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Effect of interventions on the body mass index of school-age students

ABSTRACT

OBJECTIVE: To evaluate the effect of intervention programs using nutritional education, physical activity or both on the reduction of body mass index in school-age students.

METHODS: The systematic review with meta-analysis included randomized controlled studies available from the following electronic databases for the years 1998 to 2010: PubMed, Lilacs, Embase, Scopus, Web of Science and Cochrane Library. The descriptors were: randomized controlled trial, overweight, obesity, body mass index, child, adolescent, physical activity, nutrition education and Schools. A weighted average was based on the standardized means difference and used a 95% confidence interval. The inconsistency test was utilized to evaluate the heterogeneity of studies.

RESULTS: Initially, 995 studies were identified, of which 23 were included, and 3 meta-analyses were performed. Isolated physical activity interventions did not present a significant reduction in body mass index, with a standardized mean difference of -0.02 (95%CI: -0.08; 0.04). A similar result (n= 3,524) was observed in the isolated interventions of nutritional education, with a standardized mean difference of -0.03 (95%CI: -0.10; 0.04).When the interventions with physical activity and nutritional education were combined, the result of the meta-analysis (n= 9,997) presented a statistically significant effect in the reduction of body mass index in school-age students, with a standardized mean difference: -0.37 (95%CI: -0.63; -0.12).

CONCLUSIONS: The interventions that combined physical activity and nutritional education had more positive effects in the reduction of body mass index among school-age students than when they were applied individually.

DESCRIPTORS: Child. Adolescent. Obesity, prevention & control. Body Mass Index. Food and Nutrition Education. Physical Education and Training. Motor Activity. Weight Reduction Programs. Meta-Analysis.

INTRODUCTION

Obesity is a condition where the accumulation of body fat increases and results in harm to health.[a] Despite being an ideal, this definition is difficult to apply due to the limited availability of easy to administer methods to evaluate body composition.[8] Body mass index (BMI) is used to define obesity. The World Health Organization published the new child growth standards in 2006 and made

[a] World Health Organization. Obesity: Preventing and Managing the Global Epidemic. Report of a WHO Consultation on Obesity. Geneva; 2000.

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information about BMI available in graphic and tables with percentile values and Z scores, simplifying their use at a population level.[47] The increasing prevalence of obesity threatens the health of an increasing portion of the population. It is a challenge to health services and necessitates practical methods of diagnosis and monitoring that are low cost.

The most current national level data on the nutritional status of Brazilian children age 5 years and less is the *Pesquisa de Orçamentos Familiares* (POF – Household Budget Survey) from 2008-2009 and the *Pesquisa Nacional sobre Demografia e Saúde* (PNDS – National Demographic and Health Survey) of 2006. The results of the POF show that the prevalence of overweight varied from 32% to 40% in children age five to nine years in the Southeast, South and Central-West regions and from 25% to 30% in the North and Northeast regions, which was the age group for which the increased prevalence of obesity was most dramatic.[b] There was an increased prevalence of overweight in the population age 10 to 19 years, from 3.7% to 21.7% among boys and from 7.5% to 19.4% among girls between the periods of 1974-1975 and 2009-2009.[b] The PNDS recorded a national prevalence of overweight of 6.6%, with the highest proportion in the South (8.8%) and the lowest in the North (5.2%).[c]

Lifestyle changes (a diet composed of industrialized, sugar and fat rich foods and the reduced consumption of fruits and vegetables) combined with little physical activity (increased television and videogame time and reduced practice of physical activity) in addition to lifestyle factors, contribute to the continual increase in the prevalence of overweight and obesity among children and adolescents.[41-44]

Although there is no consensus on which interventions are more adequate to decrease obesity, the approaches tend to center on changes in lifestyle, nutritional education and promotion of physical activity.[10] Schools are a strategic place to promote through education the formation of daily habits in physical activity and proper nutrition.

The objective of this study was to evaluate the effects of interventions using physical activity, nutritional education or both on the reduction of BMI in school-age children.

METHODS

A meta-analysis was performed with a criteria-based search strategy for studies published between 1998 and August of 2010, in the following electronic databases: Lilacs, PubMed, Web Of Science, Scopus, EMBASE and Cochrane Library. The following key words were used: randomized controlled trial, overweight, obesity, BMI, child, adolescent, physical activity, nutrition education and schools. Campbell et al[5] performed a systematic review in 2001 with studies published until 1998, which explains our decision to include studies beginning in that year. A search was performed from the bibliographic references of the relevant studies and of the systematic reviews concerning the topic of interest. The inclusion criteria were: randomized controlled studies with students age four to 19 years and with baseline and endline measurement of BMI, in addition to interventions using nutritional education, physical activity or both for a minimal duration of three months. The internal quality of the study was evaluated by criteria of blinded randomization proposed by Cochrane[19] and complemented by the Jadad Scale.[22] The studies were classified into four categories by the criteria of blinded randomization: Category A or Adequate (adequate randomization process); Category B or Undetermined (undescribed randomization process but the text mentions the study is randomized); Category C or Inadequate (randomization process inadequately described); Category D or Not Utilized (non-random study). Studies classified as A and B, by the analysis of blinded randomization, were included. Studies classified as C and D were excluded from review because they were considered inadequate experiments.

The criteria described by Jadad et al[22] for evaluating internal quality were randomization, double-blinding and loss to follow-up and exclusions. The results were presented by scoring (maximum of five points). A study is considered of poor quality if it receives a score $\leq$ three.

The information was independently extracted by two reviewers. The results were matched to verify concordance and the discordant results were resolved by consensus. The evaluation by the reviewers was not blinded from the authors and the study results.

A summary measure based on the standardized mean difference (SMD) was used. The calculation of this summary measure and its 95% confidence interval was according to the fixed effects model or the random effects model, depending on the heterogeneity between the studies. The test of inconsistency (I^2) was used to evaluate heterogeneity between the studies and random effects model was used for $I^2 > 50\%$.[20,21] The effect size estimated from the scale of magnitudes for effect statistics was evaluated by the SMD.[7]

[b] Instituto Brasileiro de Geografia e Estatística. Pesquisa de Orçamentos Familiares 2008-2009: antropometria e estado nutricional de crianças, adolescentes e adultos no Brasil. Rio de Janeiro; 2010.
[c] Ministério da Saúde (BR). Pesquisa nacional de Demografia e Saúde da Criança e da Mulher – PNDS 2006: dimensões do processo reprodutivo e da saúde da criança. Brasília (DF); 2009. (Série G. Estatística e Informação em Saúde).

The statistical analyses was performed using the software program Review Manager version 5.1, produced by Cochrane Collaboration, and results were presented through use of Forest Plot graphics.

RESULTS

There were 995 studies identified, including 231 duplicates; 642 were excluded after analysis of titles and abstracts because they did not meet the inclusion criteria. The full text was analyzed for 122 articles of which 37 were excluded because they did not meet the inclusion criteria. Eighty-five studies were analyzed and classified by the criteria of blinded randomization;[19] and 40 studies were classified as A or B and selected. Of these, 17 were excluded for not presenting sufficient data, for a final total of 23 included studies (Figure 1; Table).

Of the 23 studies, 16 evaluated the effect of physical activity and nutritional education as an intervention to reduce BMI, five evaluated physical activity and two evaluated nutritional education. The majority of prevention programs promoted physical activity[4,9,11-12,14,16,24,26-29,38,40,46,50,51,53] and two programs recommended physical activity.[15,55] All the studies included programs that encouraged healthy dietary habits through presentations and didactic materials. Of these studies, seven had interventions with school meals and cafeterias.[4,14,26-28,52-53]

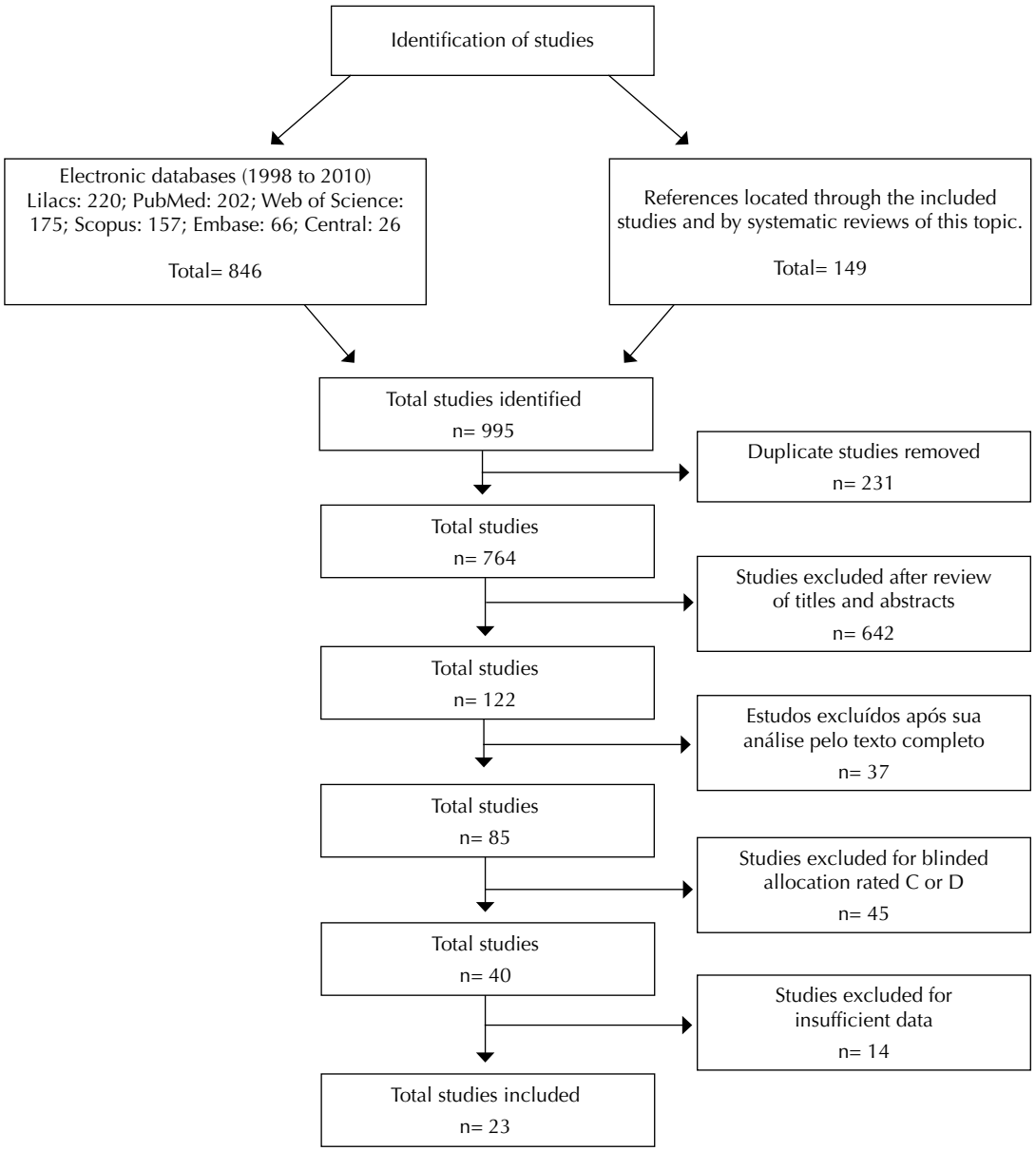


Figure 1. Study selection strategy.

Table. Characteristics of studies included in the systematic review.

1st Author	Year	Location	Age (years)	n	Intervention	Intervention period (months)	Blinding Rating	Jadad
Robinson[50]	1999	USA	± 9[a]	192	PA	6	B	2
Caballero[4]	2003	USA	7 to 10	1.409	PAPA+NE	36	B	2
Neumark-Sztainer[46]	2003	USA	± 15[a]	190	PA+NE	4	B	2
Story[54]	2003	USA	8 to 10	53	PA+NE	3	B	3
James[23]	2004	England	7 to 11	574	NE	12	A	2
Kafatos[29]	2005	Greece	± 7[a]	541	PA+NE	72	B	2
Yin[55]	2005	Georgia	± 9[a]	525	PA	8	B	2
Haerens[16]	2006	Belgium	11 to 15	1.562	PA+NE	24	B	2
Eliakim[12]	2007	Israel	5 to 6	101	PA+NE	4	B	2
Jiang[24]	2007	China	± 8[a]	2.425	PA+NE	36	B	2
Johnston[26]	2007	USA	10 to 14	66	PA+NE	3	B	2
Johnston[27]	2007	USA	10 to 14	57	PA+NE	6	B	2
Singh[52]	2007	Netherlands	12 to 13	1.053	PA+NE	8	A	2
Foster[14]	2008	USA	± 11[a]	844	PA+NE	24	B	2
Vizcaino[38]	2008	Spain	9 to 10	1.044	PA	9	A	2
Donnelly[11]	2009	USA	7 to 8	1.490	PA	36	B	2
Gentile[15]	2009	USA	± 10[a]	1.201	PA+NE	6	B	2
Muckelbauer[45]	2009	Germany	± 8[a]	2.950	NE	8	B	2
Peralta[48]	2009	Australia	12 to 13	32	PA+NE	6	A	5
Aguilar[51]	2010	Spain	9 to 11	921	PA	18	B	2
Johnston[28]	2010	USA	10 to 14	54	PA+NE	12	A	2
Mihas[40]	2010	Greence	12 to 13	208	PA+NE	3	A	2
Singhal[53]	2010	India	15 to 17	201	PA+NE	6	A	2

[a] Mean age

Legend: Year – Publication year; Location – Location of intervention; n – Sample size; Blinding rating – per Cochrane; Jadad – Jadad scale for study quality; PA – Physical activity; NE – nutritional education; PA + NE: Physical activity and nutritional education.

Seven studies were considered adequate in their randomization procedure, and it was not described in 16 studies, although the text mentioned that the study was randomized. Twenty-two studies were considered poor quality and one as good quality (Table).

Three meta-analyses were performed to evaluate the effect of interventions that isolated or combined physical activity and nutritional education about BMI among students:

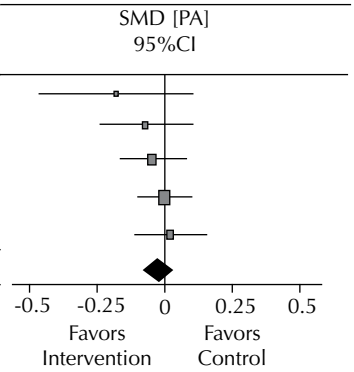
Five studies were grouped to evaluate the effect of the interventions with physical activity among students. The results with 4,172 participants did not show a statistically significant effect of the intervenitons with physical activity in the reduction of BMI, with SMD (fixed effects): -0.02 (95%CI -0.08;0.04), p = 0.46, between the intervention group (IG) compared to the control group (CG), with a trivial effect magnitude. There was no heterogeneity between studies ($I^2 = 0\%$) (Figure 2).

Two studies involving interventions with nutritional education were included and the results grouped for a total 3,524 participants, and the analysis demonstrated no statistically significant effect in the reduction of BMI, with a SMD (fixed effects): -0.03 (95%CI -0.10;004), p = 0.39 between the IG compared to the CG, with an effect magnitude considered trivial. There was heterogeneity between stuides, with low variability ($I^2 = 36\%$) (Figure 3).

To evaluate the effect of interventions with physical activity and nutritional education among students, 16 studies were grouped. The results with 9,997 participants presented a statistically significant effect of the interventions with physical activity and nutritional education together upon the BMI, with SMD (random effects): -0.37 (95%CI -0.63;-0.12), p < 0.01, between the IG compared to the CG with a small effect magnitude. There was heterogeneity between the studies, with high variability ($I^2 = 97\%$) (Figure 4).

Studies	Intervention			Control				SMD [PA]
	Mean	SD	n	Média	DP	n	Weight	95%CI
Robinson 1999	0.29	2.35	92	0.71	2.38	100	4.7%	-0.18 [-0.46.0.11]
Yin 2005	0.1	2.97	260	0.3	2.82	265	12.7%	-0.07 [-0.24.0.10]
Vizcaíno 2008	0.2	2.26	465	0.3	2.28	579	25.0%	-0.04 [-0.17.0.08]
Donnely 2009	2	2.47	792	2	2.76	698	36.0%	0.00 [-0.10.0.10]
Aguilar 2010	0.9	2.18	375	0.85	2.28	546	21.6%	0.02 [-0.11.0.15]
Total (95%CI)			1984			2188	100.0%	-0.02 [-0.08.0.04]

Heterogeneity: $Chi^2 = 2.17$. df = 4 (P = 0.70); $I^2 = 0\%$
Test for effect: Z = 0.74 (P = 0.46)



SD: Standard deviation; n: Sample size; SMD [PA]: standardized mean difference for fixed effects: CI: Confidence interval; I^2: Inconsistency test.

Figure 2. Forest Plot for the studies comparying the IG with the CG for interventions with physical activity and BMI among students.

DISCUSSION

The results of the meta-analysis for the isolated interventions with physical activity or nutritional education did not show a statistically significant effect on the reduction of BMI among students. A similar result was presented in a meta-analysis by Harris et al[18] that evaluated the effect of interventions with physical activity on BMI of children in school setting, with a SMD: -0.05 (95%CI -0.19;0.10).

Isolated interventions did not result in changes of BMI, which can be partially explained by recognition that changes to body mass do not occur in a short period. The studies included in these analysis implemented interventions with a duration longer than three months and the meta-analysis were limited by the reduced number of studies included.

There was a reduction in BMI for the meta-analysis of interventions that combined interventions with physical activity and nutritional education. A similar result was also observed by Katz[32] for combined interventions and decreased body mass with SMD: -0.29 (95%CI -0.45;-0.14) among students. This suggests that strategies to reduce and prevent obesity should focus on dietary consumption patterns and caloric expenditure through physical activity, aspects that should be prioritized in the planning of public policies for health.

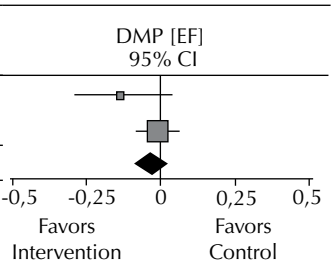
Studies about the effect of interventions upon BMI should be interpreted with caution, since the evaluation of nutritional status using this index among adolescents should consider the stage of sexual maturation. Changes in body mass can be characteristic of certain developmental phases and not the result of inadequate dietary consumption, inadequate physical activity or both.

Although it does not measure physical composition, the widespread use of BMI in epidemiologic studies as an indicator for nutritional status is justified by its ease of measurement, large availability of data on body mass, in addition to its relationship with morbidity and mortality.[2]

When analyzed individually, the studies included in this review demonstrated positive results from lifestyle changes that reduced television, videogame and computer screentime,[14-15,50] that increased the consumption of fruits and vegetables[14-15] and that reduced the consumption of foods rich in fat.[4,14] These findings reinforce the importance of developing actions and programs to change lifestyles among this age group, since their lifestyles are in formation.

Studies	Intervention			Control				SMD [PA]
	Mean	SD	n	Média	DP	n	Weight	95%CI
James 2004	0.6	1.48	295	0.8	1.71	279	16.4%	-0.13 [-0.29.0.04]
Muckebauer 2009	0.39	1.83	1641	0.41	2.02	1309	83.6%	-0.01 [-0.08.0.06]
Total (95%CI)			1936			1588	100.0%	-0.03 [-0.10.0.04]

Heterogeneity: $Chi^2 = 1.57$, df = 1 (P = 0.21); $I^2 = 36\%$
Test for effect: Z = 0.86 (P = 0.39)

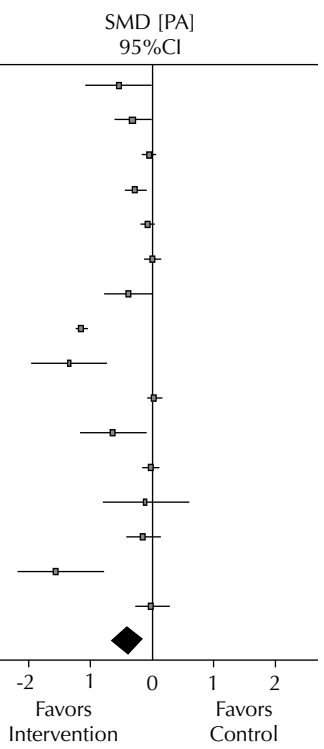


SD: Standard deviation; n: Sample size; SMD [PA]: standardized mean difference for fixed effects: CI: Confidence interval; I^2: Inconsistency test

Figure 3. Forest Plot for the studies comparying the IG with CG for interventions with nutritional education and BMI among students.

Studies	Intervention			Control				SMD [PA]
	Mean	SD	n	Média	DP	n	Weight	95%CI
Story 2003	-0.2	5.15	26	2	2.55	27	5.4%	-0.54 [-1.09.0.01]
Neumark 2003	-0.96	6.14	84	0.75	4.75	106	6.5%	-031 [-0.60.-0.03]
Caballero 2003	3	2.02	727	3.1	2.02	682	7.0%	-0.05 [-0.15.0.06]
Kafatos 2005	3.45	2.59	284	4.15	2.5	257	6.9%	-0.27 [-0.44.-0.10]
Haerens 2006	1.18	2.37	971	1.35	2.18	591	7.0%	-0.07 [-0.18.0.03]
Singh 2007	0.45	1.82	600	0.45	2.01	453	7.0%	0.00 [-0.12.0.12]
Eliakin 2007	0	0.68	54	0.3	0.86	47	6.1%	-0.39 [-0.78.0.01]
Jiang 2007	0.6	1.76	1029	2.8	2.04	1396	7.0%	-1.14 [-1.23.-1.06]
Johnston 2007	-0.56	0.69	38	0.31	0.52	19	5.1%	-1.34 [-1.95.-0.74]
Gentile 2007	0.6	2.94	582	0.5	2.94	619	7.0%	0.03 [-0.08.0.15]
Johnston 2007	-0.34	0.77	44	0.17	0.83	22	5.5%	-0.64 [-1.16.-0.11]
Foster 2008	1.99	4.72	479	2.1	4.75	365	7.0%	-0.02 [-0.16.0.11]
Peralta 2009	0.3	2.63	16	0.6	2.59	16	4.7%	-0.11 [-0.81.0.58]
Mihas 2010	-0.1	1.99	107	0.2	2.2	101	6.6%	-0.14 [-0.41.0.13]
Johnston 2010	-0.2	1.1	37	1.6	1.2	17	4.9%	-1.57 [-2.22.-0.92]
Singhal 2010	-0.07	0.71	99	-0.06	1.11	102	6.3%	-0.01 [-0.29.0.27]
Total			5177			4820	100.0%	-0.37 [-0.63.-0.12]

Heterogeneity: Tau² = 0,24; Chi²=509,31, df = 15 (P = 0.00001); I² = 97%
Test for effect: Z = 2,86 (P = 0,004)



SD: Standard deviation; n: Sample size; SMD [PA]: standardized mean difference for fixed effects: CI: Confidence interval; I²: Inconsistency test.

Figure 4. Forest Plot for studies comparying IG and CG for interventions with physical activity and nutritional education on BMI among students.

The literature documents the benefits of physical activity and of healthy nutrition upon skeletal health (mineral consent and bone density)[34-36,55] increased flexibility and aerobic capacity[6,30,55] and in the inverse relationship with cardiovascular risk factors.[6,17,33,39,49] The practice of regular physical activity, when begun in childhood or adolescence, protects adults against physical inactivity.[1,3,37]

The most challenging aspect for health promotion strategies is adherence outside of schools, since health is negatively impacted by the food industry through advertisements and commercials for calorie-dense foods. Technological advances such as videogames and computers attract children to a lifestyle of little physical activity and increased calorie consumption. Researchers foresee growth in high-speed internet and videos on screens (cable TV, VCR, DVD, videogames, computer games), according to a conference by the National Institutes of Health in the United States, and these changes will continue to incentivize lifestyle changes among children and adolescents.[25] Strategies to prevent obesity should focus on factors that prevent its development.

Interventions with families, especially parental involvement in the promotion of healthy habits, should be contemplated and estimulated by interventional programs. Children are influenced by their parents' habits; therefore, recommendations introduced in schools should be followed at home through the positive example of parents for their children, through healthy nutrition and the regular practice of physical exercise. Interventions have better results when the strategy includes a family component.[13,31]

The 23 studies included in the meta-analysis have limitations, since the majority were performed with a small sample and were considered of low quality by the Jadad scale because they did not describe the allocation randomization procedure, blinding, losses and exclusions. This implies a need for more well-designed randomized controlled clinical studies. No Brazilian study was included in this review since they did not meet the inclusion criteria.

This systematic review is subject to publication bias, since it is easier to publish studies that report beneficial effects for a given intervention, in detriment to studies that do not describe beneficial effects.

This study suggests a need for randomized controlled studies with well-designed methodologic criteria in order to evaluate the effect of interventions, especially

among Brazilian population. The results can help in calculating sample sizes during the planning of future studies to evaluate the effect of structured interventions among an intervention and control group. Interventions that combine physical activity and nutritional education present better effects on the reduction of BMI among students, as a strategy to prevent and control obesity, than if applied in an isolated manner.

REFERENCES

1. Aarnio M, Winter T, Peltonen J, Kujala UM, Kaprio J. Stability of leisure-time physical activity during adolescence: a longitudinal study among 16-, 17- and 18-year-old Finnish youth. *Scand J Med Sci Sports*. 2002;12(3):179-85. DOI:10.1034/j.1600-0838.2002.00250.x
2. Anjos LA. Índice de massa corporal (massa corporal. estatura^{-2}) como indicador do estado nutricional de adultos: revisão da literatura. *Rev Saude Publica*. 1992;26(6):431-6. DOI:10.1590/S0034-89101992000600009
3. Azevedo MR, Araújo CL, Silva MC, Hallal PC. Tracking of physical activity from adolescence to adulthood: a population-based study. *Rev Saude Publica*. 2007;41(1):69-75. DOI:10.1590/S0034-89102007000100010
4. Caballero B, Clay T, Davis SM, Ethelbah B, Rock BH, Lohman, T 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):1030-8.
5. Campbell K, Waters E, O'Meara S, Summerbell C. Interventions for preventing obesity in childhood: a systematic review. *Obes Rev*. 2001;2(3):149-57. DOI:10.1046/j.1467-789x.2001.00035.x
6. 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):963-8. DOI:10.1001/archpedi.159.10.963
7. Cohen J. Statistical power analysis for the behavioral sciences. 2.ed. Hillsdale: Lawrence Erlbaum; 1988.
8. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ*. 2000;320(7244):1240-3.
9. Danielzik S, Pust S, Müller MJ. School-based interventions to prevent overweight and obesity in prepubertal children: process and 4-years outcome evaluation of the Kiel Obesity Prevention Study (KOPS). *Acta Paediatr Suppl*. 2007;96(454):19-25. DOI:10.1111/j.1651-2227.2007.00165.x
10. Dehghan M, Akhtar-Danesh N, Merchant AT. Childhood obesity, prevalence and prevention. *Nutr J*. 2005;4(1):24. DOI:10.1186/1475-2891-4-24
11. Donnelly JE, Greene JL, Gibson CA, Smith BK, Washburn RA, Sullivan DK, et al. Physical Activity Across the Curriculum (PAAC): a randomized controlled trial to promote physical activity and diminish overweight and obesity in elementary school children. *Prev Med*. 2009;49(4):336-41. DOI:10.1016/j.ypmed.2009.07.022
12. 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):711-8.
13. Epstein LH. Family-based behavioural intervention for obese children. *Int J Obes Relat Metab Disord*. 1996;20(Suppl 1):S14-21.
14. Foster GD, Sherman S, Borradaile KE, Grundy KM, Vander Veur SS, Nachmani J, et al. A policy-based school intervention to prevent overweight and obesity. *Pediatrics*. 2008;121(4):e794-802. DOI:10.1542/peds.2007-1365
15. Gentile DA, Welk G, Eisenmann JC, Reimer RA, Walsh DA, Russell DW, et al. Evaluation of a multiple ecological level child obesity prevention program: Switch® what you Do, View, and Chew. *BMC Med*. 2009;7(1):49. DOI:10.1186/1741-7015-7-49
16. Haerens L, Deforche B, Maes L, Stevens V, Cardon G, De Bourdeaudhuij I. Body mass effects of a physical activity and healthy food intervention in middle schools. *Obesity (Silver Spring)*. 2006;14(5):847-54. DOI:10.1038/oby.2006.98
17. Hansen HS, Froberg K, Hyldebrandt N, Nielsen JR. A controlled study of eight months of physical training and reduction of blood pressure in children: the Odense schoolchild study. *BMJ*. 1991;303(6804):682-5.
18. Harris KC, Kuramoto LK, Schulzer M, Retallack JE. Effect of school-based physical activity interventions on body mass index in children: a meta-analysis. *CMAJ*. 2009;180(7):719-26. DOI:10.1503/cmaj.080966
19. Higgin J, Green S, editors. Cochrane handbook for systematic reviews of interventions. Chichester: The Cochrane Collaboration; John Wiley & Sons; 2008. (Cochrane Book Series).
20. Higgins JP, Thompson SG. Quantifying heterogeneity in a meta-analysis. *Stat Med*. 2002;21(11):1539-8. DOI:10.1002/sim.1186
21. Higgins JP, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. *BMJ*. 2003;327(7414):557-60. DOI:10.1136/bmj.327.7414.557
22. Jadad AR, Moore RA, Carroll D, Jenkinson C, Reynolds DJ, Gavaghan DJ, et al. Assessing the quality of reports of randomized clinical trials: is blinding necessary? *Control Clin Trials*. 1996;17(1):1-12. DOI:10.1016/0197-2456(95)00134-4
23. 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. DOI:10.1136/bmj.38077.458438.EE

24. 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):641-6. DOI:10.1111/j.1365-2214.2007.00738.x

25. Johnson-Taylor WL, Everhart JE. Modifiable environmental and behavioral determinants of overweight among children and adolescents: report of a workshop. *Obesity (Silver Spring)*. 2006;14(6):929-66. DOI:10.1038/oby.2006.109

26. Johnston CA, Tyler C, Fullerton G, Poston WSC, Haddock CK, McFarlin B, et al. Results of an intensive school-based weight loss program with overweight Mexican American children. *Int J Pediatr Obes*. 2007;2(3):144-52. DOI:10.1080/17477160701305864

27. Johnston CA, Tyler C, McFarlin BK, Poston WSC, Haddock CK, Reeves RS, et al. Weight loss in overweight Mexican American children: a randomized, controlled trial. *Pediatrics*. 2007;120(6):e1450-7. DOI:10.1542/peds.2006-332

28. Johnston CA, Tyler C, McFarlin BK, Poston WSC, Haddock CK, Reeves RS, et al. Effects of a school-based weight maintenance program for Mexican American children: results at 2 years. *Obesity* (*Silver Spring*). 2010;18(3):542-7. DOI:10.1038/oby.2009.241

29. Kafatos A, Manios Y, Moschandreas J. Health and nutrition education in primary schools of Crete: follow-up changes in body mass index and overweight status. *Eur J Clin Nutr*. 2005;59(9):1090-2. DOI:10.1038/sj.ejcn.1602216

30. Kahn EB, Ramsey LT, Brownson RC, Heath GW, Howze EH, Powell KE, et al. The effectiveness of interventions to increase physical activity: a systematic review. *Am J Prev Med*. 2002;22(4 Suppl):73-107.

31. Katz DL, O Connell M, Njike VY, Yeh MC, Nawaz H. Stratrgies for the prevention and control of obesity in the school setting: systematic review and meta-analysis. *Int J Obes* (*Lond*). 2008;32(12):1780-9.DOI: 10.1038/ijo.2008.158

32. Katz DL. School-based interventions for health promotion and weight control: not just waiting on the world to change. *Anu Rev Public Health*. 2009;30:253-72. DOI:10.1146/*annurev.publhealth*.031308.100307

33. Krause MP, Hallage T, Gama MP, Goss FL, Robertson R, Silva SG. Association of adiposity, cardiorespiratory fitness and exercise practice with the prevalence of type 2 diabetes in Brazilian elderly women. *Int J Med Sci*. 2007;4(5):288-92. DOI:10.7150/ijms.4.288

34. Linden C, Ahlborg HG, Besjakov J, Gardsell P, Karlsson MK. A school curriculum-based exercise program increases bone mineral accrual and bone size in prepubertal girls: two-year data from the pediatric osteoporosis prevention (POP) study. *J Bone Miner Res*. 2006;21(6):829-35. DOI:10.1359/jbmr.060304

35. MacKelvie KJ, Khan KM, Petit MA, Janssen PA, McKay HA. A school-based exercise intervention elicits substantial bone health benefits: a 2-year randomized controlled trial in girls. *Pediatrics*. 2003;112(6 Pt 1):e447-52.

36. MacKelvie KJ, Petit MA, Khan KM, Beck TJ, McKay HA. Bone mass and structure are enhanced following a 2-year randomized controlled trial of exercise in prepubertal boys. *Bone*. 2004;34(4):755-64. DOI:10.1016/j.bone.2003.12.017

37. Maia JAR, Lefevre J, Claessens A, Renson R, Vanreusel B, Beunen G. Tracking of physical fitness during adolescence: a panel study in boys. *Med Sci Sports Exerc*. 2001;33(5):765-71.

38. Martinez Vizcaíno V, Salcedo Aguilar F, Franquelo Gutiérrez R, Solera Martinez M, Sánchez Lopez M, Martinez Serrano S, et al. Assessment of an after-school physical activity program to prevent obesity among 9- to 10-years-old children: a cluster randomized trial. *Int J Obes (Lond)*. 2008;32(1):12-22. DOI:10.1038/ijo.0803738

39. 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):125-32.

40. Mihas C, Mariolis A, Manios Y, Naska A, Arapaki A, Mariolis-Sapsakos T, et al. Evaluation of a nutrition intervention in adolescents of an urban area in Greece: short- and long-term effects of the VYRONAS study. *Public Health Nutr*. 2010;13(5):712-9. DOI:10.1017/S1368980009991625

41. Mondini L, Monteiro CA. Mudanças no padrão de alimentação da população urbana brasileira (1962-1988). *Rev Saude Publica*. 1994;28(6):433-9. DOI:10.1590/S0034-89101994000600007

42. Mondini L, Monteiro CA. The stage of nutrition transition in different Brazilian regions. *Arch Latinoam Nutr*. 1997;47(2 Suppl 1):17-21

43. Monteiro CA, Mondini L, Souza AL, Popkin BM. The nutrition transition in Brazil. *Eur J Clin Nutr*. 1995;49(2):105-13.

44. Monteiro CA, Mondini L, Costa RB. Changes in composition and appropriate nutrition of family diet in the metropolitan areas of Brazil (1988-1996). *Rev Saude Publica*. 2000;4(3):251-8.

45. Muckelbauer R, Libuda L, Clausen K, Reinehr T, Kersting M. A simple dietary Intervention in the school setting decreased incidence of overweight in children. *Obes Facts*. 2009;2(5):282-5. DOI:10.1159/000229783

46. 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. DOI: 10.1016/S0091-7435(03)00057-4

47. Onis M, Blossner M, Borghi E. Global prevalence and trends of overweight and obesity among preschool children. *Am J Clin Nutr*. 2010;92(5):1257-64. DOI:10.3945/ajcn.2010.29786

48. Peralta LR, Jones RA, Okely AD. Promoting healthy lifestyles among adolescent boys: The Fitness Improvement and Lifestyle Awareness Program RCT. *Prev Med*. 2009;48(6):537-42. DOI:10.1016/j.ypmed.2009.04.007

49. Perichart-Perera O, Balas-Nakash M, Ortiz-Rodríguez V, Morán-Zenteno JA, Guerrero-Ortiz JL, Vadillo-Ortega F. Programa para mejorar marcadores de riesgo cardiovascular en escolares mexicanos. *Salud Publica Mex*. 2008;50(3):218-26. DOI:10.1590/S0036-36342008000300005

50. Robinson TN. Reducing children's television viewing to prevent obesity: a randomized controlled

trial. *JAMA*. 1999;282(16):1561-7. DOI:10.1001/jama.282.16.1561

51. Salcedo Aquilar F, Martinez-Vizcaíno V, Sánchez López M, Solera Martinez M, Franquelo Gutiérrez R, Serreno Martinez S, et al. Impact of an after-school physical activity program on obesity in children. *J Pediatrics*. 2010;157(1):36-42. DOI:10.1016/j.jpeds.2009.12.046

52. 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):565-71. DOI:10.1001/archpedi.161.6.565

53. Singhal N, Misra A, Shah P, Gulati S. Effects of controlled school-based multi-component model of nutrition and lifestyle interventions on behavior modification, anthropometry and metabolic risk profile of urban Asian Indian adolescents in North India. *Eur J Clin Nutr*. 2010;64(4):364-73. DOI:10.1038/ejcn.2009.150

54. Story M, Sherwood NE, Himes JH, Davis M, Jacobs Jr DR, Cartwright Y, et al. An after-school obesity prevention program for African-American girls: the Minnesota GEMS pilot study. *Ethn Dis*. 2003;3(1 Suppl 1):S54-64.

55. Yin ZN, Gutin B, Johnson MH, Hanes Jr J, Moore JB, Cavnar M, et al. An environmental approach to obesity prevention in children: Medical College of Georgia FitKid Project year 1 results. *Obes Res*. 2005;13(12):2153-61. DOI:10.1038/oby.2005.267

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