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Effects of school-based interventions on blood pressure in obese children: metanalysis

Efeitos de intervenções de base escolar na pressão arterial de crianças com obesidade: metanálise

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ABSTRACT

Based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement (PRISMA), a systematic review with metanalysis was conducted to identify and summarize the effects of school-based physical activity interventions that sought to control and / or reduce blood pressure (systolic and diastolic) in children and / or adolescents with overweight and / or obesity. In September 2022, potential studies were searched in five electronic databases (*Pubmed, Scielo, Scopus, Sportdiscus, and Web of Science*) and in reference lists. Randomized controlled trials conducted in schools with interventions involving physical activity and assessment of systolic and diastolic blood pressure in children and adolescents aged 6 to 19 years with overweight and / or obesity were considered for synthesis. The risk of bias was assessed using an adapted version of the Effective Public Health Practice Project tool (EPHPP). Metanalysis was developed from the random model. Four studies were included. For systolic blood pressure, a summary effect of -0.10 (95% CI: -0.39; 0.19; I2 = 0%) was observed. For diastolic pressure, the metanalysis indicated -0.33 (95% CI: -0.62; -0.04; I2 = 11%). Considering the promising effects on diastolic blood pressure, we suggest the development of more school-based interventions based on physical activity practice for overweight and / or obese populations, which may also add environmental elements, longer duration, multicomponent approaches, and parent / guardian involvement to their strategies.

Keywords: Children; Physical education; School; Blood pressure; Overweight; Obese.

RESUMO

Com base na declaração Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), foi realizada uma revisão sistemática com metanálise para identificar e sumarizar os efeitos de intervenções escolar baseadas na atividade física que buscaram o controle e / ou redução da pressão arterial (sistólica e diastólica) em crianças e / ou adolescentes com excesso de peso e / ou obesidade. Em setembro de 2022, estudos potenciais foram pesquisados em cinco bases de dados eletrônicas (Pubmed, Scielo, Scopus, Sportdiscus, e Web of Science) e em listas de referências. Foram considerados para a síntese ensaios controlados randomizados realizados em escolas, com intervenções que envolviam a atividade física e avaliação da pressão arterial sistólica e diastólica em crianças e adolescentes dos 6 aos 19 anos com excesso de peso e/ ou obesidade. O risco de viés foi avaliado utilizando uma versão adaptada do instrumento Effective Public Health Practice Project (EPHPP). A metanálise foi elaborada a partir do modelo randômico. Foram incluídos quatro estudos. Para a pressão arterial sistólica, observou-se um efeito sumarizado de -0,10 (IC 95%: -0,39; 0,19; I2 = 0%). Para a pressão diastólica, a metanálise indicou -0,33 (IC 95%: -0,62; -0,04; I2 = 11%). Considerando os efeitos promissores na pressão arterial diastólica, sugerimos o desenvolvimento de mais intervenções escolares fundamentadas na prática de atividade física às populações com sobrepeso e / ou obesidade, que possam agregar também, em suas estratégias, elementos ambientais, maior duração, abordagens multicomponentes e envolvimento dos pais / responsáveis.

Palavras-chave: *Crianças; Educação física; Escola; Pressão arterial; Excesso de peso; Obesidade.*

Introduction

It is estimated that hypertension affects approximately 1.28 billion people worldwide, and is also the leading cause of premature death[1]. Although blood pressure is less common in the population of children and adolescents, it is becoming a major public health concern[2,3]. Previous studies suggest that the school presents itself as the ideal place for the development of far-reaching strategies for health promotion, impacting a large number of children and adolescents at the same time[4,5]. Such strategies make themselves fruitful, since health-related habits introduced in childhood and adolescence tend to endure into adulthood[6].

More specifically, strategies aimed at increasing

physical activity are known to produce multidimensional health benefits for children and adolescents[7], highlighting, in particular, improvements in body composition[8–10] and blood pressure[11,12].

This evidence is important, since overweight and obesity in childhood and / or adolescence are associated with a higher risk of cardiovascular diseases, diabetes, some types of cancer, as well as hypertension and depression. However, even with all this theoretical framework, worldwide, the temporal trends of overweight and obesity are increasing, which qualifies the problem as one of the main ones on the public health agenda[3]. Thus, school-based interventions seem to help improve health indicators, such as blood pressure, which, when increased, is one of the main risk factors for cardiovascular disease[13], renal failure, stroke, retinopathy, and mortality from all causes[14]. However, the results of intervention studies have not yet been summarized. The identification of these results would enable the elaboration of preventive actions, strategies, and public policies[12].

Therefore, considering the potentiality of the school environment, as well as the importance of prior actions to the highest risk groups, the present study sought to identify and summarize the effects of school-based interventions, based on physical activity, on blood pressure (systolic and diastolic) of children and adolescents with overweight and / or obesity.

Methods

This study is part of a larger project entitled "Effects of school-based physical activity interventions on blood pressure in children and adolescents". Its design, development and reporting were based on the items in the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) statement[15].

The study protocol was previously registered and is available on the Open Science Framework: DOI 10.17605/OSF.IO/FYQC5. Overall, the project aims to investigate the effects of school-based interventions on blood pressure indicators (systolic and diastolic) in children and adolescents. In this article, more specifically, the analyses are directed at studies that involved overweight and / or obese samples.

Inclusion criteria were based on the "PICOS" strategy, specifying: Population (children and / or adolescents, aged 6-19 years[16], with overweight or obesity); Interventions (school-based interventions that involved physical activity concepts and / or practices, without restrictions on types, volumes, and intensities); Comparators (control groups that did not receive interventions); Outcome (systolic and diastolic blood pressure); and Study Design (Randomized Controlled Trial).

Potential studies were searched in different sources of information: five electronic databases (Pubmed, Scielo, Scopus, Sportdiscus, and Web of Science), Google Scholar (with verification of the first 10 pages), and manual searches in the reference lists of studies assessed for their full texts.

More specifically, on September 22, 2022, searches were conducted in the electronic databases, starting with the syntax built for Pubmed: (((school[Text Word]) OR (scholar*[Text Word])) AND ((physical activity[Text Word]) OR (physical education[Text Word]) OR (exercise[Text Word]) OR (physical fitness[Text Word]) OR (sports[Text Word]) OR (walk*[Text Word]) OR (training[Text Word]))) AND ((blood pressure[Text Word]) OR (hyperten*[Text Word]) OR systolic[Text Word] OR diastolic[Text Word] AND (randomizedcontrolledtrial[Filter])).

The work process of the review, related to the removal of duplicates, evaluation of titles, abstracts and full texts, extraction of original data and syntheses (descriptive and statistical) counted with the participation of three researchers, acting independently. The data extraction process was based on previous references, using an electronic spreadsheet, divided into three domains: descriptive (e.g., name / name of the studies, place where they were carried out, sample size, sample profile, number of schools involved); methodological (e.g., intervention time, protocol, implementation and implementers of the actions) and results. The descriptive synthesis of characteristics and methods were developed from the refinement of this information.

The metanalysis was conducted from the original data presented in the studies, using the software Review Manager (version 5.4.1)[17]. Given the heterogeneity between samples and protocols, we chose to use the random model as a priority[18], inserting in the model the post-intervention and pre-intervention means of each group (intervention and control) in order to identify the "Δ value". The difference between means for each item was calculated from the Δ values of the intervention and control groups. To analyze heterogeneity, the I2 statistic was used, taking as definitions moderate up to 50% and high equal to or above 75%.

The bias risk of the original studies included in the synthesis was assessed by an adapted version of the Effective Public Health Practice Project tool (EPHPP)[19]

previously used[20].

This adaptation involves the removal of the components 'study design', 'blinding' and 'intervention integrity', considering (i) the specific interest in randomized controlled trials; (ii) the impossibility of blinding the participants to the interventions; and (iii) the absence of information in all included studies. On the other hand, a question was added about the use of data imputation in the analysis. Thus, six methodological components were analyzed: 'selection bias'; 'confounders'; 'data collection methods'; 'withdrawals and dropouts'; 'analysis' and 'using of intention-to-treat method in analyses'. The adapted EPHPP can be requested from the corresponding author.

Results

In total, the systematic searches in the electronic databases led to the identification of 1,610 potentially relevant references. After identification and removal of duplicates (n = 531), 1,079 studies were evaluated by their titles, and subsequently 132 of them remained for evaluation by their full texts. Of these, 128 did not meet the eligibility criteria, with the most frequent reasons being "studies with heterogeneous samples" (n = 44) and "non-school based interventions" (n = 37). Thus, four articles were referred to the synthesis of this review[21-24] (Figure 1).

Per location, the studies were conducted in Australia[21,22], Denmark[23] and Serbia[24], comprising an average age of 8.7[21,23] and 9.8[22] years old. It was observed a great variation among the criteria adopted for the inclusion of children, and the interventions had as their primary objective the reduction of anthropometric indicators[22-24] (Table 1).

Regarding the profile of the participants, all the included studies involved samples of children / adolescents without major medical issues (e.g., complications of heart disease) and without physical or mental disabilities[21-24]. More specifically, populations were observed to be inactive[22,24], under vulnerabilities (e.g., residing in low-income locations[22] and residing in locations with high rates of manual labor[21]) and who had not recently used medication[23] (data not shown).

As for the Risk of Bias scores, all studies were classified as low risk of bias in the "Selection", "Data collection methods" and "Withdrawals and drop-outs" domains (Table 1). However, only one study conducted analysis using the intention-to-treat method[21].

The included interventions were conducted over two[21] to seven months[22]. All of them provided structured physical activities for the children, and in two studies, also involving parents and family members[21,23]. In two studies, interventions were implemented by previously trained physical education teachers[21,22]. Sample sizes ranged from 28[24] to 132[21] participants (Table 2).

The metanalysis was carried out based on data from 123 study participants. Concerning systolic blood pressure (Figure 2), we observed a summary effect of -0.10 (95% CI: -0.39; 0.19), with no heterogeneity (I2 = 0%). In figure 3, the interventions resulted in a sum-

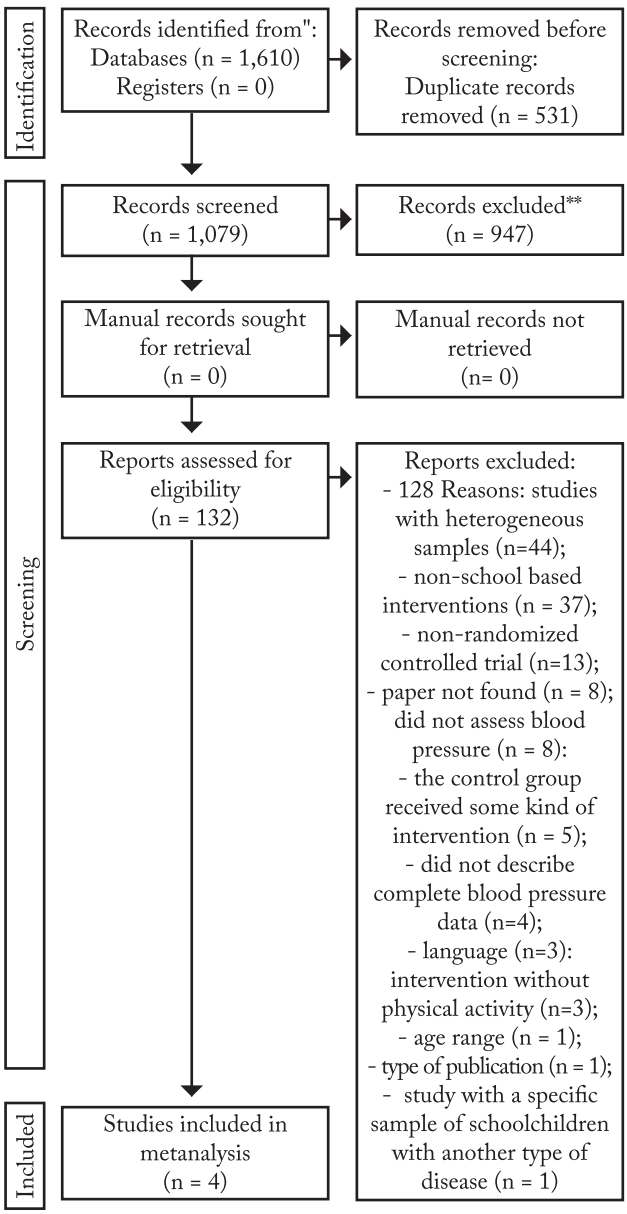


Figure 1 – Flowchart of systematic review with metanalysis Consider, if feasible to do so, reporting the number of records identified from each database or register searched. *If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools.

Table 1 – Descriptive information of included studies

Reference	Place of study (year)	Mean/ range age in baseline (%F)	Inclusion criteria	Primary outcome	Risk of bias assessment					
					Selection	Confounders	Data collection methods	Withdrawals and drop-outs	Analyses	Intention-to-treat analysis
Harder-Lauridsen et al., 2014[23]	Copenhagen-DEN (2012)	8.7 (81)	BMI > 90% percentile on the BMI curve	BMI	Low	Low	Low	Low	Low	No
Jones et al., 2015[22]	Wollongong - AUS (2010)	9.8 (46)	BMI ≥75th percentile according to IOTF cut-points	Body fat and BMI z-score	Low	Moderate	Low	Low	Moderate	No
Cvetkovic et al., 2018[24]	Nis - SRB (nd)	11–13 (0)	BMI: 20.55; <BMI<26.84	Body composition	Low	Moderate	Low	Low	Low	No
Morgan et al., 2014[21]	Hunter Region - AUS (2010-2011)	8.7 (45)	BMI: 25–40 kg/m2	Fathers' body weight	Low	Low	Low	Low	Low	Yes

Legends: %F = sample percentage of females; AUS = Australia; BMI = body mass index; DEN = Denmark; IOTF = International Obesity Task Force; nd = not described; SRB = Serbia.

Table 2 – Methodological information of included studies

Reference	Intervention lenght (months)	Physical activity protocol	Other components	Implementers	Randomized by group (Intervention / Control)
Harder-Lauridsen et al., 2014[23]	5	(I) group sessions with the children (60 min/wk); (II) group sessions with the children, their parents, and siblings (90 min/wk)	(III) two individual nutritional guidance and coaching and (IV) two common cooking and dining	A Bachelor in Nutrition and Health and a Exercise instructor	(19 / 19)
Jones et al., 2015[22]	7	(I) structured physical activity (180 min/wk)	(II) homework underpinned by Social Cognitive Theory (60 min/wk)	Trained Physical Education teachers	(19 / 18)
Cvetkovic et al., 2018[24]	3	(I) football and HIIT practices (180 min/wk); (II) regular PE classes (2 times per week)	nd	Research team	(14 / 14)
Morgan et al., 2014[21]	2	(I) group sessions with the fathers (360 min/wk); (II) group sessions with the children and their fathers (270 min/wk)	nd	Trained Physical Education teachers	(72 / 60)

Legends: HIIT = high intensity interval training; min/wk = minutes per week; nd = not described

mary effect of -0.33 (95% CI: -0.62; -0.04), also with low heterogeneity at Test I2 (11%). Even with a small number of studies, the presence of literature bias was identified in both outcomes (Figures 2 and 3).

Discussion

In the current systematic review with metanalysis, the objective was to identify and summarize the effects of school-based physical activity interventions on blood pressure in children and adolescents with overweight and / or obesity. Four studies were found, and among these, the summarized effect showed positive results on diastolic blood pressure in the intervention groups compared to the control groups.

Despite the fact that the summarized effect of systolic blood pressure has no significant difference, it is important to reinforce the evidence of previous studies, which indicate the beneficial role of physical activity on systolic blood pressure and body weight[3,25].

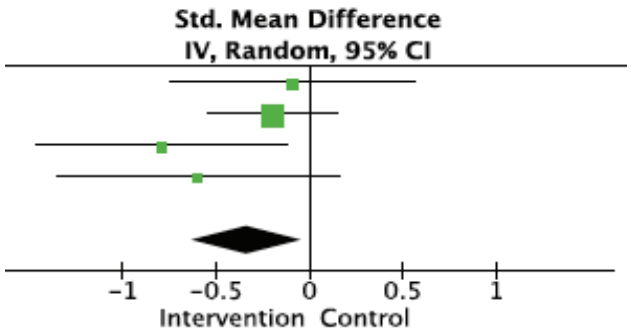
In a previous metanalysis[26] which involved healthy adults, it was revealed that resistance training, dynamic resistance and isometric resistance decrease diastolic and systolic blood pressure, while combined training only reduces diastolic blood pressure. Whereas in the

a

Study or Subgroup	Intervention Mean	Intervention SD	Intervention Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI	Year
Harder-Lauridsen et al., 2014	-1.1	9.6523	18	-0.2	9.8534	18	17.7%	-0.09 [-0.74, 0.56]	2014
Morgan et al., 2014	-3	8.511	72	-1	11.6132	60	52.0%	-0.20 [-0.54, 0.15]	2014
Jones et al., 2015	-1.45	8.0708	19	4.69	6.998	18	16.8%	-0.79 [-1.47, -0.12]	2015
Cvetkovic et al., 2018	-7.18	17.4408	14	1.89	11.3789	14	13.4%	-0.60 [-1.36, 0.16]	2018
Total (95% CI)			**123**			**110**	**100.0%**	**-0.33 [-0.62, -0.04]**	

Heterogeneity: $Tau^2 = 0.01$; $Chi^2 = 3.38$, df = 3 (P = 0.34); $I^2 = 11\%$
Test for overall effect: Z = 2.26 (P = 0.02)

b



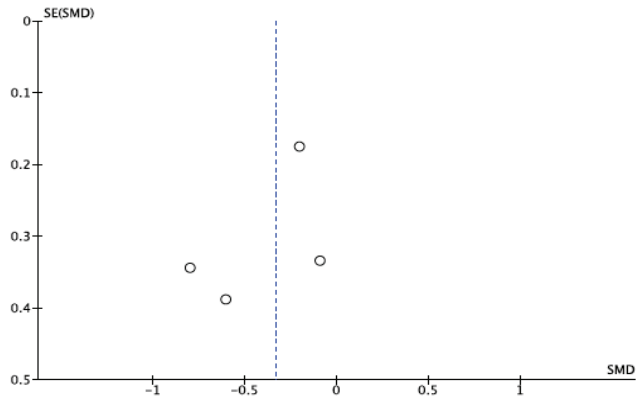


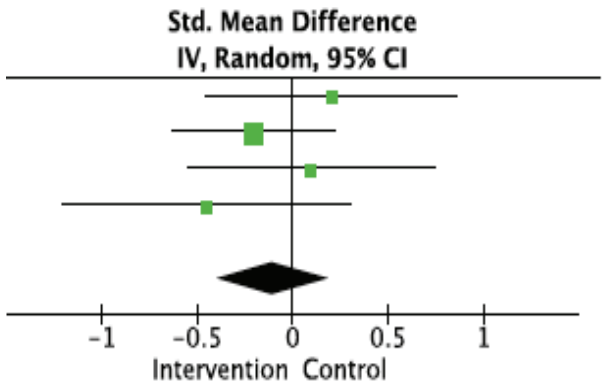
Figure 2 – Pooled effect (a) and funnel plot (b) of intervention studies (systolic blood pressure)
Legends: 95% CI = 95% confidence interval; SD = standard deviation; SE = standard error; SMD = standardized mean difference

a

Study or Subgroup	Intervention Mean	Intervention SD	Intervention Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI	Year
Harder-Lauridsen et al., 2014	2.3	9.2502	18	0.4	9.0491	18	19.4%	0.20 [-0.45, 0.86]	2014
Morgan et al., 2014	-4	8.5111	72	-2	11.6132	30	45.8%	-0.21 [-0.64, 0.22]	2014
Jones et al., 2015	0.73	13.9424	19	-0.52	11.4622	18	20.0%	0.10 [-0.55, 0.74]	2015
Cvetkovic et al., 2018	-7.14	17.2329	14	0.92	17.4408	14	14.8%	-0.45 [-1.20, 0.30]	2018
Total (95% CI)			**123**			**80**	**100.0%**	**-0.10 [-0.39, 0.19]**	

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 2.26$, df = 3 (P = 0.52); $I^2 = 0\%$
Test for overall effect: Z = 0.70 (P = 0.48)

b



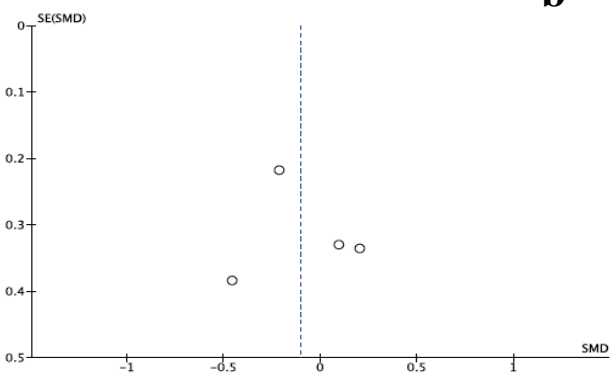


Figure 3 – Pooled effect (a) and funnel plot (b) of intervention studies (diastolic blood pressure)
Legends: 95% CI = 95% confidence interval; SD = standard deviation; SE = standard error; SMD = standardized mean

review by Busnatu et al.[27], based on evidence of 12 studies conducted with adolescents, and considered exercise or any other intervention leading to physical stress, the authors found that exercise interventions significantly improved blood pressure and cardiometabolic risk factors such as, body mass index, blood glucose level, and LDL level, which is in agreement with our findings.

Also, even though blood pressure was not the primary outcome, Noubiap et al.[28], indicates an association between high blood pressure and body mass index. In this sense, obesity and / or overweight are risk factors for hypertension and cardiovascular diseases, such as hypertension, in all age groups. Additionally, a high prevalence of hypertension is generally observed in obese children[29].

Although the result of the meta-analysis indicated low heterogeneity, this evidence should be weighted and extrapolated with caution, taking into account, in the included studies, the differences between the characteristics of the participants (e.g., age, context), the criteria adopted to define overweight / obesity and the intervention protocols (e.g., which have different durations, strategies and implementers).

As the strengths of this study, it is noteworthy that this is the first study to limit investigations regarding the impact of school-based only interventions on blood pressure. We were able to cluster the prevalence of hypertension, based on the available evidence, which allowed our review to have a scope of the prevalence of hypertension in children and adolescents.

The results highlighted the importance of early detection for planning population-level interventions for the primary prevention of hypertension in children and adolescents to reduce the risk of cardiovascular disease and prevent or treat hypertension.

The results of this study should be interpreted with caution because of the small number of papers included in the metanalysis and heterogeneity in experimental designs. We emphasize the importance that future studies can conduct their analyses using the intention-to-treat-method.

In conclusion, it was observed that the school-based physical activity interventions reviewed in this study produced statistically significant effects on the reduction of diastolic blood pressure in samples of overweight / obese children. Considering the promising effects on diastolic blood pressure, we suggest the development of more school-based interventions in the short, medium, and long term, based on physical activity practice for overweight and/or obese populations, also involving environmental aspects, longer duration, multicomponent approaches, and parental / guardian involvement.

Conflict of interest

The authors declare no conflict of interest.

Author's contributions

Wiggers E: Conceptualization, Methodology, Validation, Data analysis, Investigation, Resources, Data curation, Project administration, Visualization, Writing – original draft, Approval of the final version. Costa GP: Conceptualization, Methodology, Validation, Data analysis, Investigation, Resources, Data curation, Visualization, Approval of the final version. Ribeiro EHC: Visualization, Writing – review & editing, Approval of the final version. Caldas EC: Resources, Visualization, Writing – review & editing, Approval of the final version. Trapé AA: Resources, Visualization, Writing – review & editing, Approval of the final. Guerra PH: Conceptualization, Methodology, Validation, Data analysis, Investigation, Resources, Data curation, Supervision, Project administration, Visualization, Writing – original draft, Approval of the final version.

Declaration regarding the use of artificial intelligence tools in the article writing process

The manuscript did not use artificial intelligence tools for its preparation.

Availability of research data and other materials

The contents underlying the research text are contained in the manuscript.

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