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# Structure for the practice of physical activities in Brazilian schools, Human Development Index and Basic Education Development Index: contributions to the Report Card Brazil

## *Estrutura para a prática de atividades físicas nas escolas brasileiras, Índice de Desenvolvimento Humano e Índice de Desenvolvimento da Educação Básica: contribuições para o Report Card Brasil*

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**Abstract –** The purpose of this study was to identify structures for the practice of physical activities (PA) in Brazilian Schools and relate them to the Human Development Index (HDI), Basic Education Development Index (IDEB) and quality indicators from the Report Card Brazil (RCB). This is a descriptive study that used secondary data from INEP-Brazil to identify and classify structures for the practice of PA in Brazilian schools based on the presence of "schoolyards", "sports courts" and "sporting materials", organized by elementary and high schools. Data were organized by Macroeconomic Region and related to HDI, IDEB and Report Card Brazil Quality Classification Criteria. Thus, for "Elementary School", positive and significant relationship was observed between HDI and the presence of "schoolyards" (r=0.53; p=0.004), "sports courts" (r=0.855; p<0, 01) and "sporting materials"(r=0.764; p<0.01), while for IDEB, values followed the same logic, associated to the presence of "schoolyards" (r=0.475; p=0.01), "sports courts" (r=0.676; p<0.01) and "sporting materials" (r=0.535; p<0.01). For "High School", relationship was observed between HDI and the presence of "sports courts" (r=0.517; p<0.01) and "sporting materials" (r=0.499; p<0.01), while for IDEB, relationship was only observed with the presence of "sporting materials" (r=0.508; p<0.01). It could be concluded that the Northern and Northeastern regions of Brazil have schools with lower presence of structure for the practice of Physical Activity and that there is positive relationship of this structure with HDI, IDEB and quality indicators of the Report Card Brazil.

**Key words:** School environment; Adolescents; Physical activity; Development indicators.

**Resumo –** *O objetivo do estudo foi identificar as estruturas para atividades físicas (AF) nas escolas brasileiras e relacioná-las ao Índice de Desenvolvimento Humano (IDH), Índice de Desenvolvimento da Educação Básica (IDEB) e indicadores de qualidade do Report Card Brasil (RCB). Trata-se de estudo descritivo que utilizou dados secundários do INEP-Brasil para a identificação e classificação da estrutura para prática de AF nas escolas brasileiras, a partir da existência de "pátio", "quadras" e "materiais esportivos", organizadas por escolas do nível "fundamental" e "médio". Os dados foram organizados por Região Macroeconômica e relacionados com os Índices IDH, IDEB e os Critérios de Classificação de Qualidade do RCB. Assim, para o "Ensino Fundamental", verificou-se relação positiva entre o IDH e a existência de "pátio" (r=0,53; p=0,004), "quadra" (r=0,855; p<0,01) e material esportivo (r=0,764; p<0,01), o IDEB também apresentou relação positiva com a existência de "pátio" (r=0,475; p=0,01), "quadra esportiva" (r=0,676; p<0,01) e "material esportivo" (r=0,535; p<0,01). Para o "Ensino Médio", verificou-se relação entre o IDH e a existência de quadras (r=0,517; p<0,01) e materiais esportivos (r=0,499; p < 0,01), enquanto para o IDEB, apenas houve relação com a existência de materiais esportivos (r=0,508; p<0,01). Conclui-se que as Regiões Norte e Nordeste possuem escolas com menores frequências de estrutura para Atividade Física e que há relação positiva desta estrutura com o IDH, IDEB e classificação de qualidade RCB.*

**Palavras-chave:** *Ambiente escolar; Adolescentes; Atividade física; Indicadores de desenvolvimento.*

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## INTRODUCTION

The school represents an important space for the promotion of physical and sports activities among children and adolescents[1,2]. The presence of spaces that provide opportunities for these practices is a fundamental component for the adoption of a physically active behavior, and therefore its maintenance, throughout adult life[3].

Therefore, understanding the importance of the school structure as an indicator that provides opportunities for the practice of physical, sporting and leisure activities, allows organization and government actions to encourage PA and combat sedentary lifestyles among young people[4,5]. In Brazilian states, greater adherence to physical activity is associated with higher human development indexes (HDI)[6], which may reflect, among other elements, the population's access to education and health[7,8].

Among the relevant aspects for the indicative variation of human development, the length of stay in school and the health conditions of students stand out[7]. Behaviors such as a sedentary lifestyle or low levels of physical activity are harmful to health, a situation that can be mitigated through strategies related to the deliberate practice of physical activity in the school environment and strategies that encourage its practice outside this environment. In this sense, in addition to the school environment, actions to encourage the practice of physical activities in neighborhoods and squares should be considered, with community programs that favor the reduction of sedentary behavior and the increase in physical activity levels in this group. Therefore, improve the quality and quantity of the school structure and the increase in the stimulation of physical activities in the extra-school period can also favor the adoption of active behaviors by adolescents[9].

In addition to HDI, considering school conditions in Brazil, there is also the Basic Education Development Index (IDEB), an indicator that measures the quality of national education and aims to establish goals for improving education[8]. As criteria for its formulation, IDEB uses standardized exams (Mathematics and Portuguese), including school performance and school flow, which are represented by the pass rate and the length of stay in school[10]. Based on the understanding that the practice of Physical Activities, by the adolescent, provides improvements in motor and cognitive learning, improving school performance, and reducing the rates of obesity and other chronic-degenerative diseases. Therefore, it is assumed that the school environment, by having an adequate structure for the regular practice of physical activities, favors the adolescent's development in several aspects, which is perpetuated in adult life[11].

Therefore, detailed investigations about the type of space and its condition of use and maintenance, especially in schools, can facilitate assertive interventions regarding the regular practice of physical activities for school-age children and adolescents[12,13], likewise, when considering the absence of environmental support[14] and the lack of equipment allied to the HDI[6], it appears that the chances of reducing the levels of physical activity can be increased in this group[15,16]. Exploring the structure for the practice of physical activities and relating them to local indicators of human development can promote public policies that improve the conditions of school structures.

Based on the above, this work aims to identify the presence of structures for the practice of physical activities in Brazilian schools and relate them to the Human Development Index, Basic Education Development Index and quality indicators of the Report Card Brazil.

# METHOD

This is a descriptive study based on secondary data made available by the Anísio Teixeira National Institute of Educational Studies and Research[10], data from IBGE – IDH[17] and from IDEB-SAEB[10]. The variables under study are characterized in Box 1.

**Box 1.** Analytical table for the characterization and categorization of regional variables in Brazil, school structure, human development index, Basic Education development index and Report Card Brazil.

| VARIABLES | CHARACTERIZATION | CATEGORIES |
|---|---|---|
| Brazilian Regions | Division carried out by IBGE identifying five areas with similar characteristics. It consists of the grouping of states and municipalities into regions with the purpose of enabling the definition of a territorial base for the purposes of surveying and disseminating statistical data and subsidizing the planning and management of public policies at federal and state levels | Northern (N)<br>Northeastern (NE)<br>Midwestern (MW)<br>Southeastern (SE)<br>Southern (S) |
| Schools with Schoolyard | Indoor or outdoor space surrounded by construction elements, with area that allows the performance of recreational or other activities, connected to other spaces and to the outside through corridors, entrances or porticoes | (Yes) - The school has schoolyard<br>(No) - The school does not have schoolyard<br>For correlation analysis, data were quantitatively computed. |
| Schools with sports court | Schools with indoor or outdoor sports court prepared for the performance of certain sports practices, such as basketball, tennis, volleyball, futsal, among others | Yes) - The school has a sports court<br>(No) - The school does not have a sports court<br>For correlation analysis, data were quantitatively computed. |
| Presence of Sporting Materials | Materials for physical education and sports practices (balls, cones, volleyball net, basketball hoop, among others) | (Yes) - The school has materials for PE and sports<br>(No) - The school does not have materials for PE and sports<br>For correlation analysis, data were quantitatively computed. |
| Human Development Index - HDI | Unit of measurement used to assess the degree of development of a given society in terms of education, health and income | For this work, the value was considered in a continuous way. |
| Basic Education Development Index - IDEB | INEP's initiative to measure the performance of the Brazilian educational system based on the combination of proficiency obtained by students in large-scale external assessments (SAEB-basic education assessment system) and the pass rate (school flow). Both measures reflect structural problems in basic education in Brazil. | For this work, the value was considered in a continuous way. Ranging from 0 to 10. IDEB projects goals for Brazilian Basic Education by macro and micro-regions and by level of education. Currently, the Brazilian target for 2021 is 5.5 and 5.2 for elementary and high schools |
| Report. Card | Initiative of Brazilian researchers to map indicators related to PA in Brazil divided into 4 dimensions: daily behaviors, health outcomes, sources of influence and government strategies and investment. | A - Success with the vast majority of children and adolescents<br>B - Success with more than half of children and adolescents<br>C - Success with about half of children and adolescents<br>D - Success with less than half of children and adolescents<br>E - Success with few childrenand adolescents<br>F - Failure |

## School structure

In this study, school structure was characterized based on official data provided by INEP, which are presented in a crude manner, distributed according to the administrative dependence of the School Unit (Federal School, State School and Private School). These data indicate the "presence" and "absence" of spaces identified as: "schoolyard", "sports court" and "sporting materials", as shown in Table 1.

## Report Card Brazil

The quality indicators presented by the 2018 Report card Brazil[18] were used to identify the global variation of indicators that promote PA in children and adolescents in the school environment. The percentages of schools by regions and states that have "schoolyard", "sports court" and "sporting materials" vary from 'A' to 'F', as shown in Box 2.

**Box 2.** Categorization of the school structure in percentage levels.

| GRADE | Percentage of schools with structure for the practice of PA |
|---|---|
| A+ | 94-100 |
| A | 87-93 |
| A- | 80-86 |
| B+ | 74-79 |
| B | 67-73 |
| B- | 60-66 |
| C+ | 54-59 |
| C | 47-53 |
| C- | 40-46 |
| D+ | 34-39 |
| D | 27-33 |
| D- | 20-26 |
| F | <20 |

## Human development index – HDI

For the year 2010, HDI was obtained from data provided by the Brazilian Institute of Research and Statistics for Brazilian States[19], and in this work, the average was calculated by regions of Brazil, emphasizing that HDI has the following development categorization: 0-0.499: Very low; 0.5-0.599: Low; 0.6-0.699: Medium; 0.7-0.799: High; 8.0-1.0: Very High, according to UNDP, 2016.

## Basic education development index – IDEB

IDEB is considered an educational parameter used to identify the quality of Brazilian schools and in this study, it was considered an important variable, as it is through this Indicator that public policies are planned and implemented

to improve the conditions of Brazilian schools, which includes infrastructure for the practice of Physical Activities.

## Data analysis

Results were analyzed from raw data presented in the official reference documents, which were organized according to the Brazilian region and categorized according to quality indicators of the 2018 Report Card Brazil[15] in order to show the quality of the structures of School Units, according to each Brazilian region. Pearson's linear correlation was also applied to verify the relationships between educational quality (IDEB) and human development (HDI) indicators and structures present in School Units for each region of the country.

# RESULTS

The aim of this study was to identify the presence of structures for the practice of physical activities in Brazilian schools and relate them to the Human Development Index, Basic Education Development Index and quality indicators presented by the Report Card Brazil.

According to results, it was verified that Brazil has 126,168 schools distributed into the five Brazilian Regions, and the characterization of spaces destined to the practice of PA and sports are represented in Table 1.

According to Table 1, elementary schools in the Northern and Northeastern regions have "schoolyard" [51.26% (95%CI: 29.12-73.4)]; [70.61% (95%CI: 61.37-79.85)], "sports court" [26.47% (95%CI: 12.87-40.07)]; [24.74% (95%CI: 18.04-31.45)] and "sporting materials" [42.17% (95%CI: 24.01-60.33)]; [42.27% (95%CI: 36.67-49.86)], respectively, in smaller proportions compared to other regions of the country. With regard to high schools, the Northern region presents lower values for variable 'sporting materials' [57.33% (95%CI: 41.26-73.43)], compared to the other studied spaces.

Table 2 shows that the Brazilian IDEB had average score of 4.9 and 4.2 for elementary schools and high schools, respectively. For both education levels, this indicator is below the average in the Northern and Northeastern regions of the country. With regard to HDI, it appears that the Northern (0.684) and Northeastern (0.666) regions have lower values when compared to the Midwestern (0.753), Southeastern (0.754) and Southern (0.756) regions, which are above the HDI indicator for Brazil (0.723).

Table 3 also indicates correlation between HDI and IDEB, with "schoolyard" (r=0.532; p<0.001); (r=0.475; p=0.001), "sports court" (r=0.855; p<0.001); (r=0.676; p<0.001) and "sporting materials" (r=0.764; p<0.001); (r=0.534; p<0.001), respectively, in elementary schools, and it was identified that, for high schools, there are moderate correlations between HDI and the presence of a multi-sports court (r=0.517; p<0.001) and sporting materials (r=0.499; p < 0.001), with IDEB being related only to the presence of sporting materials (r=0.508; p < 0.001)

**Table 1.** Characterization of the sample considered in the study, by region of the country, according to the study variables

| | Variables | N (n=18987) | *95%CI* | NE (n=49240) | *95%CI* | MW (n=7324) | *95%CI* | SE (n=35476) | *95%CI* | S (n=15141) | *95%CI* | Brazil (n=126168) | *95%CI* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Elementary schools | Schoolyard | 8092 (51.26%) | *(29.12-73.4)* | 32714 (70.61%) | *(61.37-79.85)* | 6433 (88.7%) | *(81.2-96.0)* | 30984 (86.02%) | *(77.08-94.95)* | 11928 (78.8%) | *(61,8-95.8)* | 90151 (71.5%) | *(63.59-79.42)* |
| | Sports court | 4072 (26.47%) | *(12.87-40.07)* | 11523 (24.74%) | *(18.04-31.45)* | 4678 (68.75%) | *(48.31-89.19)* | 23907 (62.3%) | *(43.79-80.81)* | 11928 (71.8%) | *(56,6-87,0)* | 56108 (42.5%) | *(33.1-51.91)* |
| | Sporting materials | 7159 (42.17%) | *(24.01-60.33)* | 19058 (42.27%) | *(36.67-49.86)* | 5478 (74.18%) | *(63.78-84.57)* | 27792 (69.5%) | *(59.29-79.71)* | 12326 (78.8%) | *(67,8-89.8)* | 71813 (55.06%) | *(47.25-62.88)* |
| | IDEB | 4.4 | - | 4.5 | - | 5.1 | - | 5.2 | - | 5.1 | - | 4.9 | - |
| | Variables | N (n=2490) | *95%CI* | NE (n=7123) | *95%CI* | MW (n=2195) | *95%CI* | SE (n=12421) | *95%CI* | S (n=4505) | *95%CI* | Brazil (n=28734) | *95%CI* |
| High schools | Schoolyard | 1915 (78.27%) | *(58.7-97.84)* | 5040 (77.83%) | *(65.2-90.47)* | 2065 (90.76%) | *(81.87-99.63)* | 11334 (90.8%) | *(87.30-94.3)* | 3093 (65.1%) | *(31,1-99,1)* | 23447 (80.37%) | *(73.25-87.48)* |
| | Sports court | 1711 (63.49%) | *(46.03-80.95)* | 4419 (60.91%) | *(52.61-69.22)* | 1852 (82.93%) | *(60.27-105.58)* | 10517 (72.92%) | *(48.4-97.4)* | 3414 (73.77%) | *(53,8-93.7)* | 21913 (68.05%) | *(61.17-74.92)* |
| | Sporting materials | 1377 (57.33%) | *(41.26-73.43)* | 4584 (66.4%) | *(50.94-81.86)* | 2027 (83.6%) | *(79.93-87.27)* | 10447 (83.25%) | *(82.26-85.39)* | 3515 (77.37%) | *(57,9-96,8)* | 21950 (70.4%) | *(63.22-77.58)* |
| | IDEB | 3.6 | - | 3.9 | - | 4.4 | - | 4.4 | - | 4.4 | - | 4,2 | - |
| | IDH | 0.684 | | 0.666 | | 0.753 | | 0.754 | | 0.756 | | 0.723 | - |

Notes: N: Northern Region. NE: Northeastern Region. MW: Midwestern Region. SE: Southeastern Region. S: Southern Region. IDEB: Basic Education Development Indicator. HDI: Human Development Index. 95%CI: 95% Confidence Interval.

**Table 2.** Report card categorization of Brazilian schools in macro and micro regions of Brazil by elementary and high schools.

| Regions of Brazil/ States | ELEMENTARY SCHOOLS | | | | | HIGH SCHOOLS | | | |
|---|---|---|---|---|---|---|---|---|---|
| | HDI | IDEB | % Schools with schoolyard | % Schools with sports court | % schools with sporting materials | IDEB | % Schools with schoolyard | % Schools with sports court | % schools with sporting materials |
| **Northern** | **0.684** | **4.4** | **C** | **D-** | **D+** | **3.6** | **B+** | **B** | **C+** |
| Tocantins | 0.699 | 4.7 | A- | C- | B | 4 | A | B+ | A- |
| Pará | 0.646 | 4.1 | C- | D- | D+ | 3.4 | A- | A- | C |
| Amapá | 0.708 | 4 | B- | D- | C- | 3.4 | B+ | B- | B- |
| Roraima | 0.707 | 4.3 | C- | D- | D | 3.9 | B- | C | D+ |
| Rondônia | 0.69 | 4.9 | B+ | C | B- | 4.3 | A | A- | A- |
| Acre | 0.663 | 4.9 | D- | F | F | 3.9 | A+ | D | C- |
| Amazonas | 0.674 | 4.6 | D- | F | D | 3.6 | D+ | C+ | C |
| **Northeastern** | 0.666 | **4.5** | **B-** | **D-** | **D+** | **3.9** | **B** | **B-** | **B-** |
| Alagoas | 0.631 | 4.7 | B+ | D- | C- | 3.9 | A+ | C+ | B+ |
| Bahia | 0.66 | 4.1 | B | D- | C- | 3.5 | C | B | B- |
| Ceará | 0.682 | 5.4 | A- | C- | C- | 4.4 | A- | B+ | A- |
| Maranhão | 0.639 | 4.2 | C | F | F | 3.8 | B | D+ | C- |
| Paraíba | 0.658 | 4.3 | B- | D- | C- | 4 | B+ | C+ | D |
| Pernambuco | 0.673 | 4.8 | B- | D- | C- | 4.5 | C+ | B | B |
| Sergipe | 0.665 | 4.1 | A | D | C+ | 3.7 | A+ | B- | A- |
| Rio Grande Norte | 0.684 | 4.1 | B | D- | C | 3.5 | A- | C+ | B- |
| Piauí | 0.646 | 5 | B | D- | C- | 4 | A- | C+ | A |
| **Midwestern** | 0.753 | **5.1** | **A** | **B-** | **B+** | **4.4** | **A** | **A-** | **A-** |
| Goiás | 0.735 | 5.3 | A | C+ | B+ | 4.8 | A- | B | A- |
| Mato Grosso | 0.725 | 4.8 | B+ | C+ | B+ | 3.6 | A- | B | A- |
| Mato Grosso Sul | 0.729 | 4.8 | A+ | A- | B- | 4.2 | A+ | A | A- |
| Distrito Federal | 0.824 | 5.1 | A | B+ | B+ | 4.5 | A | A+ | A- |
| **Southeastern** | **0.754** | **5.2** | **A** | **B** | **B+** | **4.4** | **A** | **A-** | **A-** |
| Minas Gerais | 0.731 | 4.9 | A- | B- | B | 4.2 | A | B+ | A- |
| Espírito Santo | 0.74 | 5 | A- | C | B | 4.8 | A | D+ | A- |
| São Paulo | 0.783 | 5.5 | A | B+ | C+ | 4.6 | A | A | A- |
| Rio de Janeiro | 0.761 | 4.9 | A | C+ | B | 4.1 | A | A- | A- |
| **Southern** | **0.756** | **5.1** | **B+** | **B** | **A-** | **4.4** | **B** | **B+** | **B+** |
| Rio Grande do Sul | 0.746 | 4.8 | B- | C+ | B | 4.2 | D+ | C+ | C+ |
| Santa Catarina | 0.774 | 5.1 | A- | B | B+ | 4.2 | B- | B | A- |
| Paraná | 0.749 | 5.3 | A | A- | A | 4.7 | A+ | A | A |

**Table 3.** Relationship between school structure variables by level of education, Human Development Index and Basic Education Development Indicator in Brazil.

| | School spaces | Economic indicators | |
|---|---|---|---|
| | | HDI | IDEB |
| Elementary schools | *Schoolyard* | 0.532 *(p=0.004)* | 0.475*(p=0.01)* |
| | *Sports court* | *0.855(p<0.001)* | 0.676* *(p<0.001)* |
| | *Sporting materials* | 0.764 (*p<0.001*) | 0.534 (*p<0.001*) |
| High schools | *Schoolyard* | 0.113 (*p=0.574*) | *0.223 (p=0.265)* |
| | *Sports court* | 0.517* *(p<0.001)* | 0.291 (*p=0.141*) |
| | *Sporting materials* | 0.499 *(p<0.001)* | 0.508* (*p<0.001)* |

## DISCUSSION

The main results show that the Midwestern, Southeastern and Southern regions of Brazil had higher frequency of schools with better structure for the practice of physical activities, when compared to the other regions. Another finding was the positive relationship between reference indexes (HDI and IDEB) and all aspects listed in the physical structure of schools, showing high relationship between physical structure and elementary schools. About the quality indicators of the structure of School Units adopted by the Report Card Brazil, the behavior, by macroeconomic region, was similar to the HDI and IDEB behavior.

The different HDIs in the Brazilian regions also reflect the results of the analysis of structures for the practice of Physical Activity, and it has been verified in literature that increased HDI values are associated with decreased levels of physical inactivity[20]. In this sense, it is suggested that the Northern and Northeastern regions of the country, with lower HDI, are susceptible to lower levels of physical activity. According to results, higher prevalence of physical activity was found among adolescents in the Midwestern, Southern and Southeastern regions of Brazil[6].

Associations between environment and physical activity have been investigated in some studies[2,5,21,22] and reinforce the understanding that public policies are necessary and should be aimed at regional inequalities, especially in more vulnerable areas[23] in order to provide increased levels of physical activity among Brazilian adolescents[3].

This study also identified that the education quality indicator (IDEB) has positive relationship with structure for the practice of Physical Activity in elementary schools, with lower values in the Northern and Northeastern regions, when compared to the other regions of Brazil. This means that investments made in the structure of schools that provide opportunities for the practice of physical activity can lead to improvements in IDEB[24], and this index deserves attention, since educational investments in Brazil are based on the goals of this indicator.

Considering quality indicators for the school structure[18], it appears that the Northern and Northeastern regions have concepts between "B-" and "D-" regarding the presence of "sports court", "schoolyard" and "sporting materials" in elementary schools, indicating that half or less than half of children and adolescents in these regions have physical structure for the practice of Physical Activity in the school environment. It should be emphasized that spaces that favor practical experiences, in addition to promoting better learning outcomes, can provide adequate levels of Physical Activity for children and adolescents[18,25].

National and international surveillance studies[26-29] have compared regions in different countries around the world and reported that government investments should be prioritized in order to improve levels of physical activity among children and adolescents. Brazil has HDI considered high (0.723); however, about the Report Card quality indicators[18], it presents "C-" score for the 'community and environment' indicator, which includes structure for the practice of PA.

Data indicate that the amount of PA opportunities offered by schools is associated with the economic and developmental situation in which they are inserted; however, cultural elements are associated to the appreciation of sports

and Physical Activities, which can also be potential barriers or facilitators for this indicator[18].

As study limitation, it can be considered that in Brazil, some schools are both elementary and high schools, and the database used for this study is presented in a segmented way, not considering both levels of education, and data can be overlapped.

Likewise, the lack of criteria related to the condition, or not, of the use of physical structures considered by IDEB and scored in this research, promotes the understanding that their presence, as the only observation factor, due to their precariousness and consequent disuse can be a limiting factor in understanding the importance of PA practices in the school environment.

However, the quality of information and observations made allow for the elaboration of a scenario on the condition of physical structure for the practice of physical activity in Brazilian schools, favoring decision-making by public administrators.

This study showed that the Northern and Northeastern regions of Brazil have lower frequencies of physical structures aimed at the practice of physical activity, which has positive relationship with HDI and IDEB, especially when considering elementary schools. Thus, based on analyzed data, there is need to build basic structures necessary for the adequate practice of Physical Education in Schools, as this structure directly enables the practice in physical activities and reduces the sedentary behavior among children and adolescents.

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### Ethical approval

The article was written 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

Conceived and designed the experiments: RLP, AVF, MDJA, MCSR, RACS, RJSS; Performed the experiments: RLP, AVF, MDJA, MCSR, RACS, RJSS; Analyzed the data: RLP, AVF, MDJA, MCSR, RACS, RJSS; Contributed reagents/ materials/analysis tools: RLP, AVF, MDJA, MCSR, RACS, RJSS; Writing-review and editing: RLP, AVF, MDJA, MCSR, RACS, RJSS. All authors have read and agreed to the published version of the manuscript.

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