The effect of participation in school-based nutrition education interventions on body mass index: A meta-analysis of randomized controlled community trials

Jonas Augusto Cardoso da Silveira a,⁎, José Augusto de Aguiar Carrazedo Taddei a,1, Paulo Henrique Guerra b,2, Moacyr Roberto Cuce Nobre c,2

a Disciplina de Nutrologia, Departamento de Pediatria, Universidade Federal de São Paulo, Rua Loefgreen, 1647, CEP 04040-032 Vila Clementino, São Paulo, SP, Brazil
b Programa de Pós-graduação em Cardiologia, Hospital das Clínicas, Faculdade de Medicina, Universidade de São Paulo, Av. Dr. Enéas de Carvalho Aguiar, 44, Andar 1º subsolo, Bloco II-Unidade de Epidemiologia Clínica, CEP 05403-900 São Paulo, SP, Brazil
c Unidade de Epidemiologia Clínica, Instituto do Coração, Universidade de São Paulo, Av. Dr. Enéas de Carvalho Aguiar, 44, Andar 1º subsolo, Bloco II-Unidade de Epidemiologia Clínica, CEP 05403-900 São Paulo, SP, Brazil

⁎ Corresponding author. Fax: +55 11 5573 1246.
E-mail addresses: jonasnutri@yahoo.com.br (J.A.C. da Silveira), taddei.dped@epm.br (J.A.A.C. Taddei), paulohguerra@usp.br (P.H. Guerra), mrcnobre@usp.br (M.R.C. Nobre).
1 Fax: +55 11 5573 1246.
2 Fax: +55 11 26615941.

Available online 29 January 2013

Abstract

Objective. The aim of this study was to evaluate the effectiveness of school-based nutrition education interventions in reducing or preventing overweight and obesity among children and adolescents.

Methods. We conducted a systematic search of 14 databases until May 2010 and cross-reference check in 8 systematic reviews (SRs) for studies published that described randomized controlled trials conducted in schools to reduce or prevent overweight in children and adolescents. An additional search was carried out using PubMed for papers published through May 2012, and no further papers were identified. Body mass index (BMI) was the primary outcome. The title and abstract review and the quality assessment were performed independently by two researchers. The software EPPI-Reviewer3 was used to store, manage and analyze all data. This SR is registered at ClinicalTrials.gov (NCT00985972).

Results. From the 4888 references initially retrieved, only 8 met the eligibility criteria for a random-effects meta-analysis. The total population consisted of 8722 children and adolescents. Across the studies, there was an average treatment effect of −0.33 kg/m2 (−0.55, −0.11 95% CI) on BMI, with 84% of this effect explained by the highest quality studies.

Conclusion. This systematic review provides evidence that school-based nutrition education interventions are effective in reducing the BMI of children and adolescents.

© 2013 Elsevier Inc. All rights reserved.
Introduction

From 1990 to 2010, the number of overweight children under five increased worldwide by an average of 0.8 million children per year. If the rate continues rising steadily until 2020, the number of overweight pre-school children on the planet will be 59.4 million, representing 9.2% of the entire population in this age group (de Onis et al., 2010; UN, 2012). The greatest increases in body mass occur in childhood and adolescence, and childhood overweight and obesity tend to persist into adulthood. Recognizing this fact, it is important to build healthy environments around strategic sites to protect children from psychosocial, metabolic and mechanical morbidities of overweight and obesity, as they constitute the fifth leading risk factor of global mortality (Freedman et al., 2005; Han et al., 2010; Hughes et al., 2011; Li et al., 2004; Lira et al., 2010; Nobre et al., 2006; Singla et al., 2010; Van Gaal et al., 2006; Wardle et al., 2006; WHO, 2009).

The school environment has been considered a promising site for health promotion, as its organizational structure facilitates the development of interventions with multi-professional and multi-component approaches. School educational background allows both direct (e.g. classroom activities) and indirect (e.g. parental involvement) actions to protect children’s health. In addition, children and adolescents dedicate a large portion of their time to school (Hughes et al., 2011; Pérez-Rodrigo et al., 2001; Silveira et al., 2011; Wardle et al., 2006, 2007).

In this context, the aim of this review was to enhance the body of evidence, filling the gap left by past systematic reviews, regarding the effectiveness of school-based nutrition education interventions in reducing body mass index (BMI) in children and adolescents (Brown and Summerbell, 2009; CRD, 2012; Gonzalez-Suarez et al., 2009; Jaime and Lock, 2009; Perez-Morales et al., 2009; Silveira et al., 2011; Zenzen and Kridli, 2009). To our knowledge, this is the first systematic review (SR) with a meta-analysis (MA) that exclusively includes randomized controlled trials (RCTs) that address school-based nutrition education, places no limits on the date of publication and uses BMI as the primary outcome.

Methods

Design and search strategy

This SR is part of a larger project called the “Physical Activity and Nutrition Education Systematic Review Project,” and the research protocol is registered at ClinicalTrials.gov (NCT00985972). The design followed the guidelines in Centre for Reviews and Dissemination: guidance for undertaking reviews in health care (CRD, 2008), and all stages of the study, including the MA, were carried out using the web-based software Epip-Rewriter 3 (Epip-Centre, Social Sciences Research Unit, Institute of Education, University of London).

The search was performed in 14 electronic databases (PubMed/Medline, EMBASE, ISI Web of Knowledge, CENTRAL–Cochrane, ERIC, CINAHL, LILACS, PsychInfo, SPORTDiscus, ASSIA, Physical Education Index, Social Care Online, Social Services Abstracts, and Sociological Abstracts) until May 5, 2010, with no filters for date of publication or language, with the exception of languages developed in PubMed and when required was adapted to each database. The keywords were 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]))). Additionally, we performed a cross-reference check using eight related SRs (Brown and Summerbell, 2009; Gonzalez-Suarez et al., 2009; Jaime and Lock, 2009; Knai et al., 2006; Lavelle et al., 2012; Perez-Morales et al., 2009; Van Cauwenbergh et al., 2010; Zenzen and Kridli, 2009). To look for updates, we conducted the search in PubMed/Medline (the database that retrieved the most number of relevant studies in the original search) until May 23, 2012, but no additional RCTs were retrieved.

Randomized controlled community trials were eligible for this SR if they met the following criteria: 1) the intervention and control groups were contemporaneous and received the same cumulative duration of treatment or non-treatment; 2) participants were 5–18 years of age (we made no exclusions based on anthropometric classification, country, ethnic group, socioeconomic status, or gender); 3) the study reported body mass index as an outcome; 4) interventions were school-based nutrition education interventions administered by health professionals or school teachers; and 5) there were no representative sample of children with eating disorders, dyslipidemia, mental or physical disabilities, diabetes or anemia. After-school interventions and data from articles addressing impacts of interventions after varying follow-up periods were not considered.

The selection of titles and abstracts and the methodological quality assessment (MQA) were completed independently by two authors (JS and PG). In cases of disagreement or doubt, a senior researcher was consulted (MN or JT). For the MQA, we combined two tools: a modified version of the Quality Assessment Tool for Quantitative Studies of Effective Public Health Practice Project (EPHPP, 2009), which we designated a score ranging from −1 (weak) to +1 (strong), instead a classification (weak, moderate, strong), for seven covered areas (selection bias, study design, confounders, data collection method, withdrawals and dropouts, intervention integrity and analysis) resulting an overall score ranging from −5 to +7. Blinding was not considered, as we were evaluating education interventions; and, the Grading Recommendations Assessment, Development and Evaluation (GRADE, 2012) system, which points were assigned according to the type of evidence and effect size and deducted from the quality, consistency and directness, as proposed by the BMJ Clinical Evidence (ClinicalEvidence, 2012), resulting an overall score ranging from 2 to +7.

According to the distribution of the two assessment tools’ scores in tertiles, 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 statistical analysis

One researcher (JS) extracted the following data: total number of participants in each group, study length, theoretical framework, intervention components, anthropometric outcome (BMI in kg/m²), characteristics of randomization and data analysis.

We conducted the meta-analysis using the DerSimonian and Laird random-effects model because we assumed that there is heterogeneity in the characteristics of the studies (e.g., length of time and type of intervention) that influences the variability beyond chance (Egger et al., 2001; Riley et al., 2011). The percentage of variation across studies due to the heterogeneity was measured using the I² statistic. Heterogeneity was quantified using the Cochran’s Q statistic (Egger et al., 2001). A subgroup analysis by intervention duration was conducted a posteriori because there were data available for this purpose.

The mean treatment effect across the studies was summarized as the mean difference between exposed and non-exposed groups (weighted mean difference) with a 95% confidence interval (95% CI). This method weights studies according to the group size, the standard deviation and the mean response (effect size) (Egger et al., 2001).

For trials that did not take clustering effects into account or did not describe the intraclass correlation coefficient, we applied the value of 0.02 to avoid overestimating the intervention effect, as recommended in the literature (Higgins and Green, 2011; Sichieri et al., 2009). Publication bias was assessed subjectively using a funnel plot.
Emails were sent to corresponding authors requesting additional information. Only two authors who reported their BMI data with a z-score answered our emails and provided results in kg/m².

Articles providing outcomes by gender, but not for the entire population, were included separately in the meta-analysis, therefore we did not duplicate information.

Results

Search strategy

The search performed in the 14 databases, along with the cross-reference check of the 8 SRs, retrieved 4888 references, 3571 of which remained after checking for duplicates. Of 24 articles included in the qualitative synthesis (Silveira et al., 2011), 8 had sufficient data to be included in the MA (Fig. 1).

The qualitative synthesis considered studies reporting anthropometric and dietary (consumption of fruits and vegetables) outcomes. The 14 studies excluded due to outcome before the qualitative synthesis reported their results as: intake of micronutrients, knowledge about nutrition and healthy food sales in canteens. The 15 studies that were excluded after the qualitative synthesis were those that did not present BMI outcomes in kg/m².

Study characteristics

The characteristics of the studies included in the MA are described in Table 1. Two articles were entered separately, as their results were only reported by gender (Aquilani et al., 2007; Ask et al., 2010).

Five of eight studies had more than 500 participants, and all of them were level A quality (Foster et al., 2008; James et al., 2004; Jiang et al.,...
2007; Muckelbauer et al., 2009; Sichieri et al., 2009). Regarding the study duration, four studies were conducted for one year or more (Foster et al., 2008; James et al., 2004; Jiang et al., 2007; Muckelbauer et al., 2009), three had a duration between six and eleven months (Amaro et al., 2006; Aquilani et al., 2007; Sichieri et al., 2009) and only one lasted four months (Ask et al., 2010).

Five studies randomized participants at the school level. Three of them used the same sampling unit in the analysis (Foster et al., 2008; Muckelbauer et al., 2009; Sichieri et al., 2009), and the other two studies analyzed at student level (Ask et al., 2010; Jiang et al., 2007). Three studies randomized participants at the classroom level (Amaro et al., 2006; Aquilani et al., 2007; James et al., 2004), but only one did not use the classroom as the unit of analysis. Among the eight studies included in the MA, only Muckelbauer et al. (2009) stated that they used a theoretical framework, namely the Theory of Planned Behavior, to develop their intervention.

### Effects on BMI

In this MA, the total population consisted of 8451 children and adolescents. The random-effects model ($I^2 = 94.7\%$) showed that the average treatment effect across studies was a significant reduction of $0.33 \text{ kg/m}^2$ (95% CI: $-0.51, -0.15$; $z = 2.95$; $p = 0.003$) in children’s BMI (Fig. 2). Approximately 85% of this effect was attributable to studies with the highest level of quality.

In the subgroup analysis of studies with a duration longer than one year ($I^2 = 98.1\%$; $n = 1589$), we observed an increase of 45% in the effect size, representing an average reduction in BMI of $0.48 \text{ kg/m}^2$ (95% CI: $-0.76, -0.19$; $z = 3.3$; $p < 0.001$) (Foster et al., 2008; James et al., 2004; Jiang et al., 2007; Muckelbauer et al., 2009). All RCTs in the subgroup analysis were classified as high quality.

Individually, only two papers demonstrated a significant reduction in BMI in children and adolescents in the intervention groups compared with the control groups (James et al., 2004; Jiang et al., 2007). These studies were classified in the highest evidence quality level, and together they account for 30% of the weight of the average final effect derived from the meta-analysis. The interventions in both of these RCTs were carried out for more than one year using classroom activities, but Jiang et al. (2007) also focused on parental involvement.

Amaro et al. (2006) did not observe a significant reduction in children’s mean BMI, but there was a trend in favor of the intervention ($-0.21 \text{ km/m}^2$ [95% CI: $-0.50, 0.08$]). This trend was also observed by Foster et al. (2008) ($-0.04 \text{ km/m}^2$ [95% CI: $-0.18, 0.10$]) and Muckelbauer et al. (2009) ($-0.01 \text{ km/m}^2$ [95% CI: $-0.06, 0.04$]), although with less intensity. Apparently, girls receive more of a benefit from school-based nutrition education than boys do, as demonstrated by Aquilani et al. (2007) ($-1.5 \text{ kg/m}^2$ [95% CI: $-3.52, 0.52$]) and Ask et al. (2010) ($-0.1 \text{ kg/m}^2$ [95% CI: $-2.23, 2.03$]). Sichieri et al. (2009) were the only group that observed a slight increase in mean BMI ($0.10 \text{ kg/m}^2$ [95% CI: $-0.06, 0.26$]).

### Discussion

This is the first MA to exclusively investigate randomized community trials that assess the effectiveness of school-based nutrition education in reducing BMI among children and adolescents. In our first research paper, we asserted that school-based nutrition education is able to reduce the prevalence of overweight and increase fruit and vegetable consumption (Silveira et al., 2011).

We presented a qualitative synthesis and chose not to proceed with a meta-analysis due to the high heterogeneity among the studies (Armstrong et al., 2007; Jackson et al., 2005). However, after the publication of Riley et al. (2011), we recognized the validity of a random-effects meta-analysis in the context of high heterogeneity if it is assumed that the summary results represent the average treatment effect across studies and not a common intervention effect (fixed effect). In the fixed-effect MA, all heterogeneity is due to chance, with all studies assuming that the summary results represent the average treatment effect across studies.

Based on this approach and the best evidence available, it was possible to conclude that school-based nutrition education is effective in reducing children’s and adolescents’ BMI, regardless of the intervention components. Applying the observed reductions in BMI to a hypothetical obese (z-score BMI = +2 SD; BMI = 22.6 kg/m$^2$) 10-year-old...
girl, the weight loss would average 500 g (95% CI: −200, −900). This effect becomes even more noteworthy if we consider only the high-quality RCTs carried out for more than one year, where the weight reduction would be 1000 g (95% CI: −400, −1400). This is a significant effect size, considering that weight reduction is difficult to achieve (August et al., 2008; Sarwer and Dilks, 2012) and that the prevention studies that produced this finding were carried out predominantly in children of normal weight.

This conclusion produces important scientific evidence for universal school policies regarding overweight management. The BMI reduction can be mostly attributed to those who were overweight because the studies found reductions in the prevalence of overweight and obesity in addition to the reductions in BMI (Silveira et al., 2011). This effect was formally evaluated by Gonzalez-Suarez et al. (2009), who found that children exposed to school-based interventions were significantly less likely to become overweight (OR = 0.74; 0.60, 0.92 95% CI).

All efforts to prevent or reduce overweight and obesity in childhood must be considered because these conditions increase the risks of type II diabetes, hypertension, carotid-artery atherosclerosis, high levels of LDL and triglycerides and low levels of HDL in adulthood, as observed in a pooled analysis of four large cohorts (Juonala et al., 2011). Past SRs that combined physical activity and nutrition education school-based interventions produced results that followed the same trend. The pooled effect found by Waters et al. (2011) was a statistically significant reduction in BMI, with a mean difference of 0.15 kg/m² (95% CI: −0.21, −0.09); however, in the comparison by age group, in average only children between six and twelve years old benefited from the interventions (−0.15 kg/m² [95% CI: −0.21, −0.09]). In a subgroup analysis, Gonzalez-Suarez et al. (2009) observed a significant mean reduction in children’s BMI only for interventions that lasted between one and two years (−0.10 kg/m² [95% CI: −0.14, −0.06]). Other SRs performed MAs by intervention type and found no significant reduction in children’s mean BMI after nutrition education interventions; however, they included only two studies (Friedrich et al., 2012). They also included only RCTs, but they classified two studies as combined nutrition education and physical activity interventions, whereas we considered them as nutrition education interventions. In both cases, the intervention framework was based on methods to improve diet-related behaviors, and the physical activity component merely consisted of a basic message or a part of the traditional curriculum in the schools that could not be modified (Foster et al., 2008; Jiang et al., 2007). Furthermore, one of the best-designed school-based nutrition education RCTs was not included (Sichieri et al., 2009). Three other studies that fulfilled the eligibility criteria were not included in this MA (Amaro et al., 2006; Aquilani et al., 2007; Ask et al., 2010).

As illustrated above in our subgroup analysis of long-lasting RCTs and noted by another author, the duration of the nutrition education is more relevant than the intervention component per se in achieving the beneficial effects (Lavelle et al., 2012). The obvious reason for this result is that children who are followed for a longer period have more time to lose weight, but the rationale behind this statement is that behavioral changes occur over time; therefore, even a very intense program would have no detectable anthropometric effect. On the other hand, a less intensive multi-component intervention repeated for a longer period is more likely to create behavioral changes, resulting in better anthropometric outcomes.
Study strengths and limitations

In addition to the CRD guidelines, this study was also conducted in accordance with the PRISMA Statement recommendations. Our previous publication was submitted for a critical appraisal and received a positive evaluation of its methodological aspects and approaches from the Database of Abstracts of Reviews of Effects (DARE) (CRD, 2012).

The choice to include RCTs guarantees that the evidence produced by this MA is of the highest quality (especially because we also assessed the methodological quality of the studies), ensuring that our conclusions are primarily derived from the best-designed RCTs. If we had included non-RCTs, the quality of our estimates may have been reduced; the internal validity of such studies is questionable, as they are susceptible to selection bias and confounding factors.

Considering the extensive literature search and the funnel plot symmetry (Fig. 3), publication bias in this study is unlikely, another point that corroborates the consistency of this MA.

This review was based on eight RCTs conducted in seven countries in Europe, Asia, North America and South America, including students from low-, middle- and high-income families, in different cultural and socioeconomic contexts. These characteristics allow us to infer that our estimates have good external validity.

The use of BMI as the primary outcome measure provides an objective measure of nutritional status that is widely known and used in clinical and research contexts, with well-recognized reference standards, potentially reducing informant bias, observer bias and instrumentation bias. On the other hand, it would be ideal if BMI had been reported using z-scores instead of kg/m\(^2\), as the observed changes would be even more reliable if the outcome was standardized by age and gender. Additionally, results should be interpreted considering different gender characteristics and stages of sexual maturation (Table 1), when, e.g., girls tend to accumulate more fat mass than boys (Veldhuis et al., 2005).

The limited number of available RCTs makes it difficult to test the effectiveness of school-based nutrition education by evaluating the intervention components. This shortcoming presents opportunities for future researchers to identify which approaches, considering the theoretical framework and intervention components, are most effective in obtaining the expected effects over medium- and long-term periods. From the point of view of policy-making, it is also important to pursue strategies that maximize beneficial health outcomes given the financial resources available.

Conclusion

Based on randomized controlled community trials, this systematic review provides evidence that school-based nutrition education interventions are effective in reducing BMI in children and adolescents, especially if the intervention duration is longer than one school year.

Conflict of interest

The authors declare that they have no conflicts of interest.

Acknowledgments

We would like to thank Dr. Alessandro Viggiano and Dr. Rebecca Muckelbauer for answering our emails with requested data. This project was funded by a grant from the Fundação de Amparo a Pesquisa de São Paulo (FAPESP) (protocol no. 09/12438-5). The author JS received a scholarship from Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES).

References
