level	Level A	Level B	Level C
Number of studies	9	9	6
Countries (number of studies)	United States (3) Brazil (1) China (1) England (1) Germany (1) New Zealand (1) Norway (1)	The Netherlands (2) United States (3) Canada (1) England and Wales (1) Ireland (1) Norway (1)	Italy (2) United States (1) The Netherlands (1) Norway (1) Scotland (1)
Unit of randomization			
School	8	9	2
Classroom	1	0	4
Unit of analysis			
School	6	6	1
Classroom	1	0	2
Students	2	3	3
Outcomes			
Anthropometric and dietary	1	0	0
Anthropometric	5	0	3
Dietary	3	9	3
Duration of intervention in months			
1-3	1	2	1
4-6	1	1	2
7-12	4	5	2
> 12	3	1	1
Theoretical framework			
Described	3	4	3
Not described	6	5	3
Number of schools			
< 5	1	1	4
5-10	3	0	0
11-20	3	2	1
> 21	2	6	1
Number of individuals considered in analysis*			
< 99	0	0	1
100-299	1	0	3
300-599	2	2	2
600-999	3	0	0
1,000-1,499	0	4	0
1,500-1,999	0	2	0
> 2,000	3	0	0

* Reynolds et al.,[21] included in level B, do not show the total number of participants analyzed.

behavior. Mangunkusumo et al.[39] reported the use of a BCT but did not describe the variant used.

Results by quality level

A qualitative synthesis of results from the 24 studies is shown in Table 3, 4 and 5, which are divided by quality level. Outcomes related to consumption of foods other than fruits and vegetables were not considered, as they are described in only three of the studies included in the qualitative synthesis.

Quality level A. Six studies lasted more than 1 year,[19,22-25,27] one lasted between 6 and 11 months[20] and two lasted less than 6 months.[22,26,28] Only one study identified significant changes in BMI between the groups exposed and unexposed to the intervention.[19] James et al.,[27] Jiang et al.,[19] Foster et al.,[23] and Muckelbauer et al.[24] observed a significant reduction in the prevalence of overweight in the population studied, with similar values of odds ratios, namely 0.68 (95%CI [95% confidence interval] 0.46-1.00), 0.614 (95%CI 0.465-0.788), 0.65 (95%CI 0.54-0.79), and 0.69 (95%CI 0.48-0.98), respectively. Two studies observed

Table 2 - Description of the intervention components

	Quality level A									Quality level B									Quality level C					
Studies	Ashfield-Watt et al., 2009[26]	Ask et al., 2010[28]	Baranowski et al., 2000[22]	Foster et al., 2008[23]	James et al., 2004[27]	Jiang et al., 2007[19]	Muckelbauer et al., 2009[24]	Perry et al., 1998[25]	Sichieri et al., 2009[20]	Baranowski et al., 2003[29]	Bere et al., 2006[36]	He et al., 2009[30]	Horne et al., 2009[34]	Martens et al., 2008[35]	Moore & Tapper, 2008[31]	Perry et al., 2004[32]	Reynolds et al., 2000[21]	Te Velde et al., 2008[33]	Amaro et al., 2006[38]	Anderson et al., 2005[42]	Aquilani et al., 2007[40]	Ask et al., 2006[41]	Lytle et al., 2004[37]	Mangunkusumo et al., 2007[39]
Classroom activities			x	x	x		x	x	x		x	x*		x			x	x		x	x		x	
Parental involvement			x	x		x		x			x		x	x			x	x		x			x	
School nutrition policy (food or meal delivery)	x	x		x			x				x	x*†	x					x		x		x	x	
School food service (educational practices)				x				x							x	x	x							
Educational games										x									x					
Social marketing and environmental changes				x				x							x									
Individual counseling																								x
Use of internet																								x

* Components of intervention arm one.
† Component of intervention arm two.

a significant increase in mean fruit consumption, including one of 0.31 pieces/day[26] and another of 0.62 servings/day.[25] Only one study observed a statistically significant increase in mean consumption of vegetables and of vegetables and fruits combined (0.1 servings/day and 0.3 servings/day, respectively).[22] Foster et al.[23] found no significant change in mean consumption of fruits and vegetables.

Quality level B. Four trials lasted longer than 1 year[21,32-34]; two lasted between 6 and 11 months,[31,36] and three lasted less than 6 months.[29,30,35] An increase in fruit servings consumed was observed in four studies, ranging from 0.12/day to 0.73/day.[21,29,32,35] In studies that evaluated the mean fruit consumption in grams/day, the results ranged from 15 to 34.1.[33,34]

Four studies observed significant increases in vegetable intake, two in grams/day, ranging from 15 to 23.6[33,34] and the other two in servings/day, ranging from 0.24 to 0.70.[21,29] The consumption of fruits and vegetables combined showed increases that ranged from 0.15 to 1.58 servings/day[21,29,30,32] and from 25 to 56.9 g/day.[33,34] Two of the nine studies at this level of quality found no effect of intervention on the consumption of fruits and vegetables.[31,36]

Quality level C. One study lasted 2 years[37]; three studies lasted between 6 and 11 months,[38,40,42] and two studies lasted less than 6 months.[39,41] Of the three studies that assessed BMI, none promoted significant changes.[38,40,41] Only one study detected a significant change in fruit intake (+43 g/day).[42]

Discussion

This is the first SR to deal exclusively with RCTs on the effectiveness of school-based nutrition education interventions in producing changes in BMI and in fruit and vegetable intake among children and adolescents.[8-10,12,13]

In this review, eight of nine studies that assessed BMI were not successful in promoting reduction of the

Table 3 - Qualitative synthesis of primary and secondary outcomes in level A articles: pre- and post-intervention differences within and between the intervention and control groups

Articles	Primary outcome	Secondary outcome
Ashfield-Watt et al., 2009[26]	–	F (pieces/day): I = 0.37 vs. C = 0.06; 0.31 ($p < 0.01$)
Ask et al., 2010[28]	BMI: Boys, I = 0.6 vs. C = 0.4; 0.2 (p = 0.949); NS. Girls, I = 0.2 vs. C = 0.3; -0.1 (p = 0.725); NS	–
Baranowski et al., 2000[22]	–	FV (servings/day): I = 0 vs. C = -0.3; 0.3 ($p < 0.05$) V (servings/day): I = 0 vs. C = -0.1; 0.1 ($p < 0.01$) FJ (servings/day): I = -0.1 vs. C = -0.2; 0.1 ($p > 0.05$); NS
Foster et al., 2008[23]	BMI: I = 2.1 vs. C = 1.99; -0.04 (95%CI -0.27 to 0.14); NS z BMI: I = 0.1 vs. C = 0.07; -0.01 (95%CI -0.08 to 0.06); NS	Prevalence of overweight (%): I = -1.67 vs. C = 4.11; OR 0.65 (95%CI 0.54-0.79) Prevalence of obesity (%): I = 1.25 vs. C = 1.37; OR 1.09 (95%CI 0.85-1.40); NS FV (units/day): I = -1.09 vs. C = -1.05; -0.04 (95%CI -0.37 to 0.30); NS
James et al., 2004[27]	BMI: I = 0.8 vs. C = 0.7; -0.1 (95%CI -0.1 to 0.3); NS z BMI: I = 0.04 vs. C = 0.08; 0.04 (95%CI -0.04 to 0.12); NS	Prevalence of overweight/obesity (%): I = -0.2 vs. C = 7.5; 7.7 (95%CI 2.2-13.1); OR 0.68 (95%CI 0.46-1.00)*
Jiang et al., 2007[19]	BMI: I = 0.6 vs. C = 2.8; $p < 0.01$	Prevalence of overweight (%): I = -3.2 vs. C=1.8; OR 0.614 (95%CI 0.465-0.788) Prevalence of obesity (%): I = -3.8 vs. C = 1.8; OR 0.556 (95%CI 0.413-0.738)
Muckelbauer et al., 2009[24]	z BMI: I = 0.005 (0.289) vs. C = 0.007 (0.295); -0.004 (95%CI -0.045 to 0.036); NS	Prevalence of overweight (%): I = 0.06 vs. C = 1.91; OR 0.69 (95%CI 0.48-0.98)
Perry et al., 1998[25]	–	FV (servings/day): I = ND vs. C = ND; 0.58 (95%CI -0.15 to 1.31); NS F (servings/day): I = ND vs. C = ND; 0.62 (95%CI 0.10 -1.41) V (servings/day): I = ND vs. C = ND; -0.02 (95%CI -0.43 to 0.48); NS
Sichieri et al., 2009[20]	BMI: I = 0.32 vs. C = 0.22; 0.1 (95%CI -0.06 to 0.1); NS	Prevalence of overweight (%): I = 3 vs. C = 2.1; 0.9 (p = 0.13); NS Prevalence of obesity (%): I = 0.34 vs. C = 0.4; -0.06 (p = 0.95); NS

95%CI = 95% confidence interval; BMI = body mass index (kg/m^2); C = control group; F = fruit intake; I = intervention group; J = juice intake; ND = not described; NS = non significant; OR = odds ratio; V = vegetable intake; z BMI = BMI z score.
* Calculated at www.openepi.com (menu "Counts - Two by Two Table").

Table 4 - Qualitative synthesis of primary and secondary outcomes in level B articles: pre- and post-intervention differences within and between the intervention and control groups

Articles	Primary outcome	Secondary outcome
Baranowski et al., 2003[29]	–	FJV (servings/day): I = ND vs. C = ND; 0.91 (p = 0.002) F (servings/day): I = ND vs. C = ND; 0.52 (p = 0.002) V (servings/day): I = ND vs. C = ND; 0.24 (p = 0.001)
Bere et al., 2006[36]	–	FV (servings/day): I = -0.62 vs. C = 0.44; -0.38 (p = 0.76); NS FV at school (servings/day): I = -0.07 vs. C = -0.02; -0.05 (p = 0.53); NS
He et al., 2009[30]	–	FV (servings/day): Int1 = 4.4 vs. Int2 = 4.3 vs. C = 3.8; (p > 0.05); NS FV at home (servings/day): Int1 = 2.5 vs. Int2 = 2.5 vs. C = 2.4; (p > 0.05); NS FV at school (servings/day): Int1 = 1.9 vs. Int2 = 1.8 vs. C = 1.4; post-hoc analysis Int1 vs. C = 0.5 (p < 0.05)
Horne et al., 2009[34]	–	F delivered by school (g/day): I = 11 vs. C = -4; 15 (p < 0.001) V delivered by school (g/day): I = 13 vs. C = -2; 15 (p < 0.001) FV brought from home (lunchbox) (g/day): I = 30 vs. C = 5; 25 (p < 0.001)
Martens et al., 2008[35]	–	F (servings/day): I = 0.19 vs. C = 0.07; 0.12 (B-value = 0.04 [p < 0.05])
Moore & Tapper, 2008[31]	–	F at school (portions/day): I = ND vs. C = ND; 0.057 (95%CI -0.100 to 0.213); NS F in 24 h (portions/day): I = ND vs. C = ND; 0.089 (95%CI -0.199 to 0.377); NS
Perry et al., 2004[32]	–	FV (servings/day): I = 0.64 vs. C = 0.5; 0.15 (0.05 SE) (p = 0.02) F (servings/day): I = 0.37 vs. C = 0.21; 0.17 (0.04 SE) (p = 0.00) V (servings/day): I = 0.27 vs. C = 0.29; -0.02 (0.04 SE) (p = 0.55); NS
Reynolds et al., 2000[21]	–	FV (servings/day): I = 1.35 vs. C = -0.23; 1.58 (p < 0.0001) V (servings/day): I = 0.52 vs. C = -0.18; 0.70 (p < 0.0001) F (servings/day): I = 0.71 vs. C = -0.02; 0.73 (p < 0.0001)
Te Velde et al., 2008[33]	–	FV (g/day): I = 21 vs. C = -40; 56.9 (95%CI 28-85.9) V (g/day): I = 11 vs. C = -19; 23.6 (95%CI 7.8-39.3) F (g/day): I = 9 vs. C = -21; 34.1 (95%CI 14.3-54)

95%CI = 95% confidence interval; C = control group; F = fruit intake; I = intervention group; Int1 = intervention arm 1; Int2 = intervention arm 2; J = juice intake; ND = not described; NS = non significant; SE = standard error; V = vegetable intake.

index[20,23,24,27,28,38,40,41]; however, most of the interventions with durations varying from 1 to 3 years demonstrated a reduction in the prevalence of overweight and obesity. These results were expected, as significant decreases in the average BMI in populations of mostly normal individuals are unexpected. Furthermore, these data suggest that the small proportion of the changes observed were found in individuals who were close to the cutoff points for overweight and obesity.

Due to heterogeneity among the characteristics of the interventions, it would not be appropriate to conduct a meta-analysis. However, the approach of positive results may partially reflect the estimation of the effect size generated by the statistical method. Adopting this approach, four studies have reported odds ratios showing that the interventions were able to reduce rates of obesity in the studied populations. The odds ratios ranged from 0.61 to 0.69, indicating that the risk reductions were between 31 to 39%.

Applying such reduction levels in the prevalence of overweight and obesity observed in the last Brazilian national survey representing the population of state capitals (33.5% for children between 5 and 9 years old, and 20.5% for adolescents aged 10 to 19 years),[43] it can be estimated that the adoption of similar interventions – covering the entire system of elementary and secondary education in

Table 5 - Qualitative synthesis of primary and secondary outcomes in level C articles: pre- and post-intervention differences within and between the intervention and control groups

Articles	Primary outcome	Secondary outcome
Amaro et al., 2006[38]	z BMI: I = 0.345 (95%CI 0.299-0.390) vs. C = 0.405 (95%CI 0.345-0.465); -0.06; NS	–
Anderson et al., 2005[42]	–	FV (g/day): I = 33 vs. C = -7; 26 (p = 0.617); NS V (g/day): I = -17 vs. C = -15; -2 (p = 0.823); NS F (g/day): I = 50 vs. C = 7; 43 (p = 0.042)
Aquilani et al., 2007[40]	BMI: Boys: I = 0.1 vs. C = -0.5; 0.6; NS Girls: I = -0.5 vs. C = 1; -1.5; NS	–
Ask et al., 2006[41]	BMI: Boys: I = -0.8 vs. C = 0.7; -1.5* Girls: I = 0.3 vs. C=0.5; -0.2*	–
Lytle et al., 2004[37]	–	FV (servings/day): I = -0.77 vs. C = -0.27; -0.492 (95%CI -1.032 to 0.049); NS F (servings/day): I = -0.94 vs. C = -0.81; -0.143 (95%CI -0.711 to 0.425); NS V (servings/day): I = 0.13 vs. C = 0.53; -0.383 (95%CI -1.000 to 0.233); NS
Mangunkusumo et al., 2007[39]	–	V (g/day): I = 76.9 vs. C = 74.9; 2 (B-value = 3.55 [95%CI -7.9 to 15]); NS F (servings/day): I = 1.1 vs. C = 1.2; -0.1 (B-value = -0.05 [95%CI -0.16 to 0.06]); NS

95%CI = 95% confidence interval; BMI = body mass index (kg/m^2); C = control group; F = fruit intake; I = intervention group; NS = non significant; V = vegetable intake; z BMI = BMI z score.
* Did not analyze differences between groups.

the country – would result in reductions of prevalence to levels ranging from 20.4 to 23.1% and 12.5 to 14.1%, respectively, in the two age groups considered.

Of the 12 studies that adopted at least two among the three most common components (classroom activities, parental involvement, and school nutrition policy) (Table 2), 10 showed results in favor of the hypothesis that school-based nutrition education interventions are effective for reducing overweight and obesity and for increasing the consumption of fruits and vegetables among children and adolescents.

The rationale for the effectiveness of these components is justified by the extent that these actions have on the individual. The activities in the classroom, implemented as a specific nutrition education subject or included across the content of the traditional curriculum, are based on formal education, using structured information, with clear and specific objectives, to provide knowledge about the benefits of maintaining a healthy diet. The involvement of parents in this educational process enables them the opportunity to become suitable models for the children, assuming a key role in building their dietary habits. Finally, the uninterrupted supply of fruits and vegetables in the schools allows children and adolescents to have access to these foods, making feasible the incorporation in their eating habits.[44-46]

Limitations are inherent in research, especially when dealing with public health educational interventions.[11,17,47] RCT was chosen with the aim of controlling for common biases in community trials, such as those related with selection and confounding. Alternatively, we could have included non-randomized controlled trials, thereby including more studies in this review; but, if we had done so, our estimations would have been less valid, as we would have included interventions of questionable internal validity.

The choice of anthropometric indicators as the primary measure of outcome was intended to provide direct nutritional status indicators by reducing the bias generated by observers, instruments and informants. Additionally, as an indirect indicator of nutritional status, the acquisition of healthy eating habits plays a key role in preventing and reducing overweight.

Conclusion

Implication for policy makers

Interventions in schools to reduce the rates of overweight and obesity, as well as to increase consumption of fruits and vegetables, have demonstrated effectiveness in the best-designed RCTs. Characteristics of the interventions that demonstrated effectiveness are as follows: duration longer than 1 year, introduction into the regular activities of the school, involvement of parents, introduction of nutrition education into the regular curriculum and provision of fruits and vegetables by school food services.

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