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ORIGINAL RESEARCH

Effects of Intervention Programs on Child and Adolescent BMI: A Meta-Analysis Study

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***Background*:** This meta-analysis study aims to assess the efficacy of school-based and after-school intervention programs on the BMIs of child and adolescents, addressing the correlation between some moderating variables. ***Methods*:** We analyzed 52 studies (N = 28,236) published between 2000–2011. ***Results*:** The overall effect size was 0.068 ($P < .001$), school ($r = .069$) and after-school intervention ($r = .065$). Programs conducted with children aged between 15–19 years were the most effective ($r = .133$). Interventions programs with boys and girls show better effect sizes ($r = .110$) than programs that included just girls ($r = .073$). There were no significant differences between the programs implemented in school and after-school ($P = .770$). The effect size was higher in interventions lasting 1 year ($r = .095$), with physical activity and nutritional education ($r = .148$), and that included 3–5 sessions of physical activity per week ($r = .080$). The effect size also increased as the level of parental involvement increased. ***Conclusions*:** Although of low magnitude ($r = .068$), the intervention programs had a positive effect in prevention and decreasing obesity in children. This effect seems to be higher in older children's, involving interventions with physical activity and nutritional education combined, with parent's participation and with 1-year duration. School or after-school interventions had a similar effect.

***Keywords*:** obesity, effect-size, school, after-school

The International Obesity Task Force recently reported that approximately 155 million school-aged children are overweight or obese worldwide.[1] Sedentary habits such as screen viewing as well as excessive energy intake have been associated with a high risk of developing childhood obesity.[2,3] These styles of behavior have been frequently associated with low levels of physical activity (PA) and obesity,[4] which may increase the risk of several organic disorders, such has hypertension,[5–7] type 2 diabetes,[8] osteoporosis,[9–11] hypercholesterolemia, and insulin resistance.[12]

Several medical and scientific institutions (American Heart Association, Center for Disease Control USA, American College of Sports Medicine, National Institutes of Health) have demonstrated their great concern with decreased levels of PA in children and young people, declaring the adoption of an active lifestyle at this age to be of paramount importance. Understanding the factors that allow intervention programs to succeed in reducing obesity is one of the most important challenges among epidemiologists and public health researchers.

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Since childhood and youth are seen as the age periods in which PA habits are acquired and consolidated, it is of extremely important to implement PA intervention programs for young people. This type of intervention should effectively encourage children as well as their family and friends to adopt an active lifestyle.

Many intervention programs have been developed based on design priorities such as a) increasing levels of PA and education about healthy eating,[13–15] b) decreasing the sedentary behaviors,[16,17] c) increasing welfare of children by improving their body image and self-esteem,[18] as well as d) discouraging the consumption of soft drinks, promoting the consumption of water, and emphasizing the importance of balance in quality of life.[19]

Some review studies have demonstrated the heterogeneity of obesity prevention programs for children. Previous meta-analysis studies have focused on the effect size of intervention programs conducted either exclusively in school[20–24] or exclusively after-school.[25] However, there have been no meta-analysis studies that systematically review the effect of both types of intervention programs (ie, in school and after-school) on body composition (measured by BMI) in children and adolescents.

The purpose of this study is to assess the efficacy of the school-based and after school interventions programs on children and adolescents BMI reduction considering the correlation between some moderating variables, and intend to be an update of the effect size estimate of intervention programs on children BMI.

Methods and Procedures

This meta-analysis was conducted in accordance with the recommendations and criteria outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analysis statement.[26]

With the purpose to update the information related with the effect size estimation of intervention programs on children's body composition, only articles published between 2000–2011 were included. Worldwide children's obesity and overweight have been rising in the last years, which have increased concerns and publications on this subject. Part of these publications relied on descriptive studies on children's obesity incidence and only more recently research have concerned on implementing strategies to face this problem. So, this meta-analysis focuses on the effectiveness of the last years implementing programs to face children's obesity.

Data Sources and Search Strategy

The following databases were searched for articles published between 2000–2011: PubMed MEDLINE; Web of science (Web of ScienceSM; Current Contents Connect); List at EBSCO (Academic Search Complete); Latindex; SciELO.org and editors: Elsevier, Wiley, Springer, Taylor & Francis. The keywords used for searching were "physical activity interventions" or "prevention programs" and "school-based" or "after-school" and "obesity" or "overweight" and "child" or "adolescent" and "BMI" or "body composition" or "body fat." The references of all retrieved studies were examined to detect other potential relevant studies not identified by the database searches.

Inclusion Criteria

School and after-school intervention programs with children under 19 years old that used randomized controlled trials or nonrandomized clinical trials with a group that was not submitted to any intervention (control group) were included. Only studies that applied intervention programs for at least 6 weeks and reported the effect size on children's body mass index (BMI) were considered. Studies were also included that indicated the effect size of intervention or the pre- and postintervention values of BMI, BMI *z* score, BMI d score, BMI percentile, percentile of overweight/obesity, or body fat.

The selected studies applied interventions programs that aimed to a) increase the levels of PA by adapting the school curriculum and providing an effective increase in time spent in PA and sports practices (playing ball, running, jumping, dancing, volleyball, soccer, handball, swimming, aerobic exercise and other), both at school and during leisure time; b) change and control the diet of children in schools or at home by reducing intake of hyper-caloric foods and drinks and promoting increased intake of vegetables and other foods low in calories; and c) reduce sedentary activities, such as watching television or playing video games, offering follow-up sessions about healthy behaviors.

Selection of Moderator Variables

Moderator variables largely based on the models presented by Cook-Cottone et al[23] and Stice et al[27] were chosen. Two authors of the current study were responsible for separately encoding each of the moderator variables, which were then compared with ascertain the percentage of agreement. The description of the criteria for coding is presented in the following section.

Moderator Variables and Coding Criteria

The variables included as moderator were previously specified and all presented, independently of their level of significance

Age. According to the recommendations established by the American Academy of Pediatrics,[28] the prevention of obesity is a relevant concern for children of all ages. Thus, the current review will take into account the average age of children as a potential moderator. Using the mean age of each study, children 10 years of age or younger were classified as "Elementary," children who were at least 10 years of age but not older than 15 were coded as "Middle school age," and children over 15 and younger than 19 were coded as "High school age." When the ages of the participants overlapped 2 of these intervals, combined coding was used: "Elementary/Middle school age" or "Middle school age/High school age."

Sex. Since some authors[29,30] have found different effects of intervention programs, depending on the sex of the children, it is appropriate to examine sex as a moderator variable. In this study, the gender of the participants included the following groups: a) girls only, b) mixed (girls and boys), and c) mixed groups where girls and boys were analyzed separately. A group with boys only was not included in the present analysis because no intervention programs exclusively with boys were found in the literature.

In School or After-School. Several studies indicated that both intervention programs in school[31,32] and after-school[33,34] have a positive effect in prevention and in decreasing the obesity in children. In this case, the effect size of intervention programs in school varied between $r = .36$ and $r = .39$ and in after-school intervention programs varied between $r = .23$ and $r = .58$. However, the effectiveness of both types of intervention is unknown. To analyze the effect size of programs conducted in schools compared with interventions outside the school, we consider this variable as a potential moderator.

Intervention programs conducted within school were coded with "School," and those that occurred outside school were coded "After-school."

Type of Intervention. Since obesity is a multifactorial problem, intervention programs normally involve a combination of several variables, such as nutritional education, PA, and reduction of sedentary behaviors, frequently involving family members in these efforts. To examine the effect of each of these variables separately or in combination we considered them as potential moderator variables.

The type of intervention program under analytical review was cataloged as physical activity (PA), nutrition (D), or change in lifestyle (LS). When appropriate, programs combining the aforementioned variables were also included.

Duration of Intervention. Some authors[23] have shown that interventions of moderate to long terms are associated with a greater effectiveness in reducing BMI.

On the other hand, Vanhelst et al[35] reported that short-term programs are most effective. Therefore, the duration of programs was considered as a moderator variable.

The duration of the intervention programs were coded as: "<1" if the duration was between 6 weeks and 12 months, "1 year" when the duration was between 10 and 12 months (academic year and calendar year), or ">1" if the duration was more than 1 year.

Physical Activity Frequency. Several authors[36,37] have determined that low levels of PA in children and young people increase the risk of developing obesity. Nonetheless, no consensus has been reached regarding the ideal number of PA sessions needed to achieve an optimal effect. Thus, we considered the frequency of PA as a moderator variable. We code the frequency of intervention as: minimal (1–2 times per week), moderate (3–5 times per week), or high (more than 5 times per week). The intensity of PA was not considered because it is not described in most of the studies.

Parental Involvement. Family involvement is considered important in ensuring changes in nutrition and PA levels of children, since parents usually control their children's food choices and leisure-time practices PA.[22] However, the review carried out by Cook-Cottone et al[23] showed nonsignificant differences in the effects of programs that included parents compared with those that did not include them. To try to establish the effect of parental involvement on the prevention of obesity in children, we coded this variable as a potential moderator.

Parental involvement was coded as a) minimal parental involvement, b) moderate parental involvement, c) high parental involvement, or d) no parental involvement.

Outcome Measurement

Excess of weight is commonly identified by calculating the body mass index (BMI), by quantifying the body composition, or by measuring waist perimeter or skinfolds of subcutaneous fat. According to the classification proposed by Cole et al,[38] all subjects between 2–18 years were categorized in a standardized manner using the same criteria (normal weight, overweight, or obese). BMI z scores and BMI were selected as outcome measures because they have shown a high correlation with adiposity values.[39] In addition, these measures are the most commonly used in studies evaluating the effects of intervention on the prevention of obesity in children.[38,39]

However, some authors[40] have suggested that changes associated with physical growth as well as the individual variability inherent to puberty make the results of BMI by age difficult to interpret. For this reason, the use of classifications of sexual maturation is recommended to control for differences between preadolescent children and adolescents.[40]

Statistical Analysis

This meta-analysis included 19 articles where the correlation value (r) between the variables in question was present and was taken directly as the effect size value. In other studies, the value of r (effect size) was calculated using the mean values and standard deviations of the initial and final 2 groups (treatment and control). According to Cohen the effect sizes to test the significance of product moment correlation coefficient (r) are, .10, .30, and .50, for small, medium, and large, respectively.[41]

Analyses were computed using subgroups that were determined using moderator variables, and the Q_B test was used to determine the influence of each variable.

Fixed-effect analyses were conducted, and study weights (ie, how much a study is factored into an overall effect estimate) are proportional to sample size and standard error.

To test for evidence of publication bias, we examined a standard funnel plot.[42] In addition to this graphical check for bias, we also used the rank-correlation test of Begg and Mazumdar,[43] which is a formal statistical test of bias that are based on the same consideration that underlies the funnel plot.

The heterogeneity of the studies was evaluated by their statistical values for Q and I^2.[44]

Statistical analysis was performed using Comprehensive Meta-Analysis (CMA) version 2.2.048.[45]

Results

Study Selection

An initial search using the keywords described located 778 studies. After reading titles and abstracts, the number of studies was reduced to 188. Of these, 83 were experimental studies of intervention programs for children and adolescents; the others were archived since they only referenced desirable content such as determinants of obesity in children (42 studies), meta-analysis and systematic review (17 studies), prevalence of obesity in children (44 studies), or habitual physical activity (4 studies), among others.

After reading the abstracts and in some cases the full text, the number was reduced to 67 studies.

In the final refinement of the research, once the criteria for the inclusion of studies had been defined, only 52 studies fulfilled all necessary requirements.

Excluded Studies

Studies of the intervention programs that did not have a control group (1), or intervened only in subjects' diets (1), were excluded. Studies (4) involving children suffering from eating disorders or drug or alcohol problems were not used.

Trials that were only descriptive (6) were also excluded.

Studies Characteristics

Seventeen of the programs were carried out after school, while the remaining 35 occurred in school settings. Of the 52 studies included, only 11 intervention programs were exclusively based on PA. Ten intervention programs combined PA and D. Eleven intervention programs aimed at lifestyle changes (LS) by controlling variables such as interactive multimedia, nutrition education, nutrition policy, social marketing, encouragement of physical activity, and health related sessions.

There were included 9 studies involving PA and LS interventions, and 4 studies with D and LS.

Programs that combined all 3 components (PA, D, and LS) represented the remaining 7 studies.

In terms of program duration, 7 studies took place over the course of 1 year, 33 programs lasted less than 1 year, and the remaining 12 were longer than 1 year.

The intervention of the parents was requested in 26 programs; the remaining 25 studies involved only children. In 1 study, the 2 possibilities were both studied.

Participant Characteristics

The analysis included a total of 28,236 children and adolescents. In 28 of the analyzed studies, the participants were 10 years of age or younger, in 14 studies the participants were over 10 years old but not older than 15, and in 4 of them the subjects' ages were over 15 but less than 19. Age groups of 5–12 years were included in 6 studies, and a sample between 12–19 years of age was considered in 1 study. One study examined separate samples that contained one group of third graders and another group of fourth to seventh graders.

In most of the studies the samples comprised children of both genders (37 studies), while 7 of the studies had only girls. In 8 studies, boys and girls were analyzed separately.

Analysis of Studies

The synthesis of the studies included in the analysis is presented in Table 1. It shows a summary of the methodology used in each of the programs implemented in school or after school to prevent or combat obesity in children and adolescents. The number of subjects and the length of intervention is also described, as well as the evaluated outcome measurement.

The weighted mean difference in change in BMI, BMI z score, percentile BMI, and overweight/obesity between the intervention group and the control group can be seen in Figure 1. The size of each data marker indicates the weight assigned to the individual study.

Effect Analysis of Moderators

The results indicated a significant effect in 52 studies (N = 28,236) $r = .068$, $P = .000$ (95% confidence interval = 0.058, 0.079). Although this effect is of low magnitude[41] the results from the 2 different tests showed no bias' evidence of publications. The funnel plot shows a symmetrical distribution of points, reminding 1 inverted funnel, and the rank-correlation test of Begg and Mazumdar[43] ($P = .42$) confirm this lack of bias (see Figure 2).

A test for heterogeneity of variance indicates that the results of the study are significantly higher than would be expected, Q (72) = 708.046, $P = .000$. This indicates that there are studies or moderator variables that explain the variation in effect size.

Table 2 shows the effect sizes of each moderator variable on BMI.

Regarding the characteristics of the participants, it can be seen that the age is a moderator of effect size, showing a statistically significant difference between groups ($P < .001$). Interventions targeting elementary ($r = .106$) and high school aged ($r = .133$) participants had a higher effect size. Programs that intervened with children between 10 and 15 years old, despite being statistically significant ($P = .001$), demonstrated a smaller effect size ($r = .027$). There was no significant effect in the intervention group aged between 10 and 19 years ($P = .391$), although the size of its effect is positive ($r = .041$).

Intervention programs with boys and girls show the highest effect size (data from boys and girls pooled together: $r = .110$, $P < .001$). Nonetheless, other studies that applied the same intervention program to girls and boys but presented results separately for each gender revealed that the effect size was higher in the girls ($r = .030$, $P < .005$) than in the boys ($r = .005$, $P = .642$). When the intervention programs were done exclusively with girls, the effect size was higher ($r = .073$, $P = .015$).

The results show that intervention programs at school had a higher effect ($r = .069$) than the programs in after-school settings ($r = .065$), however the effect is not significantly different ($P = .770$).

When the intervention had a duration of less than 1 year, the effect size was lower ($r = .046$, $P = .000$) than those that lasted 1 year ($r = .095$, $P = .000$) or more ($r = .086$, $P = .000$). In all of these cases, the effect size between the duration of intervention was statistically significant ($P = .001$).

A statistically significant effect ($P < .005$) was found in all types of interventions considered in the present analysis (PA, LS, PA+D, D+LS, and PA+D+LS), with the exception of the PA+LS programs ($P = .060$).

The programs that focused on children's PA and D were the most successful, with an effect size of 0.148. Positive effects were also obtained by interventions only in LS ($r = .088$), and in LS combined with D ($r = .082$). When the intervention concentrated only on increasing the PA levels of children and young people, the effect size was smaller ($r = .029$) $P = .027$.

In the 11 programs that combined AF, LS, and D in the form of intervention, although the results obtained were statistically significant ($P < .001$), the effect size was only 0.047.

The effect of the programs involving PA sessions was statistically significant when the frequency of the

Table 1 Synthesis of the Studies Included in the Analysis

Authors	Name of program	Type of program	Type of intervention	Study description	N	Duration	Outcome measure	Effect size (*r*)
Alves, et al (2008)		After-School	PA	The exercise program was composed of recreational activities with moderate-intensity energy expenditure (playing ball, running, jumping, dancing), as well as aerobics sessions. All participants maintained ad *libitum* diets.	78	<1year	BMI	0.05
Amaro S, et al (2006)	Kalèdo	After-School	LS	Kalèdo on changes in nutrition knowledge and dietary behavior in a pilot study conducted in 3 middle schools in Naples, Italy.	241	<1year	BMI *z* score	0.20
Annesi JJ, et al (2009)	Youth Fit For Life	After-School	PA	Youth Fit For Life: an intervention based on social cognitive theory.	25	<1year	BMI	0.58
Angelopoulos, et al (2009)		School	LS	Dietary and physical activity: assessment integrated in the existing school curriculum, primarily combined with physical education and science and environmental classes providing the less possible disturbance. The themes covered included body image, nutrition, physical activity, fitness and environmental issues.	646	1year	BMI	0.16
Barbeau P, et al (2007)		After-School	PA+D	After-school physical activity program on body composition and cardiovascular fitness in young black girls: 30 minutes of homework time during which the subjects were provided with a healthy snack free of charge, and 80 minutes of physical activity.	201	<1year	BMI	0.04
Bayne-Smith M, et al (2004)	PATH	School	PA+LS	The Physical Activity and Teenage Health (PATH) program consisted of 30-minute classes conducted 5 days per week. Individual classes began with a brief 5- to 10-minute lecture and discussion featuring a topic related to cardiovascular health and fitness and suggestions for modifying health behaviors.	442	<1year	BMI	0.04
Caballero B, et al (2003)	Pathways	School	PA+D+LS	The Pathways Obesity Prevention Program consisted of 4 components: classroom curriculum, food service, physical activity, and family involvement.	1367	>1year	BMI	0.04
Carrel AL, et al (2005)		School	PA+D	Physical activity and nutrition education: fitness classes also received a small nutrition education component. This consisted of educational handouts to participants encouraging them to develop healthier eating habits. The frequency of fitness-oriented and standard physical education classes was 5 times every 2 weeks for a 45-minute class period.	50	<1year	BMI	0.06

(continued)

Table 1 *(continued)*

Authors	Name of program	Type of program	Type of intervention	Study description	N	Duration	Outcome measure	Effect size (*r*)
Damon S, et al (2005)	Presto	School	LS	Presto: 11 nutrition and health related sessions occurred 1 h per week in each class, as well as physical activity education.	381	<1year	BMI *z* score	–0.07
Dzewaltowski, et al (2010)	HOP'N	After-School	PA+D+LS	Healthy Opportunities for Physical Activity and Nutrition (HOP'N): included an organized daily PA session for at least 30 minutes, a daily healthful snack that included a FV, and a weekly nutrition and PA education experience.	246	>1year	BMI *z* score	0.59
Economos CD, et al (2007)	Shape Up Somerville	After-School	PA+D+LS	Shape Up Somerville: community participatory process, consisting of increasing physical activity and changes to school food service and classroom curriculum.	1178	>1year	BMI *z* score boys: control group 1	0.01
							Girls: control group 1	0.01
							Boys: control group 2	0.01
							Girls: control group 2	0.02
Edwards B, et al (2005)	Food & Fitness 101	School	PA+D	An alternative physical education class called Food & Fitness 101: aerobic activities and nutrition education.	27	1year	BMI	0.03
Eliakim A, et al (2007)		School	PA+D	Combined dietary-behavioral-physical activity intervention: consisted of adding nutrition education and providing daily exercise training.	101	<1year	BMI percentile	0.08
Farias, et al (2009)		School	PA	The program includes 2 physical education classes weekly, with aerobic activity (flexibility exercises, jumping rope, walking, jogging, alternating jumps in continuous rhythm, and recreational games), sports games (volleyball, soccer, handball, and swimming), and stretching.	383	<1year	BMI Boys	0.03
							Girls	0.02
Foster GD, et al (2008)	SNPI	School	LS	Multicomponent School Nutrition Policy Initiative (SNPI): school self-assessment; nutrition education; nutrition policy; social marketing; encouragement of physical activity, and parent outreach.	843	>1year	BMI *z* score	0.01
Goldfield GS, et al (2006)		After-School	PA+LS	The intervention program: increase physical activity and provide 30-minute access to television. activity.	30	<1year	BMI	0.09

(continued)

Table 1 *(continued)*

Authors	Name of program	Type of program	Type of intervention	Study description	N	Duration	Outcome measure	Effect size (*r*)
Goran MI and Reynolds K (2005)	IMPACT	School	LS	Interactive Multimedia for Promoting Physical Activity (IMPACT): increase levels of physical activity; decrease sedentary behavior; an interactive educational learning game based on social cognitive theory and exploration of psychosocial variables related to physical	122	<1year	BMI *z* score boys	–0.29
							Girls	0.15
Graf C, et al (2005)	STEP TWO	School	PA+D	The STEP TWO program: using a diet based on the OPTIMIX pyramidal program for nutrition for children and physical activity lasting for between 60 and 90 minutes.	184	<1year	BMI	0.00
Haerens L, et al (2006)		School	PA+D	Na intervention program: increasing physical activity time and promoting healthy nutrition.	2291	>1year	BMI *z* score boys: Intervention without parents involvement	–0.03
							Girls: Intervention without parents involvement	0.04
							Boys: Intervention with parents involvement	0.00
							Girls: Intervention with parents involvement	0.08
Harrison M, et al (2006)	Switch Off—Get Active	School	LS	'Switch Off—Get Active': health education intervention aimed at increasing physical activity and reducing screen time.	312	<1year	BMI	0.39
Jamner MS, et al (2004)	FAB	School	PA+LS	Project FAB: increase physical activity among sedentary adolescent females; included aerobic dance, basketball, swimming, and Tae Bo. One day a week discussion focusing on the health benefits of physical activity.	47	<1year	BMI percentile	0.01
Jiang J, et al (2007)		School	PA+D	The main component of the intervention program was nutrition education aimed at both the children and their parents. Increasing consumption of vegetables and fruits and physical activity.	2425	>1year	BMI	0.36

(continued)

Table 1 *(continued)*

Authors	Name of program	Type of program	Type of intervention	Study description	N	Duration	Outcome measure	Effect size (*r*)
Kafatos I, et al (2007)	Cretan Health and Nutrition Education	School	D+LS	The 'Cretan Health and Nutrition Education Program': health and nutrition education	176	>1year	BMI *z* score	0.12
Kain J, et al (2004)	Active Living Challenge	School	PA+LS	Educational program for children: diet/nutrition education for children and parents and 90 min of additional physical activity weekly (based on the Canadian Active Living Challenge).	3086	<1year	BMI *z* score boys	0.05
							Girls	–0.02
Kipping RR, et al (2008)	Eat Well and Keep Moving	School	PA	Eat Well and Keep Moving (adapted version): lessons on healthy eating, physical activity and reducing TV viewing.	472	>1year	Obesity	–0.11
Lazaar N, et al (2007)		After-School	PA	The intervention program included physical education classes and participating in less than 3 h of extra-school sports activity per week.	100	<1year	BMI *z* score	0.38
Liu A, et al (2008)	Happy 10	School	PA+D+LS	The Happy 10 program focused on the promotion of physical activity, physical growth, and development of primary school students, and on obesity control and prevention.	753	1year	BMI boys	–0.02
							Girls	0.15
Lohman T, et al (2003)	Pathways	School	D+LS	Pathways program: detail the curriculum and physical education components; and summarize the formative assessment and the school food service and family components of the intervention.	1368	>1year	BMI	0.03
Manios Y, et al (2002)		School	PA	The intervention program included health and nutrition education.	641	>1year	BMI	0.07
Martinez Vizcaino V, et al (2008)	Movi	After-School	PA	Movi program included stretching, aerobic resistance and muscular strength/resistance exercises. On average, these exercises required physical activity of moderate intensity.	1044	<1year	BMI boys	0.00
							Girls	0.01
McMurray RG, et al (2002)		School	PA+LS	The program included 3 intervention groups: exercise only (5-minute warm-up, 20–30 minutes of aerobic activities, and a 5-minute cool down);	1140	<1year	BMI	0.00
				education only (information on nutrition, smoking, and exercise, and used existing health curricula materials);				0.00
				and combined exercise and education (normal health curriculum, which did not emphasize cardiovascular disease risk factors).				0.00

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Table 1 *(continued)*

Authors	Name of program	Type of program	Type of intervention	Study description	N	Duration	Outcome measure	Effect size (*r*)
Melnyk BM, et al (2007)	COPE	After-School	PA+D+LS	The COPE Healthy Lifestyles TEEN program: session cognitive-behavioral skills building program that included physical activity.	11	<1year	BMI	0.59
Neumark-Sztainer D, et al (2003)	New Moves	School	PA	The New Moves program: promote physical education, healthy eating behaviors and explore social support.	201	<1year	BMI	0.13
Neumark-Sztainer D, et al (2009)	Ready. Set. ACTION	After-School	PA+D	Ready. Set. ACTION!': reducing soda pop; adopting healthier eating and physical activity; limiting television viewing ;promoting self-esteem and body image.	96	1year	BMI	0.36
Pangrazi RP, et al (2003)	PLAY	School	LS	Promoting Lifestyle Activity for Youth (PLAY): promote moderate to vigorous physical activity in children and habits active lifestyle. Play and physical activity;	599	<1year	BMI	0.16
				physical education only;				0.06
				play only.				0.13
Perman, et al (2008)		School	PA+LS	The intervention included sessions of fun physical activities, proper nutritional information and healthy motivations.	376	<1year	BMI percentile	0.04
Reilly JJ, et al (2006)		School	PA	The physical activity program in nursery included health education, increase physical activity and reducing sedentary behavior.	545	1year	BMI *z* score	0.00
Robbins LB, et al (2006)	Girls on the Move	After-School	LS	"Girls on the Move" program included recommendations to encourage increased levels of the physical activity and didactic information and discussions to develop skills.	77	<1year	BMI Average age of 11.25	0.14
							Average age of 12.37	0.08
							Average age of 13.44	0.03
Rosenbaum, et al (2007)		School	PA+D	The intervention program consisting of health, nutrition, and exercise classes plus an aerobic exercise program on diabetes risk health, nutrition, and exercise classes plus an aerobic exercise.	73	<1year	BMI	0.33
Sahota P, et al (2001)	APPLES	School	LS+D	The Active Program Promoting Lifestyle Education in School (APPLES): involved school community including parents, teachers, catering staff, and the school environment. School lunch modifications and promote healthy nutrition and physical activity.	636	<1year	BMI	0.00

(continued)

Table 1 *(continued)*

Authors	Name of program	Type of program	Type of intervention	Study description	N	Duration	Outcome measure	Effect size (*r*)
Salmon J, et al (2008)	Switch-play	School	PA+LS	Switch-play: reduce time spent in screen behaviors, promote participation in and enjoyment of physical activity and improve fundamental movement skills. A behavioral modification group;	268	1year	Overweight obesity	0.03
				a combined behavioral modification and fundamental movement skills group;				0.27
				a fundamental movement skills group.				0.13
Schofield L, et al (2005)		After-School	PA	The intervention program: prescription for increasing the health-related physical activity with educative program. The adolescent girls were involved in physical activity self-monitoring.	85	<1year	BMI	0.12
Singh AS, et al (2007)	DOiT	School	PA+LS	Dutch Obesity Intervention in Teenagers (DOiT): encouraged additional physical education class and increase awareness and behavioral changes concerning energy intake and energy output.	894	<1year	BMI boys	–0.01
							Girls	0.01
Skybo TA and Ryan-Wenger N (2002)	American Heart Association's Heart Power!	School	LS	American Heart Association's Heart Power!: instructional sessions on heart health, nutrition, physical activity, and living tobacco free.	56	1year	Percentile body fat	0.00
Spiegel SA and Foulk D (2006)	WAY	School	LS	Wellness, Academics & You (WAY) program: a multidisciplinary elementary school based intervention included math, science, constructivism, infused into language arts, and health curricula, encourage physical activity, along with healthy attitudes and behaviors.	1013	<1year	BMI	0.19
Stock S, et al (2007)	Healthy Buddies	School	PA+D+LS	Healthy Buddies program: fitness sessions and healthy living: being physically active, eating healthy foods, and having a healthy body image.	791	<1year	BMI K-third grades group	0.00
							Fourth-seventh grades group	0.08
Story M, et al (2003)	Girlfriends for KEEPS	After-School	PA+D	Girlfriends for KEEPS (Keys to Eating, Exercising, Playing, and Sharing) program increase physical activity, decrease sedentary behaviors, encourage the enjoyment of activity, and teach nutrition and healthy eating.	53	<1year	BMI	0.23

(continued)

Table 1 *(continued)*

Authors	Name of program	Type of program	Type of intervention	Study description	N	Duration	Outcome measure	Effect size (*r*)
Taylor RW, et al (2007)	APPLE	School	LS+D	A Pilot Program for Lifestyle and Exercise (APPLE): encourage healthy nutrition and physical activity. Community activity coordinators played a role in promoting activity during after-school hours.	730	>1year	BMI *z* score	0.15
Weintraub DL, et al (2008)	SPORT	After-School	PA	The Stanford Sports to Prevent Obesity Randomized Trial (SPORT) program: practice was devoted to learning soccer skills in the context of fun skill-building exercises. Promote positive experiences through sport with an emphasis on respect for self and others, inclusion, and teamwork.	21	<1year	BMI *z* score	–0.97
Williamson DA, et al (2007)	The Wise Mind	After-School	LS	The Wise Mind Project: modifying the school environment to improve healthy eating habits, increase physical activity, and decrease sedentary behavior at school and to encourage these same behavioral changes outside the school environment	586	>1year	BMI *z* score	–0.18
Yin ZB, Gutin, et al (2005)	The Medical College of Georgia FitKid	After-School	PA	The Medical College of Georgia FitKid Project: an after-school intervention providing homework assistance and academic enrichment for children in addition to a healthy snack and a period of physical activity to promote exercise.	447	<1year	BMI	0.02
Yin Z, Moore JB, et al (2005)	The Medical College of Georgia FitKid	After-School	PA+LS	The Medical College of Georgia Fitkid project: sessions were mostly taught by certified physical education and subject area teachers, teacher aids and paraprofessionals and consisted of a healthy snack, academic assistance and a developmentally appropriate physical activity program.	278	<1year	BMI	0.02

Note. See Appendix for full reference list for Table 1.

Abbreviations: PA, physical activity; D, nutrition; LS, life style.

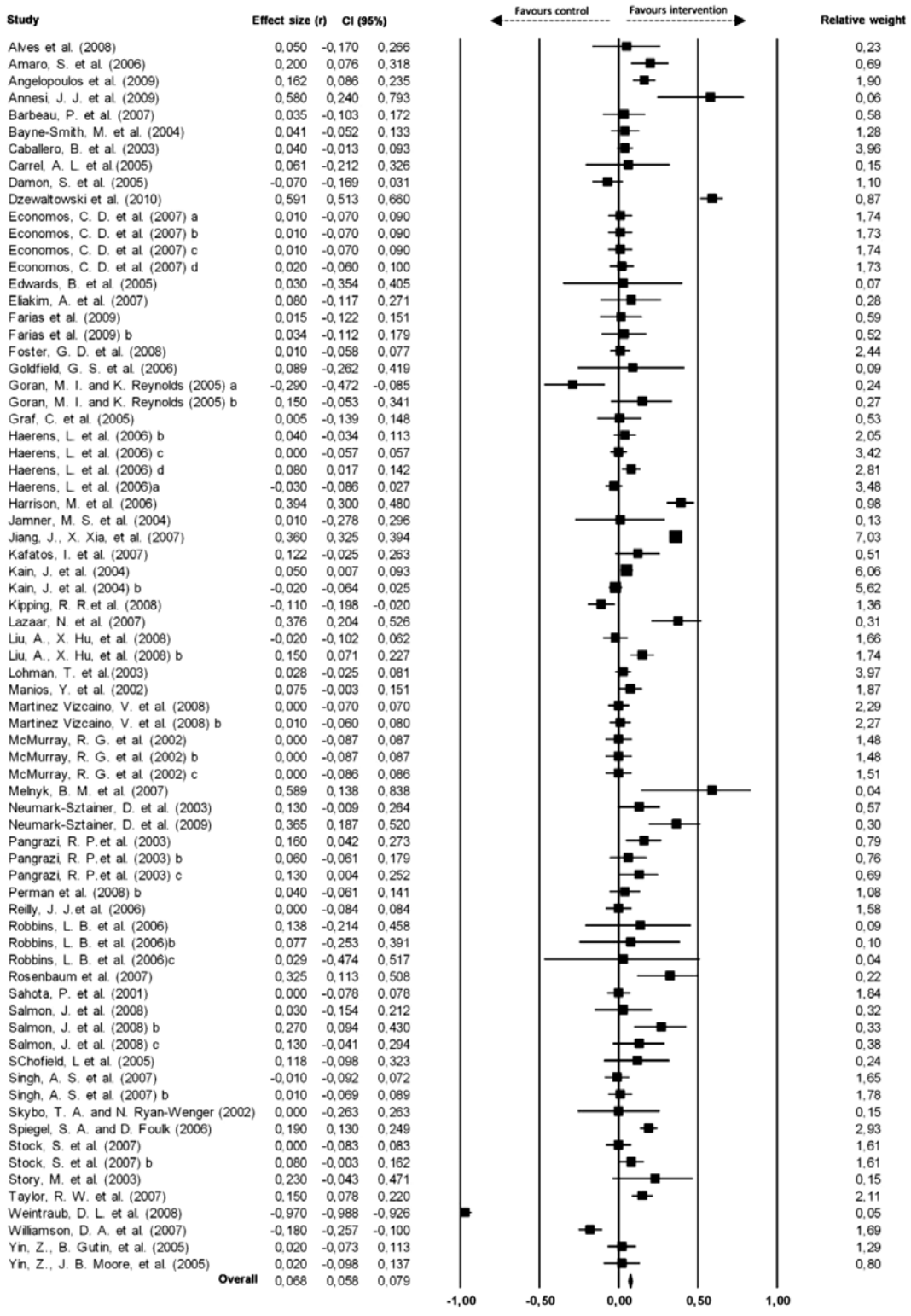

Figure 1 — Weighted mean difference in change in body composition between the intervention group and the control group. The size of each data marker indicates the weight assigned to the individual study. These weights are proportional to the inverse of the variance for each study. Larger studies tend to have less variance (because of sample size) and therefore receive more weight. CI = confidence interval.

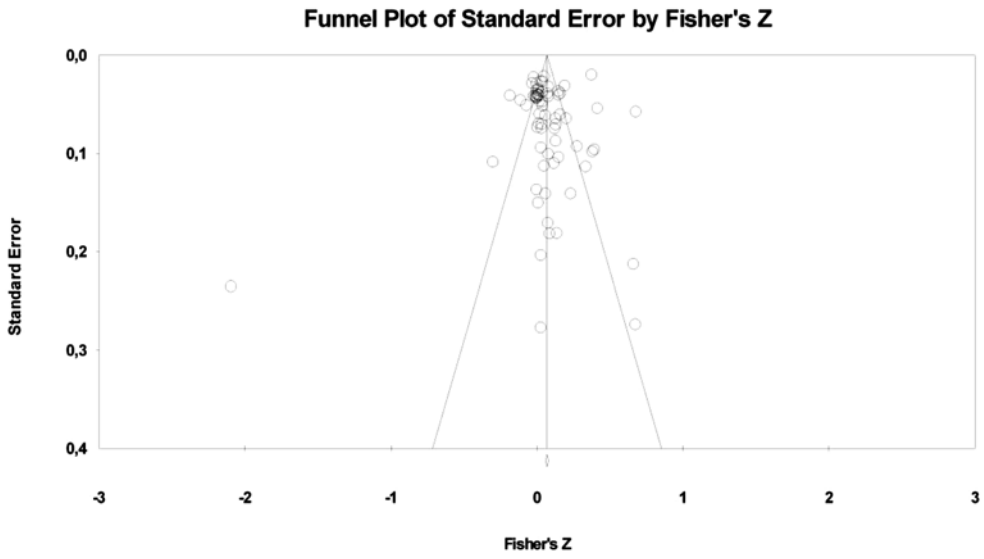

Figure 2 — Funnel plot of studies included in the analysis.

Table 2 Fixed Effects Analysis for Moderators

Moderator	Value	K	*r*	95% CI	*P*	*P* between groups
Age	Elementary	36	0.106	0.091; 0.122	0.000	0.000
	Elementary/middle school age	7	0.069	0.039; 0.100	0.000	
	Middle school age	25	0.027	0.010; 0.043	0.001	
	Middle school age/high school age	1	0.041	–0.052; 0.133	0.391	
	High school age	4	0.133	0.027; 0.236	0.014	
Sex	Males (groups mix)	10	0.005	–0.017;0.027	0.642	0.000
	Females (groups mix)	10	0.030	0.006; 0.053	0.013	
	Males+Females	44	0.110	0.096; 0.124	0.000	
	Females	9	0.073	0.014; 0.132	0.015	
Type of program	School	51	0.069	0.058; 0.081	0.000	0.770
	After-school	22	0.065	0.040; 0.090	0.000	
Duration of intervention	<1year	44	0.046	0.031; 0.062	0.000	0.001
	1year	10	0.095	0.059; 0.131	0.000	
	>1year	19	0.086	0.070; 0.101	0.000	
Type of intervention	Physical activity (PA)	17	0.029	0.003; 0.055	0.027	0.000
	Life style (LS)	16	0.088	0.061; 0.115	0.000	
	Physical activity+Nutrition (PA+D)	12	0.148	0.126; 0.171	0.000	
	Physical activity+Life style (PA+LS)	13	0.022	–0.001; 0.045	0.060	
	Nutrition+Life style (D+LS)	4	0.082	0.040; 0.124	0.000	
	Physical activity+Nutrition+Life style (PA+D+LS)	11	0.047	0.023; 0.070	0.000	
Physical activity frequency	Minimal	19	0.029	0.007; 0.050	0.008	0.001
	Moderate	22	0.080	0.064; 0.096	0.000	
	High	12	0.077	0.044; 0.109	0.000	
Parental involvement	None	37	0.047	0.030; 0.064	0.000	0.001
	Minimal	12	0.057	0.031; 0.082	0.000	
	Moderate	10	0.082	0.044; 0.120	0.000	
	High	14	0.094	0.077; 0.111	0.000	

interventions were moderate or high ($P < .005$). However, the 12 programs that occurred 3 to 5 times per week had a greater effect ($r = .080$) compared with interventions of only 1 to 2 times per week ($r = .029$, $P = .008$), or even programs that happened more than 5 times per week ($r = .077$).

In regard to parental involvement, all categories showed significant and positive effects ($P < .001$), and there were significant differences between groups ($P = .001$): no involvement ($r = .047$), minimal ($r = .057$), moderate ($r = .082$), and high ($r = .094$).

Discussion

The main objective of this meta-analysis was to assess the efficacy of intervention programs on the BMI of children and adolescents, as well as explore the possible differences between the school and after-school intervention programs.

The overall effect was of low magnitude ($r = .068$), although statistically significant ($P < .001$).

As in previous meta-analysis reviews,[23,27] the results of this study indicate that there is much work to be done to identify the best practices for preventing the onset of obesity.

In present study the magnitude of the effects produced by both school ($r = .069$) and after-school based ($r = .065$) interventions on body composition in children were very similar. Equivalent effect sizes were described by Cook-Cottone et al[23] for prevention programs in schools ($r = .05$, $P < .001$). From the studies analyzed, only 38% produced significant effects in preventing weight gain. However, in the study from Stice et al,[27] the average effect of the interventions was even lower ($r = .04$).

The low magnitude of results may be due to the great diversity of intervention programs (type of program, duration, type of activities, frequency and intensity of the sessions) applied by the different studies. In addition, it is possible that lack of involvement or attendance on the part of the children, particularly in the sessions of after-school intervention programs, may have also contributed to the observed results.

However, it was expected that PA intervention programs in school settings would have greater effects than after-school PA interventions programs. The explanation could be that the rules established during school time may lead to the impression that the goals were reached during school and there is no need to maintain the behavior after school. It is possible that the changes in PA levels and eating habits imposed through school interventions may lead to a decrease of PA as well as an increase of caloric intake after school.

The reverse can also happen. Whenever changes are made outside school, the participants can change their behavior during the time they spend in school.

In fact, the effectiveness of an intervention program in a school environment or elsewhere may be influenced by many factors that may be beyond the control of researchers. The Influence of participants' age, parental involvement, the environment/culture and socioeconomic status can impair the effectiveness of the intervention.[46]

The efficacy of the interventions can be optimized if programs consider the specific characteristics of each participant, basing their prescriptions on individual needs.

The age of the participants proved to be a moderator variable, with higher effect size in the sampled programs with participant ages between 15–19 years ($r = .133$). Theoretically, older participants are more autonomous and able to exert greater control over their food choices and PA than younger participants.[27] Teenagers are also known to be less active than children,[47] thus may have greater potential for change.[48]

Our results follow this hypothesis; however, the effect of the 36 intervention programs that included children up to age 10 was quite similar to the intervention programs that included children with ages between 15–19 years. Cook-Cottone et al[23] also found a higher effect in intervention with young children when age is analyzed as a moderator variable.

Parental and community involvement may have a stronger influence on the effectiveness of changes in dietary and PA levels in children than in adolescents.[49]

The analysis of gender as a moderator variable indicated that interventions with mixed groups (girls and boys) produced a greater effect ($r = .110$) when compared with intervention programs with girls only ($r = .073$). When the intervention programs were applied to mixed groups but data analysis was performed separately for males and females (male $r = .005$, female $r = .030$), the size of the effect was even smaller.

In both types of studies the girls always presented higher effect sizes than boys, which theoretically allows us to say that girls may be more receptive to interventions programs that promotes weight control,[27] or that the specific characteristics of the implemented programs led to better effects in girls. This brings us to the importance of verifying if altering some of the characteristics of interventions can produce better results in male subjects. Issues related to sexual maturation may also affect these results in a misleading way.[50] Therefore, in future research, authors should consider the results of sexual maturity classification as covariate to verify if the effect size of intervention programs still favors girls.

The analysis of program duration on the effectiveness of the interventions revealed that, although all programs obtained significant effects, programs with a duration of 1 year were the most effective ($r = .095$). Unexpectedly, the interventions lasting more than 1 year produced a smaller effect ($r = .086$). Likewise, the meta-analysis conducted by Cook-Cottone et al[23] revealed that programs lasting more than 32 weeks have a lower effect ($r = .05$) than programs lasting 28–32 weeks ($r = .07$).

Even though longer interventions increase the possibility of weight loss and facilitate learning skills, they can also become boring for the participants and drop-outs can occur.[46,48]

Therefore, it is possible that some specific characteristics inherent to each program may increase the adherence of its participants, as well as its effectiveness in reducing BMI.

The specific characteristics of the intervention may influence effectiveness. The analysis that follows considering the type of intervention program as a moderator variable reflects this.

Programs that combined PA and D were the most effective ($r = .148$) in reducing BMI; this was consistent with expectations that programs that address the balance between food intake and energy expenditure would prove the most effective.

This occurred in the 16 programs that also included LS ($r = .088$). Similar results ($r = .082$) were obtained by interventions that combined LS and D.

From these results we can conclude that, even in the absence of an effective increase in PA levels, intervention aiming to reduce sedentary behaviors and promoting a healthy diet can be a positive influence on BMI reduction.

When the intervention programs included PA, LS, and D simultaneously, the effects, although statistically significant, were of low magnitude ($r = .047$).

Unpredictably, the programs involving only PA and even those combining PA with LS were not successful in reducing children's BMI. It is possible that the failure of these programs is due to an insufficient amount of PA, or poor adherence by overweight children.

We can also consider other explanations, such as the idea that the unexpected results of the PA programs are not related to the PA itself, but to the selected outcome measure, namely BMI.[5] BMI may not accurately reflect a child's fat mass loss.

A detailed description of the methodologies used in the measurements, as well as the type of physical activities that were performed, including the intensity and frequency, would allow future meta-analyses to be more consistent.

The frequency of the PA sessions is typically described by the majority of the authors. Most of the programs held 3–5 sessions a week. This frequency showed a higher effect size ($r = .080$) than frequencies of 1 to 2 sessions per week ($r = .029$), or even intervention programs held more than 5 times per week ($r = .077$). It was expected that an increase of the number of sessions per week would proportionally increase the size of the effects. However, when the interventions were applied 5 days per week, the effect size was small.

Looking specifically at 3 of the studies considered allows us to see that results can conflict. For example, the intervention carried out by Dzewaltowski et al Dzewaltowski, Rosenkranz, Geller, Coleman, Welk, Hastmann, Milliken[15] with daily PA sessions, organized for at least 30 minutes, produced quite satisfactory results ($r = .59$). Melnyk et al[51] obtained exactly the same results ($r = .59$) with sessions of 20–30 minutes of PA, but with a frequency of 1–2 times week. In the study carried out by Alves et al[52] involving recreational activities of moderate energy expenditure (playing ball, running, jumping, dancing) and aerobic sessions, the effect size of reduction in the BMI of 78 children was much more modest ($r = .05$).

In the current study, the intensity of the PA was not considered, since such parameters were not described by most of the studies analyzed. Lack of information on this variable may bias the interpretation of results, since the effect size of the intervention programs in the BMI of children are exclusively based on the frequency of PA sessions.

The programs considered by our analysis to involve moderate PA frequency may have included more intense PA than the higher frequency programs. It may also be the case that children engage more effectively in the sessions when the intervention allows 1–2 days of rest.

The effect size of intervention programs increases as the level of parental intervention also increases. The programs with high parental involvement (for example, when parents are required to comply with a change of behavior) were the ones which had a significantly stronger effect ($r = .094$, $P < .001$).

In interventions that did not include the involvement of parents, the effect size was considerably lower ($r = .047$) but also statistically significant. Although the results are in line with what would be expected, it should be noted that even though the programs calls for parental involvement, their participation is not always active and assiduous.

Study Limitations

It should be mentioned that the current study does not represent the available evidence based on the topic of children's obesity prevention, but quantitative estimates the effect size of school and after-school intervention programs, including the correlation between some moderating variables, on the BMIs of children and adolescents. As it was already mentioned, only studies indexed in PubMed databases were considered, putting aside all others studies such as master or PhD thesis and nonindexed publications which could bias our results.

BMI is an outcome measure commonly used to classify children and young people (normal-weight, overweight and obese) under 18 years old.[38] However, some authors note that the body changes and interindividual variability inherent to the stage of sexual maturation may interfere with the interpretation of BMI results.[40] Jamner et al[53] suggest the use of classification tables of sexual maturation as a way of controlling for differences in the sexual development of children and adolescents.

Weighing and measuring procedures can also add substantial variability in BMI values. To try to minimize this problem, other outcome measures have been suggested (waist circumference, skinfolds, percentage of fat mass) by McCarthy[54] as a way of screening for bias caused by the use of BMI alone. However, BMI has been shown to correlate effectively with body fat even in children and adolescents.[39]

In the future, reviews should be conducted using several anthropometric measurements and evaluating their impact on the metabolic profile of children.[20]

Another limitation of our study was the difficulty of categorizing the intensity of PA prescribed by each of the intervention programs.

Indeed, it is important that the methodologies used in the interventions be described. In the review carried out by Cook-Cottone et al[23] they found low value in activities performed at high intensities ($r = .05$, $P < .001$). Further meta-analysis studies are needed to determine the effect size of this variable.

Our study did not examine socioeconomic status, which can also be a moderator variable. The research conducted by Plachta-Danielzik et al[55] over a period of 4 years has shown that the incidence of obesity decreased only among children from families of high socioeconomic status.

Easy access to healthier food, which can be more expensive in poorer neighborhoods, as well as the ability to pay sports activity fees, can make a difference in the effect of an intervention program in the prevention of obesity in children.

Conclusions

This systematic review indicated that intervention programs had a positive effect in prevention and in decreasing the obesity in children, although this effect is of low magnitude ($r = .068$). The programs with older children seem to be more effective compared with those targeted at younger children. Nonetheless, the effect sizes of interventions involving children 10 years of age or younger are very similar to those involving older children. Girls achieved higher effect sizes than boys. The intervention programs with mixed groups (girls and boys) produced a greater effect than the intervention programs with girls only.

After-school programs had a very similar effect to those interventions developed in school settings. The results of the current study also demonstrate that intervention programs of 1 year in length had a greater effect size than those with longer or shorter durations.

According to the present analysis, the intervention programs that best contribute to the prevention of obesity in children use a multifaceted approach including PA, D and parental involvement.

References

1. Taskforce IO. Childhood obesity. Available from: http://www.iotf.org/childhoodobesity.asp. 2010.
2. Vandelanotte C, Sugiyama T, Gardiner P, Owen N. Associations of leisure-time internet and computer use with overweight and obesity, physical activity and sedentary behaviors: cross-sectional study. *J Med Internet Res*. 2009;11(3):e28. PubMed doi:10.2196/jmir.1084
3. Lee HA, Lee WK, Kong KA, et al. The effect of eating behavior on being overweight or obese during preadolescence. *J Prev Med Pub Health*. 2011;44(5):226–233. PubMed doi:10.3961/jpmph.2011.44.5.226
4. Arluk SL, Branch JD, Swain DP, Dowling EA. Childhood obesity's relationship to time spent in sedentary behavior. *Mil Med*. 2003;168(7):583–586. PubMed
5. McMurray RG, Harrell JS, Bangdiwala SI, Bradley CB, Deng S, Levine A. A school-based intervention can reduce body fat and blood pressure in young adolescents. *J Adolesc Health*. 2002;31(2):125–132. PubMed doi:10.1016/S1054-139X(02)00348-8
6. Taylor RW, McAuley KA, Barbezat W, Strong A, Williams SM, Mann JI. APPLE Project: 2-y findings of a community-based obesity prevention program in primary school age children. *Am J Clin Nutr*. 2007;86(3):735–742. PubMed
7. Stock S, Miranda C, Evans S, et al. Healthy Buddies: a novel, peer-led health promotion program for the prevention of obesity and eating disorders in children in elementary school. *Pediatrics*. 2007;120(4):e1059–e1068. PubMed doi:10.1542/peds.2006-3003
8. Angermayr L, Melchart D, Linde K. Multifactorial lifestyle interventions in the primary and secondary prevention of cardiovascular disease and type 2 diabetes mellitus–a systematic review of randomized controlled trials. *Ann Behav Med*. 2010;40(1):49–64. PubMed doi:10.1007/s12160-010-9206-4
9. Must A, Strauss RS. Risks and consequences of childhood and adolescent obesity. *Int J Obes Relat Metab Disord*. 1999;23(Suppl 2):S2–S11. PubMed doi:10.1038/sj.ijo.0800852
10. Must A, Anderson SE. Effects of obesity on morbidity in children and adolescents. *Nutr Clin Care*. 2003;6(1):4–12. PubMed
11. Zametkin AJ, Zoon CK, Klein HW, Munson S. Psychiatric aspects of child and adolescent obesity: a review of the past 10 years. *J Am Acad Child Adolesc Psychiatry*. 2004;43(2):134–150. PubMed doi:10.1097/00004583-200402000-00008
12. Huang SH, Weng KP, Hsieh KS, et al. Effects of a classroom-based weight-control intervention on cardiovascular disease in elementary-school obese children. *Acta Paediatr Taiwan*. 2007;48(4):201–206. PubMed
13. Barbeau P, Johnson MH, Howe CA, et al. Ten months of exercise improves general and visceral adiposity, bone, and fitness in black girls. *Obesity (Silver Spring)*. 2007;15(8):2077–2085. PubMed doi:10.1038/oby.2007.247
14. Burrows T, Warren JM, Collins CE. The impact of a child obesity treatment intervention on parent child-feeding practices. *Int J Pediatr Obes*. 2010;5(1):43–50. PubMed
15. Dzewaltowski DA, Rosenkranz RR, Geller KS, et al. HOP'N after-school project: an obesity prevention randomized controlled trial. *Int J Behav Nutr Phys Act*. 2010;7:90. PubMed doi:10.1186/1479-5868-7-90
16. Reilly JJ, Kelly L, Montgomery C, et al. Physical activity to prevent obesity in young children: cluster randomised controlled trial. *BMJ*. 2006;333(7577):1041. PubMed doi:10.1136/bmj.38979.623773.55
17. Williamson DA, Copeland AL, Anton SD, et al. Wise Mind project: a school-based environmental approach for

preventing weight gain in children. *Obesity (Silver Spring)*. 2007;15(4):906–917. PubMed doi:10.1038/oby.2007.597
18. Neumark-Sztainer D, Haines J, Robinson-O'Brien R, et al. 'Ready. Set. ACTION!' A theater-based obesity prevention program for children: a feasibility study. *Health Educ Res*. 2009;24(3):407–420. PubMed doi:10.1093/her/cyn036
19. James J, Thomas P, Cavan D, Kerr D. Preventing childhood obesity by reducing consumption of carbonated drinks: cluster randomised controlled trial. *BMJ*. 2004;328(7450):1237. PubMed doi:10.1136/bmj.38077.458438.EE
20. 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):719–726. PubMed doi:10.1503/cmaj.080966
21. Kropski JA, Keckley PH, Jensen GL. School-based obesity prevention programs: an evidence-based review. *Obesity (Silver Spring)*. 2008;16(5):1009–1018. PubMed doi:10.1038/oby.2008.29
22. Ng C, Anderson K, McQuillen K, Yu BN. School-based obesity and type 2 diabetes prevention programs: a public health perspective. *Canadian Journal of Diabetes*. 2005;29(3):211–219.
23. Cook-Cottone C, Casey CM, Feeley TH, Baran J. A meta-analytic review of obesity prevention in the schools: 1997-2008. *Psychol Sch*. 2009;46(8):695–719. doi:10.1002/pits.20409
24. Zenzen W, Kridli S. Integrative review of school-based childhood obesity prevention programs. *J Pediatr Health Care*. 2009;23(4):242–258. PubMed doi:10.1016/j.pedhc.2008.04.008
25. Beets MW, Beighle A, Erwin HE, Huberty JL. After-school program impact on physical activity and fitness: a meta-analysis. *Am J Prev Med*. 2009;36(6):527–537. PubMed doi:10.1016/j.amepre.2009.01.033
26. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *BMJ*. 2009;339:b2535. PubMed doi:10.1136/bmj.b2535
27. Stice E, Shaw H, Marti CN. A meta-analytic review of obesity prevention programs for children and adolescents: the skinny on interventions that work. *Psychol Bull*. 2006;132(5):667–691. PubMed doi:10.1037/0033-2909.132.5.667
28. Barlow SE. Expert committee recommendations regarding the prevention, assessment, and treatment of child and adolescent overweight and obesity: summary report. *Pediatrics*. 2007;120(Suppl 4):S164–S192. PubMed doi:10.1542/peds.2007-2329C
29. Goran MI, Reynolds K. Interactive multimedia for promoting physical activity (IMPACT) in children. *Obes Res*. 2005;13(4):762–771. PubMed doi:10.1038/oby.2005.86
30. Liu A, Hu X, Ma G, et al. Evaluation of a classroom-based physical activity promoting programme. Obes. *Rev Mar*. 2008;9(Suppl 1):130–134.
31. Jiang J, Xia X, Greiner T, Wu G, Lian G, Rosenqvist U. The effects of a 3-year obesity intervention in schoolchildren in Beijing. *Child Care Health Dev*. 2007;33(5):641–646. PubMed doi:10.1111/j.1365-2214.2007.00738.x
32. Harrison M, Burns CF, McGuinness M, Heslin J, Murphy NM. Influence of a health education intervention on physical activity and screen time in primary school children: 'Switch Off–Get Active'. *J Sci Med Sport*. 2006;9(5):388–394. PubMed doi:10.1016/j.jsams.2006.06.012
33. Story M, Sherwood NE, Himes JH, et al. An after-school obesity prevention program for African-American girls: the Minnesota GEMS pilot study. *Ethn Dis*. 2003;13(1, Suppl 1):S54–S64. PubMed
34. Annesi JJ, Pierce LL, Bonaparte WA, Smith AE. Preliminary effects of the Youth Fit For Life protocol on body mass index in Mexican American children in YMCA before- and after-school care programs. *Hisp Health Care Int*. 2009;7:123–129. doi:10.1891/1540-4153.7.3.123
35. Vanhelst J, Mikulovic J, Fardy P, et al. Effects of a multidisciplinary rehabilitation program on pediatric obesity: the CEMHaVi program. *Int J Rehabil Res*. 2011;34(2):110–4. PubMed
36. Bukara-Radujkovic G, Zdravkovic D. Physical activity as an important determinant in developing childhood obesity. *Med Pregl*. 2009;62(3-4):107–113. PubMed doi:10.2298/MPNS0904107B
37. Fulton JE, Wang X, Yore MM, Carlson SA, Galuska DA, Caspersen CJ. Television viewing, computer use, and BMI among U.S. children and adolescents. *J Phys Act Health*. 2009;6(Suppl 1):S28–S35. PubMed
38. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ*. 2000;320:1240–1243. PubMed doi:10.1136/bmj.320.7244.1240
39. Sweeting HN. Measurement and definitions of obesity in childhood and adolescence: a field guide for the uninitiated. *Nutr J*. 2007;6:32. PubMed doi:10.1186/1475-2891-6-32
40. Gortmaker SL, Peterson K, Wiecha J, et al. Reducing obesity via a school-based interdisciplinary intervention among youth: Planet Health. *Arch Pediatr Adolesc Med*. 1999;153(4):409–418. PubMed doi:10.1001/archpedi.153.4.409
41. Cohen J. A power primer. *Psychol Bull*. 1992;112(1):155–159. PubMed doi:10.1037/0033-2909.112.1.155
42. Light R, Pillemar D. *Summing up: the science of reviewing research*. Cambrid, MA: Harvard University Pressge; 2005.
43. Begg CB, Mazumdar M. Operating characteristics of a rank correlation test for publication bias. *Biometrics*. 1994;50(4):1088–1101. PubMed doi:10.2307/2533446
44. Cochran W. The combination of estimates from different experiments. *Biometrics*. 1954;10(1):101–129. doi:10.2307/3001666
45. Borenstein M, Hedges L, Higgins J, Rothstein H. *Comprehensive meta-analysis versão 2.2.048*. Englewood, NJ: Biostat; 2008.
46. Graf C, Rost SV, Koch B, et al. Data from the StEP TWO programme showing the effect on blood pressure and different parameters for obesity in overweight and obese primary school children. *Cardiol Young*. 2005;15(3):291–298. PubMed doi:10.1017/S1047951105000594
47. Riddoch CJ, Bo Andersen L, Wedderkopp N, et al. Physical activity levels and patterns of 9- and 15-yr-old European

children. *Med Sci Sports Exerc*. 2004;36(1):86–92. PubMed doi:10.1249/01.MSS.0000106174.43932.92

48. van Sluijs EM, McMinn AM, Griffin SJ. Effectiveness of interventions to promote physical activity in children and adolescents: systematic review of controlled trials. *BMJ*. 2007;335(7622):703. PubMed doi:10.1136/bmj.39320.843947.BE
49. Economos CD, Hyatt RR, Goldberg JP, et al. A community intervention reduces BMI z-score in children: Shape Up Somerville first year results. *Obesity (Silver Spring)*. 2007;15(5):1325–1336. PubMed doi:10.1038/oby.2007.155
50. Kain J, Uauy R, Albala, Vio F, Cerda R, Leyton B. School-based obesity prevention in Chilean primary school children: methodology and evaluation of a controlled study. *Int J Obes Relat Metab Disord*. 2004;28(4):483–493. PubMed doi:10.1038/sj.ijo.0802611
51. Melnyk BM, Small L, Morrison-Beedy D, et al. The COPE Healthy Lifestyles TEEN program: feasibility, preliminary efficacy, & lessons learned from an after school group intervention with overweight adolescents. *J Pediatr Health Care*. 2007;21(5):315–322. PubMed doi:10.1016/j.pedhc.2007.02.009
52. Alves JG, Gale CR, Souza E, Batty GD. [Effect of physical exercise on bodyweight in overweight children: a randomized controlled trial in a Brazilian slum] *Cad Saude Publica*. 2008;24(Suppl 2):S353–S359. PubMed doi:10.1590/S0102-311X2008001400020
53. Jamner MS, Spruijt-Metz D, Bassin S, Cooper DM. A controlled evaluation of a school-based intervention to promote physical activity among sedentary adolescent females: project FAB. *J Adolesc Health*. 2004;34(4):279–289. PubMed
54. McCarthy HD. Body fat measurements in children as predictors for the metabolic syndrome: focus on waist circumference. *Proc Nutr Soc*. 2006;65(4):385–392. PubMed
55. Plachta-Danielzik S, Pust S, Asbeck I, et al. Four-year follow-up of school-based intervention on overweight children: the KOPS study. *Obesity (Silver Spring)*. 2007;15(12):3159–3169. PubMed doi:10.1038/oby.2007.376

Appendix

The following is a full list of references that were included in the final meta-analysis and cited in Table 1.

Angelopoulos PD, Milionis HJ, Grammatikaki E, Moschonis G, Manios Y. Changes in BMI and blood pressure after a school based intervention: the CHILDREN study. *Eur J Public Health*. 2009;19(3):319–325.

Bayne-Smith M, Fardy PS, Azzollini A, Magel J, Schmitz KH, Agin D. Improvements in heart health behaviors and reduction in coronary artery disease risk factors in urban teenaged girls through a school-based intervention: the PATH program. *Am J Public Health*. 2004;94(9):1538–1543.

Caballero B, Clay T, Davis SM, et al. Pathways: a school-based, randomized controlled trial for the prevention of obesity in American Indian schoolchildren. *Am J Clin Nutr*. 2003;78(5):1030–1038.

Carrel AL, Clark RR, Peterson SE, Nemeth BA, Sullivan J, Allen DB. Improvement of fitness, body composition, and insulin sensitivity in overweight children in a school-based exercise program: a randomized, controlled study. *Arch Pediatr Adolesc Med*. 2005;159(10):963–968.

Damon S, Dietrich S, Widhalm K. PRESTO–Prevention Study of Obesity: a project to prevent obesity during childhood and adolescence. *Acta Paediatr Suppl*. 2005;94(448):47–48.

Edwards B. Childhood obesity: a school-based approach to increase nutritional knowledge and activity levels. *Nurs Clin North Am*. 2005;40(4):661–669, viii–ix.

Eliakim A, Nemet D, Balakirski Y, Epstein Y. The effects of nutritional-physical activity school-based intervention on fatness and fitness in preschool children. *J Pediatr Endocrinol Metab*. 2007;20(6):711–718.

Farias ES, Paula F, Carvalho WR, Goncalves EM, Baldin AD, Guerra-Junior G. Influence of programmed physical activity on body composition among adolescent students. *J Pediatr (Rio J)*. 2009;85(1):28–34.

Foster GD, Sherman S, Borradaile KE, et al. A policy-based school intervention to prevent overweight and obesity. *Pediatrics*. 2008;121(4):e794–802.

Goldfield GS, Mallory R, Parker T, et al. Effects of open-loop feedback on physical activity and television viewing in overweight and obese children: a randomized, controlled trial. *Pediatrics*. 2006;118(1):e157–166.

Kafatos I, Manios Y, Moschandreas J, Kafatos A. Health and nutrition education program in primary schools of Crete: changes in blood pressure over 10 years. *Eur J Clin Nutr*. 2007;61(7):837–845.

Kipping RR, Payne C, Lawlor DA. Randomized controlled trial adapting US school obesity prevention to England. *Arch Dis Child*. 2008;93(6):469–473.

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):1315–1320.

Lohman T, Thompson J, Going S, et al. Indices of changes in adiposity in American Indian children. *Prev Med*. 2003;37(6 Pt 2):S91–96.

Manios Y, Moschandreas J, Hatzis C, Kafatos A. Health and nutrition education in primary schools of Crete: changes in chronic disease risk factors following a 6-year intervention program. *Br J Nutr*. 2002;88(3):315–324.

Martinez Vizcaino V, Salcedo Aguilar F, Franquelo Gutierrez R, 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.

Neumark-Sztainer D, Story M, Hannan PJ, Rex J. New Moves: a school-based obesity prevention program for adolescent girls. *Prev Med*. 2003;37(1):41–51.

Pangrazi RP, Beighle A, Vehige T, Vack C. Impact of Promoting Lifestyle Activity for Youth (PLAY) on children's physical activity. *J Sch Health*. 2003;73(8):317–321.

Perman JA, Young TL, Stines E, Hamon J, Turner LM, Rowe MG. A community-driven obesity prevention and intervention in an elementary school. *J Ky Med Assoc*. 2008;106(3):104–108.

Robbins LB, Gretebeck KA, Kazanis AS, Pender NJ. Girls on the move program to increase physical activity participation. *Nurs Res*. 2006;55(3):206–216.

Rosenbaum M, Nonas C, Weil R, et al. School-based intervention acutely improves insulin sensitivity and decreases inflammatory markers and body fatness in junior high school students. *J Clin Endocrinol Metab.* 2007;92(2):504–508.

Sahota P, Rudolf MC, Dixey R, Hill AJ, Barth JH, Cade J. Evaluation of implementation and effect of primary school based intervention to reduce risk factors for obesity. *BMJ*. 2001;323(7320):1027–1029.

Salmon J, Ball K, Hume C, Booth M, Crawford D. Outcomes of a group-randomized trial to prevent excess weight gain, reduce screen behaviors and promote physical activity in 10-year-old children: switch-play. *Int J Obes (Lond)*. 2008;32(4):601–612.

Schofield L, Mummery WK, Schofield G. Effects of a controlled pedometer-intervention trial for low-active adolescent girls. *Med Sci Sports Exerc*. 2005;37(8):1414–1420.

Singh AS, Chin APMJ, Brug J, van Mechelen W. Short-term effects of school-based weight gain prevention among adolescents. *Arch Pediatr Adolesc Med*. 2007;161(6):565–571.

Skybo TA, Ryan-Wenger N. A school-based intervention to teach third grade children about the prevention of heart disease. *Pediatr Nurs*. 2002;28(3):223–229, 235.

Spiegel SA, Foulk D. Reducing overweight through a multidisciplinary school-based intervention. *Obesity (Silver Spring)*. 2006;14(1):88–96.

Weintraub DL, Tirumalai EC, Haydel KF, Fujimoto M, Fulton JE, Robinson TN. Team sports for overweight children: the Stanford Sports to Prevent Obesity Randomized Trial (SPORT). *Arch Pediatr Adolesc Med*. 2008;162(3):232–237.

Yin Z, Gutin B, Johnson MH, et al. An environmental approach to obesity prevention in children: Medical College of Georgia FitKid Project year 1 results. *Obes Res*. 2005;13(12):2153–2161.

Yin Z, Moore JB, Johnson MH, et al. The Medical College of Georgia Fitkid project: the relations between program attendance and changes in outcomes in year 1. *Int J Obes (Lond)*. 2005;29(Suppl 2):S40–45.