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Diversity of parameters in the muscle strength evaluation of Brazilian school children and adolescents: a systematic review

Diversidade de parâmetros na avaliação da força muscular de crianças e adolescentes escolares brasileiros: revisão sistemática

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Abstract - Muscle strength (MS) is considered important indicative of global health regardless of age or clinical condition. The aim of this study was to summarize evidence from research carried out in Brazil that investigated MS in school children and adolescents, showing the objectives, tests, protocols and quantitative of youngsters who met the health criteria for MS. Systematic review conducted in the PubMed, Web of Science, Scopus, Sportdiscus, LILACS and Scielo databases, with complementary searches in reference lists. In all articles, the risk of bias was analyzed. Of the 15,609 articles initially identified, 27 were included, comprising data from 29,604 children and adolescents. The 27 studies included presented moderate (37%) and low risk of bias (63%). Three out of four studies investigating MS in children and adolescents were carried out in southern and southeastern Brazil (77.7%). It was found that 65.9% of boys and 58.2% of girls had adequate levels of MS for health, with results varying from 14.8% to 66.0% in girls and from 20.4% to 76.9% in boys. Several MS measurement protocols were identified; however, horizontal jump was the most used test to evaluate MS (59.2%). MS is a physical valence searched in children and adolescents and a variety of protocols are used. In addition, it is necessary to propose MS cutoff points based on health criteria for the accurate estimation of this physical valence in children and adolescents in Brazil.

Key words: Epidemiology; Muscle strength; Protocols; Public health.

Resumo – *A força muscular (FM) é considerada importante indicativo de saúde global independentemente da idade ou condição clínica. Objetivou-se sumarizar as evidências originárias de pesquisas realizadas no Brasil que investigaram FM em crianças e adolescentes escolares, evidenciando os objetivos, testes, protocolos e o quantitativo de jovens que atenderam os critérios de saúde para FM. Revisão sistemática conduzida nas bases de dados PubMed, Web of Science, Scopus, Sportdiscus, LILACS e Scielo, com buscas complementares em listas de referência. Em todos os artigos, o risco de viés foi analisado. Dos 15.609 artigos inicialmente identificados, 27 foram incluídos, compreendendo dados de 29.604 crianças e adolescentes. Os 27 estudos inclusos apresentaram moderado (37%) e baixo risco de viés (63%). Três a cada quatro estudos que investigaram FM em crianças e adolescentes foram provenientes de estados da região sul e sudeste do Brasil (77,7%). Foi encontrado que 65,9% de meninos e 58,2% de meninas apresentavam níveis adequados de FM para saúde, com resultados variando de 14,8% a 66,0% nas meninas e de 20,4% a 76,9% nos meninos. Diversos protocolos para mensurar FM foram identificados, contudo, o salto horizontal foi o teste mais empregado para avaliar a FM (59,2%). A FM é uma valência física pesquisada em crianças e adolescentes e uma variedade de protocolos são utilizados. Ainda, se faz necessário a proposição de pontos de corte para FM baseados em critérios de saúde para a acurada estimativa dessa valência física em crianças e adolescentes do Brasil.*

Palavras-chave: *Epidemiologia; Força muscular; Protocolos; Saúde pública.*

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INTRODUCTION

Muscle strength (MS) is one of the most important physical valences, since it is an indispensable element in the accomplishment of any type of movement, from the most simple to the most complex, being fundamental to the performance of daily activities, either recreational, domestic or physical performance, considered important indicative of global health regardless of age or clinical condition[1]. In the pediatric population, MS is essential for the improvement of motor skills[2], and the development of this physical valence is directly related to maturational progression, with higher values for boys compared to girls in all age groups[3].

Studies with children and adolescents have shown a relationship between MS levels and health prognoses[4,5]. Research conducted with male adolescents in Sweden has found that higher MS levels in adolescence were directly associated with lower risk of premature death from cardiovascular disease in adulthood[4]. Another study conducted with 669 Colombian schoolchildren found that low MS levels were directly associated with higher blood pressure (diastolic and systolic) values, higher HOMA index, and elevated triglyceride and C-reactive protein concentrations[5].

The evaluation/use of MS is necessary because this physical valence is basic to all the others, is a way to prevent specific damages, is necessary to good appearance, and is one of the elements of physical fitness related to health and performance[1]. However, since there are several types of strength (isometric, isotonic and isokinetic), there are several ways of measuring them[1]. This variety of protocols results in difficulty in comparing results between studies and there is need to compile what has been researched on this topic[6].

Although several studies conducted in Brazil have investigated the relationship between MS in children and adolescents and related aspects[7-9], information regarding the objectives addressed, quality of identified results, regional distribution of researches, tests used, classification adopted for the classification of MS levels and discussion of results were not compiled in systematic reviews or official documents intended for sports, health and physical education professionals, so that they can direct professional actions. In this sense, the systematic gathering of information is justified by objectively presenting results of research investigating MS in children and adolescents in Brazil.

The aim of this study was to verify, through a systematic review, the diversity of parameters for MS evaluation in the fulfillment of health criteria of school children and adolescents in Brazil.

METHODOLOGICAL PROCEDURES

Search strategy

The systematic review was performed from December 2017 to January 2018 in the following databases: 1) Medical Literature Analysis and Retrieval System Online (MEDLINE), through PubMed; 2) Web of Knowledge

(WEB of Science); 3) Scopus; 4) Sportdiscus, through the EBSCOhost platform; 5) Latin American and Caribbean Literature in Health Sciences (LILACS); 6) Scientific Electronic Library Online (Scielo).

The investigation of possible articles in databases was carried out using the advanced search tool (searches carried out using "keywords") available in databases based on the construction of blocks of descriptors made by the author. Descriptors were inserted in Portuguese, English and Spanish. The first block (outcome) was composed of MS terms: "muscle strength"; "muscular fitness"; "musculoskeletal fitness"; "resistance training"; "weight training"; "muscle endurance"; "muscle power"; "lower limb strength"; "upper limb strength"; "isometric strength"; "dynamic force"; "force resistance"; "isotonic contraction"; "isometric contraction". The second block was composed of terms related to the target population (children and adolescents): "young adult"; adolescents; young; adolescence; youth; adolescent; children; child; "Pre-school children." The Boolean "OR" operator was used to add in the advanced search at least one word from each block and the "AND" operator to relate the blocks of "keywords" to each other. Further information in relation to the search of studies and descriptors used can be verified in Appendix A.

The risk of bias/methodological quality assessment of studies was independently performed by three reviewers/authors (TRL, PCM, MSM). The instrument used to assess risk of bias/methodological quality was the National Heart, Lung and Blood Institute (NHLBI)[10] questionnaire for cohort and cross-sectional studies covering 14 criteria to determine the risk of bias/methodological quality of studies. This instrument evaluates the internal validity of studies and includes questions that help in the identification of possible risk of selection bias, information bias, measurement bias and confounders[10]. For each criterion evaluated, scores from 0 "no" and 1 "yes" were assigned, and at the end of the study classification, a total score was assigned to each study based on the number of positive responses to the questionnaire in relation to the total number of questions. Questionnaire questions that could not be answered by the available information and/or which were not applicable to the assessed study and/or aspects that had not been reported were excluded from the calculation to determine the final methodological quality score/risk of bias[10].

According to the subjective evaluation of the reviewers / authors, studies were classified as having good methodological quality/low risk of bias (final score ≥ 0.70), moderate methodological quality/moderate risk of bias (final score ≥ 0.50), low methodological quality / high risk of bias (final score <0.50)[11]. Three reviewers/authors (TRL, PCM, MSM) applied the methodological quality/risk of bias assessment tool for all studies that met the inclusion criteria. The reviewers/authors' non-agreement regarding the evaluation of a particular study was resolved through a consensus meeting.

The EndNote® X7 bibliographic manager software was used to create specific libraries, which allowed the identification and exclusion of duplicate studies, division and organization of results of each database.

Eligibility criteria

Articles were included according to the following criteria: original articles published in journals (review studies, theses, dissertations, abstracts of scientific meetings were excluded); to have measured MS and described in the body of the article, the test/method used to evaluate MS levels, among them: handgrip strength (HGS, isometric force), tests with isokinetic dynamometer (isokinetic force), horizontal jump (HJ, muscle power/explosive strength), vertical jump (VJ, muscle power/explosive strength), maximum repetition test (1MR) or medicine ball throw (TMB, muscle power / explosive strength); with a population of Brazilian children and adolescents aged 0-19 years (and/or mean age included in this interval), without specific clinical conditions, without diagnosis of any disease, non-athletes and of both sexes.

Articles that evaluated MS by means of localized muscle strength tests, such as the repetition tests of trunk flexion (abdominal exercises), repetition tests of elbow flexion (support), repetition tests of lumbar resistance and pull-up in the bar were not include in this review.

Article selection process

The article selection process was performed by two independent reviewers (TRL and MSM). Firstly, articles applying the inclusion criteria by reading titles and abstracts were excluded. Then, the full texts of the selected articles were read in full to determine which studies that met the inclusion criteria would be selected. In case of doubts among researchers regarding the inclusion of articles, a third researcher was consulted (DASS). After selecting the articles that would be included in the review, the studies described in the references of these selected articles were read with the objective of identifying some possible study not identified in the systematic search in databases.

RESULTS

The systematic search for articles that investigated MS in Brazilian children and adolescents identified 15,609 studies. After evaluating the total of studies by title and abstract, 95 articles had texts analyzed in full. When considering losses (n = 68), a total of 33 studies were excluded because the test used did not investigate MS as defined for the present study: [repetition test of trunk flexion (n = 28)], repetition test of elbow flexion "support" (n = 06), pull-up in bar (n = 04), lumbar resistance (n = 02), evaluation of the combination of resistance tests and MS simultaneously (n = 01)]. The other losses were related to the age group of participants (n = 02), to the study topic (n = 21), to the special groups evaluated (n = 04), the nationality of the investigated population (n = 06), and duplicate studies (n = 02). Twenty-seven original articles were included for this review (Figure 1).

Regarding the location of these studies, it was identified that the Southern and Southeastern regions of Brazil were those that most published articles on MS in children and adolescents, with 18 studies[7-9,12-27].

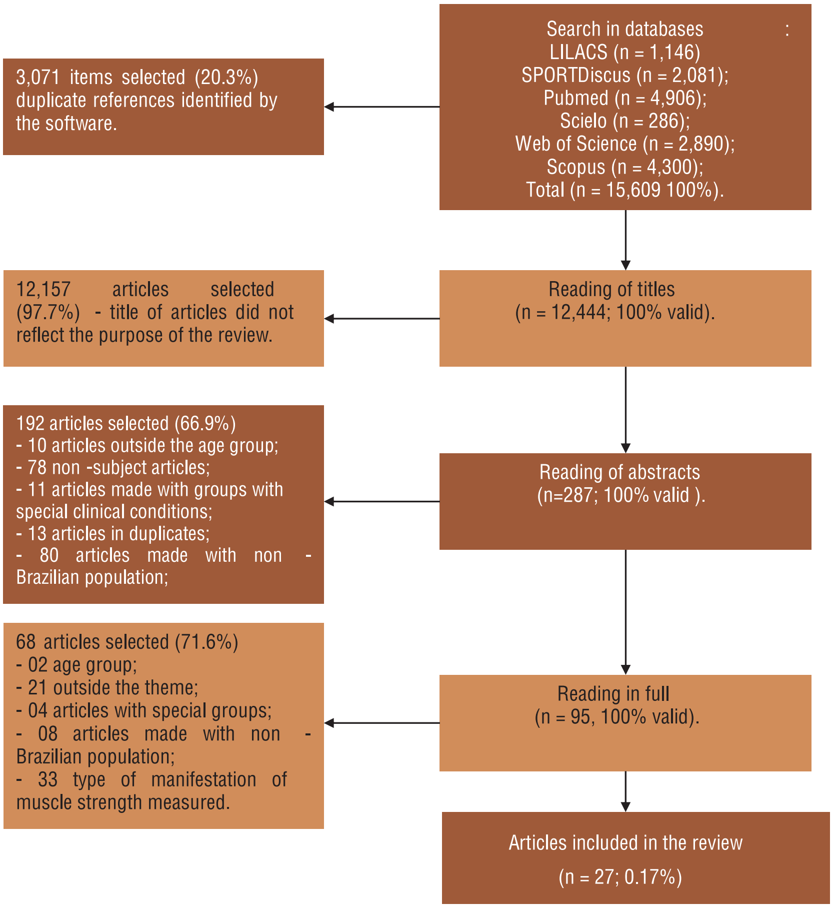

Figure 1. Results of data searches and criteria used in the selection of studies that sought to investigate MS correlates in children and adolescents in Brazil.

Regarding the design of included studies, 22 had cross-sectional[3,7-9,14-21,23-25,27-35] and five longitudinal design[12,13,22,26,36] (Table 1). The studies covered different primary goals as can be observed in Table 1; however, all of them performed MS measurements as defined in the present study.

Table 1: Descriptive characteristics of included studies.

Reference	Place of study	Population (age group)	Sex (%W)	Primary objective of the study
Evidence of longitudinal studies (n = 5)				
Britto et al.,[12]	Ilhabela, SP	44 school children (9.5 to 14.7 ± 1.87)	100	To investigate the stability of PF from childhood to adolescence
Conte et al.,[13]	Sorocaba, SP	56 school children (10-17 years old)	62.5	Influence of body mass on PF in adolescents
Biássio et al.,[26]	Ilhabela, SP	62 girls (8-18 years old)	NA	Impact of menarche on PF anthropometric and neuromotor variables
Da Silva et al.,[36]	Cariri, CE	294 girls (8-14 years)	NA	To investigate the stability of PF from childhood to adolescence
Ferrari et al.,[22]	Ilhabela, SP	1,291 students (10-11 years)	NA	To analyze and compare the changes in PF according to nutritional status and sex in schoolchildren in a period of 30 years.
Evidence from cross-sectional studies (n = 22)				
Schneider el al.,[14]	Porto Alegre, RS	57 students (7-15 years)	49.1	To compare isometric and isokinetic MS in boys and girls.

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Reference	Place of study	Population (age group)	Sex (%W)	Primary objective of the study
Ulbrich et al.,[15]	Curitiba, PR	275 school children (6-16 years old)	71.2	Compare PF according to stages of sexual maturation.
Linhares et al.,[32]	Juiz de Fora, MG	136 school children (10-14 years)	100	To describe how body composition, somatotype, basic physical qualities, dermatoglyphs and bone age behave in the various stages of sexual maturation.
Luguetti et al.,[16]	São Paulo, SP	3,145 school children (7-16 years old)	50.5	Measure PF indicators in children and adolescents, according to chronological age and gender, and classify their performance through normative tables of the PROESP-BR.
Silva and Cabral de Oliveira,[3]	São Cristóvão, SE	128 girls (11-14 years)	NA	Impact of sexual maturation on upper and lower limb strength in adolescents
Ferreira et al.,[17]	São Paulo	199 school children (6-19 years)	40.7	Determine and compare HGS values and pinch.
Arruda et al.,[19]	Londrina, PR	10 students (10.2 ± 2.2)	100	To analyze the relationship between 1MR tests with body composition, anthropometric variables, neuromotor tests and biological maturation.
Santos et al.,[33]	Vitória de Santo Antão, PE	356 school children (7-10 years)	55.0	To identify the influence of low birth weight on PF.
Lopes et al.,[7]	Maringá, PR	36 girls (13-17 years old)	NA	To compare LLS and ULS among obese and non-obese adolescents and to verify the association of MS with anthropometric variables and body composition.
Minatto et al.,[27]	Cascavel, PR	1,531 school children (6-17 years)	100	To estimate the prevalence of high adiposity and its association with musculoskeletal fitness, by economic level, in male children and adolescents.
Freitas et al.,[35]	Montes Claros, MG	2,040 girls (8-15.9 years)	NA	To identify the relationship between biological maturation, body morphology and physical performance.
Matsudo et al.,[20]	Ilhabela, SP	233 school children (10-17 years old)	54.9	To examine the association between FPM and PF in children and adolescents of different stages of sexual maturation.
De Farias et al.,[21]	Jacarezinho, PR	21 students (12-16 years)	57.1	Correlating MS with anthropometric indicators, maturational stage, neuromotor tests in adolescents.
Barbosa et al.,[28]	Muzambinho, MG	122 school children (9.9 ± 1.3)	53.2	To investigate the association between PA and PF indicators with clusters of metabolic risk factors.
Mello et al.,[30]	13 Brazilian states and FD	8,750 school children (7-17 years old)	ND	To outline the PF profile related to the sports performance of Brazilian children and adolescents.
Brandão et al.,[29]	Cuiabá, MT	414 school children (15-17 years)	55.3	Create index for PF tests based on the parameters of PROESP-BR.
Pires et al.,[23]	Santa Cruz do Sul, RS	751 school children (7-17 years old)	41.5	To test association between school dislocation and PF related to motor performance in schoolchildren.
Nunes et al.,[24]	São José, SC	1,117 school children (14-19 years old)	ND	To identify the relationship between PF with changes in blood pressure (systolic and diastolic).
Lima and Silva,[8]	São José, SC	866 school children (14-19 years)	46.8	To identify the relationship between clusters of PF indicators and sociodemographic and lifestyle factors.
Hobolt et al.,[31]	Lago de Itaipu, RJ	5,962 school children (6-17.9 years)	49.2	Develop standards to classify PF
Silva and Martins[25]	São José, SC	922 school children (14-19 years)	47.1	To investigate the impact of physical growth, body fat and lifestyle on cardiorespiratory fitness and MS in pubertal and pubescent adolescents.
Silva et al.,[9]	Florianópolis, SC	636 school children (14-19 years)	36.1	To estimate the prevalence of low levels of HGS and related sociodemographic and lifestyle factors.

W: Womem; Mean; ±: standard deviation; ND: not described; MA: Mato Grosso; FD: Federal District; MG: Minas Gerais; CE: Ceará; RJ: Rio de Janeiro; PR: Paraná, SP: São Paulo; RS: Rio Grande do Sul; SC: Santa Catarina; SE: Sergipe; MS: muscle strength; HGS: Handgrip strength; 1MR: maximum repetition; BC: body composition; PA: physical activity; PF: physical fitness; NA: not applicable; ULS: upper limb strength; LLS: lower limb strength; PROESP-BR: Project Sports Brazil - Brazil;

No study was classified with low methodological quality / high risk of bias. Moderate methodological quality/moderate risk of bias was verified in ten studies (37.0%)[7,12,13,15,19,21,23,26,28,29], while seventeen studies

(67.0%)[3,8,9,14,16,17,20,22,24,25,27,30-33,35,36] were classified with high methodological quality / low risk of bias (Table 2).

Table 2. Bias risk assessment of included studies.

Author	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Final score*	Ranking
Britto et al.,[12]	1	1	0	1	0	1	1	ND	1	1	ND	0	ND	0	0.63	Moderate risk of bias
Conte et al.,[13]	1	1	ND	0	0	1	ND	ND	1	1	1	0	NR	0	0.60	Moderate risk of bias
Schneider et al.,[14]	1	1	0	1	0	ND	ND	1	1	1	1	0	ND	1	0.72	Low risk of bias
Biassio et al.,[26]	1	1	0	1	1	1	1	ND	1	1	1	0	0	0	0.69	Moderate risk of bias
Ulbrich et al.,[15]	1	1	NR	0	0	ND	ND	ND	1	1	1	0	ND	ND	0.62	Moderate risk of bias
Linhares et al.,[32]	1	1	ND	1	ND	ND	1	ND	1	0	1	0	ND	0	0.70	Low risk of bias
Luguetti et al.,[16]	1	1	NR	1	1	ND	ND	1	1	0	1	0	ND	0	0.70	Low risk of bias
Silva and Cabral de Oliveira,[3]	1	1	1	1	1	ND	ND	ND	1	ND	1	0	ND	0	0.77	Low risk of bias
Arruda et al.,[19]	1	0	ND	1	0	ND	ND	ND	1	ND	1	0	ND	0	0.50	Moderate risk of bias
Ferreira et al.,[17]	1	1	0	1	1	0	0	1	1	NA	1	NA	NA	1	0.73	Low risk of bias
Da Silva et al.,[36]	1	1	1	1	1	1	1	NA	1	1	1	0	NR	0	0.83	Low risk of bias
Lopes et al.,[7]	1	1	0	1	0	0	0	1	1	NA	1	NA	NA	1	0.64	Moderate risk of bias
Santos et al.,[33]	1	1	1	1	1	0	0	1	1	NA	1	NA	NA	1	0.82	Low risk of bias
Freitas et al.,[35]	1	1	NR	1	0	0	0	1	1	NA	1	NA	NA	1	0.70	Low risk of bias
Matsudo et al.,[20]	1	1	NR	1	1	0	0	1	1	NA	1	NA	NA	1	0.80	Low risk of bias
Minatto et al.,[27]	1	1	1	1	1	0	0	1	1	NA	1	NA	NA	1	0.82	Low risk of bias
Farias et al.,[21]	1	1	NR	1	0	0	0	1	1	NA	1	NA	NA	0	0.60	Moderate risk of bias
Ferrari et al.,[22]	1	1	1	0	1	1	1	1	0	NA	0	NR	1	1	0.75	Low risk of bias
Barbosa et al.,[28]	1	1	NR	1	NR	0	0	1	1	NA	1	NA	NA	0	0.66	Moderate risk of bias
Brandão et al.,[29]	1	1	1	1	NR	0	0	1	0	NA	1	NA	NA	0	0.60	Moderate risk of bias
Mello et al.,[30]	1	1	1	1	1	0	0	1	1	NA	1	NA	NA	1	0.81	Low risk of bias
Lima and Silva,[8]	1	1	1	1	1	0	0	1	1	NA	1	NA	NA	1	0.81	Low risk of bias
Hobold et al.,[31]	1	1	1	1	1	0	0	1	1	NA	1	NA	NA	1	0.81	Low risk of bias
Nunes et al.,[24]	1	1	1	1	1	0	0	1	1	NA	1	NA	NA	1	0.81	Low risk of bias
Pires et al.,[23]	1	1	NR	1	NR	0	0	1	1	NA	1	NA	NA	0	0.66	Moderate risk of bias
Silva and Martins,[25]	1	1	1	1	1	0	0	1	1	NA	1	NA	NA	1	0.81	Low risk of bias
Silva et al.,[9]	1	1	1	1	1	0	0	1	1	NA	1	NA	NA	1	0.81	Low risk of bias

ND. Can not be determined; NR. Not reported; NA. Not applicable; 0. No; 1. Yes; ≥ 0.70: low risk of bias; ≥ 0.50: moderate risk of bias;< 0.50 high risk of bias; * to determine the total score, the following equation was considered: (total of positive answers / total of questions considered for that study).

MS was investigated in fourteen different ways. HJ was used to identify MS levels in 16 studies[12,13,15,16,19-21,23,27,29-33,35,36]; in 15 studies, MS was investigated through HGS[3,8,9,12,15,17,20,22,24-26,28,33,35,36]; in four studies, vertical jump without the aid of arms (VJWAA) was used to evaluate MS[12,20,22,26]; in four other studies, TMB was used[16,23,29,30]; in two studies the isokinetic strength of knee extensors (IFKE) was used as a reference for MS[14,21]; in two other studies, MS was investigated through vertical jump using arms (VJUA)[14,21]; the maximal repetition in the horizontal bench press (1MRBP) and a maximal repetition in the leg press (1MRLP) tests were used to measure MS levels in one study[7]; the tests of a maximal repetition in the extensor table (1MRET) and a maximum repetition in the biceps curl (1MRBC) thread were used in another study[19]; isokinetic strength of elbow flexors (IFE), isometric strength of the elbow flexors (ISMFE), and isometric strength of the knee extensors (ISMKE) tests were used to measure MS in one study[14]. In addition, the isokinetic strength test of knee flexors (IFKF) was also used[21] (Table 3).

Table 3. Specific characteristics of included studies.

References	Number of evaluated for MS; Follow-up time	Test used to evaluate MS	Cutoff value; Mean values of MS according to sex	Statistical tests used; Values of the analyzes
Evidence of longitudinal studies, n = 5				
Britto et al.,[12]	44; 5.1 years	VJWAA; VJUA; HJ; HGS	N.U; N.D.	Correlation; Determination coefficient
Conte et al.,[13]	56; 2 years	HJ	N.U; BMI ≥ 25 KG/M² I.E: 135.4 † (± 35.3 ‡) ♂ 127.2† (±17.5‡) ♀ F.E: 148.6 † (±30.3‡) ♂ 127.0† (±14.4‡) ♀ BMI < 25 KG/M² I.E: 177.7† (±30.9‡) ♂ 128.9† (±18.8‡) ♀ F.E: 180.4† (±36.6‡) ♂ 125.0† (±21.3‡) ♀	Comparison of proportions
Biassio et al.,[26]	62; 5 years	HGS; VJWAA	N.U; HGS PP: (2 years) 15.6* (±4.1‡) PP: (1 years) 18.3* (±4.7‡) PU: 22.3* (±4.9‡) PPU: (1 year) 24.9* (±6.1‡) P0: (2 years) 26.0* (±5.2‡) VJWAA PP: (2 years) 22.5* (±3.7‡) PP: (1 year) 24.5* (±3.8‡) PU: 25.4* (±5.0‡) PPU: (1 year) 27.5* (±5.3‡) P0: (2 years) 27.4* (±4.9‡)	ANOVA
Da silva et al.,[36]	294; 3 years	HGS; HJ	N.U; N.D;	Foulkes & Davies coefficient ÿ (self-correlation)
Ferrari et al.,[22]	1291	HGS; VJWAA	N.U; 1978-1980 HGS: 21.50* (±6.92‡) ♂ HGS: 18.74* (±4.88‡) ♀ VJWAA: 21.50† (±6.92‡) ♂ VJWAA: 18.74† (±4.88‡) ♀ 1988-1990 HGS: 19.02* (±4.25‡) ♂ HGS: 18.72* (±4.05‡) ♀ VJWAA: 24.55† (±4.82‡) ♂ VJWAA: 24.41† (±4.41‡) ♀ 1998-2000 HGS: 18.06* (±4.55‡) ♂ HGS: 16.18* (±3.60‡) ♀ VJWAA: 24.47† (±4.99‡) ♂ VJWAA: 23.51† (±4.76‡) ♀ 2008-2010 HGS: 17.92* (±3.65‡) ♂ HGS: 18.16* (±4.12‡) ♀ VJWAA: 22.38† (±5.92‡) ♂ VJWAA: 22.02† (±4.89‡) ♀	ANOVA
Evidence from cross-sectional studies, n = 22				

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References	Number of evaluated for MS; Follow-up time	Test used to evaluate MS	Cutoff value; Mean values of MS according to sex	Statistical tests used; Values of the analyzes
Scheneider et al.,[14]	57	IFE; IFKE; ISMFE; ISMKE;	N.U; ISMFE (60º) PP: 16.1[§] (±1.1[‖]) ♀ PP: 17.0[§] (±1.5[‖]) ♂ PU: 20.8[§] (±2.1[‖]) ♀ PU: 30.1[§] (±2.4[‖]) ♂ PPU: 23.9[§] (±1.6[‖]) ♀ PPU: 40.5[§] (±2.9[‖]) ♂ ISMFE (90º) PP: 19.4[§] (±1.3[‖]) ♀ PP: 17.1[§] (±1.3[‖]) ♂ PU: 22.7[§] (±1.8[‖]) ♀ PU: 28.9[§] (±2.5[‖]) ♂ PPU: 26.2[§] (±1.4[‖]) ♀ PPU: 48.2[§] (±3.2[‖]) ♂ IFE (60º) PP: 7.6[§] (±0.5[‖]) ♀ PP: 11.4[§] (±1.6[‖]) ♂ PU: 13.3[§] (±1.2[‖]) ♀ PU: 20.1[§] (±3.3[‖]) ♂ PPU: 15.0[§] (±2.0[‖]) ♀ PPU: 30.7[§] (±2.1[‖]) ♂ IFE (90º) PP: 7.1[§] (±0.9[‖]) ♀ PP: 10.7[§] (±1.7[‖]) ♂ PU: 11.8[§] (±1.8[‖]) ♀ PU: 19.7[§] (±4.0[‖]) ♂ PPU: 13.7[§] (±1.6[‖]) ♀ PPU: 28.2[§] (±1.4[‖]) ♂ ISMKE (45º) PP: 53.9[§] (±3.7[‖]) ♀ PP: 68.6[§] (±7.1[‖]) ♂ PU: 87.5[§] (±8.0[‖]) ♀ PU: 119.0[§] (±8.8[‖]) ♂ PPU: 134.1[§] (±10.5[‖]) ♀ PPU: 167.7[§] (±9.9[‖]) ♂ ISMKE (60º) PP: 68.3[§] (±5.0[‖]) ♀ PP: 83.2[§] (±6.9[‖]) ♂ PU: 103.9[§] (±7.2[‖]) ♀ PU: 143.6[§] (±7.1[‖]) ♂ PPU: 155.7[§] (±13.1[‖]) ♀ PPU: 198.5[§] (±12.4[‖]) ♂ IFKE (60º) PP: 40.6[§] (±3.0[‖]) ♀ PP: 50.1[§] (±5.2[‖]) ♂ PU: 63.3[§] (±4.9[‖]) ♀ PU: 87.1[§] (±9.1[‖]) ♂ PPU: 88.6[§] (±9.8[‖]) ♀ PPU: 136.4[§] (±11.7[‖]) ♂ IFKE (90º) PP: 38.2[§] (±3.3[‖]) ♀ PP: 44.7[§] (±4.5[‖]) ♂ PU: 64.6[§] (±4.7[‖]) ♀ PU: 88.0[§] (±10.3[‖]) ♂ PPU: 90.0[§] (±7.4[‖]) ♀ PPU: 133.4[§] (±10.3[‖]) ♂	ANOVA

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References	Number of evaluated for MS; Follow-up time	Test used to evaluate MS	Cutoff value; Mean values of MS according to sex	Statistical tests used; Values of the analyzes
Ulbrich et al.,[15]	275	HGS; HJ	N.U; HGS MAST 1: 13.25¶ (4.02‡) ♂ MAST 2: 18.03¶ (5.02‡) ♂ MAST 3: 23.24¶ (5.77‡) ♂ MAST 4: 33.85¶ (8.47‡) ♂ MAST 1: 11.44¶ (3.29‡) ♀ MAST 2: 16.38¶ (4.57‡) ♀ MAST 3: 23.27¶ (5.31‡) ♀ MAST 4: 29.00¶ (3.86‡) ♀ HJ MAST 1: 1.23¶ (0.21‡) ♂ MAST 2: 1.39¶ (0.22‡) ♂ MAST 3: 1.59¶ (0.25‡) ♂ MAST 4: 1.82¶ (0.27‡) ♂ MAST 1: 1.09¶ (0.18‡) ♀ MAST 2: 1.25¶ (0.21‡) ♀ MAST 3: 1.45¶ (0.19‡) ♀ MAST 4: 1.57¶ (0.14‡) ♀	ANOVA
Linhares et al.,[32]	136	HJ	N.D; N.U	ANOVA
Luguetti et al.,[16]	3145	HJ; TMB	PROESP-BR; HJ 7 years: 112† (±17‡) ♂ 99† (±15‡) ♀ 8 years: 122† (±18‡) ♂ 108† (±18‡) ♀ 9 years: 131† (±18‡) ♂ 116† (±18‡) ♀ 10 years: 136† (±20‡) ♂ 123† (±19‡) ♀ 11 years: 136† (±21‡) ♂ 124† (±20‡) ♀ 12 years: 144† (±25‡) ♂ 123† (±19‡) ♀ 13 years: 160† (±23‡) ♂ 125† (±23‡) ♀ 14 years: 171† (±26‡) ♂ 128† (±19‡) ♀ 15 years: 180† (±28‡) ♂ 131† (±20‡) ♀ 16 years: 187† (±25‡) ♂ 133† (±20‡) ♀ TMB 7 years: 158† (±29‡) ♂ 144† (±23‡) ♀ 8 years: 180† (±36‡) ♂ 163† (±27‡) ♀ 9 years: 201† (±35‡) ♂ 189† (±36‡) ♀ 10 years: 232† (±46‡) ♂ 216† (±42‡) ♀ 11 years: 266† (±47‡) ♂ 250† (±47‡) ♀ 12 years: 301† (±49‡) ♂ 281† (±49‡) ♀ 13 years: 374† (±71‡) ♂ 314† (±48‡) ♀ 14 years: 418† (±76‡) ♂ 321† (±43‡) ♀ 15 years: 467† (±80‡) ♂ 323† (±42‡) ♀ 16 years: 487† (±80‡) ♂ 331† (±50‡) ♀	ANOVA

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References	Number of evaluated for MS; Follow-up time	Test used to evaluate MS	Cutoff value; Mean values of MS according to sex	Statistical tests used; Values of the analyzes
Silva and Cabral de Oliveira,[3]	128	HGS; VJUA	N.U; HGS NM: 17.8* (±4.4‡) MT: 21.5* (±3.9‡) VJUA NM: 23.7† (±6.7‡) MT: 24.1† (±6.7‡)	ANCOVA
Arruda et al.,[19]	10	HJ; 1MRET; 1MRBC	N.U; 1MRET: 21.6* (±6.5‡) 1MRBC: 14.8* (±3.9‡)	Correlation
Ferreira et al.,[17]	199	HGS	N.U; (6-7 years) NDH: 11.8* (±3.94‡) ♂ DH: 12.19* (±3.66‡) ♂ NDH: 9.97* (±3.25‡) ♀ DH: 11.44* (±2.79‡) ♀ (8-10 years) NDH: 15.16* (±4.89‡) ♂ DH: 15.20* (±5.02‡) ♂ NDH: 13.84* (±2.62‡) ♀ DH: 14.66* (±3.01‡) ♀ (11-13 years) NDH: 25.39* (±7.84‡) ♂ DH: 27.64* (±7.96‡) ♂ NDH: 22.78* (±6.32‡) ♀ DH: 23.77* (±5.84‡) ♀ (14-16 years) NDH: 38.20* (±10.2‡) ♂ DH: 40.56* (±11.28‡) ♂ NDH: 29.09* (±6.23‡) ♀ DH: 29.84* (±5.84‡) ♀ (17-19 years) NDH: 45.69* (±5.47‡) ♂ DH: 46.66* (±6.01‡) ♂ NDH: 27.19* (±5.12‡) ♀ DH: 29.19* (±4.84‡) ♀	Linear Regression with mixed effects
Lopes et al.,[7]	36	1MRBP; 1MRLP	N.U; N.D	Multiple linear regression
Santos et al.,[33]	356	HGS; HJ	N.U; NWB HGS (D): 14.0* (±0.15‖) HGS (E): 13.3* (±0.16‖) HJ: 108.7† (±1.1‖) LWB HGS (D): 12.9* (±0.25‖) HGS (E): 12.4* (±0.26‖) HJ: 108.0† (±1.8‖)	ANCOVA
Freitas et al.,[35]	2040	HGS; HJ	N.U; HGS LM: 22.70* (±5.18‡) NM: 18.87* (±6.78‡) EM: 16.84* (±6.10‡) HJ LM: 125.25† (±25.41‡) NM: 114.35† (±25.53‡) EM: 106.39† (±27.26‡)	ANOVA

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References	Number of evaluated for MS; Follow-up time	Test used to evaluate MS	Cutoff value; Mean values of MS according to sex	Statistical tests used; Values of the analyzes
Matsudo et al.,[20]	233	HGS; HJ; VJWAA	< 372.78[§] / ≥ 372.79[§] HGS < 372.78[§]: 284.5[§] (±5.3[‖]) ≥ 372.79[§]: 500.4[§] (±12.6[‖]) VJWAA < 372.78[§]: 23.3[†] (±0.6[‖]) ≥ 372.79[§]: 27.8[†] (±0.6[‖]) HJ < 372.78[§]: 111.5[†] (±2.0[‖]) ≥ 372.79[§]: 138.7[†] (±3.0[‖])	Multiple linear regression
Minatto et al.,[27]	1469	HJ	Tertiles; N.D;	Binary Logistic Regression
Farias et al.,[21]	21	IFKF; IFKE; HJ	N.U; HJ 1.64[¶] (±0.31[‡]) ♂ 1.25[¶] (±0.09[‡]) ♀ IFKE (60º/s) 132.35 (±36.33[‡]) ♂ 130.94 (±33.66[‡]) ♀ IFKF (60º/s) 63.50 (±25.88[‡]) ♂ 74.36 (±33.53[‡]) ♀ IFKE (300º/s) 72.25 (±23.98[‡]) ♂ 57.56 (±24.28[‡]) ♀ IFKF (300º/s) 53.50 (±18.83[‡]) ♂ 42.07 (±15.67[‡]) ♀	Correlation; Student's t-test.
Barbosa et al.,[28]	122	HGS	N.U; N.D	Poisson Regression
Brandão et al.,[29]	414	TMB; HJ	PROESP-BR; N.D;	Multivariate factorial analysis
Mello et al.,[30]	8750	TMB; HJ	PROESP-BR; HJ 7 years: 120.78[†] (±26.37[‡]) 8 years: 124.78[†] (±25.23[‡]) 9 years: 130.17[†] (±26.02[‡]) 10 years: 137.71[†] (±24.89[‡]) 11 years: 145.64[†] (±30.05[‡]) 12 years: 154.74[†] (±29.39[‡]) 13 years: 165.94[†] (±29.78[‡]) 14 years: 180.41[†] (±32.12[‡]) 15 years: 186.13[†] (±30.80[‡]) 16 years: 190.90[†] (±29.31[‡]) 17 years: 194.80[†] (±34.80[‡]) TMB 7 years: 164.95[†] (±49.56[‡]) 8 years: 189.23[†] (±46.82[‡]) 9 years: 212.64[†] (±50.38[‡]) 10 years: 234.42[†] (±55.83[‡]) 11 years: 261.89[†] (±64.84[‡]) 12 years: 305.16[†] (±74.86[‡]) 13 years: 346.96[†] (±90.86[‡]) 14 years: 417.18[†] (±101.78[‡]) 15 years: 474.33[†] (±95.26[‡]) 16 years: 496.13[†] (±102.31[‡]) 17 years: 522.46[†] (±97.80[‡])	Descriptive statistics
Lima and Silva,[8]	866	HGS	CSEP; N.D;	Multinomial logistic regression

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References	Number of evaluated for MS; Follow-up time	Test used to evaluate MS	Cutoff value; Mean values of MS according to sex	Statistical tests used; Values of the analyzes
Hobold et al.,[31]	5962	HJ	P15, p50 and P85; (6.0-6.9 years) P15: 82.4† ♂; P50: 101.7† ♂ P85: 120.0† ♂; P15: 71.8† ♀ p50: 87.5† ♀ P85: 105.0† ♀ (7.0-7.9 years) P15: 90.5† ♂; p50: 110.9† ♂ P85: 130.2† ♂; P15: 78.5† ♀ p50: 96.1† ♀; P85: 114.9† ♀ (8.0-8.9 years) P15: 98.1† ♂; p50: 119.3† ♂ P85: 139.5† ♂; P15: 85.0† ♀ p50: 104.4† ♀; P85: 124.3† ♀ (9.0-9.9 years) P15: 104.4† ♂; p50: 126.3† ♂ P85: 147.2† ♂; P15: 90.3† ♀ p50: 111.1† ♀; P85: 131.9 ♀ (10.0-10.9 years) P15: 109.9† ♂; p50: 132.3† ♂ P85: 153.9† ♂; P15: 94.0† ♀ p50: 115.9† ♀; P85: 137.3† ♀ (11.0-11.9 years) P15: 115.5† ♂; p50: 138.5† ♂ P85: 161.0† ♂; P15: 96.6† ♀ p50: 119.2† ♀; P85: 141.1† ♀ (12.0-12.9 years) P15: 122.0† ♂; P50: 146.1† ♂ P85: 169.6† ♂; P15: 98.1† ♀ p50: 121.0† ♀; P85: 143.2† ♀ (13.0-13.9 years) P15: 129.5† ♂; p50: 154.9† ♂ P85: 179.7† ♂; P15: 98.6† ♀ p50: 121.4† ♀; P85: 143.8† ♀ (14.0-14.9 years) P15: 136.7† ♂; p50: 163.5† ♂ P85: 189.8† ♂; P15: 98.3† ♀ p50: 120.7† ♀; P85: 143.0† ♀ (15.0-15.9 years) P15: 143.0† ♂; p50: 171.4† ♂ P85: 199.0† ♂; P15: 97.6† ♀ p50: 119.3† ♀; P85: 141.6† ♀ (16.0-16.9 years) P15: 148.6† ♂; p50: 178.5† ♂ P85: 207.2† ♂; P15: 97.0† ♀ p50: 117.9† ♀; P85: 140.2† ♀ (17.0-17.9 years) P15: 153.9† ♂; p50: 185.4† ♂ P85: 215.3† ♂; P15: 96.5† ♀ p50: 116.7† ♀; P85: 139.0† ♀	Percentage curves and Student's t-test
Nunes et al.,[24]	1117	HGS	N.U; N.D.	Multiple linear regression
Pires et al.,[23]	751	TMB; HJ	N.U; ASS HJ: 1.48¶ (±0.33‡) ♂ TMB: 3.24¶ (±1.14‡) ♂ HJ: 1.24¶ (±0.24‡) ♀ TMB: 2.77¶ (±0.75‡) ♀ DSS HJ: 1.39¶ (±0.31‡) ♂ TMB: 3.05¶ (±1.21‡) ♂ HJ: 1.20¶ (±0.48‡) ♀ TMB: 2.53¶ (±0.80‡) ♀	Student t test

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References	Number of evaluated for MS; Follow-up time	Test used to evaluate MS	Cutoff value; Mean values of MS according to sex	Statistical tests used; Values of the analyzes
Silva and & Martins,[25]	1132	HGS	N.U; PU: 69.3* (±0.8‡) ♂ PPU: 70.0* (±1.5‡) ♂ PU: 43.0* (±0.5‡) ♀ PPU: 43.2* (±0.8‡) ♀	ANCOVA
Silva et al.,[9]	636	HGS	CSEP; N.D.	Binary Logistic Regression

MS: muscle strength; VJWAA: vertical jump without the aid of arms ; VJUA: vertical jump using arms; HJ: horizontal jump; HGS: handgrip strength; N.U: not used; N.D: not described; PP: pre-pubertal; PU: pubertal ; PPU: post-pubertal; I.E: Initial evaluation; F.E: final evaluation; IFE: isokinetic flexion of elbows; IFKE: isokinetic force knee extension; IFKF: isokinetic force knee flexion; ISMFE: isometric flexion of elbows; ISMKE: isometric knee extension; BMI: body mass index; TMB: throw medicine-ball; PROESP-BR: Projeto Esporte Brasil; NM: Not mature; MT: matured; LM: late maturation; NM: normal maturation; EM: early maturation; ♂: boys; ♀: girls; *: expressed in kilograms; †: values expressed in centimeters; ‡: Standard deviation; §: values expressed in Newtons; ||: standard error; ¶: values expressed in meters; 1MRET: maximum repetition extender table; 1MRBC: maximum repetition biceps curl; 1MRBP: maximum repetition bench press; 1MRLP: maximum repetition leg press; NDH: non-dominant hand; DH: dominant hand; NWB: normal weight at birth; LWB: low weight at birth; s: seconds; CSEP: *Canadian Society of Exercise and Physiology;* P15: percentile 15; p50: percentile 50; P85: percentile 85; ASS: active shift to school; DSS: passive shift to school; MAST: maturational stage.

Table 4 shows studies that classified MS as adequate or inadequate for health based on some physical test battery[8,9,16,29,30]. Five studies did this type of classification and used three different physical tests (e.g., HJ, TMB and HGS). Three studies used two different tests in the same sample (e.g., HJ, TMB)[16,29,30]. The physical test batteries PROESP/BR[37] and CSEP[6] were used in these studies. A total of 13,028 subjects aged 7-19 years were surveyed when computing all these studies and this resulted in 65.9% of boys and 58.2% of girls with adequate MS levels for health throughout Brazil.

Table 4. Characteristics of studies that classified muscle strength in categories based on test batteries that have health criteria.

Authors	Local	Sample	Age group (years)	Test to measure muscle strength	Percentage of subjects classified as having adequate muscle strength	Reference for the classification of muscular strength
Luguetti et al.,[16]	São Paulo, SP	3,145 (1,590 boys, 1,555 girls)	7 – 16	- HJ;	54% of the boys (n = 859); 43% of the girls (n = 669)	PROESP/BR §[37]
				- TMB.	67% of boys (n = 1,065); 66% of the girls (n = 1,026)	
Brandão et al.,[29]	Cuiabá, MT	414 (229 boys, 185 girls)	15 – 17	- HJ;	75.1% of the boys (n = 172); 63.2% of the girls (n = 117)	PROESP/BR §[37]
				- TMB.	76.9% of the boys (n = 176); 63.8% of the girls (n = 118)	
Mello et al.,[30]	13 states of Brazil and the Federal District	8,280 (4,967 boys, 3,313 girls)†	7 – 17	- HJ;	59.8% of the boys (n = 2,979); 56.3% of the girls (n = 1865)	PROESP/BR §[37]
		7,967 (4,724 boys, 3,243 girls)‡		- TMB.	70.3% of the boys (n = 3,321); 63.2% of the girls (n = 2050)	

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Authors	Local	Sample	Age group (years)	Test to measure muscle strength	Percentage of subjects classified as having adequate muscle strength	Reference for the classification of muscular strength
Lima and Silva,[8]	São José, SC	866 (406 boys, 460 girls)	14 – 19	- HGS.	20.4% of the boys (n = 83); 14.8% of the girls (n = 68)	CSEP[6]
Silva et al.,[9]	Florianópolis, SC	636 (230 boys, 406 girls)	14 – 19	- HGS.	36.5% of the boys (n = 84); 35.9% of the girls (n = 146)	CSEP[6]
Overall¶	All geographic regions with at least one locality	13,028 (7,179 boys, 5,849 girls)ll	7 – 19	- TMB; HGS.	62.5% (not stratified by sex) 65.9% of the boys (n = 4,729); 58.2% of the girls (n = 3,408)	

† sample size available for the horizontal jump test; ‡ sample size available for the Medicine-ball throw test; § the categories excellent, very good, good and regular were considered as suitable; ll for studies that presented more than one test to measure muscle strength (Luguetti et al.,[16]; Brandão et al.,[29]; Mello et al.,[30] was considered the information for the total calculation of the test that presented more subjects classified as adequate in relation to muscular strength (e.g., Medicine-ball throw test); ¶ for the calculation of 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)*100; HJ: horizontal jump; TMB: medicine-ball throw test; HGS: handgrip strength; SP: São Paulo state; SC: Santa Catarina state; MT: Mato Grosso state.

DISCUSSION

In the present review, 27 studies that investigated MS in children and adolescents were identified, and a large number of these studies were published after 2010[7-9,17,19-25,27-31,33,35,36], demonstrating that the subject has current research in the Brazilian scenario. Although the body of evidence regarding the cardiovascular and metabolic health benefits attributed to MS are unambiguous[4,5], it is speculated that the contemporary consolidation of recommendations for MS improvement in children and adolescents[1] could justify the recent research relating MS in studies with children and adolescents.

Regarding the methodological quality of the studies included in the review, low or moderate risk of bias was identified, and no evidence from studies with a high risk of bias/low methodological quality was identified. This shows that studies in Brazil on this subject are well delineated and yield reliable results. Although MS research was the main objective of a small part of articles included in the review[9], the high methodological rigor adopted by the studies gives a greater probability that the results regarding MS have not been biased, conferring valid interpretations and applications.

Approximately three out of four MS-related studies in children and adolescents in Brazil were conducted in the Southeastern and Southern regions of the country (77.7%). In contrast, studies from the northerner region of Brazil were not identified. The strong expansion in the number of Physical Education courses in Brazil observed in the decade of 2000[38], coupled with the demand for the qualification of higher education teachers, has exerted a strong pressure on the demand for graduate students. However, this scenario is not established in an equitable way in the country, which may have converged to the discrepancy in the number of productions in relation to MS according to the Brazilian regions[38]. In Brazil, 54.0% of *stricto sensu* graduate programs in Physical Education are concentrated in the Southeastern, 24.3% in the Southern, 10.8% in the Northeastern, 8.2% in the Midwestern and 2.7% in the Northern regions[38].

The findings of the present review indicated a high number of tests used to measure MS. This is because there is a lack of consensus regarding the MS nomenclature and the tests used to evaluate it[2]. Metabolic, physiological and muscular demands involved, or the motor action necessary to perform the measurement/test are among the limiting factors for the elaboration of a "reference" method to evaluate MS levels[2]. 1MR and repetition tests for certain percentages of 1MR (Ex: 50% of 1MR or 70% of 1MR) have been used as a "benchmark" for determination of performance-related aspects; however, the HGS test with the use of manual dynamometer is another method used to investigate MS, considered valid and indicative of general MS[2]. In addition, HJ and VJ tests (muscle strength/explosive strength) were identified as good indicators of lower limb strength and general MS[2]. This variety of MS evaluation tests shows how difficult it is to compile all this information and compare the findings.

Several criteria for classification of MS values were identified in the studies included in this review. Although higher MS levels are directly associated with general health indicators in children and adolescents[4,5], the results obtained in tests are difficult to interpret, given the lack of "reference" cutoffs to detect adequate or inadequate MS levels[2]. The criteria proposed by the Canadian Society of Exercise Physiology (CSEP) and those suggested by the Brazilian Sports Project (PROESP-BR) are among those used in studies for this classification, both elaborated with the proposition of indicating health zones and even performance[6,37]. Among the limitations of the classification of results through these criteria are the bases used to propose cutoffs based on normative standards (results presented in percentiles), which reflect the result of a subject in relation to the others, which do not excludes the possibility that this individual is positioned at a high percentile within that reference population and that the chances of presenting health problems or risk factors are higher or lower[39]. The proposal of criteria-based cutoff points is related to the achievement or not of specific values that guarantee less possibilities of developing a certain health problem, regardless of the result that this value has reached within a normative distribution, which increases the validity of the interpretation of results[39]. In this sense, Brazil should propose cutoff points based on health criteria for MS in order to have a more accurate overview of these inferences.

In the present study, the percentage of children and adolescents classified as having adequate MS levels according to some physical test battery ranged from 14.8% to 66.0% in girls and from 20.4% to 76.9 % in boys. The great diversity of protocols and cutoffs used to measure and classify the MS results makes it difficult to compare results between surveys. Studies performed in southern Brazil[8,9] were those that presented the lowest percentage of individuals classified as having adequate MS; however, the cutoff points used to classify the MS values adopted in these studies were established based on the population of Canadian children and adolescents, different from the characteristics of the Brazilian population, which may have contributed to the difference between percentages.

When considering the results of studies conducted in Brazil, 65.9% of boys and 58.2% of girls had adequate MS levels for health. In the population-based study of adolescents (15 to 19 years) in Canada, whose cutoff points for MS score classification were based on percentiles, 41% of boys and 52% of girls had adequate MS levels[40]. Other studies[4,5] did not use specific cutoff points to classify MS values, but only to distribute the values obtained in MS tests into tertiles or quartiles. The monitoring of MS levels of the Brazilian pediatric population should be permanent as a health monitoring measure.

Some limitations of the results of this systematic review should be mentioned. Since the aim of the review was to identify studies that investigated MS in children and adolescents in Brazil, it should be recognized that the reviewed studies were heterogeneous in relation to the main objective, sample size, tests and instruments used to evaluate MS, making the comparison among results difficult[9]. Another limitation is that this review did not focus on localized muscle strength tests routinely used in physical test batteries for children and adolescents[6,37]. In addition, the limited number of researches whose main objective was to investigate the relationship of MS in children and adolescents is also a limitation. However, positive aspects of this review should be emphasized, such as the coverage of MS themes identified in research conducted in Brazil. The evaluation of the methodological quality of the included studies and the high number of databases used in MS investigation studies in children and adolescents in Brazil are strengths of this review.

CONCLUSION

The diversity of goals identified in MS-related studies in children and adolescents in Brazil demonstrates the importance of this physical valence in the health / performance context. However, there is need for a greater number of studies in Brazil, since information from some Brazilian regions regarding MS in children and adolescents is unknown. Moreover, although studies conducted in Brazil have identified low proportion of children and adolescents with adequate MS levels, the high number of cutoff points and tests used to classify / measure MS makes the comparison of results difficult, where greater number of surveys using tests and similar cutoff points to evaluate and classify FM are required. In addition, although the reduced proportion of children and adolescents in Brazil with adequate MS levels is similar to that identified in literature, the need for interventions aimed at increasing MS in the pediatric population is reinforced.

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SUPPLEMENTARY FILE

Descriptors used in the systematic search

First Block:

English: muscle strength; Resistance Training; Muscle Contraction; weight training. muscular strength; muscular endurance; muscular power; muscular fitness; lower body explosive strength; upper body isometric strength; upper body strength; lower body strength; musculoesqueletical fitness; isometric strength; dynamic strength; isometric contraction; isotonic contraction.

Spanish: Fuerza muscular; aptitud muscular; aptitud musculoesquelética; entrenamiento de resistencia; entrenamiento con pesos; resistencia muscular; potencia muscular; fuerza de miembros inferiores; fuerza de miembros superiores; fuerza isométrica; fuerza dinámica; resistencia de fuerza;

Portuguese: Força muscular; aptidão muscular; aptidão musculoesquelética; treinamento de resistência; treinamento com pesos; resistência muscular; potência muscular; força de membros inferiores; força de membros superiores; força isométrica; força dinâmica; resistência de força; contração isotônica; contração isométrica.

Second Block:

English: Child; children; pediatric; adolescent; juvenile.
Spanish: Ninõ; preescolar; joven/adolescente; adulto joven.
Portuguese: adulto jovem; adolescentes/jovens/adolescência/juventude/adolescente; Crianças/criança; Pré-escolar.