

# Impact of sports participation on cardiovascular health markers of children and adolescents: Systematic review and meta-analysis

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## Abstract

### BACKGROUND

Cardiovascular diseases have a high prevalence in adults and their development begins in the first decades of life. On the other hand, sports participation in childhood and adolescence provides benefits which can delay the onset of these diseases.

### AIM

To synthesize the available literature on the impact of sports participation on cardiovascular outcomes in children and adolescents.

### METHODS

This systematic review was conducted on studies of children and adolescents (aged 8-18 years) who regularly practiced a sport and had reported cardiovascular outcomes (blood pressure and intima-media thickness) recorded. The Medline/PubMed, SciELO, Reference Citation Analysis (<https://www.referencecitationanalysis.com/>) and Bireme databases were searched.

### RESULTS

In total, 3314 publications for blood pressure and 122 publications for intima-media thickness were identified in the databases. After exclusions (*e.g.*, duplicate articles, animal studies and those that did not meet the inclusion criteria), four publications for blood pressure (449 adolescents) and two publications for intima-media thickness were included (402 adolescents). For blood pressure, all publications were longitudinal in design (follow-up ranging from 12 wk to 12 mo) and involved adolescents aged from 8 years to 18 years of age. For intima-media thickness, both publications were longitudinal in design and involved adolescents aged from 11 years to 18 years of age.

### CONCLUSION

Sports participation seems to promote benefits to cardiovascular structure and

function in adolescents. However, studies with adolescents are scarce and further research is needed to understand this phenomenon.

**Key Words:** Pediatrics; Adolescents; Sports; Blood pressure; Intima-media thickness

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**Core Tip:** Obesity, poor diet and a sedentary lifestyle increases the risk for cardiovascular disease in adulthood. On the other hand, sports participation reduces blood pressure and children and adolescents engaged in sports tend to present better arterial thickness values. In this way, those who practice sports regularly may present better cardiovascular health. In this review we seek to characterize the results of sports practice in adolescence on aspects related to cardiovascular health.

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## INTRODUCTION

Cardiovascular diseases are the main cause of death among adults[1,2] with arterial hypertension being the most prevalent[3]. Although arterial hypertension is frequently observed in adults, high blood pressure is its manifestation in children and adolescents. In fact, the prevalence of high blood pressure in early life has increased in recent years[4,5] which is concerning for health professionals as it predicts mortality related to cardiovascular diseases in adulthood[6,7].

Blood pressure monitoring is a simple and useful way to screen cardiovascular problems in clinical practice. In addition, measures of intima-media thickness (IMT) also constitute a relevant marker of cardiovascular health, being a non-invasive method used to screen atherosclerosis[8,9].

Although the occurrence of cardiovascular diseases in children and adolescents is low, habits assumed in early life are able to affect health outcomes later in life[8,10]. Increased time spent in sedentary behavior[11] and insufficient physical activity[12] are behaviors that contribute to the development of cardiovascular diseases including arterial thickening[13].

Physical activity is a relevant behavior with huge potential to affect pediatric health. In terms of cardiovascular health, regular engagement in physical exercise helps to prevent a large variety of cardiovascular diseases in adulthood[14-18], but the effects in children and adolescents are still under investigation. Similarly, the pathways by which routines of physical exercise are able to promote cardiovascular health have been widely investigated in pediatric and adult groups[19], however, relevant questions still remain, mainly in pediatric groups.

For example, there are limited data about the impact of sports participation on cardiovascular health during adolescence. This question is relevant because in the real world (different from exercise protocols performed in the laboratory), sports participation is the main manifestation of physical exercise in adolescence helping adolescents to reach moderate-to-vigorous physical activity recommendations[20-23].

However, in the literature it is unclear whether engagement in sports is beneficial to the cardiovascular system in apparently healthy adolescents. Most publications involving physical exercise and cardiovascular aspects in adolescents are focused on obese groups and the exercise protocols rarely consider sports participation[24]. Thus, the objective of this review is to synthesize the available literature on the impact of sports participation on cardiovascular outcomes (blood pressure and IMT) in children and adolescents.

## MATERIALS AND METHODS

### Search strategy

The present systematic review was conducted according to the Preferred reporting Items for Systematic Review and Meta-Analyses recommendations. The Problem was “sports participation and cardiovascular outcomes in adolescents”, the Intervention was “engagement in sports”, the Comparator was “cardiovascular outcomes in adolescents non-engaged in sports”, and the Outcome was “blood pressure

and intima-media thickness”.

The main outcome of this review was to identify changes in systolic blood pressure (SBP) and diastolic blood pressure (DBP) (mmHg) and femoral and carotid IMT (mm) attributed to sports participation in children and adolescents. Due to the limited number of publications, there was no stratification according to sports.

### Literature search and selection

Two authors independently performed the literature search from March to July 2021 and studies published until June 2021 were accessed. The search was restricted to publications in the following electronic databases: Medline/PubMed (National Library of Medicine), SciELO, Reference Citation Analysis (<https://www.referencecitationanalysis.com/>) and BIREME (Latin American and Caribbean Center on Health Sciences information). The search strategy considered the combination of nine keywords (DeCS): *Children, adolescents, youth, teenagers, pediatrics, sports, sports participation, organized sports, blood pressure, intima-media thickness and vessel thickness*, as follows.

**Blood pressure:** ((((((Children) OR (Adolescents)) OR (Youth)) OR (Teenagers)) OR (Pediatrics)) AND (((Sports) OR (Sports participation)) OR (Organized sport))) AND (Blood pressure).

**Intima-media thickness:** ((((((Children) OR (Adolescents)) OR (Youth)) OR (Teenagers)) OR (Pediatrics)) AND (((Sports) OR (Sports participation)) OR (Organized sport))) AND ((Intima-Media Thickness) OR (Vessel Thickness)).

### Inclusion criteria

In terms of language, only publications in English were considered. Data from reviews, expert opinions, case reports, editorials, rodent studies and computational studies were excluded. Cross-sectional studies were also excluded because the aim was to consider longitudinal studies that identified changes in blood pressure and IMT in adolescents engaged in sports. Finally, longitudinal studies that investigated adolescents (girls and boys) aged between 8 years and 18 years who were regularly engaged in any sport were considered eligible.

### Data extraction

A standardized Cochrane Consumers and Communication Review Groups data extraction method was used, whereby the age of the participants, sample size, sex, sports participation definition and cardiovascular health marker outcomes (systolic blood pressure, diastolic blood pressure, carotid intima media thickness and femoral intima media thickness) were collated from each study.

Initially, two independent researchers (SMV and JBU) identified potential studies eligible for this review by screening titles and abstracts. Subsequently, the same reviewers observed the inclusion and exclusion criteria, assessed the full texts and extracted data from the included studies using a standardized extraction form. In case of discrepancy, another reviewer (WT) was available throughout the screening process to verify and resolve any issue.

### Quality assessment

The Newcastle-Ottawa quality assessment scale was used, which adopts a star system to assess the quality of eight items in three different domains (selection, comparability and exposure). Each item can receive one star, except for the comparability domain (two stars). The total score of the instrument ranges from 0 to 9[25].

### Statistical analysis

In cases where standard error of the mean (SEM) and mean values for the intervention or control group were available, the SD was calculated using the following formula:  $SD = SEM \times \sqrt{n}$ .

In cases where 95% confidence intervals (95%CI) were provided for the intervention or control group, the SD was calculated as follows:  $SD = \sqrt{n \times (\text{upper limit} - \text{lower limit}) / t \text{ statistic}}$ .

The meta-analysis was performed using Review Manager software (Version 5, Cochrane Collaboration). Differences in means and 95% CI were calculated using a continuous random-effect model to incorporate heterogeneity among studies. If the number of available studies was small ( $n \leq 3$ ), a fixed effect model was applied to estimate the between study heterogeneity.

Heterogeneity between studies was assessed using the chi square test expressed by means of inconsistency indices ( $I^2$ ) (0%–25%: None, 26%–50%: Low, 51%–75%: Moderate, and 76%–100%: High). Statistical significance was set at  $P < 0.05$ .

Table 1 Blood pressure

Ref.	Title of paper	Aim/purpose	Total sample, <i>n</i> = 326	Sample age	Follow-up time	Sports	Main results	Quality assessment <sup>1</sup>
Cayres-Santos <i>et al</i> [29], 2020	Sports participation improves metabolic profile in adolescents: ABCD growth study	To analyze the impact of participation in sports with different CRF demands on changes in metabolic and cardiovascular markers in adolescents	184 adolescents ( <i>n</i> = 122 engaged in sports and <i>n</i> = 62 not engaged in sports)	Between 11-18	12 mo	High CRF: Basketball, swimming, tennis, and track and field. Low CRF: Baseball, gymnastics, judo, karate, and kung fu	SBP increased in both sports with high [2.299 mmHg (95%CI: 0.142-4.456)] and low CRF [2.806 mmHg (95%CI: 0.261-5.351)]. DBP increased in sports with high [1.896 mmHg (95%CI: 0.499-3.293)], but not in sports with low CRF [0.948 mmHg (95%CI: -0.271 to 4.562)]	7
Cayres <i>et al</i> [30], 2018	Sport-based physical activity recommendations and modifications in C-reactive protein and arterial thickness	We analyzed the effects of 1 yr of engagement in ≥ 300 min/wk of organized sports on inflammatory levels and vascular structure in adolescents	89 adolescents ( <i>n</i> = 15 sport practice and <i>n</i> = 74 non-sport practice)	Between 11-14	12 mo	Soccer, swimming, and others not shown	SBP did not change in the sports participation group [-0.309 mmHg (95%CI: -4.149 to 3.532)], but DBP did [-6.269 mmHg (95%CI: -9.313 to -3.224)]	7
Seabra <i>et al</i> [31], 2020	School-based soccer practice is an effective strategy to improve cardiovascular and metabolic risk factors in overweight children	We examined the effects of a 6-mo school-based soccer program on CV and metabolic risk factors in overweight children	40 overweight boys aged 8 to 12 yr ( <i>n</i> = 20 soccer group and <i>n</i> = 20 control group)	Between 8-12	6 mo	Soccer	SBP did not change in the soccer group (2.7 mmHg), but DBP did (-4.0 mmHg)	9
Vasconcellos <i>et al</i> [26], 2021	Does Recreational Soccer Change Metabolic Syndrome Status in Obese Adolescents? A Pilot Study	To evaluate whether a soccer program (RSP) might lower risk factors related to MetS in obese adolescents	13 adolescents aged 13-17 yr ( <i>n</i> = 6 soccer program and <i>n</i> = 7 control)	Between 12-17	12 wk	Soccer	SBP (-7.0 mmHg) and DBP (-3.0 mmHg) did not change significantly in the soccer group	8

<sup>1</sup>Quality Assessment according to Newcastle-Ottawa Scale (range 0 to 9) for cohort studies. ABCD Growth Study: Analysis of Behaviors of Children During Growth; CRF: Cardiorespiratory fitness; CV: Cardiovascular; MetS: Metabolic syndrome; RSP: Randomly assigned to experimental.

## RESULTS

### Study selection

The research team searched for publications considering two outcomes, the impact of sports participation on blood pressure and IMT.

A total of 3436 relevant studies were identified in the databases. The majority of the studies assessed blood pressure [*n* = 3314 (96.4%)], while 122 (3.6%) assessed intima media thickness. After removal of duplicates and screening of study titles and abstracts, 2307 studies remained. Following the final full-text screening process, 4 studies for systolic and diastolic blood pressure (*n* = 326) and 2 studies for intima media thickness (*n* = 273) were included in the meta-analysis. The study selection process is presented in Figure 1.

### Study outcomes

The characteristics of participants included in each study are presented in Table 1 for blood pressure and Table 2 for intima media thickness issues. Comparisons between the two groups (sports participation and control groups) are shown in Figure 2.

Table 2 Arterial thickness

Ref.	Title of paper	Aim/purpose	Total sample, <i>n</i> = 273	Sample age	Follow-up time	Sports participation definition	Main results	Quality assessment <sup>1</sup>
Cayres-Santos <i>et al</i> [29], 2020	Sports participation improves metabolic profile in adolescents: ABCD growth study	To analyze the impact of participation in sports with different CRF demands on changes in metabolic and cardiovascular markers in adolescents	184 adolescents ( <i>n</i> = 122 engaged in sports and <i>n</i> = 62 not engaged in sports)	Between 11-18	12 mo	High CRF: Basketball, swimming, tennis, and track and field. Low CRF: Baseball, gymnastics, judo, karate, and kung fu	Carotid IMT did not change in both sports with high [0.002 mm (95%CI: -0.018 to 0.023)] and low CRF [-0.001 mm (95%CI: -0.024 to 0.023)]. Femoral IMT did not change in both sports with high [0.013 mm (95%CI: -0.010 to 0.037)] and low CRF [-0.004 mm (95%CI: -0.024 to 0.033)]	8
Cayres <i>et al</i> [30], 2018	Sport-based physical activity recommendations and modifications in C-reactive protein and arterial thickness	We analyzed the effects of 1 yr of engagement in ≥ 300 min/wk of organized sports on inflammatory levels and vascular structure in adolescents	89 adolescents ( <i>n</i> = 15 Sport practice and <i>n</i> = 74 non-sport practice)	Between 11-14	12 mo	Soccer, swimming, and others not shown	Carotid IMT did not change in the sports participation group [0.006 mm (95%CI: -0.013 to 0.024)], but Femoral IMT did [-0.043 mm (95%CI: -0.081 to -0.006)]	8

<sup>1</sup>Quality Assessment according to Newcastle-Ottawa Scale (range 0 to 9) for cohort studies. CRF: Cardiorespiratory fitness; IMT: Intima-media thickness.

### Study characteristics and meta-analysis

**Blood pressure:** The four publications included 326 adolescents aged from eight to 18 years (163 engaged in sports and 163 defined as control). All the studies had a longitudinal design and the findings are detailed in Table 1. The four publications varied according to the time of follow-up (ranging from 3 mo to 12 mo) and the sports considered included soccer, swimming, judo, karate, kung fu, gymnastics, basketball, track and field and baseball. All studies were published from 2018 to 2021.

In an individual way, studies did not show relevant changes through the follow-up for SBP and DBP. However, the meta-analysis model with the sum of all studies identified a decrease in DBP in favor of the sports participation group [-1.67 mmHg (95%CI: -2.90 to -0.43)].

**IMT:** The two papers included 402 adolescents aged from 11 years to 17 years. Both studies had a longitudinal design and the findings are detailed in Table 2. The studies were conducted between 2018 and 2020 and both recorded a 12-mo follow-up. No relevant changes were observed between sports participation and control groups in either the analysis of the individual results or in the meta-analysis model (Figure 2A and D).

### Quality assessment

All 6 studies that met the inclusion criteria and from which data were extracted, presented a quality rating between good (Cayres-Santos 2020 and 2018) and high quality (Seabra 2020 and Vasconcellos). All studies clearly defined the objectives, the participants included, inclusion/exclusion criteria adopted, independent variables, outcome measures and exposure status (sport), along with training history. No studies reported investigators being blinded to participant sport/training exposures.

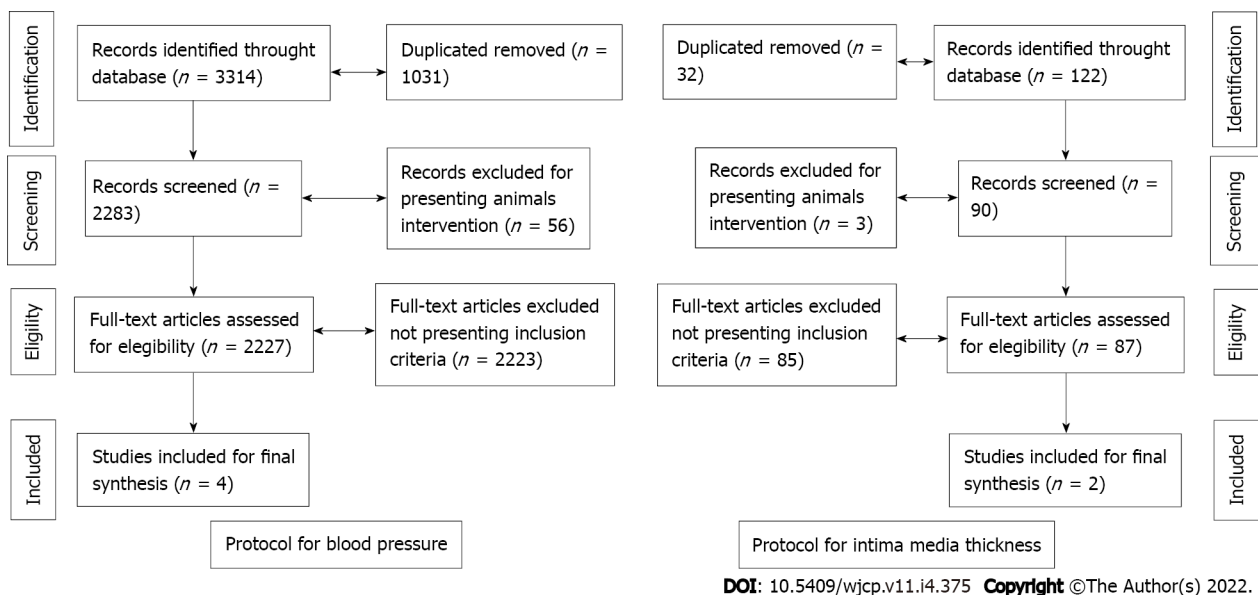


Figure 1 Flowchart.

## DISCUSSION

The aims of this review were to synthesize and analyze the available literature about the impact of sports participation on cardiovascular outcomes in children and adolescents, particularly blood pressure and intima media thickness.

For blood pressure, only four studies met the inclusion criteria. The limited number of longitudinal studies considering the impact of sports participation on cardiovascular health of pediatric groups highlights the absence of data assessing the impact of physical exercise in the real world mainly because sports participation is the most common manifestation of physical exercise in the pediatric groups[22]. Most of the literature available on this issue relies on exercise protocols carried out in research laboratories and limits application in non-laboratorial settings.

In terms of findings, sports participation seems to be related to lower DBP. In fact, the beneficial impact of physical exercise on blood pressure of obese children and adolescents seems relevant but is still unclear in non-obese groups[26]. In fact, the pathways linking physical exercise and reductions in blood pressure strongly rely on the presence of obesity mainly due to its pro-inflammatory role in the organism[26]. The four included manuscripts considered children and adolescents with and without obesity which demonstrates the potential of sports participation to affect blood pressure in non-obese children and adolescents. However, the reduced number of manuscripts limits further interpretations of the findings.

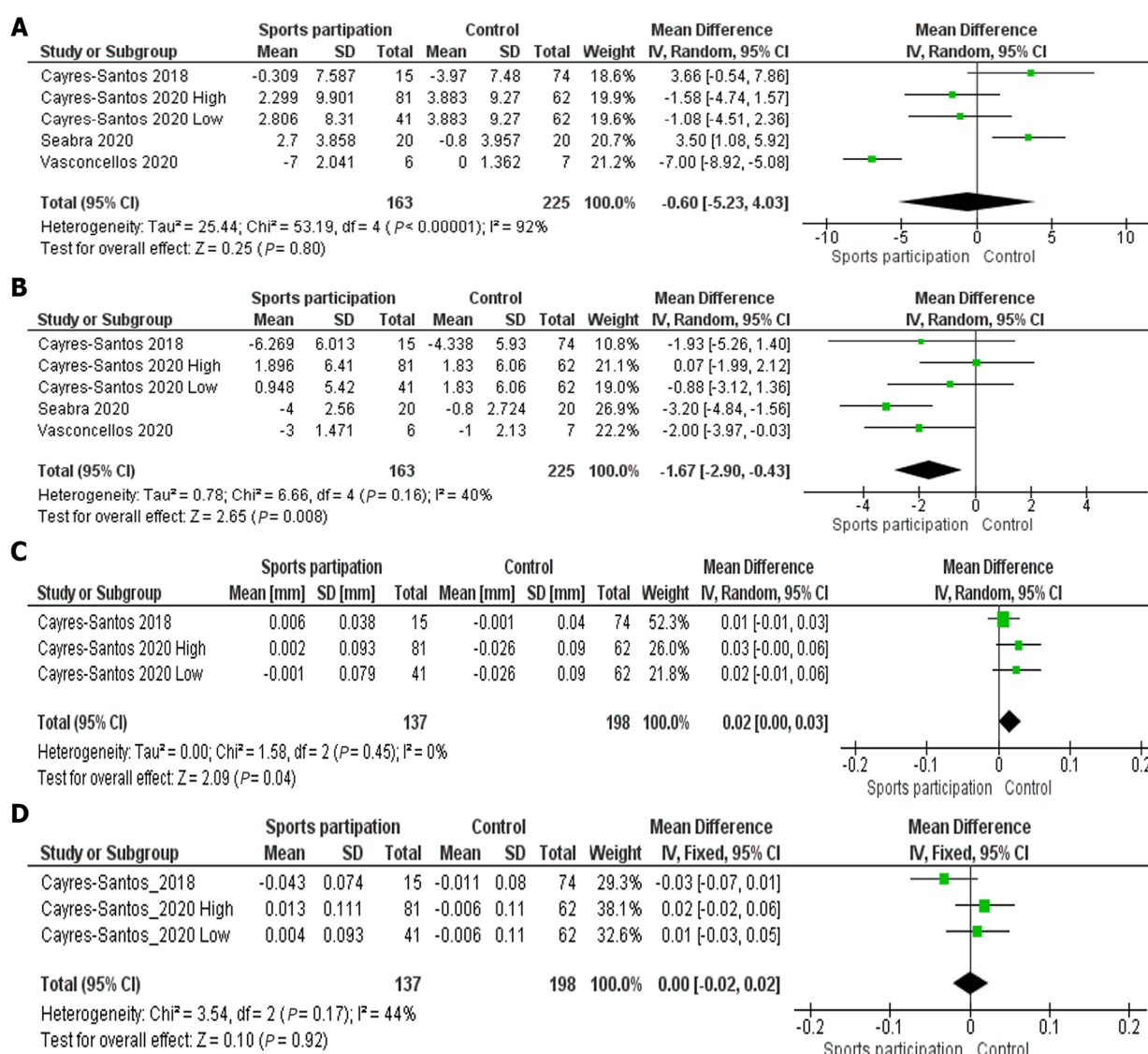
For intima media thickness, sports participation was not significantly related to any modifications. Among adults, the literature recognizes that physical exercise improves the morphometry of arteries (arterial diameter increases improving dilation capacity which leads to reduced wall thickness)[27]. Thus, regular engagement in physical exercise is pointed out as effective in primary and secondary prevention strategies to reduce arterial wall thickness and arterial stiffness, especially in at-risk populations[27,28]. However, in our study with pediatric groups, both studies were carried out by the same research team and only cohort studies were found (no randomized clinical trials) which also limits further interpretations.

### Limitations

In terms of limitations, some aspects should be considered. First, our search was restricted only to the English language, not considering manuscripts published in different languages. Second, some relevant data in our meta-analysis (*e.g.*, standard deviation of the difference) were estimated by the authors and not provided by the authors of the publication considered in the meta-analysis. Third, the reduced number of publications limits further inferences about the findings.

## CONCLUSION

In summary, although sports participation seems to be related to improvements in blood pressure (diastolic), the literature assessing the impact of sports participation on cardiovascular health in children



**Figure 2 Sports participation vs control.** A: Sports participation vs control for systolic blood pressure; B: Sports participation vs control for diastolic blood pressure; C: Sports participation vs control for carotid intima media thickness; D: Sports participation vs control for femoral intima media thickness.

and adolescents is extremely scarce.

## ARTICLE HIGHLIGHTS

### Research background

Adolescents are commonly engaged in sports but its impact on pediatric health is poorly explored in the literature.

### Research motivation

There are many adolescents engaged in sports around the world and many organizations recommend sports participation as promoters of health among adolescents. However, little is known about its impacts on pediatric health.

### Research objectives

To identify in the literature the potential benefits of sports participation on the cardiovascular health of children and adolescents.

### Research methods

We ran a systematic review with meta-analysis.

### Research results

Sports participation is related to blood pressure but not related to intima-media thickness. However, the amount of literature about the issue is extremely scarce.

### Research conclusions

The literature assessing the impact of sports participation on cardiovascular health in children and adolescents is extremely scarce and it is unclear its impact on pediatric health.

### Research perspectives

We hope these findings will be useful to motivate researchers to expand the amount of data about the impact of sports participation on the cardiovascular health of pediatric groups.

## FOOTNOTES

**Author contributions:** Torres W, Maillane-Vanegas S, Urban JB and Fernandes RA were involved in the conception, data collection, performing the analysis and interpretation of data.

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