Nutr Bras. 2024;23(3):1016-1026
doi:10.62827/nb.v23i3.3030

REVISÃO

Effect of physical activity in children and adolescents with metabolic syndrome: a systematic review

Efeitos da atividade física em crianças e adolescentes com síndrome metabólica: uma revisão sistemática

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Received: August 29, 2024; Accepted: September 13, 2024.

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Como citar
Mendes PS, Pascoal AG, Souza LP, Mori B. Effect of physical activity in children and adolescents with metabolic syndrome: a systematic review. Nutr Bras. 2024;23(3):1016-1026. doi:10.62827/nb.v23i3.3030

Abstract

Introduction: evidence demonstrates that regular physical exercise has beneficial effects in the prevention and treatment of high blood pressure, insulin resistance, diabetes, dyslipidemia and obesity in the population. Objective: To evaluate the impact of physical activity on children and adolescents with metabolic syndrome. *Methods*: Data surveys. Medline (Pubmed), Cochrane Library, LILACS/VHL. Study selection. Cross-sectional studies (2008-2022) that evaluated the ability of physical training to reduce at least one of the following outcomes: HDL-C; triglycerides; HOMA-IR, Fasting Glucose, systolic blood pressure (SBP); diastolic blood pressure (DBP), Body Mass Index (BMI); 2) Intervention (modality, intervention period, weekly session and duration, weekly frequency, intensity, number of sets and repetitions); in children and adolescents classified as having metabolic syndrome. Data extraction and analysis. Two independent reviewers extracted the data and assessed the quality of the included studies. The differences (physical training group minus control group) in the evaluated results were analyzed using (mean values and standard deviation of pre- and post-intervention, and difference between means). *Results*. Of the 1,961 articles retrieved, 03 studies were included. This review showed that the practice of physical activity, in general, was associated with a reduction in HDL-C levels (before 44.21 mg/dL (± 9.6), after 42.13 mg/dL (± 7. 76), but was associated with reductions in TG levels (before 113.87 mg/dL after 87.53 mg/dL (26.34). AND HOMA (before 2.54 mg/dL after 2.61 mg /dL) Fasting glucose (before 79.86 mg/dL (±9.22) after 82.43 mg/dL (±8.31). Physical activity is associated with reduced HDL-C levels. *Conclusion*: seems likely that physical training can play an

important role in preventing or delaying metabolic syndrome. We emphasize the need for future intervention studies that investigate the effects of physical activity with greater methodological quality.
Keywords: Children; adolescent; physical activity; metabolic syndrome.

Resumo

Introdução: evidências demonstram que a prática regular de exercícios físicos tem efeitos benéficos na prevenção e tratamento da hipertensão arterial, resistência à insulina, diabetes, dislipidemia e obesidade na população. *Objetivo*: Avaliar o impacto da atividade física em crianças e adolescentes com doenças metabólicas síndrome. *Métodos*: Pesquisas de dados. Medline (Pubmed), Biblioteca Cochrane, LILACS/BVS. Seleção de estudos. Estudos transversais (2008-2022) que avaliaram a capacidade do treinamento físico em reduzir pelo menos um dos seguintes desfechos: HDL-C; triglicerídeos; HOMA-IR, Glicose de Jejum, pressão arterial sistólica (PAS); pressão arterial diastólica (PAD), Índice de Massa Corporal (IMC); 2) Intervenção (modalidade, período de intervenção, sessão e duração semanal, frequência semanal, intensidade, número de séries e repetições); em crianças e adolescentes classificados como portadores de síndrome metabólica. Extração e análise de dados. Dois revisores independentes extraíram os dados e avaliaram a qualidade dos estudos incluídos. As diferenças (grupo de treinamento físico menos grupo controle) nos resultados avaliados foram analisadas por meio de (valores médios e desvio padrão do pré e pós-intervenção, e diferença entre as médias). *Resultados*: Dos 1.961 artigos recuperados, foram incluídos 03 estudos. Esta revisão mostrou que a prática de atividade física, em geral, esteve associada à redução dos níveis de HDL-C (antes de 44,21 mg/dL (± 9,6), após 42,13 mg/dL (± 7,76), mas foi associada a reduções de Níveis de TG (antes de 113,87 mg/dL depois 87,53 mg/dL (26,34). E HOMA (antes de 2,54 mg/dL após 2,61 mg/dL) Glicose de jejum (antes de 79,86 mg/dL (±9,22) após 82,43 mg/dL (± 8.31). A atividade física está associada a níveis reduzidos de HDL-C. *Conclusão*: parece provável que o treinamento físico possa desempenhar um papel importante na prevenção ou no retardo da síndrome metabólica. Ressaltamos a necessidade de futuros estudos de intervenção que investiguem os efeitos da atividade física. Com maior qualidade metodológica.
Palavras-chave: Crianças; adolescente; atividade física; síndrome metabólica.

Introduction

Metabolic syndrome (MS) is a set of simultaneous pathophysiological changes that predispose to the risk of chronic diseases and is related to the increasing risk of cardiovascular diseases and diabetes mellitus. SM can occur early in life; however, no conclusive evidence has indicated causal factors in the pediatric population. Its main cause is not genetic, but falls within modifiable risk factors, such as behavioral and environmental elements [1,2].

The World Health Organization recommends that children and adolescents practice moderate to vigorous physical activity (MVPA) for at least 60 minutes daily. Based on the hypothesis that greater amounts of physical activity are associated with better indicators of metabolic health, maintaining high levels of physical activity from childhood to adulthood predisposes to maintaining a healthy risk profile with reduced rates of morbidity and mortality from cardiovascular diseases and diabetes [3,4].

However, the difficulty in defining the exact relationship between physical activity and MS is due to factors such as: difficulty in accurately measuring physical activity, as most studies use recall questionnaires or self-administered diaries; lack of consensus in the literature regarding the criteria for diagnosing MS in children and adolescents and lack of sensitivity of cutoff points to define individuals at risk for the population of children and adolescents [5].

In recent years, researchers have chosen to analyze the association between physical activity and MS and its components using continuous data rather than categorical data. The adoption of the metabolic risk score appears to be plausible because it is statistically more sensitive and less susceptible to errors than dichotomous approaches [6].

Research reports that the metabolic risk score was inversely associated with total physical activity and its subdimensions of intensities [7]. However, the question remains about the effect of physical activity in children and adolescents with metabolic syndrome. Therefore, the objective of this work is to describe the effects of physical activity in children with metabolic syndrome.

Methods

This systematic review and meta-analysis is reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement. Registered in Prospero CRD42022355992. Protocol published in https://preprints.SciELO.org/index.php/SciELO/preprint/view/8066/version/8527

Search strategy and studies selection

The following databases were used without date limits: Medline (Pubmed), Cochrane Library, LILACS/BVS, a manual search of the references from the studies found in the chosen databases was carried out. We only included articles that were already published in journals. Theses and dissertations were excluded.

There was no language restriction in the search criteria. Boolean operators "OR" and "AND" were used. In PubMed, the search was per- formed using the MeSH terms and their synonyms. Related terms to MeSH were used in the other databases. The complete search strategy used for the PubMed database is shown in the Electronic Supplementary material https://pdf.ac/Gg1mF

Two independent reviewers (P.S.M. and A.G.P.) read the titles and abstracts of all papers found, and independently read the full article if the paper met the eligibility criteria. Disagreements were resolved by consensus and discussion with a third reviewer (B.M.).

Eligibility criteria

Inclusion Criteria: Children and adolescents, full-time schoolchildren, Children who agree to participate in the study and who have permission from their parents/guardians; Children who are in full physical ability to perform the tests. Exclusion Criteria Children who do not have a consent form properly signed by their parents, as well as the Minor Consent Term, Children who have a physical or cognitive disability that does not allow them to perform the physical tests and who cannot answer the questionnaires.

Data extraction

Data extraction was performed by two independent reviewers (P.S.M. and A.G.P.). Disagreements between the two reviewers regarding the conditions of the studies were resolved by a consensus meeting with the third reviewer (B.M.). For data extraction, a standardized form was used, composed of the following items: author, population, intervention data, and outcomes. For each item, the following data were extracted: 1) Population (mean age, and HDL-C; triglycerides; HOMA-IR, Fasting Glucose, systolic blood pressure(SBP); diastolic blood pressure (DBP), Body Mass Index (BMI); 2) Intervention (modality, intervention period, session, and weekly duration, weekly frequency, intensity, number of sets and repetitions); Results (mean values and standard deviation of the pre- and post-intervention, and the difference between the means).

Study quality assessment (risk of bias)

The risk of bias tool covers six domains of bias: selection bias, performance bias, detection bias, attrition bias, reporting bias, and other bias. Within each domain, assessments are made for one or more items, which may cover different aspects of the domain, or different outcomes. Quality assessment was independently performed by two unblinded reviewers (P.SM. and A.G.P.) and disagreements were resolved by consensus or by a third reviewer (B.M.).

The risk of bias was evaluated in the following form: high risk-when the methodological criteria, such as adequate sequence generation, were not reported or were not performed; low risk - when the methodological criteria were performed appropriately; unclear risk-when there was no adequate description of the criteria, making it difficult to evaluate it as high or low risk.

Results

Studies description

The initial search resulted in 1,961 studies, of which 43 were excluded because they were duplicates. We proceeded to the second phase with reading the title and abstract showing 1,918 studies. Of those analyzed in full, only 03 studies met the eligibility criteria. The selection of research and studies is represented in Figure 1. The included studies contain 5038 individuals in total. The characteristics of these studies are summarized in Tables 1 and 2.

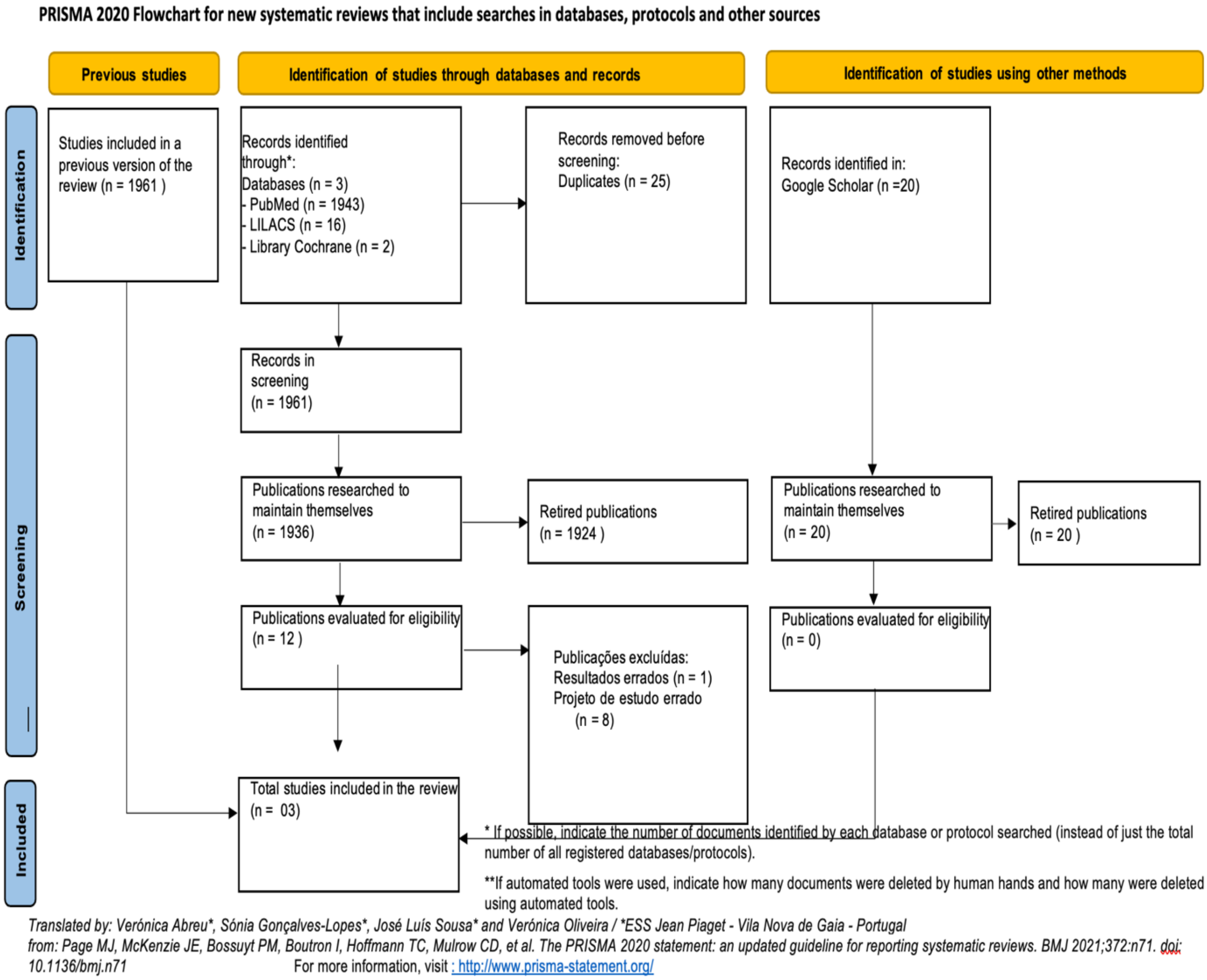

Fig. 1 - *Flow diagram of articles identified*

Table 1 - *Characterization of interventions*

Author	Years	Country	Sample (N)	Age	Physical Activity	HDL -C (mg/dL)		TG (mg/dL)		SBP (mmHg)		DBP (mmHg)		BMI (kg/m²)		Homa IR (mg/dL)		FG (mg/dL)	
						before intervention	after intervention	before intervention	after intervention	before intervention	after intervention	before intervention	after intervention	before intervention	after intervention	before intervention	after intervention	after intervention	before intervention
Faria F et al [19]	2019	BRAZIL	92 (all males)	16,0 1 ± 2,3	Volleyball: 2 days/week, 60min/day; Basketball: 2 days/week, 60min/day; Soccer: 1 day/week, 60min/day; Futsal: 2 days/week, 60min/day. Duration of treatment: 14 weeks, 56 sessions. Minimum number of sessions: 29.)	42,9 (±8,6)	38,3 (±5,9)	101.0 (65.0-286.0)	77.6 (49.0-112.5)	114.5 (±12.19)	111.25 (±0.2)	75.41 (±8.37)	76.0 (±6.79)	20,5 (± 5.3)	20 (± 1.0)	1.12 (0.36-4.35)	1.35 (0.6-3.95)	78.02 (±8.55)	83.86 (±5.92)
Coppen AM et al [20]	2008	USA	135 (105 females; 30 males)	15,7 ± 2,1	10000 steps/day. Treatment duration: 10 weeks	44,94 (±7,6)	43,79 (± 4,9)	139,61 (39.1-62.6)	107,41 (0.57)	126,6 (±11.19)	118,1(±9.1)	82,5 (± 9.42)	77,7 (±6.8)	35,7 (± 6.1)	32,45 (± 6.4)	5.32 (±0.91)	5.18 (±0.42)	unchecked	unchecked
Kelisha di R et al [21]	2007	IRAN	4811 (2563 females; 2248 males)	12,0 7 ± 3,2	Vigorous PA: 0.6h/day Treatment duration: 7 days	44,8 (±12.61)	44,3(± 12.5)	101.0 (65.0 - 286.0)	77.6 (49.0 - 112.5)	114,5(± 12.19)	111,25(± 10.2)	75.41(± 8.37)	76,0(± 6.79)	20.5(± 3.5)	18,53(± 3.8)	1.2 (±0.8)	1.3 (±0.8)	81.7 (9.9)	81.0 (±10.7)

Abbreviations: HDL -C, high density cholesterol; TG, triglycerides ; SBP, systolic blood pressure; DBP, diastolic blood pressure ; BMI, Body Mass Index; Homa IR, assesses insulin resistance; FG, Fasting Glucose; mmHg, millimeters mercury; mg/dL, unit of measure.

Assessing risk of bias

Among the included studies, 66.66% reported a low risk of confounding bias (2 of 3), 66.66% reported a low risk of selection bias (2 of 3),

66.66% had a low risk of measurement bias (2 out of 3), 66.66% described a low risk of intervention bias received (2 out of 3) and 66.66% reported having a low risk of loss bias (2 of 3) and 100% of the studies reported having low risk of bias for the domains measuring outcomes and selective reporting (3 of 3) in Figure 2.

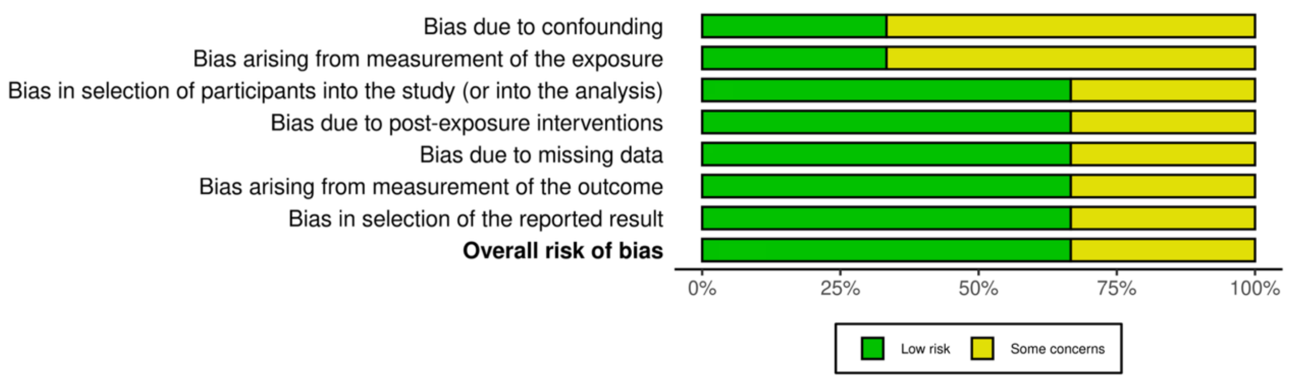

Figure 2 - *Risk of bias graph*

Discussion

Physical activity

Physical activity (PA) has been considered a promising tool for the prevention of childhood obesity and for the treatment of obesity-related metabolic dysregulation; PA interventions reported in the literature often have a limited impact on body mass index (BMI). This is likely due to the limitations of BMI, which may not be sensitive to short-term changes and may be a confounding factor related to improvements in lean mass that are not reflected in BMI.

The effect of PA may vary by gender and age, studies to date have conflicting findings. Studies have shown that girls who participated in a group randomized trial of standardized PA had reduced adiposity and lower LDL compared to controls, but no effect was observed in boys [8].

These conflicting findings may be explained, at least in part, by gender-specific behavior or variation in the timing of the onset of puberty, which occurs earlier on average in girls. Studies show that boys in general have higher activity levels compared to girls, which may have contributed to their improved metabolic levels [8]. Research has demonstrated benefits of both resistance training and aerobic exercise. A 12-week resistance training program reduced body fat, waist circumference, and waist-to-hip ratio, as well as HOMA-IR, even in the absence of change in BMI [9].

Many of the studies reviewed suggest multiple mediators of the relationship between physical activity and metabolic health. With all the studies in this area, mediation assessments are complex considering that many of the variables are closely related, it is a challenge to separate the factors that may contribute to the positive effects of PA. The two most pertinent questions in this area are whether the benefits of PA are mediated by reductions in adiposity or by improvements in physical fitness [10].

Some recent studies suggest that the benefits of PA are mediated by reductions in adiposity. In a longitudinal study of 723 healthy children aged 8 to 11 years, [11] demonstrated that the relationship between PA and SM at follow-up was not significant after adjustment for fat mass and removal of SM waist circumference. Similarly, [12] reported that both moderate PA and MVPA initially had similar impacts on the risk of metabolic syndrome, but controlling for waist circumference attenuated this effect for MVPA. [14] evaluated the impact of lifestyle habits on the risk of DM2 in childhood through a 2-year prospective longitudinal cohort study of 630 children with at least one obese parent. Higher levels of MVPA have been associated with improved insulin sensitivity as defined by HOMA-IR, in part through an effect on adiposity levels. Taken together, these results suggest that decreased adiposity may be a mediator in the causal pathway between PA and improved cardiometabolic risk profile [14].

Insulin Resistance

The fact that IR peaks in early adolescence, regardless of pubertal status [15], raises the question whether the effect of PA on IR may also vary with age. [16] explored this by following a cohort of 300 children aged 9 to 16 years with annual measurements of PA and metabolic markers. At 12-13 years of age - when insulin resistance was at its peak, adolescents who were most active had a 17% lower peak HOMA-IR ($p < 0.001$) regardless of body fat percentage and pubertal status compared with those who were less active. This difference progressively decreased over the next 3 years and disappeared by age 16, when IR returned to prepubertal levels. Although insulin resistance in adolescence is temporary, increased beta cell burden at this time may have implications for later function in adulthood. As a result, early adolescent IR may represent a unique opportunity for intervention [16].

In demonstrations by [17] found that obese and overweight adolescents who participated in an 8-month physical activity program showed improvement in fasting levels of: total cholesterol, LDL and insulin, as well as HOMA-IR, compared to controls. These results suggest a beneficial effect of PA on HOMA-IR levels; however, other metabolic improvements have not been elucidated [18,22,24,25].

Conclusion

Studies suggest that there may be differences by age and gender in the relationship between the effects of PA and MS, that different modalities of PA may result in different effects on metabolic health and that several subsequent effects of PA may be responsible for its metabolic benefits. A notable finding across studies was that most of the positive metabolic changes observed occurred in the absence of change in BMI. This highlights that lifestyle intervention studies that only include BMI as an endpoint may be missing significant intervention effects.

In general, exercise training interventions for at least eight weeks are associated with reductions in fasting insulin and HOMA-IR levels. More specifically, aerobic exercise training is associated with reductions in fasting insulin and HOMA levels, whereas combined exercise training and resistance training are not associated with the metabolic outcomes assessed. Based on these results, it seems likely that physical training may play an important role in preventing or delaying metabolic syndrome. We emphasize the need for future intervention studies that investigate the effects of physical activity on markers of metabolic syndrome in children and adolescents. It is important that future intervention studies have higher methodological quality, with adequate random sequence generation, allocation concealment and blinding of outcome assessment, aiming to increase internal validity, thus reducing heterogeneity between future studies.

Conflicts of interest

The authors declare no conflicts of interest of any nature.

Sources of funding

Own funding.

Authors contributions

Project design and supervision: Mori B; Data collection and interpretation: Mendes PS, Pascoal AG; Project writing: Souza LP; Review and editing: Mori B; Final critical review: Mori B.

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