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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

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Abstract – The present study aimed to identify and summarize evidence regarding muscle strength (MS) levels in school children and adolescents (≤ 19 years) in Brazil in order to update previously published evidence from the Report Card Brazil project. The systematic search for information was conducted in seven databases, restricted to studies published during the period from January 2018 to December 2019. Thirteen studies were included, which gathered information from 10,135 children and adolescents from seven Brazilian states. Different tests/protocols for assessing MS were identified, however, handgrip strength was the test most adopted in studies (53.8%). The prevalence of children and adolescents with MS levels considered healthy was 29.8%, considering the totality of information, and 27.6% for males and 31.8% for females. Considering full data reviewed by the Report Card Brazil project (data analyzed in this study in addition to those previously published), information regarding the assessment of MS levels in children and adolescents in Brazil came from studies conducted during the period from 2010 to 2019, which included a sample of 15,208 children and adolescents (aged 7-19 years). According to this information, the prevalence of children and adolescents with MS levels considered healthy in this period was 57.8%, 61.1% for males and 58.8% for females.

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

Resumo – *O estudo teve como objetivo identificar e sumarizar evidências referentes à avaliação dos níveis de força muscular (FM) em crianças e adolescentes escolares (≤ 19 anos) no Brasil, com o intuito de atualizar as evidências publicadas anteriormente pelo projeto Report Card Brazil. A busca sistemática das informações foi conduzida em sete bases de dados, restrita aos estudos publicados durante o período de Janeiro de 2018 a Dezembro de 2019. Treze estudos foram incluídos, o que reuniu informações de 10.135 crianças e adolescentes de sete estados brasileiros. Diferentes testes/protocolos para avaliar a FM foram identificados, contudo, a força de preensão manual foi o teste mais empregado pelos estudos (53,8%). A prevalência de crianças e adolescentes que apresentavam níveis de FM considerados saudáveis foi de 29,8% considerando a totalidade de informações, e 27,6% para os meninos e 31,8% para as meninas. Considerando a totalidade de dados revisados pelo projeto Report Card Brazil (informações analisadas neste estudo em adição aos anteriormente publicados), o corpo de informações referente a avaliação dos níveis de FM em crianças e adolescentes no Brasil foram advindas de pesquisas conduzidas durante o período de 2010 a 2019, o que reuniu amostra de 15.208 crianças e adolescentes (sete a 19 anos). De acordo com estas informações, a prevalência de crianças e adolescentes que apresentavam níveis de FM considerados saudáveis nesse período foi de 57,8%, sendo que no sexo masculino foi de 61,1% e no sexo feminino de 58,8%.*

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

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INTRODUCTION

Muscle strength, a component of health-related physical fitness, has been considered a global health marker in children and adolescent[1,2]. This attribution is based on evidence described in literature that indicates direct association between muscle strength and physical[3], cognitive, mental[4] and metabolic[2,5] health indicators in children and adolescents.

Although the contribution of muscle strength to improving overall health is unequivocal[1-5], studies have reported declining muscle strength levels in children and adolescents. A study that followed 309 schoolchildren (mean age 10.4 ± 0.3 years at baseline) for ten years in England identified annual decline in muscle strength levels of 0.58% for boys and 0.64% for girls (measured using handgrip strength)[6]. Another study, conducted with 16,199 schoolchildren (aged 11-18 years) in Lithuania, identified reduction in muscle strength levels (measured using horizontal jump) from 1992 to 2012[7].

Muscle strength can be assessed in clinical, epidemiological and sports context using computer-assisted tests, tensiometry or maximum repetitions, which may include the use of body weight or recruitment of external loads[1,2,5]. This is necessary because muscle strength can manifest in many ways (e.g., maximum strength, power, endurance), which makes it difficult to propose a reference method/instrument for assessing muscle strength levels[8] and limits the comparison of results found in literature[1,2,5,9].

Information regarding the prevalence of children and adolescents with muscle strength levels considered healthy and thus less likely of having adverse health events has been described in literature[9-11]. A study conducted with schoolchildren in Colombia estimated that 70.5% of boys, and 88.7% of girls had adequate muscle strength levels (measured using handgrip strength)[10]. Another study carried out with schoolchildren in Canada found that 41.0% of boys and 53.0% of girls had adequate muscle strength levels (measured by handgrip strength)[11]. In Brazil, a systematic review study published by the Report Card Brazil project identified that 65.6% of boys and 58.2% of girls had adequate muscle strength levels in relation to health (information from handgrip strength, medicine-ball throw and horizontal jump measurements)[9].

This study is an update of the systematic review published by Lima et al.[9] on variable muscle strength investigated in the Report Card Brazil project. The updating of scientific evidence enables identifying data obtained from new studies, and thus analyzing how this information differs from previously reported findings, or whether these results corroborate the credibility of existing information[12]. Thus, the aim of this study was to investigate and summarize the literature available during the years 2018 and 2019 regarding the assessment of muscle strength levels of children and adolescents in Brazil.

METHOD

Records

This systematic review is part of the Report Card Brazil: Health indicators for children and adolescents (3rd edition) research project. Information regarding the macro-project protocol was previously available[13]. The structuring and presentation of information contained in this review is in accordance with

recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses – PRISMA[13].

Eligibility criteria

Articles identified in literature were selected for inclusion according to the following criteria: original articles published in scientific journals; those that have described information regarding the test/method used to assess muscle strength levels, including: handgrip strength (isometric strength), tests with isokinetic dynamometers (isokinetic strength), vertical jump, horizontal jump or medicine ball throw (fast/power strength), as well as tests used to assess maximum strength (tests of 1 maximum repetition - bench press or squat); those carried out with the exclusive participation of Brazilian children and adolescents (up to 19 years of age, and/or average age included in this age group), with no special clinical condition, without diagnosis of disease and non-athletes.

Review studies, theses, dissertations and abstracts presented at scientific congresses were not included. Additionally, articles whose aim was to investigate strength resistance (e.g., trunk flexion repetition, elbow flexion repetition or body weight support) were not included in this review, since the assessment of this muscle strength dimension is the purpose of another systematic review of this macro-project.

Information sources

The systematic search of available literature included in this review is an update of study previously published by de Lima et al.[9], which composed the second edition of the Report Card Brazil: Health indicators for children and adolescents project. In that study[9], information available until January 2018 regarding articles that investigated muscle strength in school children and adolescents in Brazil was reviewed. Thus, the present review covered the available literature on muscle strength in Brazilian children and adolescents published during the period from January 2018 to December 2019. Thus, seven databases were searched: 1) Medical Literature Analysis and Retrieval System Online (MEDLINE), through PubMed; 2) Web of Science; 3) Embase; 4) SportDiscus, through the EBSCOhost platform; 5) Latin American and Caribbean Literature in Health Sciences (LILACS), through the virtual health library (VHL); 6) Scopus; 7) Scientific Electronic Library Online (SciELO).

Search strategy, descriptors and keywords

The investigation of possible articles in databases took place during the month of August 2020 through the use of an advanced search tool (searches performed using "keywords") available in databases from the elaboration of sets/blocks of descriptors related to the theme. Descriptors were selected by searching the national platform Health Sciences Descriptors (DeCS)[14] and the American platform Medical Subject Headings (MeSH)[15]. Additionally, descriptors and keywords used in literature review articles, original articles and health documents were also used. Descriptors in Portuguese, English and Spanish were inserted in databases, depending on the procedure required by the search platform.

The first block (outcome) was composed of terms related to muscle strength: "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 block consisted of descriptors related to the population of interest: (children and adolescents): "adolescent", "adolescents", "school-age", "child", "children", "young", "youth", "childhood", "school-children", "teen", "teenager", "school-teenager" and "preschool children". The third and last block was composed of the term referring to the location of interest (Brazil): "Brazil". The "OR" Boolean operator was used in the advanced search (in each database) in order to add at least one word from each block, and the "AND" Boolean operator in order to link word blocks together. Additional information regarding the systematic search strategies used in each database is available in Supplementary File 1.

Selection of studies

The selection of articles was conducted by two researchers (TRL & PCM) independently. Initially, articles that did not meet the inclusion criteria were excluded after reading titles and abstract. The next step consisted of reading the remaining articles in full, which were included in this review as they are in accordance with aims and inclusion criteria. There were no doubts among researchers regarding the inclusion of articles. The lists of references of articles included in this review were read in order to identify possible studies not identified in the systematic search conducted in databases. However, no studies were identified in addition to those previously verified.

The EndNote® X9 bibliographic manager software (Philadelphia, USA) was used for the elaboration of specific libraries that allowed the identification and exclusion of duplicate studies, division and organization of results identified in each database.

Extraction of results

Information inserted in included articles was extracted by two researchers independently. Information analyzed was as follows: name of authors, place where the study was carried out, population investigated (number of subjects and age group), primary aim of the study, number of subjects with information regarding muscle strength and follow-up time (longitudinal studies), test used to assess muscle strength, muscle strength values according to the test used and gender, cutoff points used to classify muscle strength levels identified in the study (when available), statistical tests used and values derived from these analyses. Additionally, information regarding the percentage of children and adolescents classified as with adequate/healthy muscle strength levels was described.

Methodological quality/risk of bias

Evaluation of the methodological quality/risk of bias was carried out by two researchers (CASAJ & SZ) independently. Divergences between evaluators

regarding the evaluation of the methodological quality/risk of bias of studies were discussed and resolved in a consensus meeting and consultation with a third evaluator (TRL).

The National Institutes of Health (NIH)'s Quality Assessment Tool (USA) methodological quality/risk of bias assessment tool for cross-sectional and longitudinal studies (https://www.nhlbi.nih.Gov/health-topics/ study-quality-assessment-tools) was used to assess the methodological quality/risk of bias in each included study. This evaluation tool classifies each study based on 14 criteria related to the research problem, studied population, recruited groups, eligibility criteria, sample size, assessed exposure, time in relation to the expected effect, exposure levels of interest, exposure measures and evaluation, outcome measures, blindness in the evaluation of results, follow-up rate and statistical analysis.

According to this instrument, for each criterion, positive score of +1 was assigned when the answer to that question was positive (yes), while score of zero (0) was assigned when answer other than positive was given (that is, "no", "not applicable", "not reported" or "cannot be determined"). The specific global score of the study, according to this instrument, could vary from zero to 14, and quality score was determined by the following ratio: (number of questions with positive score "+1"/number of questions with score of zero "0")[16]. The instrument questions that could not be answered by the available information and/or were not applicable to the evaluated study and/or aspects that had not been reported were excluded from the calculation to determine the final methodological quality/risk of bias score[16].

RESULTS

The systematic search for studies that investigated muscle strength in Brazilian children and adolescents identified 4,546 articles (after excluding duplicate titles and studies outside the period covered in this review) during the period from January 2018 to December 2019. A total of 110 articles were evaluated by titles and abstract, and, after excluding articles with themes unrelated to the aim of the present study, 21 articles were fully evaluated for eligibility. Of this total, 08 studies were excluded (outside the theme, n = 01; not performed with the Brazilian population, n = 01; did not investigate muscle strength, n = 03; muscle strength investigated through muscle resistance tests, n = 03). The references of included studies were analyzed in order to identify possible information on the theme not verified during the systematic search; however, no additional studies in relation to those previously identified were included. Thus, 13 studies[17-29] were included in this review (Figure 1).

Thirteen studies with cross-sectional design were part of the present review. Of this total, seven studies were carried out in the southern region of Brazil (Santa Catarina, n = 04; Paraná, n = 03)[19,21-24,26,27], two studies in the southeastern region (São Paulo, n = 01; Minas Gerais, n = 01)[18,29], two studies in the northeastern region (Alagoas, n = 01; Piauí, n = 01)[25,28] and one study in the northern region (Amazonas)[17]. Additionally, one study[20] was conducted in states included in the southern and southeastern regions of Brazil (Paraná and São Paulo, respectively). With regard to the age group of participants, 10

studies were conducted with participants aged 10 years or older[17,19-24,26,27,29]. Two studies were carried out with the participation of children and adolescents[18,25], and one study was carried out exclusively with children[28]. The aims of each study are described in Table 1.

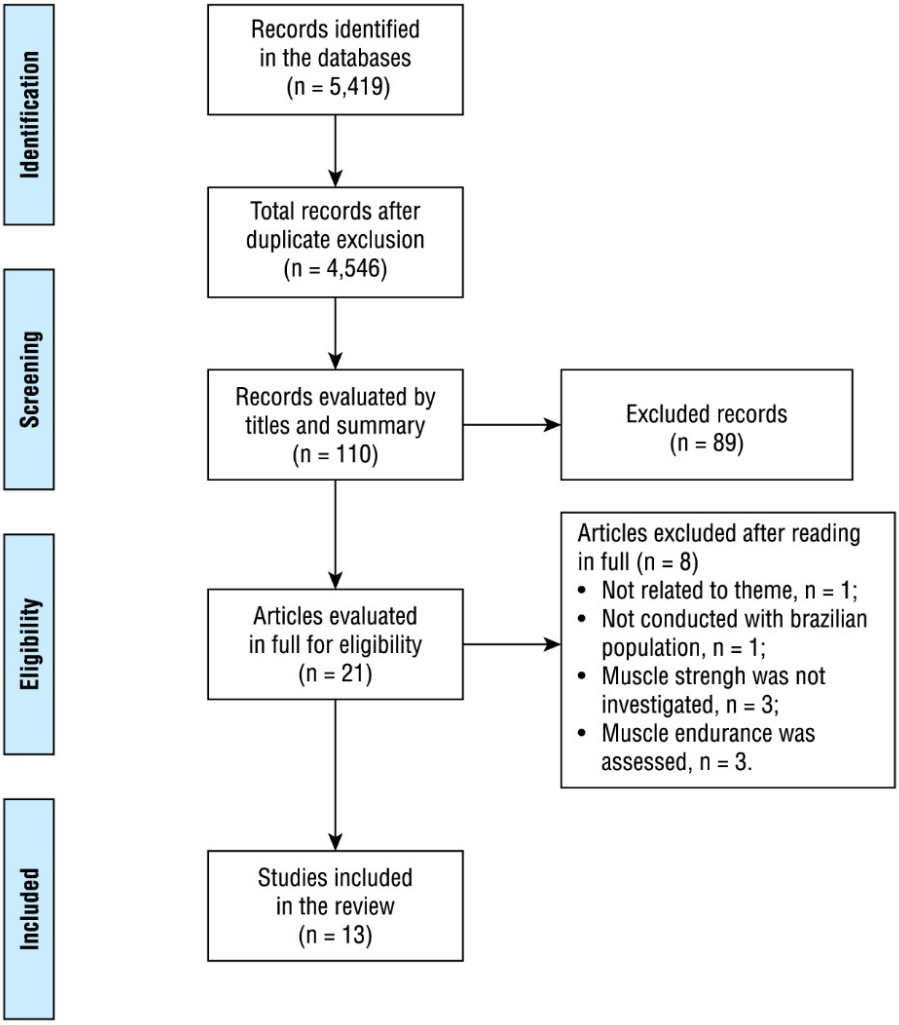

Figure 1. Flowchart of the search for articles and criteria used in the selection of studies that investigated muscle strength in children and adolescents in Brazil during the years 2018-2019.

With regard to the evaluation of the methodological quality/risk of bias of studies covered in this review, considering the type (epidemiological) and design (cross-sectional) of studies included in this review, questions regarding the evaluation of repeated information, blindness of evaluators regarding results and the follow-up rate of individuals included in studies were not evaluated. Among information evaluated, questions regarding assessing the exposure before measuring the result, and the time required to verify the effect of this exposure on the outcome were the questions with the highest number of results with score "0". Thus, the score regarding the methodological quality/risk of bias of studies included in this review ranged from 0.54 to 0.82 (Table 2).

Table 1. Description of the characteristics of the selected studies (n = 13).

Author	Study location	Age group	Number of appraised (% females)	Objective of the study
Lima et al.[20]	Southwest São Paulo (São Paulo State - Brazil) and Norte Pioneiro (Parana State - Brazil)	12-15 years	387 (56.8)	To investigate the relationship between health-related physical fitness indicators and adolescent motor performance and health.
Lima et al.[26]	São José (Santa Catarina State - Brazil)	14-19 years	923 (54.2)	To estimate the prevalence of low levels of handgrip strength in adolescents and to verify associated sociodemographic factors, lifestyle and body weight status.
Lima et al.[24]	São José (Santa Catarina State - Brazil)	14-19 years	909 (53.4)	Identify the sociodemographic, physical activity and physical fitness factors associated with flexibility.
Claumann et al.[23]	São José (Santa Catarina State - Brazil)	15-19 years	1,058 (46.1)	To estimate the prevalence of dissatisfaction with body image and to verify the association between dissatisfaction with thinness and excess weight and components of health-related physical fitness in adolescents.
Daloia et al.[18]	Ribeirão Preto (São Paulo State - Brazil)	5-15 years	110 (50.0)	Evaluate the development of isometric muscle strength muscle groups of upper and lower limbs.
Lopes et al.[27]	Lago de Itaipu (Parana State - Brazil)	10-17 years	3,849 (52.6)	Evaluate the association between body mass index and health-related physical fitness indicators.
Moraes et al.[25]	Teresina (Piauí State - Brazil)	3-17 years	300 (not described)	Determine the reliability and validity of the criteria and constructs of the International Fitness Scale (IFIS), version in Portuguese, in a Brazilian pediatric population.
Morais et al.[19]	Curitiba (Parana State - Brazil)	13-17 years	39 (0.0)	Compare absolute and relative muscle strength with body mass, fat-free mass and localized fat-free mass of upper and lower limbs among obese and non-obese adolescents.
Miranda et al.[29],	Juiz de Fora (Minas Gerais State -Brazil)	11-17 years	1,490 (44.3)	Evaluate anthropometric, psychomotor and maturational characteristics, investigate the proportion of motor talents, analyze the relationship between diagnosis of motor talent and maturation stage, and compare the profile of student-athletes and non-athlete students.
Santos et al.[22]	São José (Santa Catarina State - Brazil)	14-19 years	695 (51.5)	To investigate the association between components of health-related physical fitness (aerobic fitness, muscle strength, flexibility and body composition) with resting heart rate in Brazilian adolescents.
Rodrigues et al.[21]	São José dos Pinhais (Paraná State - Brasil)	15-17,9 years	204 (42.2)	To verify the association between the level of physical activity and the frequency of structured physical activity with components of health-related physical fitness in adolescents.
Luz et al.[28]	Not described (Alagoas State - Brazil)	8 years	71 (0.0)	To analyze the effect of the level of motor coordination on performance in several tests of physical fitness of prepubescent boys, before and after controlling the effect exerted by body mass.
Silva Reis et al.[17]	Manaus (Amazonas State -Brazil)	11-14 years	100 (31.0)	Assess the levels of physical fitness related to health and motor performance.

Handgrip strength was used to measure muscle strength in seven studies[22-26,28,29]. Another five studies[17,20,25,27,28] assessed muscle strength using horizontal jump, whereas in four studies[17,20,28,29], muscle strength was assessed using medicine-ball throw. In addition, shoulder adduction isometric strength, elbow flexion isometric strength, elbow extension isometric strength, knee extension isometric strength, knee flexion isometric strength, plantar flexion strength and isometric dorsiflexion strength were used to assess muscle strength in one study[18]. Finally, maximum repetition tests in bench press, one maximum repetition in the performance of arm curl and one maximum repetition in the leg press were used to measure muscle strength levels in one study[19]. Vertical jump test with arm thrust and the lower limb power test on the vertical jump platform were

adopted in one study[21]. Further details regarding cutoff points used in studies to classify muscle strength values, quantitative results of evaluations and statistical tests adopted in the investigation of relationships tested were described in Supplementary File 2.

Table 2. Evaluation of the methodological quality/risk of bias in the inserted studies.

Author (s)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Score*
Claumann et al.[23]	1	1	1	1	1	0	0	1	1	NA	1	NA	NA	1	0.81
Silva Reis et al.[17]	1	0	NR	1	0	0	0	1	1	NA	1	NA	NA	1	0.60
Daloia et al.[18]	1	1	1	1	0	0	0	1	1	NA	1	NA	NA	1	0.71
Moraes et al.[19]	1	0	NR	1	0	0	0	1	1	NA	1	NA	NA	1	0.60
Moraes et al.[25]	1	1	1	1	0	0	0	1	1	NA	1	NA	NA	1	0.72
Lima et al.[20]	1	1	1	1	1	0	0	1	1	NA	1	NA	NA	0	0.72
Lima et al.[26]	1	1	1	1	1	0	0	1	1	NA	1	NA	NA	1	0.81
Lima et al.[24]	1	1	1	1	1	0	0	1	1	NA	1	NA	NA	1	0.81
Lopes et al.[27]	1	1	1	1	1	0	0	1	1	NA	1	NA	NA	1	0.82
Luz et al.[28]	1	0	1	1	0	0	0	1	1	NA	1	NA	NA	0	0.54
Miranda et al.[29]	1	1	1	1	0	0	0	1	1	NA	1	NA	NA	1	0.73
Rodrigues et al.[21]	1	1	NR	1	0	0	0	1	1	NA	1	NA	NA	1	0.77
Santos et al.[22]	1	1	1	1	1	0	0	1	1	NA	1	NA	NA	1	0.82

Note. NR: Not reported; NA: Not applicable; 0: No; 1: Yes; * to determine the total score, the following equation was considered: (total positive answers/total questions considered for that study).

Table 3 presents data from the three studies that classified muscle strength as adequate or inadequate using a battery of physical assessments[20,23,26]. In all, 2,180 students were investigated, 29.8% of them had adequate muscle strength levels. Considering gender, 27.6% of boys and 31.8% of girls were classified as having adequate muscular strength levels.

Table 3 also presents information referring to previous systematic review conducted by de Lima et al.[9] and information from this systematic review. Results indicated that in Brazil, studies on the prevalence of children and adolescents in Brazil that met health criteria for muscle strength were published from 2010 to 2019 and resulted in a total sample of 15,208 participants aged 7-19 years. The prevalence of children and adolescents in Brazil who met health criteria for muscle strength in this period was 57.8%, with 61.1% for boys and 58.8% for girls.

DISCUSSION

The present systematic review found that 27.6% of boys and 31.8% of girls had adequate muscle strength levels (29.8% when grouped). When grouping data from the present review with data from previous systematic review carried out by Lima et al.[9] for the same macro-project, it is observed that the prevalence of children and adolescents who meet adequate muscle strength criterion is 57.8%, 61.1% for boys and 58.8% for girls. It is hypothesized that the reduction in the prevalence of Brazilian schoolchildren with adequate muscle strength levels in 2018-2019 compared to 2010-2017 (reduction of 52.3% when grouped; reduction of 58.1% for boys; reduction of 45.4% for girls) may be related to greater engagement in sedentary behaviors (e.g., screen time) and non-compliance with physical activity recommendations for this age group[11]. However, as the investigated period of studies in this review (two years of publication) is short, it is important to continue monitoring the population for more precise inferences

about these findings. Although muscle strength is relevant to the physical and metabolic health of children and adolescents[2,5], the analysis of results obtained is difficult to interpret, given the absence of reference cutoff points to detect adequate or inadequate muscle strength levels[8]. In studies included in this systematic review, the classification of values obtained by the test used to assess muscle strength (handgrip strength) in studies conducted by Claumann et al.[23] and de Lima et al.[26], cutoffs having the Canadian population as a reference were used[30]. Conversely, in the study conducted by Lima et al.[20], the values identified were classified based on the Brazilian population[31]. However, although both criteria were developed based on areas beneficial for health, both cutoff points were elaborated based on normative values (Canadian or Brazilian population), which may limit the validity of the classification of values according to such criteria. Results similar to these had already been observed by de Lima et al.[9], which indicate that although such limitations regarding the absence of cutoff points based on health criteria had already been recognized and available to researchers in Brazil, no advances were identified in Brazil during the years 2019 and 2019 in this topic.

Table 3. Characteristics of the studies in the present review that classified the results according to muscle strength levels and the summary of the previous systematic review published by de Lima et al.[9].

Author	Study location	Sample	Age group (years)	Test used to measure/ assess muscle strength	Percentage of individuals classified as having adequate/ healthy strength levels	Reference adopted for the classification of the identified values
Current review study						
Claumann et al.[23]	São José, Santa Catarina State	870 (412 men; 458 women)	15-19	Handgrip strength	19.1% (not stratified); 15.3% men (n = 63); 22.5% women (n = 103)	Canadian Society of Exercise and Physiology[30]
Lima et al.[26]	São José, Santa Catarina State	923 (436 men; 487 women)	14-19	Handgrip strength	33.7% men (n = 149); 40.3% women (n = 200)	Canadian Society of Exercise and Physiology[30]
Lima et al.[20]*	São Paulo State and Santa Catarina State	387 (167 men; 220 women)	12-15	Medicine-ball throw; Horizontal jump	40.7% men (n =68); 30.4% women (n = 67); 42.5% men (n =71); 25.0% women (n = 55);	Project Sport Brazil[31]
Total current systematic review†	South and Southeast of Brazil	2,180 (1,015 men; 1,165 women)	12-19	Handgrip strength; Medicine-ball throw; Horizontal jump	29.8% (not stratified, n = 650); 27.6% men (n = 280); 31.8% women (n = 370)	Canadian Society of Exercise and Physiology[30]; Project Sport Brazil[31]
Total previous systematic review[9]	All geographic regions with at least one locality	13,028 (7,179 men, 5,849 women)	7-19	Medicine-ball throw; Handgrip strength	62.5% (not stratified by sex, n = 8,137); 65.9% men (n = 4,729); 58.2% women (n = 3,408)	Project Sport Brazil[31]; Canadian Society of Exercise and Physiology[30]
Updated information‡	All geographic regions with at least one locality	15,208 (8,194 men; 7,014 women)	7-19	Handgrip strength; Medicine-ball throw; Horizontal jump	57.8% (not stratified by sex, n = 8,787); 61.1% men (n = 5,009) 58.8% women (n = 3,778)	

Note. *For TOTAL, the values of the medicine ball throw test of the study de Lima et al. 2018 were considered; †To calculate the percentage of subjects with adequate muscle strength, the following equation was considered: (number of subjects classified as having adequate muscle strength/number of subjects from all studies considered) X 100; ‡information from the previous systematic review published by Lima et al.[9] and this systematic review.

Greater number of studies with the aim of investigating muscle strength in children and adolescents were carried out in the southern region of Brazil. The scenario referring to scientific production not only in relation to muscle strength,

but to other physical fitness indicators also related to the health of children and adolescents (e.g., aerobic fitness) has been based on studies conducted in the southern and southeastern regions of Brazil[9,32]. This condition, in addition to limiting the identification of the specific characteristics of children and adolescents from other Brazilian regions, may reflect the lack of recognition of specific subgroups that should be more privileged in terms of strategies aimed at improving muscle strength.

Although the study conducted by Luz et al.[28] was the first study in Brazil[9] that this project found from the methodology used with the aim of investigating muscle strength in a sample exclusively composed of children, further information from studies carried out with a sample of this age group is still needed. Based on these findings, it is hypothesized that common concerns regarding the submission of children to the performance of maximum strength efforts, such as the potential risk of injury to epiphyseal plaques or cartilage, may discourage researchers from adopting this test modality[33]. This assumption is based on a review study that compiled information from surveys that assessed strength resistance in Brazilian schoolchildren[34], in which approximately 20.0% of information analyzed came from studies conducted exclusively with children (≤ 10 years of age).

With regard to the methodological quality/risk of bias identified in this review, scores ranging from 0.54 to 0.82 according to the analysis tool from cross-sectional studies suggested by NIH[16] were attributed to studies analyzed. It is necessary to emphasize that although the tool used was exclusively developed for use in cross-sectional studies, limitations may have contributed to the reduction of scores attributed to studies. Some items included by the tool and usually not evaluated in studies with design/theme included in this review, such as assessing the exposure before measuring the result, and the time required to verify the effect of this exposure on the outcome, questions in all articles inserted in this review obtained minimum score, contributing to the reduction of scores attributed to included studies. In addition, considering that the period comprised by childhood and adolescence causes numerous changes that directly impact muscle strength (e.g., sexual maturation, behavioral aspects)[35-37], the longitudinal monitoring of this population subgroup is justified, although the totality of evidence included in this review was exclusively derived from studies with cross-sectional design.

Some limitations of this research must be recognized: 1) many studies identified in the national literature and included in this review were not primarily aimed at investigating the relationship between muscle strength and different outcomes; 2) although the systematic search for information regarding muscle strength has been conducted in a large number of databases, it is possible that relevant content in relation to this topic may not have been included (e.g., articles accepted for publication but not published); 3) failure to investigate all muscle strength manifestations such as strength resistance.

CONCLUSION

As described in a previous review[9], the proportion of studies aimed at investigating themes related to muscle strength in children and adolescents in Brazil came from specific regions of the country, which reinforces the need for studies in different regions (e.g., northern, northeastern and mid-western regions), which would contribute to greater validity of information regarding

this theme. The small amount of evidence from surveys exclusively conducted with a population of children (only one study since the beginning of the historical series - 2010) makes evident the need for greater number of studies that investigate muscle strength in this population subgroup. In addition, considering the reduction in the prevalence of school children and adolescents who met health criteria in relation to adequate muscle strength levels in Brazil during the years 2018 and 2019 (compared to the period from 2010 to 2017), strategies aimed not only at monitoring health indicators, but also at reducing sedentary activities and encouraging physical activity, with emphasis on those that include counter-resistance efforts, are necessary. Considering the totality of data reviewed by the Report Card Brazil project (information analyzed in this study in addition to those previously published), the prevalence of children and adolescents with muscle strength levels considered healthy was 57.8%, 61.1% for boys and 58.8% for girls.

COMPLIANCE WITH ETHICAL STANDARDS

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Ethical approval

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

Conflict of interest statement

The authors have no conflict of interests to declare.

Author Contributions

Conception and design of the experiment: DASS. Experiments carried out: TRL, PCM. Data analysis: TRL, PCM, DASS. Contribution with reagents/research materials/analysis tools: TRL, PCM, CASAJ, MSM, SZ, LLB, JACC, DASS. Article writing: TRL, PCM, CASAJ, MSM, SZ, LLB, JACC, DASS. All authors read and approved.

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SUPPLEMENTARY MATERIAL

Supplementary material accompanies this paper.

Supplementary File 1: Free access in https://osf.io/fvws2/

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