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The effect of school intervention programs on the body mass index of adolescents: a systematic review with meta-analysis

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Abstract

Effective obesity interventions in adolescent populations have been identified as an immediate priority action to stem the increasing prevalence of adult obesity. The purpose of this meta-analysis was to make a quantitative analysis of the impact of school-based interventions on body mass index during adolescence. Studies were retrieved from PubMed, Scopus, Science Direct and Web of Science databases. Results were pooled using a random-effects model with 95% confidence interval considered statistically significant. Of the 18 798 possible relevant articles identified, 12 articles were included in this meta-analysis. The global result showed a low magnitude effect, though it was statistically significant ($N = 14\,428$), global e.s. = −0.055, $P = 0.004$ (95% CI = −0.092, −0.017). Heterogeneity was low among the studies ($I^2 = 9.017\%$). The funnel plot showed no evidence of publication bias. The rank-correlation test of Begg ($P = 0.45641$) and Egger's regression ($P = 0.19459$) confirmed the absence of bias. This meta-analysis reported a significant effect favoring the interventions; however, future research are needed since the reported the evidence was of low magnitude, with the studies following a substantial range of approaches and mostly had a modest methodological quality.

Introduction

Obesity is essentially caused by an imbalance between energy intake and expenditure over a period, resulting in excessive fat accumulation. This imbalance results from a complex combination of factors and it varies from one person to another, making it extremely difficult to control. Obesity is generally defined in terms of body mass index (BMI); although BMI does not represent a direct measure of body fat, it is well correlated with other forms of body fat measuring, and therefore it is widely used. For adults, a BMI ranging from 25 to 29.9 kg/m^2 represents overweight and a BMI greater than or equal to 30 kg/m^2 defines obesity. For children and adolescents, age and sex-specific BMI cut-offs are used to classify overweight and obesity, and BMI is usually expressed in percentiles; BMI values between the 85th and the 95th percentile represent overweight and BMI values greater than 95th percentile express obesity [1, 2].

Although the prevention of obesity is a primary public health goal, effective interventions are also required to treat the pre-existing obesity in

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adolescent populations, and to stem the increasing prevalence of adult obesity [3]. Long-term weight loss and its maintenance in children and adolescents could only be achieved if lifestyle behaviors, such as physical inactivity and unhealthy eating habits, are modified and replaced with healthier habits that persist throughout life [4] Schools provide a favorable setting for interventions that focus on the promotion of healthy behaviors, as children and adolescents spend a large part of their time there. But while schools alone cannot solve the childhood obesity epidemic, it is also unlikely that childhood obesity rates can be reversed without strong school cooperation and support [5, 6].

Prior reviews suggest that most school-based programs have positive effects, resulting in significant improvements in nutrition knowledge, healthy behavior (physical activity, sedentary behavior and dietary intake) and self-efficacy. However, their impact on BMI is not at all consistent [7–11]. Likewise there is numerous evidence suggesting that multi-targeted interventions in school environment, especially at early ages, favor the implementation of healthy habits; however, there is less information of interventions targeting adolescents [11, 12]. Interventions vary in protocol, content, approach, duration and other supplemental components. The understanding of the effect of this type of interventions and its variables is crucial to estimate the benefit of existing programs as well as the need for improvement. Thus, the purpose of this meta-analysis was to make a quantitative analysis of the impact of school-based interventions on adolescents' BMI.

Materials and methods

Search procedures

PubMed, Science Direct, SCOPUS and Web of Science databases were systematically searched to identify potentially relevant studies. The search process was limited to studies published over a 5-year period, from January 2013 to April 2018. The literature search was conducted between May and August 2018. The following combination of key terms was used: (*school-based* OR *intervention* OR *prevention* OR *program*) AND (*adolescents* OR *youth* OR *teenagers*) AND (*obese* OR *overweight* OR *body mass index* OR *BMI* OR *weight*) AND (*RCT* OR *randomized controlled trials*). In addition, the reference lists of previous reviews were searched in order to detect other potential studies, not identified by the databases search. The current meta-analysis is reported based on the PRISMA guidelines [13].

Eligibility criteria

The analysis and selection of the studies was done by one researcher. For inclusion, the studies had to be published between January 2013 and April 2018, include adolescents aged from 12 to 18 years, incorporate school intervention programs reporting BMI change (regardless of the intervention approach used and its duration), include a control group receiving none or minimal intervention or an alternative intervention, have a randomized controlled design and be published in English.

The studies were excluded if they included children in their sample and if they present no separate analysis for the adolescent population.

Quality assessment

The methodological quality of the studies was assessed by one reviewer (R.S.D.) using the Downs and Black scoring system [14], which is a valid, reliable and strong instrument. This scale consists of 27 items divided into the following subscales: reporting (10 items), external validity (3 items), internal validity—bias and confounding (13 items) and power of the study (1 item). The original scale has a total score of 32 points. We used a modified version in which the power question was simplified and awarding either 1 or 0 points depending on the presence of a power analysis, identical to previous studies [15–17]. Therefore, this modified version has a total score of 28 points, with higher scores indicating a higher methodological quality of the study. A corresponding quality level was attributed to each study: excellent (24–28 points), good (19–23 points), moderate (14–18 points) or poor (<14 points) [18].

Data extraction and analysis

The following data were extracted from each study: author, year of publication, country, sample size, gender, age range or school grade, intervention duration and components and main outcomes. BMI was selected as the primary outcome measure because it is frequently measured and reported in studies assessing the effect of obesity-related interventions.

The random-effects model was used due to the wide variety of samples and methods among the studies included. The heterogeneity between studies was estimated with the I^2 index, with values of 25, 50 and 75% showing low, moderate and high degrees of heterogeneity, respectively. This index describes the percentage of total variation across studies because of heterogeneity rather than chance [19].

Potential publication bias was assessed using a funnel plot. In addition, the Begg's rank-correlation method [20] and Egger's regression intercept method [21] were used to statistically assess publication bias ($P < 0.05$ was considered statistically significant).

Analyses were conducted using the software Comprehensive Meta-Analysis, version 2.2.057.

Results

Study selection

Figure 1 shows the PRISMA flowchart of the articles screening process. The databases and manual search located 18 798 studies. After reading its titles and abstracts, the number of articles for full-text reading was reduced to 64. In the final refinement of the research, 12 articles met the eligibility criteria, and thus were included in this meta-analysis. One study [22] evaluated three distinct interventions, then this meta-analysis assessed the effect of 14 interventions, a number that will be considered in future references.

Characteristics of the studies

The studies were published between 2013 and 2018, and the highest number of the studies was published in 2013 ($n = 5$) [22–26]. The studies were conducted in seven different countries across four continents, with predominance of the studies conducted in the United States ($n = 4$) [24–27]. The sample size ranged from 82 [25] to 3538 [22] participants at baseline. The majority of the studies included participants of both genders ($n = 8$), three were limited to female participants [23, 28, 29] and one included only male participants [30]. Most studies included individuals despite their BMI status; only three studies restricted the participation to individuals with a BMI above the 85th percentile [25, 27, 28]. Detailed data on socioeconomic characteristics, ethnicity and urban/rural setting were not always reported. Information regarding the maturational development was not available as well.

Characteristics of the interventions

The type, duration and frequency of the intervention varied among the studies. The duration of the interventions, from the baseline to its end, varied from 8 weeks [33] to 2 years [22]. The protocols of the interventions exhibited high variability. Most of the studies ($n = 6$) reported interventions combining physical activity with educational sessions for the promotion of healthy behaviors [23, 24, 28–31], one of those studies also included environmental changes [28]. Three studies described educational interventions [25, 26, 32], and one study offered an intervention based exclusively on physical activity [33]. One study combined educational sessions with environmental changes, like the increase of the availability of healthy foods and physical activity infrastructures [22]. Four studies also integrated tailored feedback messages and/or individual counseling sessions in its interventions [22, 25–27]. The participation of parents in the intervention was reported in six studies [24, 28–32]. Table I summarizes the characteristics of each eligible study included in this meta-analysis.

Effect analysis

All of the 14 interventions were pooled for meta-analysis. This meta-analysis included 14 428 participants and demonstrated that school-based

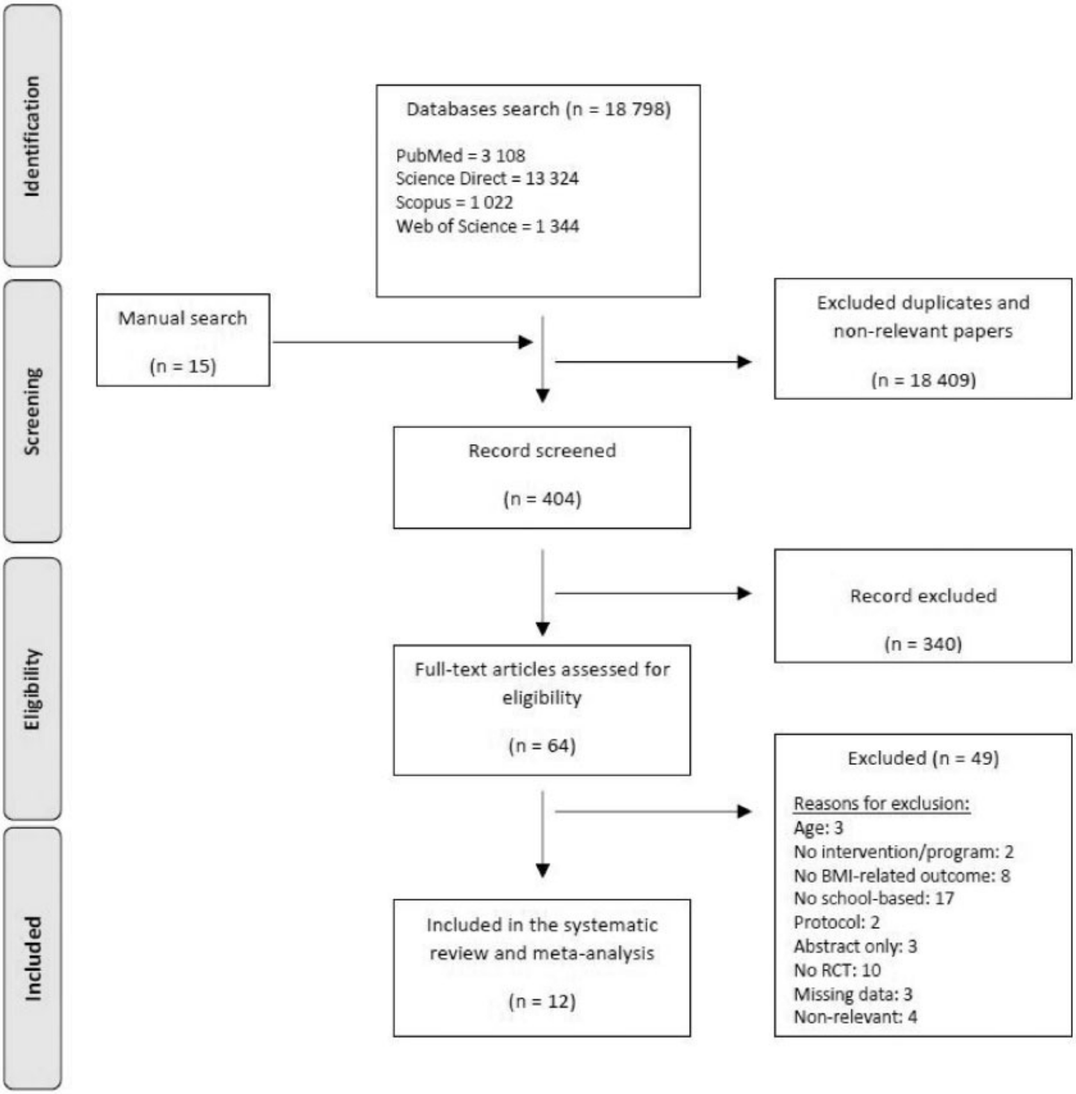

Fig. 1. PRISMA flow diagram of study selection process.

interventions were able to reduce BMI, global e.s. = −0.055 kg/m^2, $P = 0.004$ (95% CI = −0.092, −0.017). The global effect was positive and statistically significant, although it had a low magnitude.

Individually only two interventions produced a significant effect on BMI [24, 33]. The other interventions did not show any significant effect, although the majority ($n = 9$) favored the intervention group [22, 23, 26, 28–31]. Figure 2 presents the effect size of each study.

The heterogeneity test indicates that results were homogeneous among studies (I^2 = 9.017%]. This result indicates that almost all of the dispersion is caused by random errors, and therefore makes no sense attempting to explain it otherwise. The symmetrical distribution of the points in the funnel plot

Table I. *Characteristics of studies examining the effect of school-based interventions on BMI*

Authors, year (country)	Sample	Intervention	Duration	Main results	Quality
Bonsergent et al., 2013 [22] (France)	n =3538 (age: 15.6 ± 0.7) Gender: mixed BMI status: mixed PA: not measured	(i) Education intervention: dietary and PA lectures; group-work to solve problems related to eating habits, PA and environment; themed-parties to reinforce the knowledge; (ii) Environment intervention: increasing the availability of fruits, vegetables, bread and dairy products, water and physical activity; (iii) Screening and care intervention: anthropometric measurement and eating disorders screening; educational sessions about foot, PA and changes in nutritional habits	2 y	Significant increase on BMI and decrease on BMI z-score in all interventions Ow/ob prevalence decreased significantly only in the screening and care intervention	11
Dewar et al., 2013 [23] (Australia)	n = 357 (age: 13.2 ± 0.5) Gender: female BMI status: mixed PA: measured (accelerometers)	Promotion of healthy through: enhanced school sport sessions, lunchtime PA sessions, nutrition workshops, interactive educational seminars, pedometers for self-monitoring, handbooks, parent newsletter and text messages	12 m	Increase on BMI and decrease on BMI z-score (not significant) Significant decrease in % body fat	17
Melnyk et al., 2013 [24] (United States)	n = 807 (age: 14.74 ± 0.73) Gender: mixed BMI status: mixed PA: measured (pedometers)	15-session educational and cognitive–behavioral skills-building program guided by cognitive theory, with PA as a component of each session (15–20 min of PA to promote regular exercise)	15 w	Significant decrease in BMI Overweight proportion decreased	17
Pbert et al., 2013 [25] (United States)	n = 82 (age: 15.8 ± 1.02) Gender: mixed BMI status: >85th percentile PA: measured (accelerometers)	Counseling sessions focusing on a healthy lifestyle conducted by the school nurses, with goals setting toward behavior change	2 m	No significant differences in BMI, BMI z-score, % body fat and WC	15
Whittemore et al., 2013 [26] (United States)	n = 384 (age: 15.31 ± 0.69) Gender: mixed BMI status: mixed PA: measured (survey)	Lessons, goal setting, self-monitoring, health coaching and social networking. The lessons focused on the topics of nutrition, PA, metabolism and portion control. CST lessons included social problem solving, stress reduction, assertive communication and conflict resolution	Not specified (12 lessons)	Significant decrease in weight but not BMI	16
Smith et al., 2014 [30] (Australia)	n = 361 (age: 12.7 ± 0.5) Gender: male	Multicomponent intervention designed to prevent unhealthy weight gain by increasing PA,	8 m	No significant effects on BMI, WC and % body fat, though	16

(continued)

Table I. *(continued)*

Authors, year (country)	Sample	Intervention	Duration	Main results	Quality
	BMI status: mixed PA: measured (accelerometers)	reducing screen time and lowering SSB consumption		they all favored the intervention	
van Nassau et al., 2014 [31] (the Netherlands)	$n = 1486$ (age: 12–14) Gender: mixed BMI status: mixed PA: measured (self-report)	12 theoretical lessons + 4 physical education lessons focused on: (i) reducing intake of SCB, (ii) reducing intake of high-energy snacks/ sweets, (iii) reducing screen time, (iv) increasing levels of PA and (v) consuming a daily breakfast	2 y	No significant effects on BMI, BMI *z*-score, WC and skinfolds sum	16
Eather et al., 2015 [33] (Australia)	$n = 96$ (age: 15.4 ± 0.5) Gender: mixed BMI status: mixed PA: not measured	Crossfit fitness program with sessions 2×/week	8 w	Significant effect decreasing BMI and a BMI *z*-score	17
Nawi and Jamaludin, 2015 [32] (Malaysia)	$n = 108$ (age: 16) Gender: mixed BMI status: mixed PA: measured (survey)	Website with information on healthy lifestyle, diet and ways to overcome obesity; interactive chat sessions; weight monitorization	12 w	Significant decrease of mean BMI, WC and % body fat	14
Leme et al., 2016 [29] (Brazil)	$n = 253$ (age: 16.10 ± 0.05) Gender: female BMI status: mixed PA: measured (survey)	Program designed to reinforce healthy dietary and PA behaviors and included enhanced physical education sessions, school-break PA sessions, nutrition and PA handbooks, interactive seminars, nutrition workshops, weekly nutrition and PA key messages, parental newsletters, weekly health messages using WhatsApp® and diet and PA diaries for self-monitoring	6 m	No significant effect on BMI and BMI *z*-score, but the results favored the interventionSignificant group-by-time interaction regarding WC	15
Pbert et al., 2016 [27] (United States)	$n = 126$ (age: 15–18) Gender: mixed BMI status: >85th percentile PA: measured (accelerometers)	Educational sessions related to nutrition and PA conducted by the school nurse + after school exercise program (3×/week)	8 m	No significant effect on BMI, % body fat and WC, although for BMI and %body fat the results favored the intervention	19
Bagherniya et al., 2018 [28] (Iran)	$n = 172$ (age: 12–16) Gender: female BMI status: >85th percentile PA: measured (survey)	Sport workshops; private consulting sessions; exercise sessions; family PA sessions; increasing school facilities for PA; parents' newsletter	30 w	BMI and WC decreased favorably but were not significant	15

BMI, body mass index; WC, waist circumference; PA, physical activity; SCB, sugar-containing beverages; ow/ob, overweight/ obesity; CST, coping skills training; y, year; m, month; w, weeks.

Study name	Statistics for each study						
	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Dewar et al, 2013	-0,038	0,117	0,014	-0,267	0,190	-0,328	0,743
Whittemore, Jeon, Grey, 2013	-0,018	0,105	0,011	-0,224	0,188	-0,171	0,864
Smith, et al, 2014	-0,166	0,117	0,014	-0,395	0,064	-1,412	0,158
Van Nassau et al, 2014	-0,058	0,056	0,003	-0,167	0,051	-1,045	0,296
Eather,Morgan & Lubans, 2015	-0,504	0,224	0,050	-0,943	-0,066	-2,254	0,024
Nawi and Jamaludin, 2015	0,082	0,203	0,041	-0,316	0,481	0,405	0,686
Leme et al, 2016	-0,017	0,145	0,021	-0,301	0,268	-0,115	0,908
Pbert et al, 2016	0,136	0,190	0,036	-0,237	0,509	0,715	0,474
Bagherniya et al, 2018	-0,303	0,162	0,026	-0,621	0,015	-1,867	0,062
Bonsergent et al, 2013	-0,034	0,034	0,001	-0,100	0,032	-1,005	0,315
Bonsergent et al, 2013	-0,027	0,034	0,001	-0,093	0,039	-0,809	0,419
Bonsergent et al, 2013	-0,055	0,034	0,001	-0,121	0,011	-1,620	0,105
Melnyk et al, 2013	-0,197	0,076	0,006	-0,346	-0,047	-2,580	0,010
Pbert et al, 2013	0,150	0,221	0,049	-0,284	0,584	0,678	0,498
	-0,055	0,019	0,000	-0,092	-0,017	-2,869	0,004

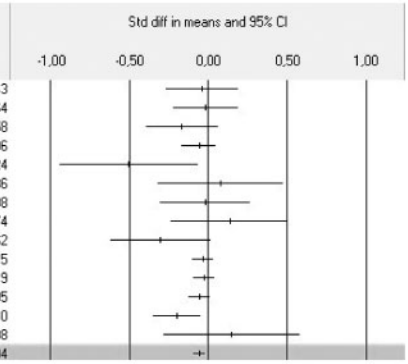

Fig. 2. Forest plot of standardized mean difference (95%) in change of body mass index.

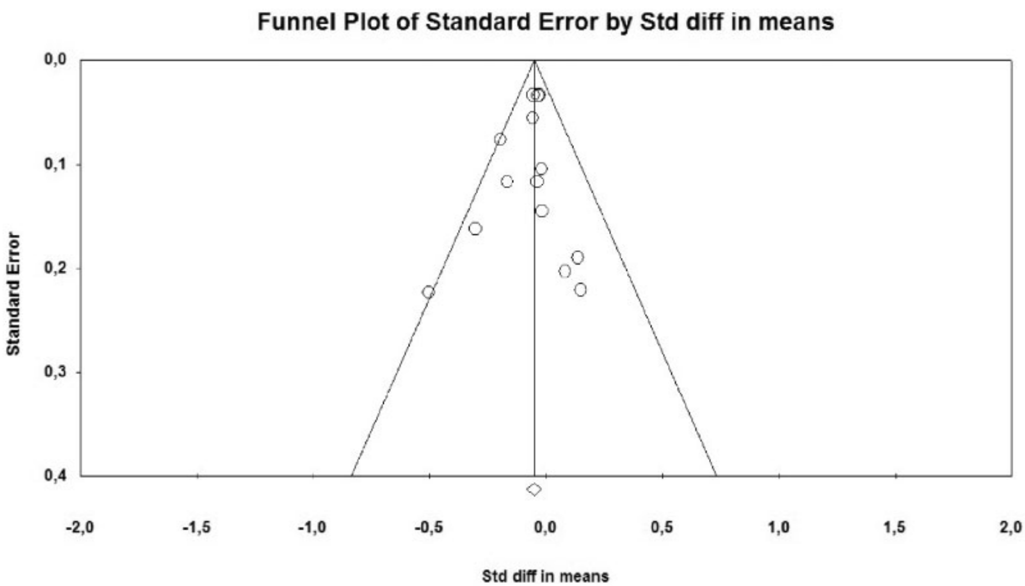

Fig. 3. Funnel plot to assess the publication bias of studies.

showed no evidence of publication bias (Fig. 3]. The rank-correlation tests of Begg ($P = 0.45641$) and Egger's regression ($P = 0.19459$) confirm the absence of bias.

Method quality

Downs and Black checklist scores ranged from 12 to 19 points (mean: 15.75; median: 16; mode: 17]. Most studies ($n = 10$) were classified as moderate [23–26, 28–33], one study [27] was classified as good and one study had poor methodological quality [22]. The criteria satisfied more often were related to the reporting subscale. External validity and confounding subscales were the ones obtaining the worst result, mainly because the information was not clearly reported or not reported at all. Although all studies were reported as RCTs, most did not satisfy the randomization criteria. In the bias subscale, the less frequently satisfied items were related to blinding (participants and researchers), though blinding is difficult to achieve in these programs.

Discussion

The purpose of this meta-analysis was to assess the impact of school-based interventions on the BMI of adolescents. Overall, the global effect of the interventions was positive, although very modest. This result is similar to the ones found by previous reviews [34–36].

Several extrinsic factors (e.g. level of engagement with the intervention, parental involvement, lifestyle behaviors, socioeconomic status and psychological factors) can affect the success of the interventions, so the reduced effect sizes in the intervention group were not entirely unexpected. The majority of the studies included in this meta-analysis comprised predominantly non-overweight adolescents representing prevention interventions rather than treatment interventions and treatment studies is more likely to produce effective results than prevention studies. In fact, it is important to note that treatment studies, particularly in overweight participants, were not the purpose of this review. Nevertheless, it should be noted that changes in BMI are not easy to demonstrate, especially if the length and intensity of the interventions have not been adequate. Most interventions ($n = 10$) lasted less than a year, and their intensity was not always reported.

The information regarding the total amount of daily physical activity is not clearly described in the studies included in this meta-analysis. Also, the great diversity of intervention programs makes it difficult to compare results across studies and therefore conclude which characteristics are the most effective. The environment also plays an important role in the prevalence of obesity. Healthy school environments, comprising facilities for exercise practice, with more access to water and healthy foods could help minimize the possibility to have regular unhealthy behaviors [37] and contribute to mitigate the fundamental drivers of excessive weight gain, which are physical inactivity and poor diet [38].

The use of BMI as an indicator of overweight and obesity is widespread. BMI is defined as weight divided by height squared (kg/m^2), and as it is based on only weight and height, it does not represent an actual measure of adiposity and does not reflect actual body fatness. As an indirect measure of obesity, BMI has some weaknesses. BMI does not consider age nor gender. The percentage of body fat increases with age, while muscle mass decreases, but the weight and height of an individual do not necessarily reflect those changes. Furthermore, the relation between body fat and BMI is different for women and men [39]. Also, BMI does not consider sexual maturation stages and, some of the weight and height changes that occur during growth are a characteristic of some developmental phases [40, 41] and result in substantial increases in BMI but do not represent an increase of body fat. Similarly, it does not consider ethnicity and there is evidence that ethnicity influences the relation of BMI with body fat [42]. Therefore, BMI should be used simultaneously with other adiposity measures to provide more accurate results regarding body fat [39, 43].

Despite their modest effect in BMI, some of the interventions included in this meta-analysis reported positive results toward healthy behaviors such as (i) a reduction in sedentary behaviors [23, 25–31], (ii) an increase in the consumption of fruits and vegetables [25–27, 29] and (iii) a decrease in sugary drinks and fat rich foods consumption [25–27, 31]. These relevant findings reinforce the importance of promoting programs that focus on lifestyle behaviors at these ages, since adolescents are still being educated and these changes could contribute to the development of a sustainable healthier lifestyle.

The methodological quality of the studies was mostly moderate, indicating weaknesses in research methods, and the lack of strong evidence does not allow drawing solid conclusions about the effectiveness of obesity prevention initiatives at school. In future studies it would be important to consider randomization as an additional quality criterion, controlling (and reporting) in more detail the factors that may cause bias in pre-intervention (e.g. confounding variables, selection of participants and measurement of interventions) and post-intervention (e.g. drop-out from intended interventions, missing data and measurement of outcomes). It would also be relevant to find a strategy to apply blinding to these programs (at least from the researchers).

In this meta-analysis, we also wanted to explore the differences between the diverse types of programs. The wide variety of approaches combined in each intervention, the differences in length and intensity, as well as the tool used to measure their impact, combined with the low heterogeneity of results found by our analysis, limited the possibility to conclude about the most effective characteristics. However, it should be noted that some variability and flexibility are expected in these interventions, in order to address to different social contexts, values and interests, especially during adolescence. In fact, for an intervention to be considered evidence based and with generalized results, the study needs to be replicated with adapted methods or, as is more usual, by modifying the content to the target population in a different setting [44]. As schools are very diverse cultural contexts, future replication studies should point to a strategy of incremental knowledge accumulation [45], understanding the impact of different components of the intervention (e.g. the technological resources used, the role of the participants) and their interaction with the school setting (e.g. school characteristics, nutritional quality of school meals and existing school curriculum) and agents (e.g. training of teachers involved, parental involvement). As stated by Schwarz et al. [45], this will allow us to know not only whether a given intervention is effective but above all which components and combinations of components and contexts are relevant to achieve their real purpose; this is vital practical information so that interventions can be effectively applied in our schools.

Limitations

The present study has several limitations. The analysis and selection of the studies was done only by one researcher, which may have caused some bias. Ideally, at least two researchers should have independently worked on this review. All non-RCT studies were excluded. Only English written articles were included, which is another limitation. Most of the studies presented in this meta-analysis included a higher percentage of female individuals, which can cause gender bias; future studies should ideally include similar percentages of both genders.

Conclusion

The evidence concerning the effectiveness of school-based interventions to reduce the BMI in adolescent is diversified. More and better studies are needed in order to provide insight about an effective framework to be implemented in the school setting. Despite the modest results reported in this meta-analysis on BMI changing, there is no doubt that the promotion of healthy behaviors should be implemented in all schools, as they are fundamental to the development of a sustainable healthy lifestyle.

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Conflict of interest statement

None declared.

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