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Prevalence of Brazilian children and youth who meet health criteria for cardiorespiratory fitness: systematic review

Prevalência de crianças e adolescentes brasileiros que atenderam critérios de saúde para aptidão cardiorrespiratória: uma revisão sistemática

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Abstract – The study aimed to systematically review the literature to identify the prevalence of Brazilian children and adolescents that meet health criteria for cardiorespiratory fitness (CRF). The search was performed in the electronic databases (PubMED, SciELO, LILACS, Scopus, SPORTDiscus and Web of Science) and list of references of identified articles. Inclusion criteria were: population composed of children and/or adolescents (0-19 years or average age up to 19 years); studies with Brazilian children and/or adolescents and observational studies with cross-sectional or longitudinal design. The process of analysis of studies involved reading titles, abstracts and full texts. After these phases, 60 articles were eligible. Regarding the design, two studies were longitudinal. Of the total studies included, 49 presented moderate methodological quality values and 11 presented low methodological quality values, according to National Heart, Lung, and Blood Institute instrument. The prevalence of children and adolescents who met CRF health criteria varied among studies (7.5% to 70.4%), and this variation was higher in girls than in boys. Total of 49.093 individuals aged 6-19 years were surveyed to compute all of these studies, resulting in 32.2% of subjects (27.7% of boys and 28.4% of girls) with CRF levels adequate for health around Brazil. These results may help to screen the pediatric population at risk if CRF is considered as a health measure.

Key words: Adolescence health; Oxygen uptake; Peer review; Physical fitness.

Resumo – *O estudo teve como objetivo revisar sistematicamente a literatura para identificar a prevalência de crianças e adolescentes brasileiros que atendem aos critérios de saúde para aptidão cardiorrespiratória (CRF). A busca foi realizada nas bases de dados eletrônicas (PubMED, SciELO, LILACS, Scopus, SPORTDiscus e Web of Science) e lista de referências dos artigos identificados. Os critérios de inclusão foram: população considerada criança e/ou adolescente (idade de 0 a 19 anos ou com média de idade até 19 anos); estudos com amostra de crianças e/ou adolescentes de nacionalidade brasileira e estudos observacionais com delineamento transversal ou longitudinal. O processo de análise dos estudos envolveu leitura de títulos, resumos e textos completos. Após essas fases, 60 artigos foram elegíveis. Em relação ao delineamento, dois estudos foram longitudinais. Do total de estudos incluídos, 49 estudos apresentaram valores moderados para qualidade metodológica e 11 apresentaram valores baixos para qualidade metodológica, conforme instrumento da National Heart, Lung, and Blood Institute. As prevalências de crianças e adolescentes que atenderam aos critérios de saúde para CRF variaram entre os estudos (7.5% a 70.4%), sendo essa variação maior nas meninas que nos meninos. Total de 49.093 jovens de seis a 19 anos foi pesquisado ao computar todos esses estudos e isso resultou em 32,2% de sujeitos (27,7% dos meninos e 28,4% das meninas) com níveis adequados de CRF para a saúde ao redor do Brasil. Esses resultados podem auxiliar no rastreamento da população pediátrica que se encontra em risco se for considerado a CRF como medida de saúde.*

Palavras-chave: *Aptidão física; Consumo de oxigênio; Revisão por pares; Saúde do adolescente.*

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INTRODUCTION

Physical fitness is a characteristic of a multifactorial nature, usually understood as the ability to perform daily movements and tasks that involve physical-motor efforts without showing excessive fatigue[1]. The distinctive aspect of physical fitness is the multidimensional expression that includes cardiorespiratory, morphological, motor, metabolic and muscular dimensions[1]. Cardiorespiratory fitness (CRF) has been one of the most studied components in the universe of physical fitness[2-4]. Defined as the ability to provide oxygen to muscles and to use it to generate energy during physical exercise, the importance of CRF is highlighted in the strong relationship with performance in sports modalities and in association with a more positive health profile[1,2,5].

Epidemiologically, CRF has gained increasing importance in the expression of population health, since it provides a good indication of the ability of various organs and body systems involved in the movement, being therefore considered an important health marker in the pediatric context[2,6]. It has been reported that moderate to high CRF levels in children and young adults are associated with lower incidence of cardiometabolic risk factors, improved mental and bone health, and academic performance[6]. Considering the period of childhood and adolescence as critical phases for the development of CRF[6,7] and potentially sensitive to the influence of environmental factors, the evaluation and monitoring of CRF levels can significantly contribute to the identification of children and adolescents with unsatisfactory levels, predict future behaviors and states, and for the promotion of health throughout life[2,6,7].

CRF can be evaluated through different laboratory and field tests and interpreted in normative and criterial terms[2,6]. The normative reference assigns meaning to individual performance in differential terms, since it is possible to determine percentage performance ranks by comparing pairs of the same age and sex and identifying high, medium and low performance; however, without a direct link with health outcomes[2]. The criterion assessment allows the description in individual terms relative to a criterion measure that identifies the minimum amount of CRF required for good health (healthy cardiometabolic profile)[2,3,8]. The interpretation referenced by criterion represents a way to identify the percentage of children and young people in the healthy zone or not regarding CRF. This specification was constructed differently in each of the batteries and physical-motor tests, with different cut-points emerging in literature, which may lead to some confusion regarding the cardiorespiratory health status of children and adolescents[2,3,8].

Regardless of evaluation (normative or criterial), literature has revealed worrying data regarding the CRF levels of children and adolescents. Tomkinson et al.[4], in a secular trend study with children and adolescents from 19 countries, showed a moderate decline in CRF equivalent to 7.3% over the study period (1981 to 2014). In a meta-analysis[5], the CRF of children

and adolescents from 50 countries was investigated, concluding that Brazil was among the countries with the worst cardiorespiratory performance (42nd position). In this scenario, studies carried out in Brazil have shown that approximately 80% of children at school ages had CRF below that established for health[9,10] and that this condition has not changed in the last decade (1999 to 2010)[10].

Through the above-mentioned evidence, as well as the undeniable importance of CRF as a health marker, the international literature shows an effort to systematize the cardiorespiratory performance of children and adolescents[2,5,6]. In Brazil, although there is information associated with CRF behavior in the pediatric population from different cities and contexts, these results are not systematized, and there is no national level knowledge. In this sense, the present study aims to systematically review the literature to identify the prevalence of Brazilian children and adolescents who meet the health criteria regarding CRF. The relevance of this analytical and interpretative effort has epidemiological and public health impact, since, in addition to quantifying children and adolescents with adequate or inadequate CRF levels, it also contributes to: (1) identify Brazilian sites and regions of higher and lower prevalence in the healthy CRF zone and thus to recognize places with greater needs of public policies for health promotion; (2) understand how the relationship between CRF and health has been studied in pediatric populations in Brazil; and (3) identify which tests are used and their cut-points.

METHODOLOGICAL PROCEDURES

The method of this systematic review was consistent with the PRISMA statement[11]. The systematic search was performed on PubMED, SciELO, LILACS, Scopus, SPORTDiscus and Web of Science databases. For the search, three blocks of descriptors were developed: Block 1: *"physical fitness"*, *"aerobic capacity"*, *"aerobic fitness"*, *"cardiorespiratory capacity"*, *"cardiovascular fitness"*, *"aerobic power"*, *"aerobic endurance"*, *"cardiorespiratory endurance"*, *"oxygen consumption"*, *"maximum oxygen consumption"*, *"maximal oxygen uptake"*, *"VO2 maximal"*; Block 2: *child*, schoolchildren, adolescent*, student*; Block 3: *Brazil**. Within each block, the "OR" Boolean operator was used and between blocks, the "AND" operator was used. The "prevalence" indicators were not included in the search to reduce possible losses of relevant publications. Parentheses were used to combine search terms by outcome, exposure and population categories. Quotation marks were used to search for exact terms or expressions. Asterisk was used to search for all words derived from the same prefix. Automatic database filters were not used. The search process was finalized in February 2018, which is considered the final observation period for all databases.

The results of the search in each database were exported to the EndNote® reference manager software version X7 (Thomson Reuters, New York, USA).

Inclusion criteria

The inclusion criteria were: a) population consisted of children and/or adolescents (age 0-19 years or with mean age of up to 19 years) according to the World Health Organization[12]; (b) studies carried out with sample of children and/or adolescents of Brazilian nationality; (c) observational studies (with cross-sectional or longitudinal design).

Exclusion Criteria

The exclusion criteria were: (a) athletes (members of competitive sports teams); (b) children and/or adolescents with special needs (with diagnosis of acute or chronic diseases, physical or intellectual disability); (c) theses, dissertations, monographs, abstracts, book chapters, points of view and review articles, validation and/or reproducibility articles, articles of cut-point determination; (d) articles that did not present numerical data, classifying individuals according to CRF (quantity or prevalence of fit and/or unfit, regardless of parameter considered).

Procedures

The search, extraction and reading of articles were carried out by two independent evaluators (CASAJ and HEGN). If there was no consensus among peers, a third evaluator (DASS) was required to resolve the disagreement. Data extracted were the authors' name/year, methodological quality score, study site, age group, population and sample, study design, stratification, test used to measure CRF, cut-point used to classify CRF and prevalence/quantity of eligible individuals in relation to CRF.

To evaluate the methodological quality of studies, the instrument proposed by the National Heart, Lung, and Blood Institute[13] was used. This instrument evaluates 14 criteria of the internal validity of studies, and the higher the risk of bias, the lower the score referring to the methodological quality considered for the study. The following are among the criteria analyzed: clarity of the study's objective, definition, selection and participation of the study population, definition, selection and participation of the study population, definition and evaluation of the study variables, study period, and statistical analysis. Each question is scored with "0" or "1", with "0" applied to questions answered with "no" and "1" for those answered with "yes" or "not applicable". The "not applicable" option was used when it was not possible to evaluate one of the instrument criteria due to the type of study (as in the case of the cross-sectional design). The total score was obtained by summing the score of each question, and studies with values of 13 and 14 are considered with good methodological quality, from 9 to 12, of reasonable quality and values below nine are considered of low quality[14].

RESULTS

A total of 1,106 articles were found; however, 440 were duplicates, resulting in 666 articles. After reading the titles and abstracts, 502 studies were

excluded, and then 164 articles were read in their entirety. Of these, 44 studies were included because they presented the eligibility criteria and, after reading the references, 16 studies were included, totaling 60 studies in the present review (Figure 1).

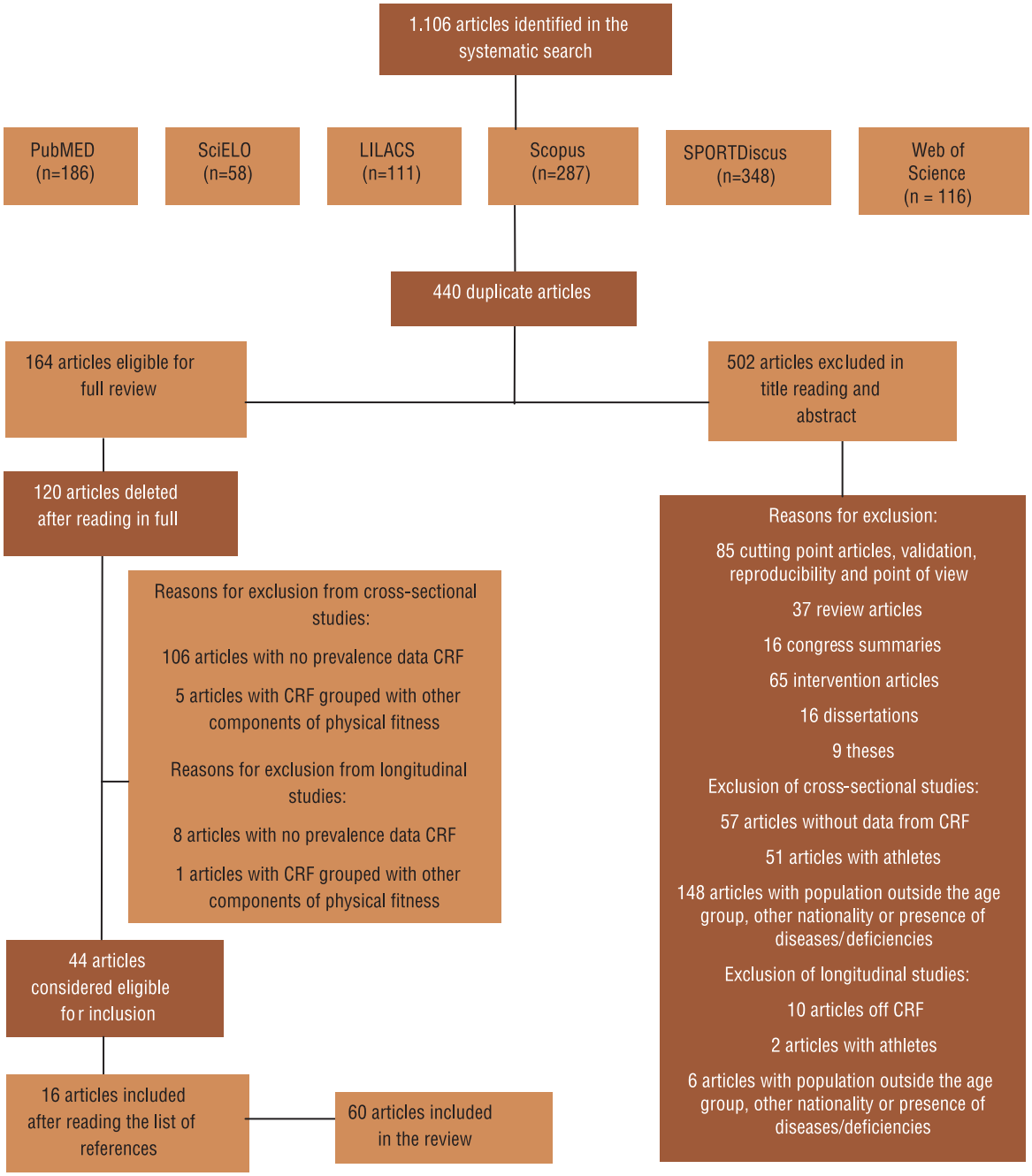

Figure 1 – Flow chart of search, selection and exclusion of articles.

The characteristics of the 60 studies included in the review were presented in Table 1. The population evaluated covered the age group from 6 to 19 years. Studies were published between 2005 and 2017. Twelve studies were carried out in the southeastern region, 6 in the northeastern,

39 in the southern, 1 in the northern region and two in all regions of the country (northern, northeastern, southern, southeastern and midwestern). Of these studies, two had longitudinal design[15,16], the others presented cross-sectional design. Regarding the aims of studies, 23 had as main aim to estimate the prevalence of CRF in children or adolescents who met (or did not meet) the health criteria[9,10,17-37].

The methodological quality of studies was presented in Table 2. Of included studies, 49 presented moderate methodological quality values and 11 presented low values[16,17,22,23,28,31,35,36,38-40]. Among studies that presented low methodological quality, questions 6, 7 and 14 were not answered in any of them, and nine studies did not answer questions 3 and 5 and eight did not answer questions 2 and 4.

Table 1. Description of studies on the prevalence of aerobic fitness in Brazilian children and/or adolescents.

Author(s)	Place of accomplishment	Age range	Population/ Sample	Study outline	Purpose of the study
Andreasi et al.[73]	Botucatu (Sao Paulo)	7- 15	Not available/ 988 (♂: 522; ♀: 466)	Cross-sectional	To analyze associations between health-related physical fitness and the anthropometric and demographic indicators of children at three elementary schools in Botucatu, SP, Brazil.
Araujo et al.[17]	Aracaju (Sergipe)	10-14	Not available/ 288 (♂: 142; ♀: 146)	Cross-sectional	Evaluate the cardiorespiratory fitness (CRF) and the body mass index (BMI) of schoolchildren according to the cutoff points established by the Fitnessgram®. Just as determine the influence of BMI on CRF in children and propose an equation for predicting VO2max from the body composition
Barbosa Filho et al.[58]	Curitiba (Parana)	$\overline{x}$ =14.2	115.524/ 1.555 (♂: 737; ♀: 818)	Cross-sectional	To analyze potential socioeconomic indicators, PA opportunities, and behavioral correlates of cardiorespiratory and muscular fitness among boys and girls from Curitiba, southern Brazil.
Bergmann et al.[74]	Caxias do Sul (Rio Grande do Sul)	7-12	33.241/ 1.442 (♂: 721; ♀: 721)	Cross-sectional	To examine the independent and combined influence of cardiorespiratory fitness (CRF), body mass index (BMI) and percentage of fat (% fat) on total cholesterol (TC) and blood pressure (BP) in male and female youth.
Brito et al.[75]	Curitiba (Parana)	10-14	8.140/ (♂: 614)	Cross-sectional	To investigate the impact of physical activity (PA) and cardiorespiratory fitness (CRF) levels on the prevalence of overweight and high blood pressure levels in adolescents.
Casonatto et al.[76]	Londrina (Parana)	7-11	Not available/ 978 (♂: 518; ♀: 460)	Cross-sectional	To investigate the association between body mass index (BMI) status and health-related physical fitness in Brazilian children.
Castro et al.[62]	Aracaju (Sergipe)	15-18	627/ 326 (♂: 183; ♀: 143)	Cross-sectional	To investigate the association between the four components (body composition, flexibility, muscular strength and cardiorespiratory endurance) of health-related physical fitness (HRPF) and academic performance of high school students, as measured by all the disciplines that make up the high school curriculum in Brazil.

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Author(s)	Place of accomplishment	Age range	Population/ Sample	Study outline	Purpose of the study
Coledam et al.[77]	Londrina (Parana)	10-18	55.475/ 716 (♂: 335; ♀: 381)	Cross-sectional	To analysing the association between socioeconomic indicators and adolescents' physical activity and health-related fitness.
Coledam et al.[78]	Londrina (Parana)	10-18	55.475/ 737 (♂: 365; ♀: 372)	Cross-sectional	To analyze the factors associated with CRF in school students.
Coledam and Ferraiol[79]	Londrina (Parana)	10-18	55.475/ 736 (♂: 367; ♀: 369)	Cross-sectional	To examine associations of engagement in physical education classes with physical fitness and obesity, according to sports practice, among Brazilian students.
Costanzi et al.[80]	Caxias do Sul (Rio Grande do Sul)	7-12	33.241/ 1.413 (♂: 714; ♀: 699)	Cross-sectional	To establish the prevalence of high blood pressure and associated factors in children from 7 to 12 years of the city of Caxias do Sul (RS).
Dorea et al.[18]	Jequie (Bahia)	7-12	26.500/ 342 (♂: 182; ♀: 160)	Cross-sectional	To analyze the health-related physical fitness in school children from seven to 12 years, from Jequie, BA, Brazil.
Fronza et al.[69]	Sao Bonifacio (Santa Catarina)	10-19	297/ 283 (♂: 151; ♀: 132)	Cross-sectional	To identify the prevalence of excessive TV viewing time during weekdays and the weekend controlling for sociodemographic characteristics and health risk factors in an adolescent population (aged 10–19 years) from a small town and rural area.
Gaya et al.[15]	Santa Cruz do Sul (Rio Grande do Sul)	7-17	Not available/ 405 (♂: 209; ♀: 196)	Longitudinal	To verify the four-year incidence of overweight (Ow) and obesity (Ob) and cardiorespiratory fitness (CRF) on levels in a sample of Brazilian children and adolescents and to identify the associated socio-demographic and nutritional characteristics of these subjects' parents.
Glaner et al.[19]	Erval Grande (Rio Grande do Sul); Concordia, Saudades e Chapeco (Santa Catarina)	10,5- 17,4	160.912/ ♂ 721	Cross-sectional	To compare the physical fitness related to the health of male, rural and urban adolescents, by age, as well as to verify the percentage of the criteria-referenced by AAHPERD (1988) for a recommended physical fitness in relation to health.
Gonçalves and Silva[20]	São Jose (Santa Catarina)	14-19	5.182/ 879 (♂: 415; ♀: 464)	Cross-sectional	To evaluate the prevalence of low CRF levels and to analyze the association with sociodemographic factors, lifestyle and excess body fatness among adolescents of southern Brazil.
Gonçalves and Silva[81]	Paulo Lopes (Santa Catarina)	14-19	193/ 84 (♂: 35; ♀: 49)	Cross-sectional	To analyze the association between lower levels of CRF and sociodemographic factors, lifestyle and excess body fatness in students of high school in a small city of the south of Brazil.
Gonçalves and Silva[82]	São Jose (Santa Catarina)	14-19	5.182/ 910 (♂: 519; ♀: 613)	Cross-sectional	To determine the prevalence and factors associated with low levels of lumbar force in adolescents.

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Author(s)	Place of accomplishment	Age range	Population/ Sample	Study outline	Purpose of the study
Guedes et al.[21]	Montes Claros (Minas Gerais)	6-18	84.675/ 2.849 (♂: 1392; ♀: 1457)	Cross-sectional	To identify the proportion of children and adolescents of the school population from Montes Claros, Minas Gerais, Brazil, who meet the health–related criteria determined by physical fitness components.
Guedes et al.[83]	Montes Claros (Minas Gerais)	6-18	84.675/ 2.849 (♂: 1392; ♀: 1457)	Cross-sectional	To identify the sociodemographic and behavioral factors most strongly associated with the health standards based on physical fitness component scores in a representative sample of Brazilian schoolchildren.
Lima and Silva[84]	São Jose (Santa Catarina)	14-19	5.182/ 866 (♂: 406; ♀: 460)	Cross-sectional	To analyze the association between clusters of negative physical fitness indicators with sociodemographic and lifestyle variables of adolescents from a city in southern Brazil.
Luguetti et al.[22]	Sao Paulo (Sao Paulo)	7-16	Not available/ 3145 (♂: 1590; ♀: 1555)	Cross-sectional	a) To evaluate indicators of physical fitness in children and adolescents according to chronological age and gender; b) To classify their performance using the PROESP-BR normative tables
Mascarenhas et al.[23]	Lapa (Parana)	7-10	Not available/ 81 students	Cross-sectional	To compare physical fitness related to health and performance of a school in the public a private teaching in the city of Lapa-PR
Mello et al.[24]	Uruguaiana (Rio Grande do Sul)	10-17	15.210/ 1.455 (♂: 714; ♀: 741)	Cross-sectional	To identify the prevalence and possible associations between excess of body weight and low CRF adjusted for sex and age in children and adolescents of a southern city of Brazil.
Minatto et al.[25]	São Bonifacio (Santa Catarina)	10-17	3008/ 277 (♂: 145 ♀: 132)	Cross-sectional	To determine the prevalence of the presence of concomitant low health-related physical fitness components with sociodemographic factors among Brazilian adolescents living in in a small town formerly colonized by German settlers.
Minatto et al.[65]	Januaria (Minas Gerais)	14-17	4.495/ 627 (♂: 266 ♀: 361)	Cross-sectional	To verify association of CRF fitness with socio-demographic indicators (age, economic level and area of domicile) and nutritional status in school adolescents from 14 -17 years old living in a medium / low HDI municipality.
Minatto et al.[26]	Sao Bonifacio (Santa Catarina)	10-17	291/ 277 (♂: 145; ♀: 132)	Cross-sectional	To identify the health-related physical fitness profile of Brazilian adolescents (10–17 years) living in a small town of German colonization and to describe the prevalence of those with low levels of physical fitness according to sex and age.
Minatto et al.[27]	Cascavel (Parana)	10-17	19.915/ (♀: 1.223)	Cross-sectional	To estimate the prevalence of low CRF and its association with excess body fat, considering the sexual maturation and economic level in female adolescents.
Nascimento et al.[28]	Ipatinga (Minas Gerais)	10-11	4.106/ 269 (♂: 118; ♀: 151)	Cross-sectional	To check the body fat and cardiovascular fitness (CR) prevalence in 118 boys and 151 girls (10- 11 years old), and to analyze these in relation to criterion referenced (CR).

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Author(s)	Place of accomplishment	Age range	Population/ Sample	Study outline	Purpose of the study
Nogueira and Pereira[29]	Fortaleza (Ceara)	11-16	1421/ 344 (♂: 236; ♀: 108)	Cross-sectional	To analyze the prevalence of care the criteria of health related physical activity and its association with the sex, the age group and the time of participation in the sports social program of Vilas Olympias in adolescents of the city of Fortaleza, Ceará (CE).
Oliveira et al.[61]	Criciuma (Santa Catarina)	10-14	13.508/ 1.081/ (♂: 545; ♀: 536)	Cross-sectional	To identify the sociodemographic and physical fitness factors associated with low levels of physical activity in adolescents of a city in the South of Brazil.
Paludo et al.[30]	Londrina (Parana)	10-12	Not available/ 115 (♂: 61; ♀: 54)	Cross-sectional	To analyze estimation of cardiorespiratory fitness (CRF) in adolescents aged 10 to 12 years by means of the 9-minute run/walk test. A total of 115 adolescents (61 boys and 54 girls) took part in the study.
Pelegrini et al.[9]	Five Brazilian regions (North, Northeast, Midwest, Southeast and South)	7-17	Not available/ 7.507 (♂: 4.114; ♀: 3.393)	Cross-sectional	To analyze the physical fitness of Brazilian schoolchildren, according to a health-referenced criteria assessment.
Pereira et al.[31]	Fortaleza (Ceara)	14-17	771/ 308 (♂: 177; ♀: 131)	Cross-sectional	To verify the mean levels of body mass index (BMI), blood pressure (BP) and CRF, the prevalence of deviations from the normality of these variables and the associations between them, in adolescents of a public school in a social risk area in the city of Fortaleza, state of Ceará.
Pereira et al.[32]	Uruguaiana (Rio Grande do Sul)	10-17	15.210/ 1.455 (♂: 714; ♀: 741)	Cross-sectional	To identify the prevalence and associated factors with low Health-Related Physical Fitness in adolescents.
Petroski et al.[33]	Januaria (Minas Gerais)	14-17	4.495/ 627 (♂: 266; ♀: 361)	Cross-sectional	Evaluating health-related physical fitness (HRPF) in adolescents from a town having a medium/low Human Development Index (HDI).
Petroski et al.[70]	Florianopolis (Santa Catarina)	15-19	Not available/ 605 (♂: 217; ♀: 388)	Cross-sectional	To verify associations between health-related physical fitness and sociodemographic factors in adolescents from a Brazilian state capital.
Petroski et al.[66]	Januaria (Minas Gerais)	14-17	4495/ 627	Cross-sectional	To verify the association between physical fitness and sociodemographic factors in adolescents domiciled in urban and rural areas.
Reis et al.[85]	Santa Cruz do Sul (Rio Grande do Sul)	7-17	20.380/ 2.335 (♂: 1.033; ♀: 1302)	Cross-sectional	To evaluate the possible association between hyperuricemia and cardiorespiratory fitness (CRF) levels/nutritional profile, grouped into a single variable, in schoolchildren.
Reuter et al.[38]	Santa Cruz do Sul (Rio Grande do Sul)	7-17	Not available 1243 (♂: 563; ♀: 680)	Cross-sectional	To identify possible relationships of dyslipidemia with cardiorespiratory fitness and obesity combined, in children and adolescents.
Ronque et al.[34]	Londrina (Parana)	7-10	15.778/ 511 (♂: 274; ♀: 237)	Cross-sectional	To analyze body adiposity and motor performance in children high socioeconomic level, according to na evaluation referenced by health criteria.

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Author(s)	Place of accomplishment	Age range	Population/ Sample	Study outline	Purpose of the study
Ronque et al.[86]	Londrina (Parana)	15	109/ 78 (♂: 45; ♀: 33)	Cross-sectional	To analyze the relationship between cardiorespiratory fitness (CRF) and body adiposity indicators in adolescents of both sexes.
Sakamoto et al.[39]	Maringa (Parana)	15-17	59/ 55 (♂: 31; ♀: 24)	Cross-sectional	To evaluate the prevalence of arterial hypertension and overweight among teenagers at a private school in the city of Maringá, Paraná State, Brazil, as well as the links among blood pressure levels, body mass index and physical fitness.
Serassuelo Junior et. al.[35]	Cambe (Paraná)	11-12	Not available/ 235 (♂: 108; ♀: 127)	Cross-sectional	To analyze the levels of physical fitness related to health in schoolchildren low income in the municipality of Cambé / PR.
Schubert et al.[40]	Londrina (Parana)	8-16	Not available/ 401 (♂: 236; ♀: 165)	Cross-sectional	To verify if there is an association between nutritional status, physical fitness level and body image in children and adolescents.
Silva et al.[36]	Luis Eduardo Magalhaes (Bahia)	14,4-15,5	Not available/ 258 (♂: 122; ♀: 136)	Cross-sectional	a) To compare physical growth and the health-related physical fitness (HRPF) of adolescents of different levels socioeconomic by sex; b) To analyze the HRPF adolescents through the use of criteria of reference
Silva et al.[16]	Conselheiro Lafaiete (Minas Gerais)	14-16	Not available/ 86 (♂: 41; ♀: 45)	Longitudinal	To check the influence of the holidays in physical fitness of schoolchildren.
Silva et al.[87]	Caxias do Sul (Rio Grande do Sul)	11-17	41.534/ 1.550 (♂: 759; ♀: 863)	Cross-sectional	a) To describe the prevalence of active commuting to school and; b) To identify barriers associated with the means of commuting to school.
Silva et al.[72]	Florianopolis (Santa Catarina)	14-19	Not available/ 656 (♂: 233; ♀: 423)	Cross-sectional	To investigate the effects of socioeconomic, demographic and lifestyle factors on abdominal obesity in adolescents from a Brazilian state capital.
Silva et al.[68]	Western of Santa Catarina	14-17	4.582/ 601 (♂: 269; ♀: 332)	Cross-sectional	To identify the prevalence and factors associated with high body fat in adolescents.
Silva et al.[67]	Januaria (Minas Gerais)	14-17	15.464/ 627 (♂: 266; ♀: 361)	Cross-sectional	To verify the prevalence and factors associated with high body fat in adolescents from Januária-MG, Brazil.
Silva et al.[88]	13 cities in the western region of Santa Catarina	14-17	4.582/ 601 (♂: 269; ♀: 332)	Cross-sectional	To determine the prevalence and factors associated with low levels of lumbar strength in adolescents.
Silva et al.[71]	Florianopolis (Santa Catarina)	15-17	12.741/ 696 (♂: 264; ♀: 432)	Cross-sectional	To identify the characteristics of adolescents at higher risk of low levels of aerobic fitness.
Silva et al.[60]	Criciuma (Santa Catarina)	10-14	13.508/ 1.081 (♂: 545; ♀: 536)	Cross-sectional	The purpose was to investigate the factors related to aerobic fitness (CRF) levels of adolescents in southern Brazil.
Silva et al.[10]	Five Brazilian regions (North, Northeast, Midwest, Southeast and South)	6-9	14.903/ 11.083 (♂: 5.937; ♀: 5.146)	Cross-sectional	To verify the secular changes in aerobic fitness levels and to identify factors over a decade related to low levels of aerobic fitness in Brazilian children.
Souza et al.[89]	Londrina (Parana)	11-13	377/ 282 (♂: 136; ♀: 146)	Cross-sectional	To analyze the association between CRF and regular participation in sports in adolescents.

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Author(s)	Place of accomplishment	Age range	Population/ Sample	Study outline	Purpose of the study
Straatmann and Veiga[63]	Niteroi (Rio de Janeiro)	12-19	928/ 639 (♂: 250; ♀: 389)	Cross-sectional	To examine the associations between CRF and physical activity with indicators of adiposity in an adolescent population.
Straatmann et al.[64]	Niteroi (Rio de Janeiro)	12-19	928/ 639 (♂: 250; ♀: 389)	Cross-sectional	To examine the association between classifications obtained with the CRF and physical activity level in adolescents, as well as the agreement between tertiles and z-score distribution of the variables generated with these methods (distance covered and total physical activity score).
Valente et al.[90]	Tucurui (Para)	14-17	Not available/ 377 (♂: 210; ♀: 167)	Cross-sectional	To determine the associations between physical fitness, sociodemographic factors and overweight prevalence of adolescent schoolchildren from urban and rural cities.
Vasques et al.[37]	Florianopolis (Santa Catariana)	10-15	Not available/ 963 (♂: 450; ♀: 513)	Cross-sectional	To identify the behavior of CRF during adolescence and to describe the prevalence of adolescents who attended and did not met the recommended criteria for health by sex, age and socioeconomic level.

Note. ♂ male; ♀ women; $\overline{x}$ mean.

Table 2. Evaluation of the methodological quality of included studies.

Author(s), year	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Total score
Andreasi et al.[73]	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	NA	Yes	NA	NA	No	10
Araujo et al.[17]	Yes	Yes	No	Yes	No	No	No	No	Yes	NA	Yes	NA	NA	No	08
Barbosa Filho et al.[58]	Yes	Yes	Yes	No	Yes	No	No	Yes	Yes	NA	Yes	NA	NA	No	10
Bergmann et al.[74]	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	NA	Yes	NA	NA	No	10
Brito et al.[75]	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	NA	Yes	NA	NA	No	10
Casonatto et al.[76]	Yes	Yes	Yes	Yes	No	No	No	Yes	No	NA	Yes	NA	NA	No	09
Castro et al.[62]	Yes	Yes	Yes	No	Yes	No	No	Yes	Yes	NA	Yes	NA	NA	Yes	11
Coledam et al.[77]	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No	NA	No	NA	NA	Yes	10
Coledam et al.[78]	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	NA	Yes	NA	NA	Yes	12
Coledam and Ferraiol[79]	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	NA	Yes	NA	NA	No	10
Costanzi et al.[80]	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	NA	Yes	NA	NA	Yes	12
Dorea et al.[18]	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	NA	Yes	NA	NA	No	11
Fronza et al.[69]	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	NA	Yes	NA	NA	Yes	11
Gaya et al.[15]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	No	10
Glaner et al.[19]	Yes	Yes	Yes	Não	Yes	No	No	Yes	Yes	NA	Yes	NA	NA	No	10
Gonçalves and Silva, 2016[20]	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	NA	Yes	NA	NA	Yes	11
Gonçalves and Silva[81]	Yes	Yes	No	Yes	No	No	No	Yes	Yes	NA	Yes	NA	NA	Yes	10
Gonçalves and Silva[82]	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	NA	Yes	NA	NA	Yes	12
Guedes et al.[21]	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	NA	Yes	NA	NA	No	11
Guedes et al.[83]	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	NA	Yes	NA	NA	No	11
Lima and Silva[84]	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	NA	Yes	NA	NA	Yes	12
Luguetti et al.[22]	Yes	Yes	No	Yes	No	No	No	Yes	No	NA	Yes	NA	NA	No	08
Mascarenhas et al.[23]	Yes	No	No	No	No	No	No	Yes	Yes	NA	Yes	NA	NA	No	08
Mello et al.[24]	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	NA	Yes	NA	NA	No	10
Minatto et al.[25]	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	NA	Yes	NA	NA	Yes	12
Minatto et al.[65]	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	NA	Yes	NA	NA	No	12

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Author(s), year	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Total score
Minatto et al.[26]	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	NA	Yes	NA	NA	Yes	12
Minatto et al.[27]	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	NA	Yes	NA	NA	Yes	11
Nascimento et al.[28]	Yes	No	Yes	No	No	No	No	Yes	Yes	NA	Yes	NA	NA	No	08
Nogueira and Pereira[29]	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	NA	Yes	NA	NA	No	11
Oliveira et al.[61]	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	NA	Yes	NA	NA	No	11
Paludo et al.[30]	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	NA	Yes	NA	NA	No	10
Pelegrini et al.[9]	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	NA	Yes	NA	NA	No	10
Pereira et al.[31]	Yes	No	No	No	No	No	No	Yes	Yes	NA	Yes	NA	NA	No	08
Pereira et al.[32]	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	NA	Yes	NA	NA	No	11
Petroski et al.[33]	Yes	Yes	Yes	No	Yes	No	No	No	Yes	NA	Yes	NA	NA	No	09
Petroski et al.[70]	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	NA	Yes	NA	NA	Yes	11
Petroski et al.[66]	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	NA	Yes	NA	NA	Yes	11
Reis et al.[85]	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	NA	Yes	NA	NA	Yes	11
Reuter et al.[38]	Yes	No	No	Yes	No	No	No	Yes	Yes	NA	Yes	NA	NA	No	08
Ronque et al.[34]	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	NA	Yes	NA	NA	No	11
Ronque et al.[86]	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	NA	Yes	NA	NA	No	09
Sakamoto et al.[39]	Yes	No	Yes	Yes	No	No	No	No	Yes	NA	Yes	NA	NA	No	08
Serassuelo Junior et al.[35]	Yes	No	No	No	No	No	No	Yes	Yes	NA	Yes	NA	NA	No	07
Schubert et al.[40]	Yes	Yes	No	No	Yes	No	No	No	Yes	NA	Yes	NA	NA	No	08
Silva et al.[36]	Yes	No	No	No	No	No	No	Yes	Yes	NA	Yes	NA	NA	No	07
Silva et al.[16]	Yes	No	No	No	Yes	No	No	Yes	Yes	No	Yes	No	Yes	No	06
Silva et al.[87]	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	NA	Yes	NA	NA	Yes	12
Silva et al.[72]	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	NA	Yes	NA	NA	Yes	11
Silva et al.[68]	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	NA	Yes	NA	NA	Yes	12
Silva et al.[67]	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	NA	Yes	NA	NA	No	11
Silva et al.[88]	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	NA	Yes	NA	NA	Yes	12
Silva et al.[71]	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	NA	Yes	NA	NA	No	11
Silva et al.[60]	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	NA	Yes	NA	NA	No	11
Silva et al.[10]	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	NA	Yes	NA	NA	Yes	12
Souza et al.[89]	Yes	No	Yes	Yes	No	No	No	Yes	Yes	NA	Yes	NA	NA	No	09
Straatmann and Viega[63]	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	NA	Yes	NA	NA	No	10
Straatmann et al.[64]	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	NA	Yes	NA	NA	Yes	12
Valente et al.[90]	Yes	No	No	Yes	No	No	No	Yes	Yes	NA	Yes	NA	NA	Yes	09
Vasques et al.[37]	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	NA	Yes	NA	NA	No	10

NA: Not applicable. Q1: Was the research question or objective in this study clearly stated?; Q2: Was the study population clearly specified and defined?; Q3: Was the participation rate of eligible persons at least 50%?; Q4: Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?; Q5: Was a sample size justification, power description, or variance and effect estimates provided?; Q6: For the analyses in this study, were the exposures of interest measured prior to the outcome(s) being measured?; Q7: Was the time frame sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?; Q8: For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as a continuous variable)?; Q9: Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?; Q10: Were the exposures assessed more than once over time?; Q11: Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?; Q12: Were the outcome assessors blinded to the exposure status of participants?; Q13: Was loss to follow-up after baseline 20% or less?; Q14: Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposures and outcomes?

Studies verified the CRF of children and/or adolescents by different tests: 6-minute walk/run test, 9-minute walk/run test, treadmill ergospirometry, mCAFT test and 20-meter shuttle-run test. Different

cut-points were found in the reviewed literature, with 17 studies using the FITNESSGRAM classification[41,42,43,44,45], 14 studies used PROESP-BR[46,47,48,49,50,51], 11 studies used AAHPERD[52,53,54], eight the Physical Best[54], seven used the CSEP[55], one study used cut-point proposed by Bergmann et al.[56], one study the parameter of Rodrigues et al.[57] and one used classification from the sample standards[58]. For one study[39], it was not possible to identify the cut-point used, since the reference presented by the authors[59] did not report classification information (Table 3).

The prevalence of children and adolescents with adequate CRF varied among studies, and the lowest prevalence found was 7.5%[60,61] and the highest prevalence was 70.4%[23], both studies carried out in the southern region of the country. The northeastern region showed variation from 13.1%[62] to 54.4%[29] of healthy CRF levels. For the southeastern region, the variation was from 24.1%[63,64] to 64.6%[33,65-67].

Regarding gender, in boys, the prevalence of individuals with healthy CRF ranged from 10.0%[68] to 72.5%[25,26,69], and in girls from 3.7%[60,61] to 79.4%[70-72]. A total of 49,093 children and young from six to 19 years of age were screened for all these studies, resulting in 32.2% (27.7% of boys and 28.4%) of subjects with CRF levels adequate for health throughout Brazil (Table 3).

Table 3. Studies on the prevalence of aerobic fitness in Brazilian children and/or adolescents.

Author(s), year	Age range	Sample that did the CRF test	Physical test used	Reference for cut-point	Prevalence of fit individuals (Absolute frequency)
Andreasi et al.[73]	7-15	932 (♂: 493; ♀: 439)	9-minute run/walk test	PROESP-BR[48]	Total: 57.5% (n=536) Sex ♂: 59.0% (n=291) ♀: 55.8% (n=245)
Araujo et al.[17]	10-14	288 (♂: 142; ♀: 146)	20 meters shuttle run	FitnessGram[41]	Total: 49.2% (n=142) Sex ♂: 55.6% (n =79) ♀: 42.9% (n =63)
Barbosa Filho et al.[58]	$\bar{x}$ =14.2	1.555 (♂: 737; ♀: 818)	20 meters shuttle run	Classification by patterns of the sample itself	Total: 47.0% (n=729) ♂: 48.1% (n =354) ♀: 45.9% (n =375)
Bergmann et al.[74]	7-12	1.403 (♂: 699; ♀: 704)	9-minute run/walk test	Bergmann et al.[56]	Total: 42.6% (n=598) Sex ♂: 43.0% (n =299) ♀: 42.2% (n =299)
Brito et al.[75]	10-14	♂: 614	20 meters shuttle run	Rodrigues et al.[57]	Total: 32.4% (n=199)
Casonatto et al.[76]	7-11	978 (♂: 518; ♀: 460)	9-minute run/walk test	AAHPERD[54]	Total: 27.9% (n=273) Sex ♂: 24.1% (n =125) ♀: 32.2% (n =148)
Castro et al.[62]	15-18	326 (♂: 183; ♀: 143)	1.600 meters running/ walking test	AAHPERD[54]	Total: 13.1% (n= 43) Sex ♂: 11.5% (n =22) ♀: 14.7% (n =21)
Coledam et al.[77] Coledam et al.[78] Coledam and Ferraiol[79]	10-17	736 (♂: 367; ♀: 369)	20 meters shuttle run	FitnessGram[44]	Total: 44.2% (n=326) Sex ♂: 56.9% (n=209) ♀: 31.7% (n=117)

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Author(s), year	Age range	Sample that did the CRF test	Physical test used	Reference for cut-point	Prevalence of fit individuals (Absolute frequency)
Costanzi et al.[80]	7-12	1.413 (♂: 714; ♀: 699)	9-minute run/walk test	PROESP-BR[46]	Total: 41.0% (n=564)
Dorea et al.[18]	7-12	342 (♂: 182; ♀: 160)	9-minute run/walk test	Physical Best[54]	Total: 13.2% (n=45) Sex ♂: 15.0% (n=23) ♀: 14.0% (n=22)
Gaya et al.[15]	7-17	310 (♂: 160; ♀: 150)	9-minute run/walk test	PROESP-BR[49]	Baseline Total: 57.3% (n=178)
Glaner et al.[19]	10,5- 17,5	♂: 721	1.600 meters running/ walking test	AAHPERD[54]	Total: 61.6% (n=444)
Gonçalves and Silva[20] Gonçalves and Silva[82] Lima and Silva[84]	14-19	879 (♂: 415; ♀: 464)	Canadian modified aerobic fitness test - mCAFT	CSEP[55]	Total: 12.5% (n=110) Sex ♂: 14.7% (n=61) ♀: 10.6% (n= 49)
Gonçalves and Silva[81]	14-19	84 (♂: 35; ♀: 49)	Canadian modified aerobic fitness test - mCAFT	CSEP[55]	Total: 16.7% (n=14) Sex ♂: 31.4% (n=11) ♀: 6.1% (n=03)
Guedes et al.[21] Guedes et al.[83]	6-18	2.849 (♂: 1.392; ♀: 1.457)	20 meters shuttle run	FitnessGram[41] FitnessGram[44]	Total: 38.0% (n=1.085) Sex ♂: 44.1% (n=614) ♀: 32.3% (n=471)
Mello et al.[24] Pereira et al.[32]	10-17	1.250 (♂: 663; ♀: 587)	9-minute run/walk test	PROESP-BR[a]	Total: 25.9% (n=324) Sex ♂: 31.7% (n=210) ♀: 19.4% (n=114)
Luguetti et al.[22]	7-16	3145 (♂: 1590; ♀: 1555)	9-minute run/walk test	PROESP-BR[47]	Total: 51.0% (n=1605) Sex ♂: 52.0% (n=827) ♀: 50.0% (n=778)
Mascarenhas et al.[23]	7-10	81	9-minute run/walk test	PROESP-BR[50]	Total: 70.4% (n=57)
Fronza et al.[69] Minatto et al.[25] Minatto et al.[26]	10-17	277 (♂: 145; ♀: 132)	20 meters shuttle run	FitnessGram[44]	Total: 67.8% (n=188) Sex ♂: 72.5% (n=105) ♀: 63.1% (n=83)
Minatto et al.[27]	10-17	♀: 1,223	20 meters shuttle run	FitnessGram[45]	Total: 48.7% (n=596)
Nascimento et al.[28]	10-11	269 (♂: 118; ♀: 151)	1.600 meters running/ walking test	AAHPERD[54]	Total: 29.4 % (n= 79) Sex ♂: 13.6% (n=16) ♀: 41.7% (n= 63)
Nogueira and Pereira[29]	11-16	344 (♂: 236; ♀: 108)	9-minute run/walk test	PROESP-BR[48]	Total: 54.4 % (n= 187) Sex ♂: 53.0% (n=125) ♀: 57.4 % (n= 62)
Oliveira et al.[61] Silva et al.[60]	10-14	1,081 (♂: 545; ♀: 536)	9-minute run/walk test	AAHPERD[52]	Total: 7.5% (n=81) Sex ♂: 11.2% (n=61) ♀: 3.7% (n=20)
Paludo et al.[30]	10-12	115 (♂: 61; ♀: 54)	9-minute run/walk test Ergospirometry on a treadmill	Physical Best[54] FitnessGram[45]	Total: 25.2% (n=29) Sexo ♂: 24.6% (n=15) ♀: 26.0% (n=14) Total: 24.3% (n=28) Sex ♂: 24.6% (n=15) ♀: 24.1% (n=13)

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Author(s), year	Age range	Sample that did the CRF test	Physical test used	Reference for cut-point	Prevalence of fit individuals (Absolute frequency)
Pelegrini et al.[9]	7-10	7,507 (♂: 4,114; ♀: 3,393)	9-minute run/walk test	Physical Best[54]	Total: 20.6% (n=1.550) Sex ♂: 19.2% (n=790) ♀: 22.4% (n=760)
Pereira et al.[31]	14-17	308 (♂: 177; ♀: 131)	9-minute run/walk test	PROESP-BR[49]	Total: 24.7% (n=76) Sex ♂: 16.9% (n=30) ♀: 35.1% (n=46)
Minatto et al.[65] Petroski et al.[66] Petroski et al.[33] Silva et al.[67]	14-17	627 (♂: 266; ♀: 361)	1.600 meters running/ walking test	Physical Best[54]	Total: 64.6% (n = 405) Sex ♂: 64.7% (n=172) ♀: 64.5% (n=233)
Petroski et al.[70] Silva et al.[71] Silva et al.[72]	15-19	696 (♂: 264; ♀: 432)	Canadian modified aerobic fitness test - mCAFT	CSEP[55]	Total: 68.5% (n=477) Sex ♂ 50.8% (n=134) ♀ 79.4% (n=343)
Reis et al.[85]	7-17	2,335 (♂: 1,033; ♀: 1,302)	9-minute run/walk test	PROESP-BR[51]	Total: 46.6% (n=1.087) Sex ♂: 58.1% (n =600) ♀: 37.4% (n =487)
Reuter et al.[38]	7-17	1,243 (♂: 563; ♀: 680)	9-minute run/walk test	PROESP-BR[49]	Total: 49.2% (n=611)
Ronque et al.[34]	7-10	511 (♂: 274; ♀: 237)	9-minute run/walk test	Physical Best[54]	Total: 29.4% (n=150) Sex ♂: 27.0% (n =74) ♀: 32.0% (n =76)
Ronque et al.[86]	15	78 (♂: 45; ♀: 33)	20 meters shuttle run	FitnessGram[41]	Total: 50.0% (n=39) Sex ♂: 42.2% (n =19) ♀: 60.6% (n =20)
Sakamoto et al.[39]	15-17	55 (♂: 31; ♀: 24)	20 meters shuttle run	Leger and Lambert[58]	Total: 62.0% (n=34) Sex ♂: 54.8% (n =17) ♀: 70.8% (n =17)
Serassuelo Junior et al.[35]	11-12	235 (♂: 108; ♀: 127)	9-minute run/walk test	AAHPERD[54]	Total: 18.7% (n=44) Sexo ♂: 15.0% (n =16) ♀: 22.0% (n =28)
Schubert et al.[40]	8-16	401 (♂: 236; ♀: 165)	9-minute run/walk test	PROESP-BR[50]	Total: 55.4% (n=222)
Silva et al.[36]	14,5-15,5	258 (♂: 122; ♀: 136)	1.600 meters running/ walking test	AAHPERD[54]	Total: 35.7% (n=92) Sex ♂: 37.7 % (n =46) ♀: 33.8% (n =46)
Silva et al.[16]	14-16	86 (♂: 41; ♀: 45)	1.600 meters running/ walking test	AAHPERD[54]	Baseline Total: 38.4% (n=33) Sex ♂: 38.3% (n=16) ♀: 37.5% (n=17)
Silva et al.[88]	14-17	601 (♂: 269; ♀: 332)	20 meters shuttle run	FitnessGram[43]	Total: 54.2% (n=326)

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Author(s), year	Age range	Sample that did the CRF test	Physical test used	Reference for cut-point	Prevalence of fit individuals (Absolute frequency)
Souza et al.[89]	11-13	282 (♂: 136; ♀: 146)	20 meters shuttle run	FitnessGram[41]	Total: 55.0% (n= 156) Sex ♂: 44.0% (n=60) ♀: 66.0% (n=96)
Silva et al.[87]	11-17	1,550 (♂: 759; ♀: 863)	20 meters shuttle run	FitnessGram[41]	Total: 38.6% (n=598)
Silva et al.[68]	14-17	601 (♂: 269; ♀: 332)	20 meters shuttle run	FitnessGram[42]	Total: 10.6% (n=64) Sex ♂: 10.0% (n =27) ♀: 11.1% (n=37)
Silva et al.[10]	6-9	11,083 (♂: 5,937; ♀: 5,146)	9-minute run/walk test	AAHPERD[52]	Total: 16.0% (n=1,771) Sex ♂: 14.5% (n=861) ♀: 17.7% (n =911)
Straatmann and Veiga[63] Straatmann et al.[64]	12-19	639 (♂: 250; ♀: 389)	9-minute run/walk test	PROESP-BR[48]	Total: 24.1% (n = 154) Sex ♂: 23.4% (n = 59) ♀: 24.4% (n = 95)
Valente et al.[90]	14-17	377 (♂: 210; ♀: 167)	1.600 meters running/ walking test	AAHPERD[52]	Total: 64.7% (n=244) Sex ♂: 64.7% (n = 136) ♀: 64.5% (n = 108)
Vasques et al.[37]	10-15	963 (♂: 450; ♀: 513)	20 meters shuttle run	FitnessGram[41]	Total: 48.1% (n = 463) Sex ♂: 32.0% (n = 144) ♀: 62.2% (n = 319)
Total	6-19	49,093† (♂: 26,284; ♀: 25,358)	Field tests: 20 meters shuttle run 1.600 meters running/ walking test 9-minute run/walk test 6-minute run/walk test Degrau Canadian modified aerobic fitness test - mCAFT	Different propositions	Total: 32.2%* (n=15.789) Sex ♂: 27.7%* (n = 7.291) ♀: 28.4%* (n = 7.195)

Note. ♂ male; ♀ women; $\overline{x}$: median; PROESP: Project Sports Brazil; CRF: cardiorespiratory fitness; CSEP: Canadian Society for Exercise Physiology; AAHPERD: American Alliance for Health Physical Education Recreation and Dance; a without reference because the article does not include the year of the cut-point of PROESP-BR; * value calculated based on the following equation: [(number of subjects with adequate aerobic fitness/number of subjects in the total sample) * 100]; † sum of the total sample of the studies collected, without stratifying by sex - for the studies that only investigated one of the two sexes, the value of the sample was computed in the sex-specific information.

Table 4. Cut points of the PROESP-BR[48,49], AAHPERD[54] and Fitnessgram[44] for children and adolescents stratified according to sex and age

Age (years)	PROESP-BR[48] 9-minute run/walk test (m)	PROESP-BR[49] 9-minute run/walk test (m)	AAHPERD[54] 9-minute run/walk test (m)	FITNESSGRAM[44] 20 meters shuttle run ($VO_{2máx}$)
Boys				
5	-	-	≥1.069.85	Participation in the running
6	-	-	≥1.170.43	Participation in the running
7	≥1069	≥1.082	≥1.316.74	Participation in the running
8	≥1137	≥1.120	≥1.458.47	Participation in the running
9	≥1202	≥1.230	≥1.517.90	Participation in the running
10	≥1264	≥1.260	≥1.545.34	≥40.2
11	≥1322	≥1.290	≥1.577.34	≥40.2
12	≥1376	≥1.352	≥1.609.34	≥40.3
13	≥1427	≥1.417	≥1.723.64	≥41.1

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Age (years)	PROESP-BR[48] 9-minute run/walk test (m)	PROESP-BR[49] 9-minute run/walk test (m)	AAHPERD[54] 9-minute run/walk test (m)	FITNESSGRAM[44] 20 meters shuttle run ($VO_{2máx}$)
14	≥1472	≥1.487	≥1.788.57	≥42.5
15	≥1513	≥1.556	≥1.853.49	≥43.6
16	≥1548	≥1.574	≥1.918.41	≥44.1
17	≥1577	≥1.535	≥1.983.33	≥44.2
17+	-	-	≥1.983.33	≥44.3
Girls				
5	-	-	≥1.042.42	Participation in the running
6	-	-	≥1.104.60	Participation in the running
7	≥997	≥992	≥1.228.95	Participation in the running
8	≥1042	≥1.040	≥1.241.76	Participation in the running
9	≥1082	≥1.100	≥1.303.02	Participation in the running
10	≥1115	≥1.111	≥1.335.02	≥40.2
11	≥1141	≥1.140	≥1.353.31	≥40.2
12	≥1160	≥1.150	≥1.453.90	≥40.1
13	≥1171	≥1.160	≥1.442.01	≥39.7
14	≥1174	≥1.171	≥1.476.76	≥39.4
15	≥1174	≥1.188	≥1.511.50	≥39.1
16	≥1174	≥1.155	≥1.546.25	≥38.9
17	≥1174	≥1.110	≥1.581.00	≥38.8
17+	-	-	≥1.581.00	≥38.6

PROESP-BR: Project Sports Brazil; AAHPERD: American Alliance for Health, Physical Education, Recreation and Dance; m: meters.

DISCUSSION

This study indicated that, between 2005 and 2017 (period of publications of articles included in this systematic review), the prevalence of children and adolescents in Brazil meeting the health criteria for CRF was 32.2% (the highest prevalence of 70.4% in the city of Lapa, Paraná, and the lowest prevalence of 7.5% in the city of Criciúma, Santa Catarina). These differences in the prevalence of CRF adequate for health can be explained by the variation in the CRF assessment protocols and by the variation in cut-points for CRF classification[91].

We emphasize the variety of tests used by studies to evaluate CRF (6-minute walk/run test, 9-minute walk/run test, treadmill ergospirometry, mCAFT test and 20-meter shuttle-run test) being considered submaximal[70-72,81,82,84] and maximal tests[9,10,15-40,58,60-69,73-80,83,85-90] in a direct[30] or indirect way[9,10,15,17-40,58.60-70.72-80.83.85-90].

The use of submaximal protocols to estimate VO_2peak has less precision than maximum protocols[92]; however, they are more practical to apply in samples with greater number of individuals[93]. Direct methods are more accurate when compared to indirect methods, but in addition to the high cost, there is need for specialized personnel for the application of tests and time spent with each individual, so they are less used[92], as observed in this review.

The variability of the different protocols used in studies of this review makes it difficult to compare results, considering that each method used to estimate CRF can produce different results due to different construct validity levels[2,5,8]. Treadmill protocols, for example, result in VO_2peak approximately 9% higher than cycle ergometer protocols[94]. Furthermore, the same test may have different parameters. The 20-meter shuttle-run test (used by 19 studies of the 60 included) allows the analysis of performance by number of laps, predicted VO_2peak and CRF stages. The question as to which estimate (VO_2peak or number of laps) should be used seems to be frequent among researchers[95]. In addition, there are at least five prediction equations available to estimate VO_2peak using the 20-meter shuttle-run test[2,5,8]. Even when applied to the same collective test, such as the 20-meter shuttle-run test, test performance can be altered by the level of motivation and competitive spirit among students, which may also influence the results[37]. Therefore, cautious interpretation of results is necessary.

It is possible to make evaluative decisions through two types of references: references by norms and references by criterion. This discrepancy in cut-points to classify subjects with adequate or inadequate CRF levels was also found in this review. The norm-based evaluative decision (usually presented in percentage tables) makes it possible to compare the performance of individuals with pairs (same sex and age)[8]. For example, a 12-year-old adolescent who had VO_2peak estimate of 30 mL/kg/min can be analyzed by means of a percentage table, if that value was higher or lower when compared to other adolescents in the same age group. However, it is not possible to determine from these normative standards if the VO_2peak value of 30mL/kg/min is considered good or not for a healthy CRF zone. Therefore, evaluation referenced by criterion becomes more appropriate in the approach of indicators directed to health, considering that this type of reference does not aim to indicate individuals regarding the position they occupy in the group, but to the position in relation to the cut-point to ensure better health levels[96]. On the other hand, the norm-referenced evaluation is useful when the purpose is to establish comparisons among individuals by information presented by the group to which they belong, thus allowing a precise identification of the magnitude of inter-subjective differences that may arise[96].

Among the 60 studies included in this review, seven different cut-points were identified; the most used were references by PROESP-BR[49] (three studies) and FITNESSGRAM[44] criteria (seven studies); and references by PROESP-BR[48] (three studies) and AAHPERD[54] standards (six studies). Systematic review of standards referenced by criteria for CRF identified 10 different patterns for children and adolescents, which produced different percent estimates of healthy CRF[8]. Thus, when analyzing a 17-year-old adolescent who has walked 1,535 meters in the 9-minute walk/run test, for PROESP-BR[49] criteria, this adolescent is in the healthy CRF zone. However, analyzing this same adolescent by the AAHPERD[54] cut-points, there would still be an additional 448.33 meters (approximately 30% more) of the

test course for this adolescent to have aerobic performance considered good for health (Box 4). Therefore, when interpreting the results of motor tests using analysis referenced by criterion, it is necessary to take into account that the same value, produced by the same subject at the same time, can receive different judgment if analyzed before another cut-point proposal, which emphasizes the need for standardization of classification criteria.

Despite the fact that the northern region of Brazil is considered the largest region of the country (covering seven states), only one study was developed in this region, and the concentration of research development occurred in the southern region (39 studies). In fact, there is concentration of greater scientific development in the southeastern and southern regions of Brazil and scarcity in the northern region[97]. The southeastern and southern regions of Brazil accounted for more than three-quarters of the total Brazilian scientific production in the period between 2007 and 2009, while the northern and midwestern regions together did not reach 10% of the national total[97]. Regional inequality in scientific production is closely associated with the marked disparities in the distribution of scientific and technological resources[98]. In this context, the southeastern and southern regions of Brazil are favored by the concentration of historically consolidated universities and research institutes[99] and the greater availability of human and financial resources[100].

When analyzing the prevalence of healthy CRF levels separated by Brazilian regions, it was observed that studies carried out in the northeastern region presented variation from 13.1% to 54.4%[29]. For the southeastern region, the variation was from 24.1% to 64.6%. However, the region that presented the largest variation was the southern region, with the lowest prevalence of 7.5% and the highest of 70.4% of healthy CRF levels. Brazil is a country with continental dimension that has different ethnicities and different socio-cultural and behavioral aspects from one region to another[101]. For example, when analyzing self-reported skin color, 22.6% and 70.3% of adolescents living in the northern region are white and brown/black skin color, respectively, while in the southern region, only 30.8% of adolescents described themselves as brown/black and 64.1% white[102]. When healthy eating habits are analyzed, 70.3% of adolescents in the southeastern region reported eating healthy foods five days or more a week. The prevalence of healthy eating habits for young people in the northern region is almost half (39.3%). In addition, physical activity is practiced on a regular basis (greater than or equal to 150 minutes per week) by approximately 67% of adolescents in the southern region, and for adolescents in the northeastern region, prevalence decreases by almost 10% (54.6%). All these factors (skin color, healthy eating habits and regular practice of physical activity) influence CRF[20,81]. For these reasons, comparisons between the prevalence of CRF levels should be interpreted with caution[2,5,8].

This systematic review identified some gaps in Brazilian studies. Among the 60 included studies, 11 studies had low methodological quality regarding the instrument used[13]. The methodological quality of studies is

of great relevance for the systematic review, as it influences the magnitude of results. When quality is not adequate, the results may become untrue, hampering the completion of the review[103]. It was observed that most studies did not use sexual maturation (51 studies) and level of physical activity (40 studies) as control variables in CRF data analyses. These variables directly influence CRF levels in children and adolescents[60].

This systematic review has some limitations that should be considered. First, the included studies are heterogeneous in terms of age, sample size and cut-points to evaluate CRF. This heterogeneity, together with potential confounders, such as maturational stage and level of physical activity of adolescents, may have partially affected the results. Second, some studies did not present the prevalence of CRF in the total sample or stratified by sex. Therefore, these values were calculated by the authors of these studies, which may have affected the results.

The present review was carried out in a systematic way, with the use of six different databases, including studies that were rigorously reviewed in pairs through a tool to analyze their methodological quality, which allows verifying aspects of internal and external validity. In addition, this research did not stipulate specific period of publication of results, which could suggest publication bias, depending on the period of publication. In addition, this review gathered data on the prevalence of healthy CRF of 49,093 Brazilian participants during the entire phase of childhood and adolescence (zero to 19 years), making it possible to compare Brazilian results with other countries of different cultures and customs, helping researchers of the health area in the screening of the pediatric population at risk if CRF is considered as a health measure.

The results of this study help complement standards referenced by criterion on CRF, especially in children and adolescents, who are likely to have healthy aerobic performance. Together, normative reference standards and standards referenced by criterion could be used in physical education and other health research areas to screen pediatric populations at risk and to compare the aerobic performance of children and adolescents in different settings, different populations, and different times. In addition, repeated measurements in the same population could identify temporal trends of CRF. In fact, time trends can help monitor the impact of policies implemented to improve CRF and the overall health of a given population and can help predict the health of future generations.

On average, three out of ten Brazilian adolescents presented healthy CRF. Six different tests to evaluate CRF and eight different reference criteria were used by studies, and years (and data) of the most commonly used reference criteria were also different. The region with the highest and lowest concentration of studies on the prevalence of CRF was the southern and northern regions, respectively.

The monitoring and standardization of CRF guidelines should be performed to provide a uniform interpretation of CRF among children and adolescents. Consistent and periodic CRF monitoring could help

guide and evaluate health promotion policies and interventions aimed at reducing physical inactivity and encouraging regular physical activity and healthy behaviors to improve the general health of the population. The school environment is the most conducive for the promotion of physical activity, considering that the physical education class is the main way to create habits associated with health improvement and maintenance[104].

COMPLIANCE WITH ETHICAL STANDARDS

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Conflict of interest statement

The authors have no conflict of interests to declare.

Author Contributions

DASS is the principal investigator and conceived the idea of the manuscript. ECAG, CASAJ, HEGN draft of the first version of the paper and made the extractions of the data. MCS provided substantial contributions to the conception of the study. All authors read and approved the final manuscript.

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