Rev Bras Cineantropom Desempenho Hum

review article

https://doi.org/10.1590/1980-0037.2026v28e109296

Muscle strength in Brazilian children and adolescents from 2020 to 2024: an updating systematic review of the Brazilian Report Card Project

Força muscular em crianças e adolescentes brasileiros de 2020 a 2024: uma revisão sistemática de atualização do Projeto Report Card Brasil

Tiago Rodrigues de Lima[1]
https ://orcid.org/0000-0003-4568-2255
Jean Carlos Parmigiani De Marco[1]
https ://orcid.org/0000-0003-3764-0362
Clair da Costa Miranda[1]
https ://orcid.org/0009-0006-3941-8000
Priscila Custódio Martins[2]
https ://orcid.org/0000-0002-6388-5550
Letícia Gonçalves[3]
https ://orcid.org/0000-0002-9653-8440
Matheus Silveira Pedroso[3]
https ://orcid.org/0000-0002-7611-3795
Andreia Pelegrini[1]
https ://orcid.org/0000-0001-8862-9636
Diego Augusto Santos Silva[3]
https ://orcid.org/0000-0002-0489-7906

1 Universidade do Estado de Santa Catarina. Centro de Ciências da Saúde e do Esporte. Departamento de Educação Física. Grupo de Estudos e Pesquisa em Cineantropometria. Florianópolis, SC. Brasil.
2 Universidade do Extremo Sul Catarinense. Grupo de Estudos e Pesquisa em Promoção da Saúde. Criciúma, SC. Brasil.
3 Universidade Federal de Santa Catarina. Centro de Desportos. Núcleo de Pesquisa em Cineantropometria e Desempenho Humano. Florianópolis, SC. Brasil.

Received: October 14, 2025
Accepted: March 10, 2026

How to cite this article
Lima TR, De Marco JCP, Miranda CC, Martins PC, Gonçalves L, Pedroso MS, Pelegrini A, Silva DAS. Muscle strength in Brazilian children and adolescents from 2020 to 2024: An updating systematic review of the Brazilian Report Card Project. Rev Bras Cineantropom Desempenho Hum 2026, 28:e109296. DOI: https://doi.org/10.1590/1980-0037.2026v28e109296

Corresponding author
Tiago Rodrigues de Lima.
Grupo de Estudos e Pesquisa em Cineantropometria, Centro de Ciências da Saúde e do Esporte, Departamento de Educação Física, Universidade do Estado de Santa Catarina
Rua Pascoal Simone, 358, 88080-350, Coqueiros, Florianópolis (SC), Brasil.
E-mail: tiagorodriguesdelima@gmail.com, tiagopersonaltrainer@gmail.com

Scientific Editor
Kelly Samara da Silva

Abstract – The present study aimed to identify and summarize evidence regarding muscle strength in Brazilian children and adolescents (aged ≤19 years), in order to update the 2018 and 2019 data previously published by the Brazilian Report Card Project. A systematic search was conducted across seven databases, with a focus on studies published between January 2020 and December 2024. Thirty-six studies, originating from the five major regions of Brazil, were included. Handgrip strength was the most frequently adopted test across the included studies (29 out of 58 measurements – 50%). The prevalence of children and adolescents with adequate levels of muscle strength was 44.1% (40.1% for males and 47.8% for females). Compared to the results of the previous review (2018–2019), an increase was observed in the prevalence of youth with adequate muscle strength levels (from 29.8% to 44.1%). However, upon analyzing the totality of the Brazilian Report Card Project data (which includes 17,379 participants since 2010), the combined prevalence of adequate muscle strength was 56.1% (58.8% for boys; 53.0% for girls), suggesting a declining trend over the years. Despite the punctual increase in the 2020–2024 period, the majority of young Brazilians still do not reach adequate levels of muscle strength, which reinforces the need for public health strategies to promote muscle-strengthening activities.

Key words: Adolescent health; Child health; Epidemiological monitoring; Physical fitness.

Resumo – *O objetivo do presente estudo foi identificar e sumarizar as evidências referentes à força muscular em crianças e adolescentes (idade ≤ 19 anos) no Brasil, a fim de atualizar os dados de 2018 e 2019 publicados anteriormente pelo Projeto Report Card Brasil. A busca sistemática foi conduzida em sete bases de dados, restrita a estudos publicados durante o período de janeiro de 2020 a dezembro de 2024. Foram incluídos 36 estudos, oriundos das cinco grandes regiões do Brasil. A força de preensão manual foi o teste mais frequentemente adotado nos estudos (29/58 mensurações – 50%). A prevalência de crianças e adolescentes com níveis adequados de força muscular foi de 44,1% (40,1% para o sexo masculino e 47,8% para o sexo feminino). Ao comparar com os resultados da revisão anterior (2018-2019), observou-se um aumento na prevalência de jovens com níveis adequados de força muscular (de 29,8% para 44,1%). Contudo, ao analisar a totalidade dos dados do Projeto Report Card Brasil (que inclui 17.379 participantes desde 2010), a prevalência combinada de força muscular adequada foi de 56,1% (58,8% para os meninos; 53,0% para as meninas), sugerindo uma tendência de declínio ao longo dos anos. Apesar do aumento pontual no período de 2020 a 2024, a maioria dos jovens brasileiros ainda não atinge níveis adequados de força muscular, o que reforça a necessidade de estratégias de saúde pública para a promoção de atividades de aprimoramento da força muscular.*

Palavras-chave: *Saúde do adolescente; Saúde da criança; Monitoramento epidemiológico; Aptidão física.*

INTRODUCTION

Muscle strength has been described as a relevant indicator of general health in children and adolescents[1]. Evidence described in the literature has identified a direct association between adequate levels of muscle strength and health indicators, including increased bone mass[1], reduced body fat, and increased muscle mass[1-3], as well as improved indicators related to cardiometabolic health[4-6]. Furthermore, muscle strength has been related to better indicators of mental health and cognitive performance in the pediatric population[1,7].

Despite its unequivocal importance, international[8] and national[9] studies have reported a declining trend in muscle strength levels among youth. Furthermore, it is speculated that this scenario of declining muscle strength may have been aggravated by the COVID-19 pandemic, which imposed drastic lifestyle changes, resulting in a significant reduction in physical activity and an increase in sedentary behavior[10,11]. This context raises the hypothesis that the muscle health of children and adolescents may have been negatively impacted, making the continuous monitoring of muscle strength levels a public health priority.

In Brazil, the national monitoring of muscle strength has been carried out through periodic systematic reviews. A previous review, which compiled data up to the year 2017, identified that approximately 62% of youth presented adequate levels of muscle strength[4]. The subsequent updating study, with data from 2018 and 2019, observed a reduction in the prevalence of children and adolescents with adequate muscle strength levels, suggesting the onset of a declining trend[12].

Given the behavioral changes that have occurred since then, and with the publication of new studies, a new update becomes indispensable, not only to verify the recent trajectory of this relevant health indicator but also to analyze how new information compares to previous findings and consolidate the understanding of this specific topic (11). Therefore, the objective of the present study was to update the previous systematic review[12], summarizing the evidence published during the years 2020 to 2024 regarding muscle strength in Brazilian children and adolescents.

METHOD

Records

This systematic review is part of the Report Card Brazil: Health indicators for children and adolescents research project (4th edition). The macro-project protocol is registered on an open access platform and can be accessed at Silva et al.[13]. The information added to the study refers to an update of the results previously reported, which aimed to summarize the totality of evidence available in the literature regarding the investigation of muscle strength in Brazilian children and adolescents up to January 2018[4], and from January 2018 to December 2019[12]. The methodology adopted for reporting the information in the present study is in accordance with the guidelines established by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement[14].

Eligibility criteria

Articles identified in the literature according to specific criteria were selected for this review. We considered original studies published in scientific journals that detailed the tests or methods used for muscle strength assessment.

The tests included handgrip strength measurements (isometric strength), evaluations with isokinetic dynamometers (isokinetic strength), vertical jump, horizontal jump, and medicine ball throw tests (power/explosive strength), in addition to procedures for measuring maximal strength through one-repetition maximum tests, such as the one-repetition maximum test assessed via the bench press or back squat exercise. Furthermore, only studies conducted exclusively with Brazilian children and adolescents, aged up to 19 years or whose mean age fell within this range, without special clinical conditions, without disease diagnosis, and who were not athletes, were considered.

Review studies, theses, dissertations, and abstracts presented at scientific conferences were not included. Additionally, articles whose objective was to investigate strength endurance, such as repetitions of trunk flexion or body weight support, were excluded.

Information sources

The selection of studies that employed muscle strength in the investigation of different relationships of interest in Brazilian children and adolescents was restricted to the period between January 2020 and December 2024, and was conducted in seven different databases: i) Medical Literature Analysis and Retrieval System Online (MEDLINE), via PubMed; ii) Web of Science; iii) Embase; iv) SportDiscus, via the EBSCOhost platform; v) Latin American and Caribbean Health Sciences Literature (LILACS), via the Virtual Health Library (VHL); vi) Scopus; vii) Scientific Eletronic Library Online (SciELO).

Search strategy, descriptor, and keywords

The search for articles was conducted in March 2025, utilizing the advanced keyword-based search tool available in each of the investigated databases. The process involved formulating sets/blocks of descriptors related to the theme, which were selected through searches on the national platform "Descritores em Ciências da Saúde (DeCS)" and the North American platform "Medical Subject Headings (MeSH)". In addition to the described information sources, descriptors and keywords were extracted from literature review articles, original studies, and health-related documents. The descriptors, available in Portuguese, English, and Spanish, were incorporated into the databases according to the specific requirements of each search platform.

The first set of descriptors, referring to the outcome, encompassed terms associated with muscle strength, such as: 'muscle strength', 'resistance training', 'muscular contraction', 'weight training', 'muscular endurance', 'muscle power', 'muscular fitness', 'upper limb strength', 'lower limb strength', 'musculoskeletal fitness', 'isometric strength', 'dynamic force', 'isometric contraction', 'isotonic contraction', and 'physical fitness'. The second set of descriptors corresponded to the population of interest, covering children and adolescents. Terms such as 'adolescent', 'adolescents', 'school-age', 'child', 'children', 'young', 'youth', 'childhood', 'school-children', 'teen', 'teenager', 'school-teenager', and 'preschool children' were used. The third and final set of descriptors referred to the geographic location of interest, represented by the term 'Brazil'. In the advanced search conducted in each database, the Boolean operator 'OR' was used to ensure the inclusion of at least one term from each set, while the Boolean operator 'AND' was utilized to connect the different sets of descriptors. Complementary information on the systematic search strategies used in each database can be consulted in Supplementary File 1 (Supplementary Material).

Selection of studies

The selection of articles was conducted independently by two researchers (TRL & JCPDM). Initially, studies that did not meet the inclusion criteria were excluded after analyzing the titles and abstracts. In the subsequent stage, the remaining articles were fully examined and included in the review to align with the predefined objectives and criteria. There were no disagreements between the researchers regarding the inclusion of the studies. To broaden the scope of the search, the reference lists of the included articles were checked with the aim of identifying potential studies not detected in the systematic search of the databases. However, no new articles were identified beyond those previously selected.

The organization and management of the data were performed using the EndNote® X9 software (Philadelphia, USA), which allowed for the creation of specific libraries to identify and remove duplicate studies, as well as the categorization and systematization of the results obtained from each database.

Extraction of results

The information present in the selected articles was extracted independently by two researchers. Data analysis covered the following aspects: identification of the authors, study location, year of data collection, methodological design, age range of participants, total number of evaluated individuals, and the main objective of the research. Furthermore, we examined the strategy adopted for muscle strength assessment, including the test/instrument used, the protocols employed, the statistical procedures applied, and the variable analyzed in relation to muscle strength, as well as the study's main findings. The percentage of children and adolescents classified as presenting adequate or healthy levels of muscle strength was also recorded.

Methodological quality/risk of bias

The quality/risk of bias assessment of the included studies was based on the instrument provided by the National Heart, Lung, and Blood Institute for observational cohort/cross-sectional studies[15]. This instrument is based on the analysis of 14 items that cover methodological aspects according to the study design. For cross-sectional studies, items 12 ("Blinding of assessors") and 13 ("Loss to follow-up after baseline was 20% or less?") were recorded as not applicable. For each criterion, a score of +1 was assigned when the answer was positive ('yes'), while a score of zero (0) was assigned in the other cases ('no', 'not applicable', 'not reported', or 'cannot be determined'). The study-specific global score ranges from zero to 14, and the quality/risk of bias score is determined by the ratio between the number of questions with a positive score (+1) and the number of questions with a zero score (0) (Supplementary File 2). Thus, the articles included/analyzed in this review could receive scores ranging from 0.0 (high risk of bias) to 1.0 (low risk of bias). In cases of disagreement between the two researchers responsible for the risk of bias assessment (TRL & JCPDM), a third researcher (AP), experienced in this type of study, was consulted through a consensus meeting.

RESULTS

The systematic search for studies on muscle strength in Brazilian children and adolescents resulted in the identification of 2,272 articles, after removing duplicate titles and studies outside the period analyzed in this review (January 2020 to December 2024). Initially, 136 articles were selected for evaluation based on their titles and abstracts. Following the exclusion of studies whose theme did not align with the study's objective, 41 articles underwent a full-text eligibility assessment. Of these, five studies were excluded for not meeting the established criteria: three for addressing unrelated topics and two for assessing muscle strength exclusively through muscle endurance tests. Additionally, the references of the included studies were examined to identify any possible additional information on the topic that had not been captured in the systematic search. However, no new studies were incorporated beyond those previously identified. Thus, a total of 36 studies were included in this review (Figure 1).

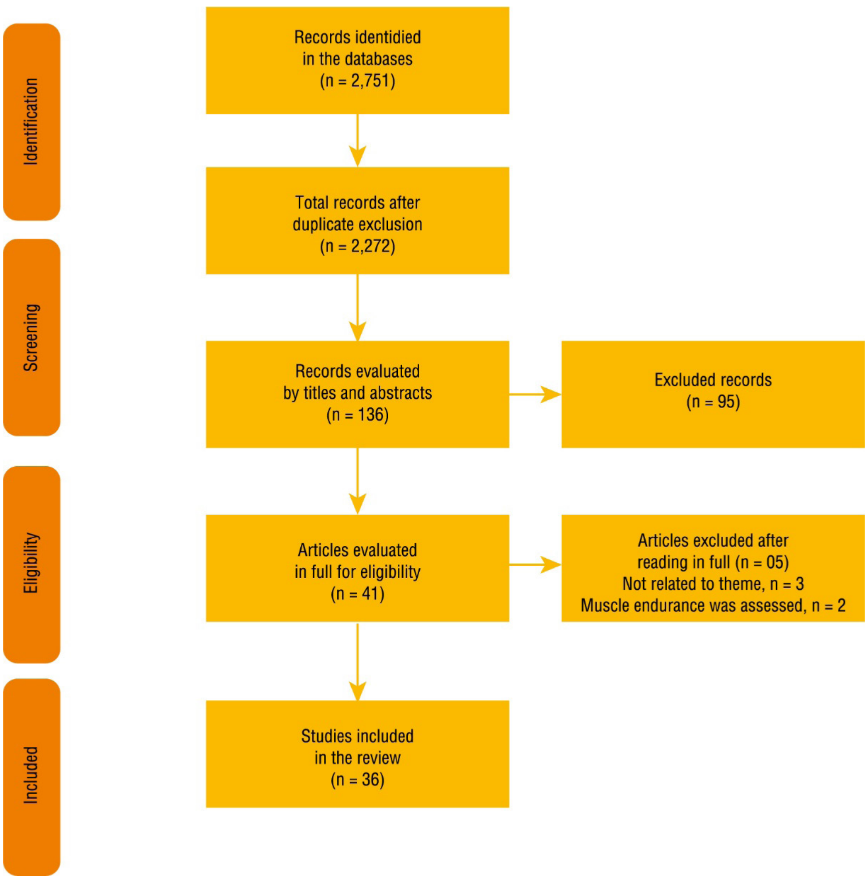

Figure 1. Flowchart of the search for articles and criteria used in the selection of studies that investigated muscle strength in children and adolescents in Brazil during the years 2020-2024.

The evidence for this review originated from 36 studies, across 10 Brazilian states in all five regions of the country. The included studies analyzed samples ranging from 28[6] to 94,484[16] children and adolescents, with ages spanning from 3 to 19 years (Table 1).

Regarding the study designs, the majority of the summarized information originated from cross-sectional research, with only one included study assessing the information longitudinally[6]. Among the themes addressed, the relationship between muscle strength and cardiometabolic variables or cardiometabolic risk was investigated in 11 studies[17,20,21,36,37,40,42-44,46,47], while the relationship between muscle strength and lifestyle-related habits was the objective of six studies[9,19,22,27,28,31]. The association between muscle strength and anthropometric and body composition variables was investigated in eight studies[5,9,16,19,26,30,34,42]. The relationship between muscle strength and bone indicators[23,33,35], or the muscle strength with cognitive/academic performance[32,39,45] was investigated in three studies each. Additionally, studies included in the present review aimed to analyze the relationship between muscle strength and biological variables[9,19,41] or the secular trend of muscle strength[9,38]. Other objectives analyzed by the studies included in the present review involved the establishment of normative values for muscle strength[18], the relationship between muscle strength and running performance[48], and changes in muscle strength values in the immediate return to in-person school activities after the lockdown due to the COVID-19 pandemic and three months after the release of in-person activities[6]. In addition to the relationships directly investigated, in three studies, muscle strength was investigated as a moderating variable in the relationship between behavioral variables[29] and health[24,25] (Table 1).

Figure 2 presents information regarding the use of muscle strength tests according to the theme of the analyzed studies. Overall, muscle strength measurement through handgrip strength was the most utilized test to investigate the different objectives analyzed by the studies (29/58 measurements – 50.0%), followed by the use of the horizontal jump test (15/58 measurements – 26.0%). Other tests used to assess muscle strength by the analyzed studies included the medicine-ball throw (10/58 measurements – 17.2%), vertical jump (1/58 measurements – 1.7%), bench press (1/58 measurements – 1.7%), leg press (1/58 measurements – 1.7%), and biceps curl (1/58 measurements – 1.7%) (Figure 2).

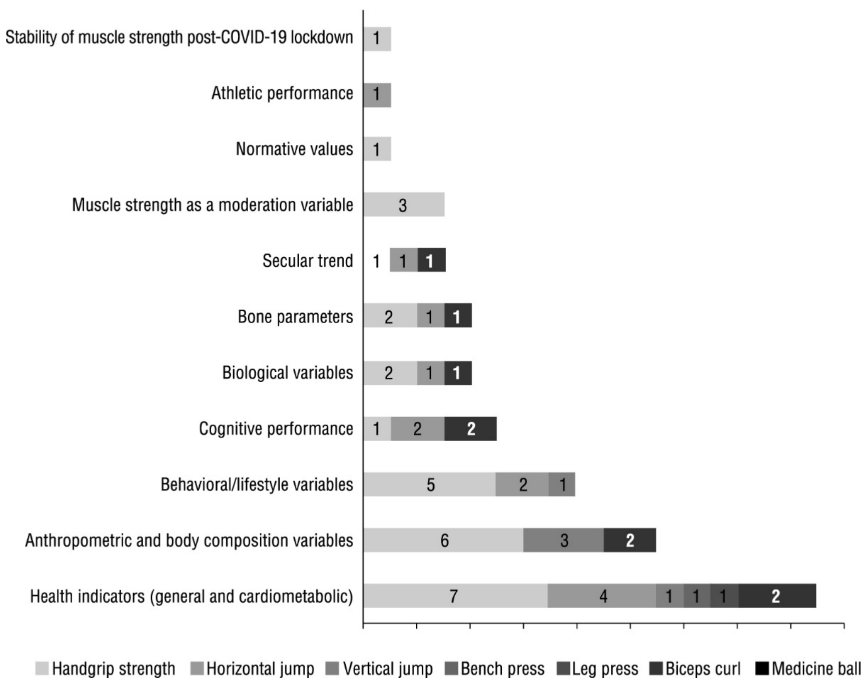

Figure 2. Use of muscle strength tests according to the theme of the analyzed studies.

Table 1. General characteristics of studies on muscle strength in Brazilian children and adolescents during the years 2020 to 2024.

Author	Study design, location, and year of data collection	Age range / Number of participants (% female)	Tests applied, procedures, and use of the obtained results	Study objective	Key findings related to muscle strength
Martins et al.[17]	Cross-sectional - Florianópolis, SC (2015)	10–16 years; n = 353 (54.9)	Handgrip - Hydraulic dynamometer; - Both hands; - Standing position with the elbow fully extended along the body; - Two trials; - Sum of the peak result from both hands; - Raw scores/data	To examine the association between phase angle and isolated and grouped physical fitness indicators in adolescents.	Handgrip strength was associated with the phase angle in male adolescents ($\beta = 0.03$; $p < 0.01$). Conversely, no association was found for this relationship in females ($\beta = 0.02$; $p < 0.08$). The handgrip strength z-scores were directly associated with the phase angle in male adolescents ($\beta = 0.20$, $p < 0.01$). For girls, no association was identified between handgrip strength z-score and phase angle ($\beta = 0.17$, $p < 0.08$).
Bim et al.[18]	Cross-sectional – Florianópolis and São José, SC (2007, 2015, 2017/18)	14-19 years; n = 2637 (54.1)	Handgrip - Hydraulic dynamometer; - Both hands; - Standing position with the elbow fully extended along the body; - three trials; - Sum of the peak result from both hands; - Body mass-normalized values	To establish normative values for handgrip strength in adolescents, according to chronological age and sexual maturation	Handgrip strength reference values were established based on norm-based criteria.
Bim et al.[19]	Cross-sectional - Florianópolis, SC (2017/2018)	15–18 years; n = 971 (48.9)	Handgrip - Hydraulic dynamometer; - Both hands; - Standing position with the elbow fully extended along the body; - three trials; - Sum of the peak result from both hands; - Raw scores/data	To identify handgrip strength levels and the associated modifiable and non-modifiable risk factors among adolescents.	Among boys, age ($\beta = 0.108$, $p < 0.05$), height ($\beta = 0.402$, $p < 0.05$), weight status ($\beta = 0.221$, $p < 0.05$), balanced diet ($\beta = 0.125$, $p < 0.05$), and physical activity ($\beta = 0.114$, $p < 0.05$) were positively associated with handgrip strength. Among girls, only height ($\beta = 0.380$, $p < 0.05$) and BMI ($\beta = 0.172$, $p < 0.05$) were associated with handgrip strength.
de Lima et al.[20]	Cross-sectional - São José, SC (2019)	14–19 years; n = 351 (55.6)	Handgrip - Hydraulic dynamometer; - Both hands; - Standing position with the elbow fully extended along the body; - three trials; - Sum of the peak result from both hands; - Raw scores/data - Body mass-normalized values - BMI-normalized values - Height-normalized values; - Fat mass-normalized values	To investigate the association between different indices of muscle strength and cardiometabolic variables in adolescents.	Raw handgrip strength and/or handgrip strength normalized for height was directly associated with waist circumference [up to 32.8 cm, standard error = 4.7] and diastolic blood pressure (up to 8.8 mmHg, standard error = 0.8), and inversely associated with high-density lipoprotein cholesterol (up to −8.0 mg/dL, standard error = 14.1). Handgrip strength normalized for body mass, BMI, or fat mass was inversely associated with waist circumference (up to −17.5 cm, standard error = 2.2). According to sex, handgrip strength normalized for fat mass was inversely associated with triglycerides (boys: 0.02 times lower, standard error = 0.01; girls: 0.05 times lower, standard error = 0.01) and HOMA index assessment (boys: 0.02 times lower, standard error = 0.01; girls: 0.06 times lower, standard error = 0.01), and inversely associated with C-reactive protein only among boys (0.03 times lower, standard error = 0.01).

Table 1. Continued...

Author	Study design, location, and year of data collection	Age range / Number of participants (% female)	Tests applied, procedures, and use of the obtained results	Study objective	Key findings related to muscle strength
de Lima et al.[21]	Cross-sectional - São José, SC (2019)	14–19 years; n = 351 (55.6)	Handgrip - Hydraulic dynamometer; - Both hands; - Standing position with the elbow fully extended along the body; - three trials; - Sum of the peak result from both hands; - Raw scores/data - Body mass-normalized values - BMI-normalized values - Height-normalized values; - Fat mass-normalized values	To examine the association between absolute and body size-normalized muscle strength and cardiometabolic risk factors among adolescents.	Among men, handgrip strength normalized for body mass was inversely associated with obesity, glucose imbalance, and low-grade systemic inflammation marker ($p < 0.05$). When considering BMI in the normalization of handgrip strength, muscle strength was inversely associated with obesity and high blood pressure ($p < 0.05$). Furthermore, handgrip strength normalized for fat mass was inversely associated with obesity ($p < 0.05$). In the investigation of the relationship between muscle strength and cardiometabolic risk factors among women, handgrip strength normalized for body mass was inversely associated with obesity, dyslipidemia, and glycemic imbalance. Similarly, handgrip strength normalized for BMI was inversely related to obesity, dyslipidemia, glycemic imbalance, and low-grade systemic inflammation marker. Additionally, handgrip strength normalized for fat mass was inversely associated with obesity and glycemic imbalance. Furthermore, when compared to those without cardiometabolic risk factors, raw handgrip strength and handgrip strength normalized for height were directly associated with the presence of two or more cardiometabolic risk factors among men. Among women, handgrip strength normalized for body mass, BMI, and fat mass were inversely associated with the presence of two or more cardiometabolic risk factors when compared with those without cardiometabolic risk factors.
Lemos et al.[22]	Cross-sectional - João Pessoa, PB (2019–2020)	3-5 years; n = 270 (51.1)	Horizontal jump - Arms loose alongside the body; - Two attempts; - Raw values (cm)	To analyze the associations between the composition of 24-hour movement behaviors and physical fitness in preschoolers, and to investigate the predicted changes in physical fitness when time in active behaviors is reallocated.	The composition of daily time use was significantly associated with lower-body muscle strength ($p = 0.01$; $R2 = 0.07$). For lower-body muscle strength, only reallocations between sleep and light physical activity yielded significant associations ($p < 0.05$). In contrast, reallocations to moderate-to-vigorous intensity physical activity did not cause significant changes in the movement behaviors assessed based on 5-minute time increments (ranging from 5 to 15 minutes).
Saraiva et al.[23]	Cross-sectional - Presidente Prudente, SP (2014)	4–15 years; n = 243 (29.7%)	Handgrip strength - Electronic dynamometer; - Both hands; - Seated with the elbow flexed at 90º; - 1 attempt (or 1 trial); - Average of the value obtained from the sum of the values obtained in both hands; - Raw values	To examine the association between handgrip strength and bone mineral density in children and adolescents.	In girls, handgrip strength was positively associated with greater bone mineral density of the arms [$\beta = 0.006$; $p < 0.001$], legs [$\beta = 0.014$; $p < 0.001$], pelvis [$\beta = 0.019$; $p < 0.001$], trunk [$\beta = 0.013$; $p < 0.001$], spine [$\beta = 0.013$; $p = 0.008$], and total body [$\beta = 0.009$; $p < 0.001$]. The same was true for boys, in whom greater handgrip strength was related to greater bone mineral density of the arms [$\beta = 0.006$; $p < 0.001$], legs [$\beta = 0.017$; $p < 0.001$], pelvis [$\beta = 0.014$; $p < 0.001$], trunk [$\beta = 0.009$; $p < 0.001$], spine [$\beta = 0.008$; $p < 0.001$], and total body [$\beta = 0.007$; $p < 0.001$].

Table 1. Continued...

Author	Study design, location, and year of data collection	Age range / Number of participants (% female)	Tests applied, procedures, and use of the obtained results	Study objective	Key findings related to muscle strength
Todendi et al.[24]	Cross-sectional - Santa Cruz do Sul, RS (2014–2015)	7–17 years; n =1701 (55.4)	Horizontal jump - Arms held loosely at the sides; - Two trials; - Raw scores (cm)	To examine the moderating role of cardiorespiratory fitness and muscle strength on the association between an exercise-related gene and adiposity in children and adolescents.	A significant interaction term for muscle strength, assessed by horizontal jump ($p = 0.044$) × rs16835198 FNDC5—was observed. Furthermore, moderate and high levels of muscle strength protected against greater waist circumference and higher BMI.
Todendi et al.[25]	Cross-sectional - Santa Cruz do Sul, RS (2014–2015)	7-17 years; n = 1471 (56.1)	Horizontal jump - Arms held loosely at the sides; - Two trials; - Raw scores (m)	To examine the moderating role of physical fitness in the association between the genetic risk score and body mass index in children and adolescents.	It was identified that muscle strength moderated the relationship between ≥5 risk alleles and BMI in adolescents.
Confortin et al.[26]	Cross-sectional - São Luís, MA (2016)	18 – 19 years; n = 2339 (52.5)	Handgrip strength - Electronic dynamometer; - Both hands; - Seated with the elbow flexed at 90º; - 3 trials; - Average of the value obtained in the dominant hand; - Raw values	To analyze the association between fat mass index and lean body mass with handgrip strength.	For every 1 kg/m2 increment in fat mass index, handgrip strength was reduced by 0.72 kgf for boys and 0.35 kgf for girls. For every 1 kg/m2 increase in lean mass index, handgrip strength increased by 2.18 kgf for boys and 1.26 kgf for girls.
Confortin et al.[27]	Cross-sectional - São Luís, MA (2016)	18-19 years; n = 2433 (52.1)	Handgrip strength - Electronic dynamometer; - Both hands; - Seated with the elbow flexed at 90º; - 3 trials; - Average of the value obtained in the dominant hand; - Raw values	To analyze the association between food consumption according to the degree of food processing and handgrip strength in Brazilian adolescents.	For boys, the adjusted analysis showed an association between greater handgrip strength and the 3rd tertile of culinary preparations consumption (β: 1.95; 95% CI: 0.80; 3.10), and between lower handgrip strength and the 3rd tertile of ultra-processed food consumption (β: -2.25; 95% CI: -3.40; -1.10). Among girls, the consumption of culinary preparations in the 3rd tertile was associated with greater handgrip strength (β: 0.76; 95% CI: 0.05; 1.46).
Confortin et al.[28]	Cross-sectional - São Luís, MA (2016)	18-19 years; n = 2515 (52.4)	Handgrip strength - Electronic dynamometer; - Both hands; - Seated with the elbow flexed at 90º; - 3 trials; - Average of the value obtained in the dominant hand; - Raw values	To analyze the association between sleep duration and handgrip strength in adolescents.	Sleep duration was not associated with handgrip strength (β: -0.07; 95% CI: -0.48; 0.36).

Table 1. Continued...

Author	Study design, location, and year of data collection	Age range / Number of participants (% female)	Tests applied, procedures, and use of the obtained results	Study objective	Key findings related to muscle strength
da Costa et al.[29]	Cross-sectional - Santa Cruz do Sul, RS (2014–2015)	12–17 years; n = 1071 (57.6)	Horizontal jump - Arms held loosely at the sides; - Two trials; - Raw scores (m)	To identify whether the components of physical fitness play a moderating role in the relationship between screen time (TV time) and adiposity levels.	No significant interactions were identified for muscle strength in the association between screen time and adiposity variables.
de Souza et al.[30]	Cross-sectional - São Paulo, SP (2017–2018)	6 – 14 years n = 167 (28.3)	Handgrip - Hydraulic dynamometer; - Both hands; - Sum of the peak result from both hands; - Raw scores/data	To investigate whether birth weight determines physical fitness parameters in childhood/adolescence, and to establish the influence of environmental or biological factors on this relationship.	When handgrip strength was tested as a dependent variable, it was found that high birth weight, male sex, and advanced age emerged as important determinants for both hands, explaining 39.4% of the variance on the right side (R2 = 0.394) and 32.1% of the variance on the left side (R2 = 0.321).
Estivaleti et al.[31]	Cross-sectional - Ilhabela, SP (2015 – 2019)	9 – 11 years n = 120 (52.5)	Handgrip - Hydraulic dynamometer; - Both hands; - Standing position with the elbow flexed at 90º; - Two trials; - Sum of the peak result from both hands Vertical Jump Test 1 - Hands on hips Test 2 - Arm swing - Raw values (cm) Horizontal jump - Raw values (cm)	To describe and compare physical fitness variables based on adherence to the physical activity recommendation, measured by accelerometry.	Handgrip strength was significantly higher in the group that did not follow the recommendations compared to those who did follow them ($p<0.05$). Lower-limb strength obtained through the vertical jump test without arm swing was higher in those who met the physical activity recommendations ($p=0.032$). No differences were identified between those who met the physical activity recommendations and those who did not, regarding strength values obtained from the vertical jump test with arm swing ($p=0.085$). Lower-limb strength obtained through the horizontal jump test did not differ between those who met the recommendations compared to those who did not ($p=0.076$).
Fochesatto et al.[32]	Cross-sectional - Porto Alegre, RS (2017)	6 – 11 years n = 317 (48.0)	Horizontal jump - Arms loose alongside the body; - Two attempts; - Raw values (cm) Medicine-ball throw - 2kg ball; - Seated with knees extended; - Back in contact with the wall; - Two trials; - Best distance achieved (or Maximum distance obtained); - Raw values (cm)	To determine the relationship between physical fitness components and fluid intelligence in normal-weight and overweight/obese children.	No association was identified between fluid intelligence and lower-limb strength, measured by the horizontal jump, in adolescents with normal weight status ($\beta = 0.005$; $p = 0.74$) and overweight/obesity ($\beta = 0.015$; $p = 0.64$). No association was identified between fluid intelligence and upper-limb strength, measured by the medicine ball throw, in adolescents with normal weight status ($\beta = 0.010$; $p = 0.27$) and overweight/obesity ($\beta = 0.012$; $p = 0.30$).

Table 1. Continued...

Author	Study design, location, and year of data collection	Age range / Number of participants (% female)	Tests applied, procedures, and use of the obtained results	Study objective	Key findings related to muscle strength
Mello et al.[33]	Cross-sectional - Porto Alegre, RS Phase 1: 2017 - 2018 Fase 2: 2011 - 2020	6 – 11 years Phase 1: n = 160 Phase 2: n = 8750	Horizontal jump - Parallel feet; - Semi-flexed knees); - Torso/Trunk leaning forward; - Two trials; - Best distance; - Raw values (cm) Medicine-ball throw - 2kg ball; - Seated with knees extended; - Back in contact with the wall; - Two trials; - Best distance achieved (or Maximum distance obtained); - Raw values (cm)	To propose cut-points for physical fitness tests based on childhood bone health indicators.	A value lower than 70% for the area under the ROC curve was identified using the strength measured by the horizontal jump test. The areas under the ROC curve were 0.712 and 0.806 (boys and girls), with total bone mineral density of the spine and pelvis as the result of the medicine ball throw. In the validation analysis, it was identified that children classified as at risk for low bone mass based on the medicine ball throw were approximately four times more likely to have low bone mineral density in the total spine and pelvis than their peers (OR: 3.95; $p = 0.004$). When stratified by sex, the associations remained with high odds ratios, ranging from 3.75 in boys (OR: 3.75; $p = 0.040$) to 3.59 in girls, indicating a higher probability of having low bone mineral density in the total spine and pelvis.
Nevill et al.[34]	-Cross-sectional - Santa Cruz do Sul, RS (2004, 2017)	7 – 17 years n = 11018 (53.3)	Horizontal jump - Parallel feet; - Semi-flexed knees); - Torso/Trunk leaning forward; - Two trials; - Best distance; - Raw values (cm) Medicine-ball throw - 2kg ball; - Seated with knees extended; - Back in contact with the wall; - 2 Two trials; - Best distance achieved (or Maximum distance obtained); - Raw values (cm)	To identify the most appropriate body shape associated with six athletic performance tests, using three-dimensional allometry (height, body mass, and waist circumference), in a sample of Brazilian children and adolescents.	Height was positively associated with lower-limb strength values, whereas waist circumference was inversely associated with muscle strength ($p<0.001$). Furthermore, body mass demonstrated a negative association with the lower-limb strength test ($p<0.001$).
Pelegrini et al.[35]	Cross-sectional - São José, SC -2016	10 – 14 years n = 118 (50.8)	Handgrip - Hydraulic dynamometer; - Both hands; - Standing position with the elbow fully extended along the body; - Two trials; - Sum of the peak result from both hands; - Raw scores/data	To investigate the associations between handgrip strength, fat-free mass, and fat mass with bone mineral density among adolescents.	The final models, adjusted for sexual maturation, included fat-free mass (girls – $b=0.419$, $p<0.001$; boys – $b=0.455$, $p<0.001$) and handgrip strength (girls – $b=0.358$, $p<0.05$; boys – $b=0.325$, $p<0.05$). Together, these variables explained 51.8% and 62.9% of the variation in bone mineral density, in girls and boys, respectively.

Table 1. Continued...

Author	Study design, location, and year of data collection	Age range / Number of participants (% female)	Tests applied, procedures, and use of the obtained results	Study objective	Key findings related to muscle strength
Saldanha Filho et al.[36]	Cross-sectional - Santa Cruz do Sul, RS (2011)	7 – 17 years n = 1200 (54.6)	Horizontal jump - Parallel feet; - Semi-flexed knees; - Torso/Trunk leaning forward; - Two trials; - Best distance; - Raw values (cm) Medicine-ball throw - 2kg ball; - Seated with knees extended; - Back in contact with the wall; - Two trials; - Best distance achieved (or Maximum distance obtained); - Raw values (cm)	To verify whether there was an association between performance-related physical fitness levels and clustered cardiometabolic risk score among children and adolescents.	Lower-limb strength [–0.272 (95% CI: –0.368; –0.1770)] was inversely associated with the clustered cardiometabolic risk score. No association was identified for the relationship between upper-limb strength and the clustered cardiometabolic risk score.
de Lima and Silva[37]	Cross-sectional - São José, SC -2019	14 – 19 years n = 811 (51.1)	Handgrip - Hydraulic dynamometer; - Both hands; - Standing position with the elbow fully extended along the body; - three trials; - Sum of the peak result from both hands; - Raw scores/data - Body mass-normalized values - Allometry normalized values	To investigate the association between handgrip strength indices and high blood pressure, verify the discriminatory capacity of handgrip strength to identify high blood pressure in adolescents, and propose handgrip strength cut-points to be used for the early identification of high blood pressure if a good discriminatory power is identified between the variables.	Handgrip strength indices were not associated with high blood pressure ($p<0.05$), and ROC curve analyses showed non-significant discriminatory accuracy for most of the analyzed handgrip strength indices ($p<0.05$) in identifying high blood pressure in boys and girls. The Area Under the Curve (AUC) values ranged from 0.499 (95% CI [0.403–0.596] for allometrically adjusted handgrip strength among overweight or obese boys) to 0.595 (95% CI [0.546–0.643] for handgrip strength among boys).
Nevill et al.[38]	Cross-sectional - Brazil (1999 – 2022)	6 – 17 years n = 65,139 (43.9)	Horizontal jump - Parallel feet; - Semi-flexed knees; - Torso/Trunk leaning forward; - Two trials; - Best distance; - Raw values (cm) Medicine-ball throw - 2kg ball; - Seated with knees extended; - Back in contact with the wall; - 2 Two trials; - Best distance achieved (or Maximum distance obtained); - Raw values (cm)	To describe the secular trend and variation (dispersion) in physical fitness scores among Brazilian youth from 2005 to 2022.	Muscle strength values obtained from the horizontal jump test showed a secular trend of decline ($\beta=-0.232$; $p<0.001$). Muscle strength values obtained from the medicine ball throw test showed a secular trend of increase ($\beta=0.814$; $p<0.001$).

Table 1. Continued...

Author	Study design, location, and year of data collection	Age range / Number of participants (% female)	Tests applied, procedures, and use of the obtained results	Study objective	Key findings related to muscle strength
Santana et al.[39]	Cross-sectional - Vale do Capiberibe, PE-2017	13 – 15 years n = 911 (61.5)	Handgrip - Hydraulic dynamometer; - Both hands; - Standing position with the elbow fully extended along the body; - three trials; - Sum of the peak result from both hands; - Raw scores/data	To analyze the association between health-related physical fitness components (analyzed individually or as a cluster of variables) and academic performance in students.	Among boys, handgrip strength was positively associated with academic performance (Mathematics) (β=0.188; p=0.004). This association was not identified among girls.
Souza et al.[40]	Cross-sectional - Fortaleza, CE (2017 – 2018)	10 – 17 years n = 173 (46.8)	Horizontal jump - Parallel feet; - Semi-flexed knees; - Torso/Trunk leaning forward; - Two trials; - Best distance; - Raw values (cm) Medicine-ball throw - 2kg ball; - Seated with knees extended; - Back in contact with the wall; - Two trials; - Best distance achieved (or Maximum distance obtained); - Raw values (cm)	To evaluate the relationship between anthropometric measures, physical activity levels, and physical fitness in schoolchildren.	Schoolchildren categorized as having low cardiovascular risk by waist circumference had significantly higher mean horizontal jump scores. No differences in medicine ball throw strength values were observed based on cardiovascular risk (waist circumference).
Bergmann et al.[41]	Cross-sectional - Brasil (1999 – 2018)	7 – 16 years n = 87,766 (44.8)	Horizontal jump - Parallel feet; - Semi-flexed knees; - Torso/Trunk leaning forward; - Two trials; - Best distance; - Raw values (cm) Medicine-ball throw - 2kg ball; - Seated with knees extended; - Back in contact with the wall; - Two trials; - Best distance achieved (or Maximum distance obtained); - Raw values (cm)	To examine the effect of relative age on muscle power in a large sample of Brazilian children and adolescents.	Among both boys and girls, there was a sequential increase in the frequency of individuals classified as very good/excellent as relative age increased.

Table 1. Continued...

Author	Study design, location, and year of data collection	Age range / Number of participants (% female)	Tests applied, procedures, and use of the obtained results	Study objective	Key findings related to muscle strength
Bim et al.[5]	Cross-sectional - São José, SC (2014)	10–14 years n = 118 (50.8)	Handgrip strength - Electronic dynamometer; - Both hands; - Standing position with the elbow fully extended along the body; - Two trials; - Sum of the peak result from both hands - Raw scores/data	To evaluate the mediating effects of lean mass and fat mass on the relationship between body mass index (BMI) and handgrip strength in adolescents.	Lean mass was a significant mediator of the relationship between BMI and handgrip strength.
Camargo Corrêa et al.[42]	Cross-sectional - Curitiba, PR (2010 – 2011)	14,24 ± 1,6* years n = 1752 (51.7)	Handgrip - Hydraulic dynamometer; - Both hands; - Seated with the elbow flexed at 90º; - Two trials; - Sum of the mean scores from both hands - Body mass-normalized values Horizontal jump - Parallel feet; - Semi-flexed knees; - Torso/Trunk leaning forward; - Two trials; - Best distance; - Raw values (cm)	To investigate the association between muscular fitness and cardiovascular risk factors in adolescents.	Among boys, handgrip strength showed a significant inverse association with the z-score-based BMI index (β=–0.524, p<0.05) and the cardiovascular risk index (β=–0.340, p<0.05), and a positive association with the z-score-based cardiorespiratory fitness index (β=0.377, p<0.05). Similarly, among girls, handgrip strength showed a significant inverse association with the z-score-based BMI index (β=–0.436, p<0.05) and the cardiovascular risk index (β=–0.326, p<0.05), and a positive association with the z-score-based cardiorespiratory fitness index (β=0.315, p<0.05). Among boys, muscle strength assessed by the horizontal jump showed an inverse association with the z-score-based BMI index (β=–0.329, p<0.05) and the cardiovascular risk index (β=–0.257,p<0.05), and a positive association with the z-score-based cardiorespiratory fitness index (β=0.460,p<0.05). Similar results were observed in girls, where muscle strength assessed by the standing long jump showed an inverse association with the z-score-based BMI index (β= –0.108, p<0.05) and the cardiovascular risk index (β=–0.099, p<0.05), and a positive association with the z-score-based cardiorespiratory fitness index (β=0.223, p<0.05).

Table 1. Continued...

Author	Study design, location, and year of data collection	Age range / Number of participants (% female)	Tests applied, procedures, and use of the obtained results	Study objective	Key findings related to muscle strength
de Lima and Silva[43]	Cross-sectional - São José, SC -2019	14 – 19 years n = 351 (55.6)	Handgrip - Hydraulic dynamometer; - Both hands; - Standing position with the elbow fully extended along the body; - three trials; - Sum of the peak result from both hands; - Allometry (theoretical allometric exponent); - Allometry (including body mass and height); - Allometry (including fat-free mass and height)	To investigate the association between allometric indices of muscle strength and cardiovascular risk factors in adolescents.	The muscle strength index based on the theoretical allometric exponent was associated with a lower probability of obesity (OR: 0.52; 95% CI: 0.46–0.58), dyslipidemia (OR: 0.87; 95% CI: 0.81–0.93), glycemic imbalance (OR: 0.48; 95% CI: 0.20–0.91), and high C-reactive protein (OR: 0.56; 95% CI: 0.33–0.96). When considering the allometric muscle strength index that included body mass and height, an increase in muscle strength was associated with lower probabilities of high C-reactive protein (OR: 0.88; 95% CI: 0.80–0.97). Furthermore, the allometric muscle strength index including fat-free mass and height, was inversely related to high C-reactive protein (OR: 0.81; 95% CI: 0.73–0.90). When looking at the association between allometric muscle strength indices and combined cardiometabolic risk factors, the allometric muscle strength index based on the theoretical allometric exponent was associated with a lower probability for the combinations of obesity/dyslipidemia (OR: 0.44; 95% CI: 0.23–0.85), obesity/glycemic imbalance (OR: 0.20; 95% CI: 0.12–0.37), and obesity/high C-reactive protein (OR: 0.30; 95% CI: 0.16–0.56). The allometric muscle strength indices that included body mass and height, and fat-free mass and height were associated with lower probabilities for the combinations of obesity/glycemic imbalance (OR: 0.69; 95% CI: 0.56–0.87 and OR: 0.56; 95% CI: 0.37–0.87) and obesity/high C-reactive protein (OR: 0.83; 95% CI: 0.72–0.95 and OR: 0.72; 95% CI: 0.56–0.93). Muscle strength scaled based on the theoretical allometric exponent was associated with a lower probability (OR: 0.54; 95% CI: 0.28–0.89) for the presence of three or more cardiometabolic risk factors compared to those without cardiometabolic risk factors.
De Marco et al.[9]	Cross-sectional - Florianópolis, SC (2007 – 2017/2018)	14 – 19 years n = 1661 (54.7)	Handgrip - Hydraulic and electronic dynamometer; - Both hands; - Standing position with the elbow fully extended along the body; - Two trials; - Sum of the peak result from both hands; - Allometry (including body mass and height)	To analyze the secular trend in handgrip strength in adolescents using allometry and to identify the associated factors.	The comparison of handgrip strength between the surveys indicated a negative secular trend in both sexes ($p<0.001$). In boys, there was a positive association of handgrip strength with age and fat-free mass in both surveys. In 2017/18, there was a positive association with sexual maturation and a negative association with sitting time and fat percentage. In girls, fat-free mass was positively associated with handgrip strength in both surveys. In 2007, there were positive associations of handgrip strength with age and vigorous physical activity, while in 2017/18, negative associations were observed with economic level and sitting time.
Dos Santos de Fontes et al.[44]	Cross-sectional - Serra, ES (2014 – 2016)	6 – 18 years n = 833 (43.4)	Handgrip - Hydraulic dynamometer; - Both hands; - Standing position with the elbow fully extended along the body; - Three trials; - Peak result - Raw scores/data	To investigate the independent effects of handgrip strength and muscle mass on blood pressure levels in children and adolescents.	After adjusting for covariates, no differences were identified in systolic blood pressure values between handgrip strength groups in either boys or girls.

Table 1. Continued...

Author	Study design, location, and year of data collection	Age range / Number of participants (% female)	Tests applied, procedures, and use of the obtained results	Study objective	Key findings related to muscle strength
Fernandes et al.[45]	Cross-sectional - Rio de Janeiro, RJ - 2020	10 – 15 years n = 131 (49.0)	Horizontal jump - Parallel feet; - Semi-flexed knees; - Torso/Trunk leaning forward; - Two trials; - Best distance; - Raw values (cm) Medicine-ball throw - 2kg ball; - Seated with knees extended; - Back in contact with the wall; - 2 attempts (or 2 trials); - Best distance achieved (or Maximum distance obtained); - Raw values (cm)	To investigate the relationship between physical fitness, executive function, and academic performance in children and adolescents.	No correlation was identified between muscle strength and variables related to executive functions and academic performance.
Ferreira et al.[46]	Cross-sectional - Campinas, SP - 2018	11 – 16 years n = 152 (55.3)	Horizontal jump - Parallel feet; - Semi-flexed knees; - Torso/Trunk leaning forward; - Two trials; - Best distance; - Raw values (cm) Medicine-ball throw - 2kg ball; - Seated with knees extended; - Back in contact with the wall; - 2 attempts (or 2 trials); - Best distance achieved (or Maximum distance obtained); - Raw values (cm)	To examine the association between physical fitness levels, body composition parameters, and phase angle among adolescents.	Muscle strength, as assessed by the standing long jump, was not associated with phase angle variability in boys and girls. Muscle strength assessed by the medicine ball throw accounted for 13.2% of the phase angle variability in boys, in a model adjusted for fat-free mass, height, and agility test. Among girls, muscle strength assessed by the medicine ball throw test was not associated with phase angle variability.

Table 1. Continued...

Author	Study design, location, and year of data collection	Age range / Number of participants (% female)	Tests applied, procedures, and use of the obtained results	Study objective	Key findings related to muscle strength
Leite et al.[47]	Cross-sectional - Curitiba, PR - 2019	10 – 17 years n = 120 (56.7)	Bench press - Best result; - Raw values (kg) Leg press - Best result; - Raw values (kg) Biceps curl - Best result; - Raw values (kg)	To evaluate the mediating role of muscle mass in the relationship between physical fitness and cardiometabolic risk factors in adolescents.	In both boys and girls, muscle strength obtained through biceps curl was not mediated by the lean mass index or muscle/fat ratio in the association with cardiometabolic risk factors. In girls, the inverse relationship between fat mass and muscle strength, assessed by the 1-repetition maximum (1RM) leg press test and cardiometabolic risk factors, was mediated by the lean mass index (33%). In boys, the direct relationship between muscle strength, assessed by the 1RM leg press 45 test and cardiometabolic risk factors, was mediated (16%) by the muscle/fat ratio. In both boys and girls, the lean mass index and the muscle-to-fat ratio were not mediators in the relationship between muscle strength obtained through elbow flexion and cardiometabolic risk factors.
Mello et al.[48]	Cross-sectional - Brazil (2000 – 2022)	6 – 18 years n = 77,384 (44.6)	Horizontal jump - Parallel feet; - Semi-flexed knees; - Torso/Trunk leaning forward; - Two trials; - Best distance; - Raw values (cm)	To determine the relationship between horizontal jump performance and sprint performance according to sprint levels in children and adolescents.	A significant correlation was found between standing long jump performance and 20-meter sprint test performance (R2 cubic for boys: 0.265; R2 cubic for girls: 0.204). For both boys and girls, the highest R2 value was observed in the "regular" (P40–60), "good" (P60–80), and "very good" (P80–98) categories. Regarding these three categories, for every additional centimeter in the horizontal jump, a reduction of 0.005 and 0.007 seconds, respectively, was expected in the 20-meter test.
Moraes Junior et al.[6]	- Longitudinal (3 months) - Curitiba, PR (2022)	14.08 ± 0.8* years n = 28 (32.1)	Handgrip - Hydraulic dynamometer; - Elbow flexed at 90º; - Two trials; - Peak result; - Raw scores/data	To observe the changes and individual responses of adolescents regarding anthropometry, cardiometabolic profile, vitamin D concentrations, physical fitness, and motor competence in the immediate return and three months after returning to school activities following lockdown.	No differences were found in muscle strength, as assessed by handgrip strength, when comparing the means obtained immediately after returning from the COVID-19 pandemic lockdown and three months after the start of school activities.
Nevill et al.[16]	Cross-sectional - Brasil (1999 – 2022)	6 – 18 years n = 94,484 (44.8)	Horizontal jump - Parallel feet; - Semi-flexed knees; - Torso/Trunk leaning forward; - Two trials; - Best distance; - Raw values (cm) Medicine-ball throw - 2kg ball; - Seated with knees extended; - Back in contact with the wall; - 2 attempts (or 2 trials); - Best distance achieved (or Maximum distance obtained); - Raw values (cm)	To examine which key body size characteristics are consistently associated with success across a variety of physical fitness tests, while also identifying characteristics that benefit only specific tests.	The logarithmic body mass variable and raw body mass both showed a negative relationship in determining standing long jump values, suggesting that a general decline in horizontal jump distance occurs with increasing body mass (when controlled for age or within age ranges). The terms for arm span and time before/after peak height velocity (calculated as the age-height interaction) were positive (p<0.001), suggesting that jump distance benefits children with longer arms and whose age is a few years before peak height velocity (and/or who are tall for their age). The logarithmic and raw body mass terms, used to predict the medicine ball throw test, were both positive, suggesting that the medicine ball throw distance increases with body mass. The terms for arm span and time before/after peak height velocity (calculated as the age-height interaction) were both positive (p<0.001), suggesting that the medicine ball throw distance benefits children who have longer levers and whose age is a few years before peak height velocity (and/or who are tall for their age).

Detailed information regarding the methodological quality/risk of bias, including the specific scores achieved by each study according to the items evaluated, can be accessed in detail in Table 2. Overall, the methodological quality/risk of bias assigned to the studies ranged from 0.45 to 0.73 (Table 2). Table 3 presents the estimated prevalences of achieving adequate muscle strength levels according to age group, considering information from the studies included in this review and the studies included in previous Brazilian Report Card Project reviews[4,12]. Overall, only three studies[49,51,52] reported information on achieving adequate levels of muscle strength. In the study conducted by de Lima and Silva[49], the prevalence of achieving adequate muscle strength levels was 13.3% for the 14–15 age group, 18.3% for the 16–17 age group, and 23.5% for the 18–19 age group. In the study carried out with the participation of 636 schoolchildren in the city of Florianópolis – Brazil[51], 49.3% and 60.2% of the schoolchildren in the 14–16 and 17–19 age groups, respectively, had adequate levels of muscle strength. Furthermore, in the study conducted with adolescents in the city of São José – Brazil, 32.5% of girls aged 14–15 years, 43.4% of girls aged 16–17 years, and 45.9% of girls aged 18–19 years achieved adequate levels of muscle strength[52]. Regarding the estimated prevalence of achieving adequate muscle strength levels in boys, 24.0% of those evaluated aged 14–15 years, 35.5% of participants aged 16–17 years, and 44.9% of those evaluated aged 18–19 years achieved adequate levels of muscle strength[52].

In addition to the information regarding the prevalence of achieving adequate muscle strength levels according to age group, the results of studies that classified muscle strength values concerning the achievement or non-achievement of adequate levels, using specific cut-off points suggested by physical assessment batteries in general and according to sex, can be accessed in Table 3. Of the total participants analyzed (n=2,171), 44.1% were classified as having achieved adequate muscle strength levels. Considering the results by sex, 40.1% (n=418) of the boys and 47.8% (n=540) of the girls achieved adequate muscle strength levels.

In addition to the aforementioned results, Table 3 also combines data from the systematic review by Lima et al.[12] with the data from the present review, totaling 17,379 Brazilian participants (7 to 19 years of age). The results showed that 56.1% of the youth evaluated achieved adequate levels of muscle strength, specifically 58.8% of the boys and 53.0% of the girls.

DISCUSSION

The present systematic review study, by updating the data from the previous review of this Project[12], identified new and important evidence regarding the prevalence of adequate muscle strength in Brazilian children and adolescents. By analyzing the studies conducted during the years 2020 to 2024, this review identified that 44.1% of the participants achieved adequate levels of muscle strength. The synthesis of evidence also identified differences according to sex, with 40.1% of boys and 47.8% of girls having adequate muscle strength levels.

In a direct comparative analysis with the 2018–2019 period[54], the overall prevalence of adequate muscle strength increased from 29.8% to 44.1%. This increase was consistently observed in both boys (from 27.6% to 40.1%) and girls (from 31.8% to 47.8%). However, it is speculated that these findings do not reflect a real and generalized improvement in the muscle strength of the young population, but rather that the identified increase is punctual, stemming from the methodological heterogeneity and sampling bias of the analyzed studies.

Table 2. Methodological assessment of the included studies.

Author (s)	Quality assessment point[a]														Score for the methodology quality[b]
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	
Estivaleti et al.[31]	1	1	0	1	0	0	0	NA	1	0	1	NA	NA	0	0.45
Souza et al.[40]	1	1	0	1	0	0	0	NA	1	0	1	NA	NA	0	0.45
Bim et al.[18]	1	1	0	1	0	0	0	NA	1	0	1	NA	NA	NA	0.50
Bergmann et al.[41]	1	1	0	1	0	0	0	1	1	0	1	NA	NA	0	0.50
Bim et al.[5]	1	1	0	1	0	0	0	0	1	0	1	NA	NA	1	0.50
Fernandes et al.[45]	1	1	CD	1	0	0	0	NA	1	0	1	NA	NA	0	0.50
de Souza et al.[30]	1	1	CD	1	0	0	0	0	1	0	1	NA	NA	1	0.55
Fochesatto et al.[32]	1	1	CD	1	0	0	0	0	1	0	1	NA	NA	1	0.55
Santana et al.[39]	1	1	CD	1	0	0	0	0	1	0	1	NA	NA	1	0.55
Leite et al.[47]	1	0	CD	1	1	0	0	0	1	0	1	NA	NA	1	0.55
De Marco et al.[9]	1	1	CD	1	0	0	0	NA	1	0	1	NA	NA	NA	0.56
Martins et al.[17]	1	1	0	1	1	0	0	0	1	0	1	NA	NA	1	0.58
Bim et al.[19]	1	1	0	1	1	0	0	0	1	0	1	NA	NA	1	0.58
de Lima et al.[20]	1	1	0	1	1	0	0	0	1	0	1	NA	NA	1	0.58
de Lima et al.[21]	1	1	0	1	1	0	0	0	1	0	1	NA	NA	1	0.58
Confortin et al.[26]	1	1	1	1	0	0	0	0	1	0	1	NA	NA	1	0.58
Confortin et al.[28]	1	1	1	1	0	0	0	0	1	0	1	NA	NA	1	0.58
Pelegrini et al.[35]	1	1	0	1	1	0	0	0	1	0	1	NA	NA	1	0.58
Moraes Junior et al.[6]	1	1	0	1	0	1	CD	0	1	NA	1	NA	NA	0	0.60
Nevill et al.[16]	1	1	CD	1	0	0	0	NA	1	0	1	NA	NA	1	0.60
Todendi et al.[24]	1	1	CD	1	0	0	0	1	1	0	1	NA	NA	1	0.64
da Costa et al.[29]	1	1	CD	1	1	0	0	0	1	0	1	NA	NA	1	0.64
Nevill et al.[34]	1	1	1	1	0	0	0	NA	1	0	1	NA	NA	1	0.64
Saldanha Filho et al.[36]	1	1	0	1	1	0	0	NA	1	0	1	NA	NA	1	0.64
Camargo Corrêa et al.[42]	1	1	CD	1	1	0	0	0	1	0	1	NA	NA	1	0.64
de Lima and Silva[43]	1	1	0	1	1	0	0	NA	1	0	1	NA	NA	1	0.64
Ferreira et al.[46]	1	1	CD	1	1	0	0	0	1	0	1	NA	NA	1	0.64
Mello et al.[48]	1	1	CD	1	0	0	0	1	1	0	1	NA	NA	1	0.64
Lemos et al.[22]	1	1	1	1	0	0	0	1	1	0	1	NA	NA	1	0.67
Saraiva et al.[23]	1	1	1	1	1	0	0	0	1	0	1	NA	NA	1	0.67
Confortin et al.[27]	1	1	1	1	0	0	0	1	1	0	1	NA	NA	1	0.67
de Lima and Silva[37]	1	1	0	1	1	0	0	1	1	0	1	NA	NA	1	0.67
Nevill et al.[38]	1	1	CD	1	0	0	0	NA	1	1	1	NA	NA	NA	0.67
Dos Santos de Fontes et al.[44]	1	1	1	1	1	0	0	0	1	0	1	NA	NA	1	0.67
Todendi et al.[25]	1	1	CD	1	1	0	0	1	1	0	1	NA	NA	1	0.73
Mello et al.[33]	1	1	CD	1	1	0	0	1	1	0	1	NA	NA	1	0.73

Note. a: (Q1) Defined research question; (Q2) clear study population; (Q3) > 50 % participation rate; (Q4) uniform inclusion and exclusion criteria; (Q5) sample size justification; (Q6) exposure of interest measured before outcome; (Q7) sufficient time frame between exposure and outcome; (Q8) examination of different levels of exposure in relation to outcome; (Q9) defined and evenly applied exposure methods; (Q10) exposure assessed more than once over time; (Q11) defined and consistently applied outcome measure (Q12); blinding of assessors; (Q13) loss of follow-up < 20 %; (Q14) key potential confounding variables measured and adjusted statistically for impact between exposure and outcome; b: number of positive answer / total of answered questions ratio; Yes = 1; No = 0. CD: cannot determine; NA: not applicable; NR: not reported.

Table 3. Results of studies in this review and previous Report Card Project reviews[4,12] that classified outcomes based on muscle strength levels by age group; characteristics of studies in this review that classified outcomes based on muscle strength levels regardless of age group; and updated prevalences of achieving adequate muscle strength levels previously reported by the Brazilian Report Card Project[12].

Author	Study location	Age group / Sample size	Tests used	Percentage of individuals classified as having adequate/healthy muscle strength levels	Reference used for classification
Lima and Silva[49§]	São José	14 – 19 years; n = 866; Boys, n = 406; Girls, n = 460; 14-15 years, n = 255; 16-17 years, n = 509; 18-19 years, n = 102	Handgrip	17.4% (total sample, n = 151) 20.4% (boys, n = 83) 14.8% (girls, n = 68) 13.3% (age group 14-15 years, n = 34) 18.3% (age group 16-17 years, n = 93) 23.5% (age group 18-19 years, n = 24)	Canadian Society for Exercise Physiology[50]
Silva et al.[51§]	Florianópolis	14-19 anos, n = 636; Boys, n = 230; Girls, n = 406; 14-16 years, n = 420; 17-19 years, n = 216	Handgrip	53.0% (total sample, n = 337) 36.5% (boys, n = 84) 62.3% (girls, n = 253) 49.3% (age group 14-16 years, n = 207) 60.2% (age group 17-19 years, n = 130)	Canadian Society for Exercise Physiology[50]
de Lima et al.[52‖]	São José	14-19 years, n = 923 (Boys, n = 436; Girls, n = 487; Girls, 14-15 years; n = 152 Girls, 16-17 years; n = 292 Girls, 18-19 years; n = 43 Boys, 14-15 years; n = 122 Boys, 16-17 years; n = 244 Boys, 18-19 years; n = 70	Handgrip	37.8% (total sample, n = 349) 33.7% (boys, n = 149) 40.3% (girls, n = 200) 32.5% (girls, 14-15 years; n = 51) 43.4% (girls, 16-17 years; n = 128) 45.9% (girls, 18-19 years; n = 21) 24.0% (boys, 14-15 years; n = 30) 35.5% (boys, 16-17 years; n = 87) 44.9% (boys, 18-19 years; n = 32)	Canadian Society for Exercise Physiology[50]
Bim et al.[19]	Florianópolis, Santa Catarina	15 – 18 years n = 971 (Boys, n = 496; Girls, n = 475)	Handgrip	34.6% (total sample, n = 336) 26.2% (boys, n = 130) 43.4% (girls, n = 206)	Canadian Society for Exercise Physiology[50]
Saldanha Filho et al.[36*]	Santa Cruz do Sul, Rio Grande do Sul	7 – 17 years n = 1,200 (Boys, n = 545; Girls, n = 655)	Medicine ball throw; Horizontal jump	Medicine ball throw 51.8% (total sample, n = 622) 52.8% (boys, n = 288) 51.0% (girls, n = 334) Horizontal jump 29.5% (total sample, n = 354) 21.8% (boys, n = 119) 35.9% (girls, n = 235)	*Projeto Esporte Brasil*[53]
Total[†] **(results of the present systematic review)**	South of Brazil	7 – 18 years n = 2,171 (Boys, n = 1041; Girls, n = 1130)	Medicine ball throw; Horizontal jump	44.1% (total sample, n = 958) 40.1% (boys, n = 418) 47.8% (girls, n = 540)	Canadian Society for Exercise Physiology[50]; *Projeto Esporte Brasil*[53]
Total[‡] **(results of the previous systematic reviews of this project)**	All geographical regions with at least one locality	7 – 19 years n = 15,208 (Boys, n =8,194); Girls, n = 7,014)	Handgrip; Medicine ball throw; Horizontal jump	57.8% (total sample, n = 8,787) 61.1% (boys, n = 5,009) 58.8% (girls, n = 3,778)	Canadian Society for Exercise Physiology[50]; *Projeto Esporte Brasil*[53]
Updated information[‡]	All geographical regions with at least one locality	7 – 19 years n = 17,379 (Boys, n= 9,235; Girls, n = 8,144)	Medicine ball throw; Horizontal jump	56.1% (total sample, n = 9,745) 58.8% (boys, n = 5,427) 53.0% (girls, n = 4,318)	

Note. *For the TOTAL, the values from the medicine ball throw test from the Saldanha Filho et al.[36] study were considered; †To calculate the percentage of individuals with adequate muscular strength, the following equation was considered: (number of individuals classified with adequate muscular strength / number of individuals from all considered studies) ×100; ‡Information from previous systematic reviews linked to the Brazil Report Card Project[4,12] and this systematic review. §Information originating from a study included in the first systematic review related to the Brazil Report Card Project[4]; ‖Information originating from a study included in the second systematic review related to the Brazil Report Card Project[12].

The studies that reported muscle strength prevalence were conducted in samples concentrated in regions of high socioeconomic status (e.g., a capital city in the South region of Brazil, or a municipality with more than 50% of participants in classes A/B)[19,36]. The concentration of results stemming from these regions biases the prevalence toward artificially higher levels of muscle strength adequacy, as they do not represent the national scenario. Additionally, the use of different cut-off points and the utilization of varying tests may have contributed to the identification of higher adequacy prevalences[19,36].

Despite this, when combining the data from the previous review[54] with those from the present review, which totaled 17,379 participants, a significant reduction in the prevalence of youth with adequate muscle strength levels was observed. The combined analysis identified that 56.1% of Brazilian youth achieved adequate muscle strength levels (58.8% for boys and 53.0% for girls). This indicates that, despite the punctual increase observed in the 2020–2024 period, the prevalence of adequate strength in this period was still lower than the general average of previous years, reinforcing the hypothesis of a long-term declining trend. It is hypothesized that the decrease in the overall prevalence of muscle strength adequacy may be related to factors such as the increase in sedentary behavior and low adherence to physical activity recommendations, as previously hypothesized[54]. However, the difficulty in interpreting and comparing results persists, since the absence of reference cut-off points, based on health criteria and validated for the Brazilian population, as well as the use of different tests by the studies to evaluate muscle strength and its manifestations, remains a central methodological challenge in the area.

The declining trend in muscle strength, observed in the combined analysis, is consistent with the behavioral changes documented in the young Brazilian population, especially in the post-COVID-19 pandemic period[55-57]. Studies conducted in Brazil during social isolation showed a statistically significant reduction in physical activity time and, conversely, an expressive increase in time dedicated to sedentary behaviors, such as screen time, both on weekdays and weekends[55-57]. Research carried out with Brazilian schoolchildren, for example, indicated that children were seven times more likely to be physically active outdoors for one hour or more before the pandemic than during the pandemic, evidencing a drastic change in this behavioral pattern[56].

This change in habits has a direct relationship with muscle health[58]. The literature has reported an inverse association between screen time and levels of strength[59] and physical fitness[60] in children and adolescents. A worrying phenomenon, pediatric dynapenia (i.e., loss of muscle strength not associated with neuromuscular diseases), has been directly related to a sedentary lifestyle[61]. The reduction in outdoor play and structured physical activities, replaced by hours in front of screens, limits the neuromuscular stimuli essential for the development of muscle strength during growth phases[61]. Thus, it is hypothesized that the decline in the prevalence of adequate strength over the years, as suggested by the combined data described in this review, may be a direct reflection of this transition to a less active lifestyle, exacerbated by the effects of the pandemic.

Regarding methodological quality/risk of bias, the studies included in this review presented a score that ranged from 0.45 to 0.73. These values are slightly lower than those observed in the previous review (0.54 to 0.82), suggesting that methodological weaknesses persist in studies conducted in Brazil.

The maintenance of studies with moderate to high risk of bias reinforces the need for greater methodological rigor in future research, especially regarding the control of confounding variables (e.g., sexual maturation, level of physical activity) and the adoption of longitudinal designs, which, although more complex, are essential for establishing more robust causal relationships between muscle strength and health outcomes in children and adolescents.

Given this scenario, the promotion of physical activity that includes strength training becomes an indispensable public health strategy. The Brazilian Physical Activity Guide[62] already recommends that children and youth participate in activities that strengthen muscles and bones. Improving muscle strength levels through planned and supervised activities is safe and offers multiple benefits for this age group, including improved body composition, increased bone mineral density, and enhanced mental health[1]. The punctual increase in adequate strength prevalence (2020–2024) may, perhaps, indicate a localized success of interventions or a greater awareness of the topic in the post-pandemic period, but the general declining trend reinforces the need for continuous and expanded actions to reverse this worrying picture.

While the previous review (2018–2019) highlighted a strong concentration of studies in the South region of Brazil and an absence of a common focus regarding the investigation of muscle strength, the findings summarized in this review revealed a thematic diversification, with prominent emphasis on the relationship between muscle strength and health outcomes. The most prominent topic was the relationship between muscle strength and cardiometabolic risk, the subject of 11 studies. This result is consistent with the growing body of evidence that credits muscle strength with unique and independent benefits related to the metabolic and cardiovascular health of children and adolescents[1-3].

Regarding the findings of this review (2020–2024), the reduced number of studies that aimed to investigate the impact of the COVID-19 pandemic on muscle strength in Brazilian children and adolescents is noteworthy. Only one of the 36 included studies had this objective, finding no significant changes in handgrip strength in a small sample of schoolchildren followed for three months[6]. Furthermore, it is highlighted that no study with data collection in the context of the pandemic estimated the prevalence of achieving adequate muscle strength. Investigating the impact of the pandemic on muscle strength in national studies is justified because it contributes to understanding the long-term consequences for the health of young Brazilians, identifying possible deficits that may require public health interventions in the future.

Additionally, it is crucial to contextualize the findings of this review. Although the included studies were published during the years 2020 to 2024, a detailed analysis of the data revealed that more than 80% of the studies used data collected before the onset of the pandemic in 2020. This interval between the data collection period and publication is common in the scientific community, but in this specific case, it has significant implications: the majority of the evidence summarized in this review does not reflect the reality of muscle strength in Brazilian children and adolescents during or after the pandemic period, but rather the pre-COVID-19 scenario. Consequently, the results presented here should be interpreted as a snapshot of research conducted before the pandemic, and not as a representation of the current state of muscle strength in this population, which may have been substantially altered by the lifestyle changes imposed during the 2020 to 2022 period[55-57].

Some limitations of the present systematic review must be acknowledged: 1) although studies published during the years 2020 to 2024 were included, the majority of the information came from research carried out with data collected before the COVID-19 pandemic, which limits the understanding of the potential impact that lifestyle changes during the pandemic period may have caused on muscle strength levels in Brazilian children and adolescents. Furthermore, no study with data collection in the context of the pandemic estimated the prevalence of achieving adequate muscle strength levels in this population; 2) the non-inclusion of studies not published in scientific journals (e.g., theses, dissertations) may contribute to publication bias; 3) although distinct databases were used to gather the information for this review, it is possible that studies published on platforms not included in this review were not incorporated; 4) the reduced number of studies that aimed to estimate the prevalence of adequate muscle strength levels is considered a limitation, as it may restrict the extrapolation of the observed prevalences to other Brazilian regions; 5) the limited number of studies that aimed to classify muscle strength values considering the age group of the evaluated individuals is considered a limitation of this review, as it prevents the estimation of the prevalence of achieving adequate muscle strength levels for children and adolescents.

The present systematic review update identified a relevant declining trend in the prevalence of adequate muscle strength in Brazilian children and adolescents when the data were analyzed considering the historical totality. The combined analysis of studies up to 2024 indicated that only 56.1% of youth achieved adequate levels of muscle strength (58.8% for boys; 53.0% for girls). Despite the growing focus of the national literature on investigating the relationship between muscle strength and cardiometabolic health outcomes, methodological challenges and a significant gap persist in the investigation of post-pandemic effects. Given this scenario, the implementation of public health strategies aimed at promoting muscle-strengthening activities is necessary, with a view to reversing the declining trend in muscle strength and protecting the future health of children and adolescents in Brazil.

COMPLIANCE WITH ETHICAL STANDARDS

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. This study was funded by the authors.

Data Availability Statement

Research data is only available upon request.

Ethical approval

This research is in accordance with the standards set by the Declaration of Helsinki.

Conflict of interest statement

The authors have no conflicts of interest to declare.

Author Contributions

Experiments carried out: TRL, JCPDM; Data analysis: TRL, JCPDM, AP, DASS; Contribution with reagents/research materials/analysis tools: TRL, JCPDM, CCM, PCM, LG, MSP, AP, DASS; Article writing: TRL, JCPDM, CCM, PCM, LG, MSP, AP, DASS. Conception and design of the experiment: DASS. All authors read and approved.

REFERENCES

1. Smith JJ, Eather N, Morgan PJ, Plotnikoff RC, Faigenbaum AD, Lubans DR. The health benefits of muscular fitness for children and adolescents: a systematic review and meta-analysis. Sports Med. 2014;44(9):1209-23. https://doi.org/10.1007/s40279-014-0196-4. PMid:24788950.
2. de Lima TR, Martins PC, Guerra PH, Silva DAS. Muscular fitness and cardiovascular risk factors in children and adolescents: a systematic review. J Strength Cond Res. 2020;34(8):2394-406. https://doi.org/10.1519/JSC.0000000000002840. PMid:30273286.
3. de Lima TR, Martins PC, Moreno YMF, Chaput JP, Tremblay MS, Sui X, et al. Muscular fitness and cardiometabolic variables in children and adolescents: a systematic review. Sports Med. 2022;52(7):1555-75. https://doi.org/10.1007/s40279-021-01631-6. PMid:35020179.
4. Lima TR, Moraes MS, Martins PC, Silva VS, Silva DAS. Diversity of parameters in the muscle strength evaluation of Brazilian school children and adolescents: a systematic review. Rev Bras Cineantropom Desempenho Hum. 2018;20(4):497-516. https://doi.org/10.5007/1980-0037.2018v20n4p497.
5. Bim MA, de Pinto AD, Claumann GS, Pelegrini A. Mediation effects of lean mass and fat mass on the relationship between body mass index and handgrip strength. Am J Hum Biol. 2024;36(4):e24004. https://doi.org/10.1002/ajhb.24004. PMid:37860994.
6. Moraes FB Jr, Tadiotto MC, Lenardt B, Mota J, Matos O, Leite N. Importance of Return to Usual and School Activities After Social Isolation in Recovering Vitamin D Concentrations, Physical Fitness, and Motor Performance in Adolescents. Int J Environ Res Public Health. 2024;21(11):1494. https://doi.org/10.3390/ijerph21111494. PMid:39595761.
7. Chiang H-L, Chuang Y-F, Chen Y-A, Hsu CT, Ho CC, Hsu HT, et al. Physical fitness and risk of mental disorders in children and adolescents. JAMA Pediatr. 2024;178(6):595-607. https://doi.org/10.1001/jamapediatrics.2024.0806. PMid:38683586.
8. Sandercock GR, Cohen DD. Temporal trends in muscular fitness of English 10-year-olds 1998–2014: An allometric approach. J Sci Med Sport. 2019;22(2):201-5. https://doi.org/10.1016/j.jsams.2018.07.020. PMid:30098974.
9. De Marco JCP, de Araújo Pinto A, Brazo-Sayavera J, Külkamp W, de Lima TR, Pelegrini A. Secular trends and sociodemographic, biological, and behavioural factors associated with handgrip strength in adolescents in southern Brazil: An allometric approach. J Sports Sci. 2024;42(9):776-84. https://doi.org/10.1080/02640414.2024.2364137. PMid:38869478.
10. Xiang M, Zhang Z, Kuwahara K. Impact of COVID-19 pandemic on children and adolescents' lifestyle behavior larger than expected. Prog Cardiovasc Dis. 2020;63(4):531-2. https://doi.org/10.1016/j.pcad.2020.04.013. PMid:32360513.

11. Stockwell S, Trott M, Tully M, Shin J, Barnett Y, Butler L, et al. Changes in physical activity and sedentary behaviours from before to during the COVID-19 pandemic lockdown: a systematic review. BMJ Open Sport Exerc Med. 2021;7(1):e000960. https://doi.org/10.1136/bmjsem-2020-000960. PMid:34192010.

12. Lima TR, Martins PC, Alves CAS Jr, Moraes MS, Zanlorenci S, Borges LL, et al. Report Card Brazil: systematic review of muscle strength assessment in children and adolescents in Brazil. Report Card Brasil: revisão sistemática sobre avaliação da força muscular em crianças e adolescentes no Brasil. Rev Bras Cineantropom Desempenho Hum. 2021;23:e80292. https://doi.org/10.1590/1980-0037.2021v23e80292.

13. Silva DAS, Pelegrini A, Pinto AA, Christofaro DGD, Ferrari GLM, Nunes HEG, et al. Report Card Brazil: Health indicators for children and adolescents [Internet]. 4th ed. Charlottesville (VA): Center for Open Science; 2026 [cited 2026 Apr 1]. Available from: https://osf.io/y2q8z/

14. Moher D, Liberati A, Tetzlaff J, Altman DG, Group P. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Int J Surg. 2010;8(5): 336-41. https://doi.org/10.1016/j.ijsu.2010.02.007. PMid:20171303.

15. National Heart, Lung, and Blood Institute. Quality assessment tool for observational cohort and cross-sectional studies. Bethesda (MD): NHLBI; 2014.

16. Nevill AM, Duncan MJ, Nobre GC, Gaya A, Myers T, Mello JB. Identifying the key body size and maturity characteristics associated with superior physical fitness performance tests: does one size fit all? Sport Sci Health. 2024;20(3):1051-63. https://doi.org/10.1007/s11332-024-01196-7.

17. Martins PC, de Lima LRA, Berria J, Petroski EL, da Silva AM, Silva DAS. Association between phase angle and isolated and grouped physical fitness indicators in adolescents. Physiol Behav. 2020;217:112825. https://doi.org/10.1016/j.physbeh.2020.112825. PMid:31991158.

18. Bim MA, Pinto ADA, Silva DAS, Rodrigues AM, Pelegrini A. Normative values of handgrip strength in adolescents according to chronological age and sexual maturation. Motriz. 2021;27:e1021004421. https://doi.org/10.1590/s1980-65742021004421.

19. Bim MA, Pinto AA, Scarabelot KS, Claumann GS, Pelegrini A. Handgrip strength and associated factors among Brazilian adolescents: A cross-sectional study. J Bodyw Mov Ther. 2021;28:75-81. https://doi.org/10.1016/j.jbmt.2021.06.010. PMid:34776203.

20. de Lima TR, Sui X, de Lima LRA, Silva DAS. Muscle strength and its association with cardiometabolic variables in adolescents: does the expression of muscle strength values matter? World J Pediatr. 2021;17(6):597-608. https://doi.org/10.1007/s12519-021-00460-x. PMid:34533773.

21. de Lima TR, Sui X, Silva DAS. Normalization of muscle strength measurements in the assessment of cardiometabolic risk factors in adolescents. Int J Environ Res Public Health. 2021;18(16):8428. https://doi.org/10.3390/ijerph18168428. PMid:34444178.

22. Lemos L, Clark C, Brand C, Pessoa ML, Gaya A, Mota J, et al. 24-hour movement behaviors and fitness in preschoolers: A compositional and isotemporal reallocation analysis. Scand J Med Sci Sports. 2021;31(6):1371-9. https://doi.org/10.1111/sms.13938. PMid:33599022.

23. Saraiva BTC, Agostinete RR, Freitas Júnior IF, de Sousa DER, Gobbo LA, Tebar WR, et al. Association between handgrip strength and bone mineral density of Brazilian children and adolescents stratified by sex: a cross-sectional study. BMC Pediatr. 2021;21(1):207. https://doi.org/10.1186/s12887-021-02669-1. PMid:33910521.

24. Todendi PF, Brand C, de Castro Silveira JF, Burns RD, Martínez JA, Fiegenbaum M, et al. Cardiorespiratory Fitness and Muscular Strength Moderates the Relationship between FNDC5 Polymorphism and Adiposity in Children and Adolescents. Int J Environ Res Public Health. 2021;18(18):9797. https://doi.org/10.3390/ijerph18189797. PMid:34574727.

25. Todendi PF, Brand C, Silveira JFC, Gaya AR, Agostinis-Sobrinho C, Fiegenbaum M, et al. Physical fitness attenuates the genetic predisposition to obesity in children and adolescents. Scand J Med Sci Sports. 2021;31(4):894-902. https://doi.org/10.1111/sms.13899. PMid:33274504.

26. Confortin SC, Aristizábal LYG, Bragança M, Cavalcante LC, Alves JDA, Batista RFL, et al. Are fat mass and lean mass associated with grip strength in adolescents? Nutrients. 2022;14(16):3259. https://doi.org/10.3390/nu14163259. PMid:36014765.

27. Confortin SC, Barbosa AR, de Oliveira BR, da Silva Magalhães EI, Bragança MLBM, de Britto E Alves MTSS, et al. The consumption of culinary preparations and ultra-processed food is associated with handgrip strength in teenagers. Nutr J. 2022;21(1):66. https://doi.org/10.1186/s12937-022-00818-5. PMid:36273143.

28. Confortin SC, Batista RFL, Barbosa AR, Wendt A, Crochemore-Silva I, Alves MTSSBE, et al. Is sleep time associated with handgrip strength in adolescents from the 1997/1998 Sao Luis Birth Cohort? Cien Saude Colet. 2022;27(3):1147-55. https://doi.org/10.1590/1413-81232022273.03132021. PMid:35293451.

29. da Costa N, Silveira JFC, Schneiders LB, Sehn AP, Reuter ÉM, Hobkirk JP, et al. Moderating Role of Physical Fitness in the Association Between TV Time and Adiposity Parameters in Adolescents. Am J Health Promot. 2022;36(7):1104-11. https://doi.org/10.1177/08901171221086951. PMid:35414246.

30. de Souza LV, de Meneck F, Parizotto GP, Franco M. Low birth weight and its relation to physical fitness parameters in children: Its negative effect on muscle strength and cardiorespiratory endurance. Am J Hum Biol. 2022;34(1):e23595. https://doi.org/10.1002/ajhb.23595. PMid:33709521.

31. Estivaleti JMO, Bergamo RR, Oliveira LC, Beltran DCG, Silva Junior JPD, Santos MD, et al. Physical activity level measured by accelerometry and physical fitness of schoolchildren. Rev Paul Pediatr. 2022;41:e2021230. https://doi.org/10.1590/1984-0462/2023/41/2021230. PMid:36102399.

32. Fochesatto CF, Gaya ACA, Cristi-Montero C, Brand C, Dias AF, Ruschel Bandeira D, et al. Association between physical fitness components and fluid intelligence according to body mass index in schoolchildren. Appl Neuropsychol Child. 2022;11(4):640-6. https://doi.org/10.1080/21622965.2021.1924718. PMid:34043918.

33. Mello JB, Pedretti A, Bergmann GG, Gaya AR, Ubago-Guisado E, Gaya ACA. Sprint and upper limbs power field tests for the screening of low bone mineral density in children. Front Physiol. 2022;13:1066462. https://doi.org/10.3389/fphys.2022.1066462. PMid:36569752.

34. Nevill A, Brand C, de Castro Silveira JF, Sehn AP, Reuter CP. Identifying the ideal "body shape" associated with athletic performance using three-dimensional (height, body mass and waist) allometry. J Sports Sci. 2022;40(16):1865-73. https://doi.org/10.1080/02640414.2022.2116527. PMid:36101023.

35. Pelegrini A, Bim MA, Alves AD, Scarabelot KS, Claumann GS, Fernandes RA, et al. Relationship between muscle strength, body composition and bone mineral density in adolescents. J Clin Densitom. 2022;25(1):54-60. https://doi.org/10.1016/j.jocd.2021.09.001. PMid:34756705.

36. Saldanha N Fo, Priscila Reuter C, Francisco De Castro Silveira J, Borfe L, Pollo Renner JD, Pohl HH. low performance-related physical fitness levels are associated with clustered cardiometabolic risk score in schoolchildren: a cross-sectional study. Human Mov. 2022;23(3):113-9. https://doi.org/10.5114/hm.2022.107976.

37. de Lima TR, Silva DAS. Handgrip strength is not associated with high blood pressure and does not have good discriminatory power for high blood pressure in adolescents. J Strength Cond Res. 2023;37(1):46-54. https://doi.org/10.1519/JSC.0000000000004388. PMid:36515589.

38. Nevill AM, Duncan MJ, Gaya A, Mello JB. Secular trends in the physical fitness of Brazilian youth: Evidence that fitness is declining for the majority but not for a fit minority. Scand J Med Sci Sports. 2023;33(10):2079-89. https://doi.org/10.1111/sms.14440. PMid:37403435.

39. Santana CCA, Barros MVG, Medeiros FRC, Rangel Júnior JFLB, Cantieri FP, Alarcon D, et al. Does physical fitness relate to academic achievement in high school students? J Phys Act Health. 2023;20(11):1018-26. https://doi.org/10.1123/jpah.2022-0534. PMid:37536682.

40. Souza GAC, Maia CSC, de Oliveira KA, Marques Braga RA, Soares ES, Verde SMML, et al. Evaluation of the relationship between nutritional status, levels of physical activity and physical strength in adolescents. Clin Nutr ESPEN. 2023;53:182-8. https://doi.org/10.1016/j.clnesp.2022.12.007. PMid:36657912.

41. Bergmann GG, Mello JB, Gaya ACA, Fonseca FS, Silva AF, Ferreira GD, et al. Relative age effect on muscle power in Brazilian youth: a population study. Rev Bras Cineantropom Desempenho Hum. 2024;26(1):1-12. https://doi.org/10.1590/1980-0037.2024v26e98244.

42. Camargo Corrêa R, Marcio da Silva J, Castilho dos Santos G, et al. Associação da aptidão muscular isolada e combinada com fatores de risco cardiovascular em adolescentes brasileiros: um estudo transversal. Rev Bras Prescr Fisiol Exerc. 2024;18(114):187-97.

43. de Lima TR, Silva DAS. Muscle strength indexes and its association with cardiometabolic risk factors in adolescents: an allometric approach. Res Q Exerc Sport. 2024;95(1):289-302. https://doi.org/10.1080/02701367.2023.2197024. PMid:37369134.

44. Dos Santos de Fontes PA, Zaniqueli D, Siqueira JH, Morra EA, Martinho LCAP, Oliosa PR, et al. Role of muscle mass in the association between handgrip strength and blood pressure in children and adolescents. J Hum Hypertens. 2024;38(2):128-33. https://doi.org/10.1038/s41371-023-00863-5. PMid:37770564.

45. Fernandes V, Silva A, Carvalho A, Ribeiro S, Deslandes A. Physical fitness, executive functions, and academic performance in children and youth: a cross-sectional study. Behav Sci. 2024;14(11):1022. https://doi.org/10.3390/bs14111022. PMid:39594323.

46. Ferreira GOC, Ferrari G, Langer RD, Cossio-Bolaños M, Gomez-Campos R, Lázari E, et al. Phase angle and its determinants among adolescents: influence of body composition and physical fitness level. Sci Rep. 2024;14(1):13697. https://doi.org/10.1038/s41598-024-62546-6. PMid:38871752.

47. Leite N, Tadiotto MC, de Moraes FB Jr, de Menezes-Junior FJ, Corazza PRP, da Silva LR, et al. Examining the mediating role of muscle quantity in adolescents: associations with adiposity, cardiorespiratory fitness, muscular fitness, and cardiometabolic risk factors. Sci Rep. 2024;14(1):12030. https://doi.org/10.1038/s41598-024-61805-w. PMid:38797741.

48. Mello JB, Preissler AAB, Schons P, Ojeda-Aravena A, Hurtado J, Paez J, et al. Changes in the relationship between sprint and horizontal jump performance according to sprint levels in children and adolescents. Int J Perform Anal Sport. 2024;24(1):90-103. https://doi.org/10.1080/24748668.2023.2291247.

49. de Lima TR, Silva DAS. Clusters of negative health-related physical fitness indicators and associated factors in adolescents. Rev Bras Cineantropom Desempenho Hum. 2017;19(4):436-49.

50. Canadian Society for Exercise Physiology. The Canadian physical activity, fitness & lifestyle appraisal CSEP's plan for healthy living. Ottawa (ON): Canadian Society for Exercise Physiology; 1997.

51. Silva DAS, Pelegrini A, de Castro JAC, de Lima TR, de Sousa GR, de Lima Silva JMF, et al. Low handgrip strength levels among adolescents in a city in southern Brazil. J Bodyw Mov Ther. 2017;21(4):884-9. https://doi.org/10.1016/j.jbmt.2017.03.004. PMid:29037644.

52. de Lima TR, de Sousa GR, de Castro JAC, Silva DAS. Prevalência de baixos níveis de força muscular e fatores associados em adolescentes de uma cidade do sul do Brasil. Rev Bras Educ Fis Esporte. 2019;33(1):115-26. https://doi.org/10.11606/issn.1981-4690.v33i1p115-126.

53. Gaya AR, Gaya ACA, Pedretti A, Mello JB. Projeto Esporte Brasil, PROESP-Br: manual de medidas, testes e avaliações. Porto Alegre: PROESP-Br; 2021.

54. Lima TR, Martins PC, Alves CAS Jr, Moraes MS, Zanlorenci S, Borges LL, et al. Report Card Brazil: Systematic review of muscle strength assessment in children and adolescents in Brazil. Rev Bras Cineantropom Desempenho Hum. 2021;23:e80292. https://doi.org/10.1590/1980-0037.2021v23e80292.

55. Leite Miranda F, Fernandes CH, Myiamoto Meirelles L, Faloppa F, Ejnisman B, Cohen M. The impact of COVID-19 social isolation on physical activity and sedentary behavior in Brazilian children and adolescents. Rev Bras Ortop. 2025;60(1):s00441800941. PMid:40084289.

56. de Souza Filho AN, Bezerra TA, de Souza AA, de Souza CT, Barros LVP, Tassitano RM, et al. Impact of COVID-19 pandemic on 24-hour movement behaviors among preschoolers from Brazil. Int J Popul Stud. 2024;10(3):91-8. https://doi.org/10.36922/ijps.0975.

57. Molleri N, Gomes SC Jr, Marano D, Zin A. Survey of the adequacy of Brazilian children and adolescents to the 24-hour movement guidelines before and during the COVID-19 pandemic. Int J Environ Res Public Health. 2023;20(9):5737. https://doi.org/10.3390/ijerph20095737. PMid:37174254.

58. Oh K-H, Min J-Y, Seo K, Min K-B. Association of sedentary lifestyle with skeletal muscle strength and mass in US adolescents: results from the National Health and Nutrition Examination Survey (2011-2014). J Prev Med Public Health. 2025;58(3):278-88. https://doi.org/10.3961/jpmph.24.614. PMid:39901754.

59. Edelson LR, Mathias KC, Fulgoni VL 3rd, Karagounis LG. Screen-based sedentary behavior and associations with functional strength in 6–15-year-old children in the United States. BMC Public Health. 2015;16(1):116. https://doi.org/10.1186/s12889-016-2791-9. PMid:26846277.

60. Dong Q, Liu H, Fu Q. Associations between physical fitness and different aspects of screen time in children and adolescents. Sci Rep. 2025;15(1):25607. https://doi.org/10.1038/s41598-025-11625-3. PMid:40664882.

61. Faigenbaum AD, MacDonald JP. Dynapenia: it's not just for grown-ups anymore. Acta Paediatr. 2017;106(5):696-7. https://doi.org/10.1111/apa.13797. PMid:28235140.

62. Brasil. Ministério da Saúde. Secretaria de Atenção Primária à Saúde. Departamento de Promoção da Saúde. Guia de Atividade Física para a População Brasileira [Internet]. Brasília (DF): Ministério da Saúde; 2021 [cited 2025 Oct 11]. Available from: https://www.gov.br/servidor/pt-br/siass/assuntos/noticias/guia-de-atividade-fisica-para-a-populacao-brasileira

SUPPLEMENTARY MATERIAL

Supplementary material accompanies this paper.
Supplementary File 1. Free access in https://osf.io/cs2n6/.
Supplementary File 2. Free access in https://osf.io/cs2n6/.
This material is available as part of the online article from https://doi.org/*10.1590/1980-0037.2026v28e109296*