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Flexibility of Brazilian children and adolescents: a systematic review of the literature

Flexibilidade de crianças e adolescentes brasileiros: uma revisão sistemática da literatura

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Abstract – Flexibility is related to specific tissue properties of the body, which aim to determine the maximum range of motion of the joints without injury. This study aimed to identify and summarize the evidence on prevalence of adequate levels of flexibility in Brazilian children and adolescents (6 to 19 years old). We performed a systematic search of studies published from 2009 to 2019 in six databases (MEDLINE/PubMed; Scopus; SportDiscus; LILACS; Web of Science; SCIELO). Fourteen studies that compiled data from 11,666 participants in seven different Brazilian states were included. All studies conducted sit and reach tests to assess flexibility. Among all the children and adolescents in the analyzed studies, 58.9% of the total (62.0% of boys and 50.9% of girls) had adequate flexibility. We conclude that more than half of Brazilian children and adolescents have adequate flexibility for health.

Key words: Adolescent; Physical fitness; Child; Flexibility.

Resumo – *A flexibilidade está relacionada com propriedades específicas teciduais que permitem a amplitude máxima de movimento articular sem a presença de lesão. O presente estudo teve como objetivo identificar e sintetizar as evidências sobre a prevalência de níveis adequados de flexibilidade em crianças e adolescentes brasileiros (6 a 19 anos). Foi realizada uma busca sistematizada de estudos publicados de 2009 a 2019 em seis bases de dados (MEDLINE/PubMed; Scopus; SportDiscus; LILACS; Web of Science; SCIELO). Foram incluídos 14 estudos que compilaram dados de 11.666 participantes em sete estados brasileiros diferentes. Todos os estudos realizaram teste de sentar e alcançar para avaliar a flexibilidade. Dentre todas as crianças e adolescentes dos estudos analisados, 58,9% do total (62,0% dos meninos e 50,9% das meninas) apresentaram flexibilidade adequada. Concluímos que mais da metade das crianças e adolescentes brasileiros possuem flexibilidade adequada para a saúde.*

Palavras-chave: *Adolescente; Aptidão física; Criança; Flexibilidade.*

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INTRODUCTION

Flexibility is related to specific tissue properties of the body, which aim to determine the maximum range of joint movement without the presence of injury[1]. The American College of Sports Medicine (ACSM)[2] describes the importance of flexibility for athletic performance, but also for everyday life activities. Moreover, ACSM considers flexibility a part of the health-related components of physical fitness[2].

Flexibility may vary according to factors determined by internal characteristics related to the individual's development (i.e., tissue morphology, age) and external characteristics (i.e., level of physical activity or practice of a specific sports modalities)[3]. In general, male adolescents have higher levels of flexibility in more advanced puberty when compared to females, who, in turn, have higher levels in terms of absolute values. However, regardless of sex and puberty, children and adolescents should be encouraged to achieve optimal levels of flexibility, given that it affects the quality of daily activities with autonomy, through actions such as maintaining correct posture, reducing stress on the joints, and improved performance in motor activities[4].

In this context, it is necessary to characterize levels of flexibility of Brazilian children and adolescents since this component of physical fitness is strongly associated with daily activities. Moreover, the evidence summarized may help physical education teachers, sports trainers, and policymakers to create opportunities and interventions targeting flexibility improvement. Thus, the aim of this systematic review was to analyze the evidence in the literature on the levels of flexibility in Brazilian children and adolescents, updating the evidence previously published by the Report Card Brazil project[5].

METHODS

This systematic review is part of the Global Matrix 4.0 initiative of the Active Healthy Kids Global Alliance[6] based on the "Report Card Brazil: Health Indicators for Children and Adolescents (3rd edition)" project, which updates a previous systematic review by expanding the number of bibliographic databases, the search strategy, and the temporal window of published articles. Details about the Brazil's Report Card 4.0 protocol may see in Open Science Framework[7].

This systematic review was carried out from October 30, 2020, to November 30, 2020, through searches in some databases of the scientific literature. As databases used for research were: Medical Literature Analysis and Retrieval System Online (MEDLINE) through PubMed; Scopus; SportDiscus; Latin American and Caribbean Literature in Health Sciences (LILACS); Web of Science; and Scientific Electronic Library Online (SCIELO).

Search strategy

For the search and selection of potential studies, we used the advanced search strategy of the respective databases, in addition to specific filters available in each database. The terms or "keywords" were placed in three blocks. These words

or terms should appear at least in the title or abstract of the study. Boolean operators were used for the advanced search. The "OR" operator was used to add at least one term from each block and the "AND" operator had the function of associating the blocks of terms and keywords with each other. The operator "NOT" was used to eliminate studies that did not correspond to the purpose of the study. The asterisk (*) was used to represent words with more characters that could be plural or similar.

Block 1 covered the terms related to the population and age group of the study (6 to 19 years): Child; Teen; Adolescent; Youth. Block 2 corresponded to the main indicator of the study, flexibility, containing the terms: Flexibility; pliability; range of movement; stretching; Physical Fitness; Fitness Test; shoulder stretch. A third block was added to eliminate articles with an adult population.

All searches were performed on October 28, 2020, by two pairs of reviewers (NAR/TRST and LRAL/BCAM) using descriptors in Portuguese and English. The articles had to be published between 2009 and December 2019. For this systematic review, only original articles were considered. Information contained in dissertations/theses, communications/works in scientific events, and research protocols were not considered for the present study.

Study selection

After searching the electronic databases, potential articles were imported into a bibliographic reference manager (Endnote X6® software [Philadelphia, USA]) and duplicate articles were excluded. The selection process was carried out by two pairs of reviewers (NAR/TRST and LRAL/BCAM) and a third researcher (GF) was called when there were discrepancies and need for resolution. After initially checking the title and abstract, the articles were read in full. Only articles that met the criteria for the indicator studied here were considered for the final report (Figure 1).

Data collection process

Information about authorship, year of publication, study site, sample size, and percentage of participants by sex and age group was extracted from eligible studies by two reviewers (EE and JZ), and a third reviewer (GF) solved the discrepancies. In addition, information was extracted regarding the flexibility tests used, cutoff points, and the total prevalence of participants that met the flexibility criteria, stratified by sex and their classifications, if available.

Eligibility criteria

The inclusion criteria were original studies involving Brazilian children and adolescents (6 to 19 years old) that measured flexibility and reported the interpretation of adequacy of this physical fitness component to health criteria in order to estimate prevalence of participants. Studies of any design (observational or intervention) published in Portuguese, English, or Spanish from January 2009 to December 2019 were considered when they reported baseline data.

Studies were excluded if: 1) the issue was outside the scope of this review; 2) participants were younger (< 6 years) or older (> 19 years); 3) they involved participants of nationalities other than Brazilian; 4) children and adolescents had chronic conditions (HIV infection, congenital heart disease, cancer or chromosomal abnormalities), or were athletes. Studies such as narrative and systematic reviews, case reports, monographs, dissertations, and theses were also excluded.

Risk of bias assessment

Risk of bias and methodological quality were assessed (ECM) using the instrument proposed for cohort and cross-sectional studies of the National Heart, Lung and Blood Institute[8]. This instrument allows the evaluation of the internal validity of the studies, in answers of "yes = 1" and "no = 0" in 14 questions to identify the possible risk of selection bias, information, measurement and confounding factors, classifying them as possible. the final score at 0.70: low risk of bias; ≥ 0.50: moderate risk of bias; <0.50 high risk of bias.

RESULTS

The systematic search for studies that investigated the levels of flexibility in Brazilian children and adolescents retrieved a total of 9,796 articles, of which 2,546 were excluded as being duplicated titles, and 7,084 articles were excluded after assessment by titles and abstracts. Then, a total of 163 articles were select to full-text review, and 149 articles were excluded after criteria assessment (outside the scope of this review, n = 117; Children and Adolescents with chronic condition, n = 25; non-Brazilian sample, n = 17, participants outside the age group, n = 04). Finally, 14 articles remained selected and eligible in proposed inclusion criteria. Figure 1 shows the flowchart of the search of this systematic review.

Fourteen studies were included for the present systematic review with publication dates ranging from 2009 to 2019. Of this total, six studies were conducted in the South region of Brazil (Paraná, n = 4; Santa Catarina, n = 1; Rio Grande do Sul; n = 1)[9-14]; four studies, in the Southeast region (São Paulo, n = 01; Minas Gerais, n = 03)[15-18]; and three studies, in the Northeast region (Sergipe n = 1; Pernambuco n = 1, Ceará; n = 1)[19-21]. Additionally, one study was conducted in the South and Southeast regions (São Paulo and Paraná)[22].

Thus, this review included 11,666 participants (male, n= 4,593, female, n = 7,064). Regarding the age group participants, six studies were carried out with children and adolescents in the range of 6 to 18 years of age (n = 7,252). Seven studies exclusively showed participants aged over 10 years (n = 4,061)[11-13,18,19,21,22] and one study was conducted only with participants aged under 10 years old (n = 344)[20]. With regard the participants' sex, thirteen studies were conducted with male and female children and adolescents, and one study assessed the flexibility of only female participants (n = 2,604)[10]. The detailed information of each study is in the Table 1.

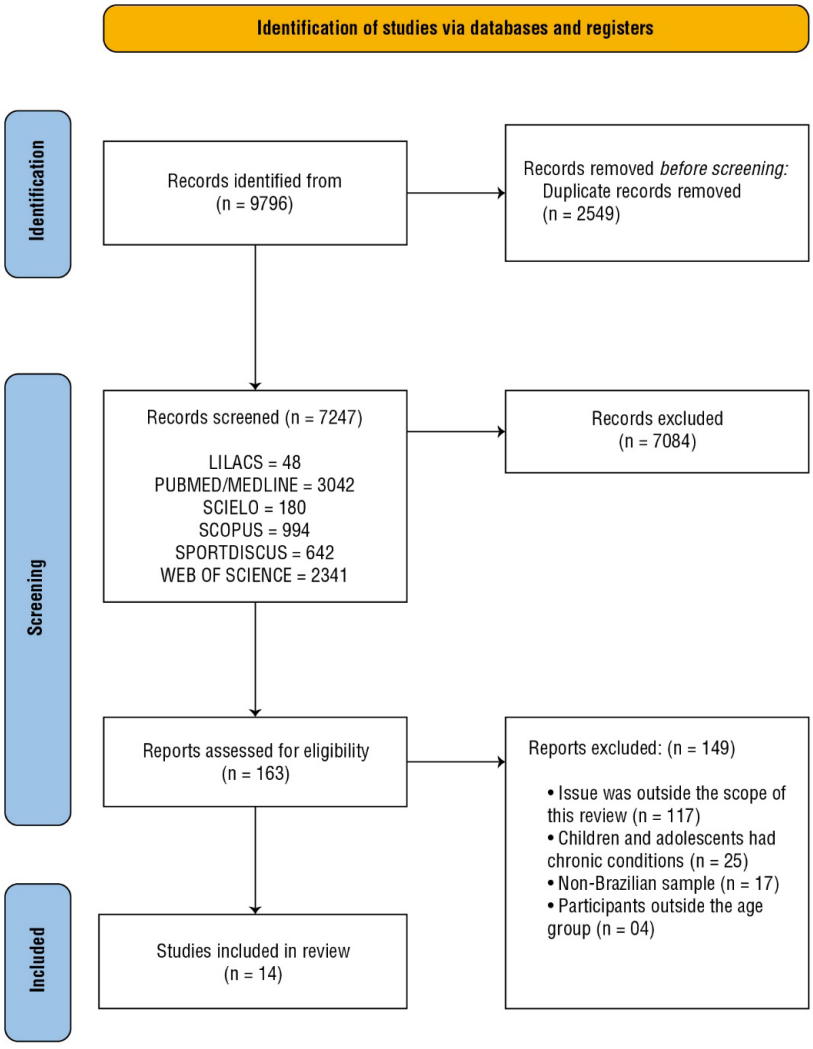

Figure 1. Flowchart of the search process results according PRISMA.

Table 1. Studies included on the present review (n=14) on flexibility in Brazilian children and adolescents, Brazil, 2020.

Author, year	City - State	Both n	Female % (n)	Male % (n)	Age
Andreasi et al.[15], 2010	Botucatu - SP	946	47.1 (446)	52.9 (500)	7 to 15 yr
Arruda e Oliveira[9], 2012	Londrina - PR	113	47.8 (54)	52.2 (59)	8 to 16 yr
Castro e Oliveira[19], 2016	Aracaju - SE	326	43.9 (143)	56.1 (183)	15 to 18 yr
Guedes et al.[16], 2012	Montes Claros - MG	2849	51.1 (1457)	48.9 (1392)	6 to 18 yr
Lima et al.[22], 2018	Sudoeste - SP e Norte - PR	387	56.8 (220)	43.2 (167)	12 to 15 yr
Martins-Costa et al.[17], 2015	Belo Horizonte - MG	250	50.0 (125)	50.0 (125)	7 to 15 yr
Minatto et al.[10], 2010	Cascavel - PR	2604	100.0 (2604)	-	8 to 17 yr
Minatto et al.[11], 2016	São Bonifácio - SC	277	47.7 (132)	52.3 (145)	10 to 17 yr
Nobre et al.[20], 2020	Vitória de Santo Antão - PE	499	49.1 (245)	50.9 (245)	7 to 10 yr
Nogueira e Pereira[21], 2014	Fortaleza - CE	344	31.4 (108)	68.6 (236)	11 to 16 yr
Pereira et al.[12]	Uruguaiana - RS	1455	50.9 (741)	49.1 (714)	10 to 17 yr
Petroski et al.[18], 2011	Januária - MG	627	57.6 (361)	42.4 (266)	14 to 17 yr
Pires-Júnior et al.[13], 2018	Londrina - PR	588	44.7 (263)	55.3 (325)	12 to 17 yr
Schubert et al.[14], 2016	Londrina - PR	401	41.1 (165)	58.9 (236)	8 to 16 yr

Note. n: sample size.

Prevalence of adequate flexibility in Brazilian children and adolescents and the type of physical fitness battery used are shown in Table 2. All studies conducted sit and reach tests to assess flexibility. Five studies evaluated the flexibility through in the Projeto Esporte Brasil (PROESP-BR®)[12,14,15,21,22], three studies used the Fitnessgram®[11,16,20], and two studies were carried out with the American Alliance for Health, Physical Education, Recreation and Dance (AAHPERD®)15,16. Only one study was conducted both Physical Best and Fitnessgram battery6. Overall, the mean percentage of participants with adequate flexibility levels was 58.92% (34.5-71.8%), of which 60.14% (36.3-73.1%) are female participants and 62.14% (33.6-76.9%) are male participants. Additionally, one study did not show the results of flexibility test separated by sex[14].

Table 2. Prevalence of adequate flexibility in Brazilian children and adolescents, Brazil, 2020.

Authors	Physical Fitness Battery*	% Who meets criteria of adequate flexibility		
		Both % (n)	Male %(n)	Female % (n)
Andreasi et al.[15]	PROESP-BR	71.6 (677)	71.0 (355)	72.2 (322)
Arruda e Oliveira[9]	PHYSICAL BEST / FITNESSGRAM	68.1 (77)	71.2 (42)	64.8 (35)
Castro e Oliveira[19]	AAHPERD	67.7 (221)	58.5 (107)	76.9 (110)
Guedes et al.[16]	FITNESSGRAM	67.9 (1930)	72.3 (1006)	63.4 (924)
Lima et al.[22]	PROESP-BR	65.9 (255)	61.7 (103)	69.1 (152)
Martins-Costa et al.[17]	Sit-and-reach test*	43.6 (109)	53.6 (67)	33.6 (42)
Minatto et al.[10]	Sit-and-reach test*	65.2 (1698)	-	65.2 (1698)
Minatto et al.[11]	FITNESSGRAM	59.3 (166)	73.1 (106)	45.5 (60)
Nobre et al.[20]	FITNESSGRAM	47.5 (237)	54.7 (134)	42.0 (103)
Nogueira e Pereira[21]	PROESP-BR	71.8 (247)	67.8 (160)	80.6 (87)
Pereira et al.[12]	PROESP-BR	66.9 (913)	63.4 (453)	74.4 (551)
Petroski et al.[18]	AAHPERD	59.2 (371)	60.9 (162)	57.6 (208)
Pires-Júnior et al.[13]	Sit-and-reach test*	34.5 (203)	36.3 (93)	36.5 (110)
Schubert et al.[14]	PROESP-BR	35.7 (143)	NR	NR

Note. *All studies used the sit and reach test, citing the original protocol (*Wells and Dillon, 1952*)[23] or fitness battery. NR: not reported; n: sample size; PROESP-BR: Projeto Esporte Brasil; FITNESSGRAM: AAPHERD: American Alliance for Health, Physical Education, Recreation and Dance.

Regarding the evaluation of the methodological quality/risk of bias of studies covered in this review, the score ranged from 0.5 (moderate risk of bias) to 0.8 (low risk of bias), of which eight studies showed low risk of bias[10,12,14,16,18-21] while six studies showed moderate risk[9,11,13,15,17,22]. Some questions (i.e., follow-up rate of individuals included) were not evaluated due to the design of studies included in this review (Table 3).

DISCUSSION

This systematic review summarizes studies about flexibility from Brazil containing field-based health-related tests that can be performed by children and adolescents (6 to 18 years) and are used to verify health status. We found that 58.9% (n = 7.247) of Brazilian children and adolescents had adequate flexibility levels, which 50.9% are female and 62.0% are male participants. Four different flexibility batteries were identified; however, Fitnessgram® and PROESP-BR® battery are the most used in the studies included. This

Table 3. Risk of bias assessment in the studies included on the systematic review on flexibility in Brazilian children and adolescents, Brazil, 2020.

Reference	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Final Score	Classification
Andreasi et al.[15]	1	1	0	1	0	0	NA	NA	1	NA	1	0	NA	1	0.6	Moderate risk of bias
Arruda e Oliveira[9]	1	1	0	1	0	0	NA	NA	1	NA	1	0	NA	0	0.5	Moderate risk of bias
Castro e Oliveira[19]	1	1	1	1	1	0	NA	NA	1	NA	1	0	NA	1	0.8	Low risk of bias
Guedes et. al.[16]	1	1	1	1	1	0	NA	NA	1	NA	1	0	NA	1	0.8	Low risk of bias
Lima et al.[22]	1	1	0	1	0	0	NA	NA	1	NA	1	0	NA	0	0.5	Moderate risk of bias
Martins-Costa et al.[17]	1	1	0	1	0	0	NA	NA	1	NA	1	0	NA	0	0.5	Moderate risk of bias
Minatto et al.[10]	1	1	1	1	1	0	NA	NA	1	NA	1	0	NA	1	0.8	Low risk of bias
Minatto et al.[11]	1	1	0	1	0	0	NA	NA	1	NA	1	0	NA	0	0.5	Moderate risk of bias
Nobre et al.[20]	1	1	1	1	1	0	NA	NA	1	NA	1	0	NA	1	0.8	Low risk of bias
Nogueira e Pereira[21]	1	1	1	1	1	0	NA	NA	1	NA	1	0	NA	1	0.8	Low risk of bias
Pereira et al.[12]	1	1	1	1	1	0	NA	NA	1	NA	1	0	NA	1	0.8	Low risk of bias
Petroski et al.[18]	1	1	1	1	1	0	NA	NA	1	NA	1	0	NA	0	0.7	Low risk of bias
Pires-Júnior et al.[13]	1	1	0	1	0	0	NA	NA	1	NA	1	0	NA	1	0.6	Moderate risk of bias
Schubert et al.[14]	1	1	1	1	1	0	NA	NA	1	NA	1	0	NA	0	0.7	Low risk of bias

Note. Q1. Was the research question or objective in this paper 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 paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?. Q7. Was the timeframe 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 continuous variable)?. Q9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?. Q10. Was the exposure(s) 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 exposure(s) and outcome(s)?; 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, we considered the following equation: (total of positive answers / total of questions considered for that study).

knowledge can be useful for selecting standardized and validated flexibility tests and batteries in children and adolescents.

Among children and adolescents, flexibility is associated with numerous health outcomes, thus assessing flexibility has been suggested to be a reliable tool to monitor health in youth[24]. Of studies included in this systematic review, only three[10,13,17] addressed flexibility as the main objective; the others focused on different dimensions of physical fitness. According to Marques et al.[25], flexibility was the least represented physical fitness components in the batteries, notwithstanding they were present in at least 50% of the identified physical fitness batteries. Consequently, flexibility studies have been neglected in papers, and among health-related physical fitness variables, flexibility presents a minor number of published manuscripts[26]. Our results show the need for further studies addressing flexibility as the main point of surveillance in children and adolescents, since this is an essential component for maintaining the capacity to achieve tasks of daily life[27].

Regarding the differences between sexes, it was identified in studies that girls present better flexibility absolute levels when compared with boys; however, boys have a greater proportion of children and adolescents who reach the health criteria for flexibility[12,15,17,19,21]. Corroborating this finding, the study by Tomkinson et al.[28] identified higher flexibility levels for girls when compared to boys among children and adolescents from 30 European countries. While the underlying causes of the sex-specific differences are clear for flexibility, there is a need for longitudinal cohort studies to better understand what mechanisms drive sex-specific and age-specific differences in physical fitness throughout childhood and adolescence[28].

With regard to the ratio of children and adolescents meeting health criteria, it may be clarified by the cultural perspective in which there is a greater involvement of boys in the practice of physical activity when compared with girls[29], since the regular practice of physical activity is linked to the improvement of health-related physical fitness variables[30,31].

Although all studies used the same test to assess flexibility (sit and reach), four studies followed the Fitnessgram® standardization[9,11,16,20], assessing one leg at a time, while five studies followed standardization of the test used in the PROESP-BR®[12,14,15,21,22]. This may be due to the fact that the Fitnessgram® is one of the most widely used for assessing flexibility in children and adolescents, because it is easy to implement in population surveillance studies, it has a low operational cost, short duration, and provides important contextual information about physical fitness levels[32,33]. In this sense, Fitnessgram® is the most accepted at the international level; however, it should be highlighted that most studies used PROESP-BR®[12,14,15,21,22], which was generated with the objective of evaluating patterns of body composition, nutritional status, health-related physical fitness, and athletic performance in Brazilian children and adolescents, and is a particular reference for the standardization of responses obtained in children and adolescents in Brazil.

This review presents issues that should be different: 1) instruments used for evaluation; 2) Cut-off points and agreements between the studies with the methods and analyzes used, a fact that makes it difficult to compare more accurate results on the flexibility of the sample; 3) the moderate risk of bias in most of the selected articles. Despite the main data analysis of the literature,

this review summarized and made systematic search into the main bases of the literature performed the search in different languages.

In conclusion, more than a half of children and adolescents of both sexes had adequate flexibility levels to health criteria. We recommend the use of flexibility tests to allow a better evaluation of physical fitness and health in different scenarios of physical activity and sports practice since flexibility is an important component for athletic performance and activities of daily life. Cut-off points by age should be more explored in the future and the subject in different Brazilian regions, thus comprising genetic, environmental aspects and studies that may interfere in cities.

COMPLIANCE WITH ETHICAL STANDARDS

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Ethical approval

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

Conflict of interest statement

The authors have no conflict of interests to declare.

Author Contributions

Participated in the analysis, interpretation and writing of the work: TRST, ECM, BCAM, NAR; Participated in the collection of information, analysis and interpretation, literature survey and critical review: EES, ISZ, JZS, ERV; Participated in the conception and development, methodological design, supervision, data collection, analysis and interpretation, writing and critical review: LRAL and GF.

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