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Blood Pressure Assessment and Health-Related Physical Fitness in School-Aged Children

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ABSTRACT

The study aimed to evaluate blood pressure and health-related physical fitness among middle school students from São João dos Patos, Maranhão, contributing to the prevention of deleterious effects associated with COVID-19. The sample consisted of 118 children and/or adolescents, 67 males and 51 females, aged 10 to 15 years. Physical fitness was assessed using the *Programa Esporte Brasil* test battery, which includes cardiorespiratory endurance, flexibility, and abdominal endurance tests, in addition to blood pressure (BP) measurement using a professional arm-type BP monitor. Regarding cardiorespiratory endurance classification, 78% of boys and 70% of girls demonstrated poor cardiorespiratory capacity. Flexibility results showed that males exhibited a higher proportion of poor flexibility levels (25%) compared with females (20%). Furthermore, for abdominal endurance, 67% of boys and 51% of girls were classified as having poor abdominal strength. BP classification indicated that boys had a higher percentage of elevated BP (19.4%) than girls (15.7%). In addition, systolic BP was positively correlated with body weight (r = 0.46), although the correlation was considered weak. Overall, the study revealed a high prevalence of low physical fitness and increased risk of developing hypertension. Consequently, these individuals may be more susceptible to severe stages of COVID-19.

KEYWORDS: Physical fitness, Blood pressure, COVID-19, Child, Heath.

INTRODUCTION

At the end of 2019, five years ago, the world was taken by surprise by the emergence of a disease originating in China. Initially believed to be only a severe pneumonia caused by a new type of coronavirus, the infection rapidly spread across several countries. The virus was officially designated as SARS-CoV-2 by the International Committee on Taxonomy of Viruses (ICTV) and was declared a pandemic by the World Health Organization (WHO) on March 11, 2020, receiving the name coronavirus disease 2019 (COVID-19).[1-3]

Although COVID-19 primarily affected adults and older individuals, children and adolescents with comorbidities—such as chronic renal and pulmonary diseases, malignant disorders, diabetes, hypertension, obesity, sickle cell anemia, immunological disorders, chromosomal abnormalities, heart disease, and congenital malformations—were also at increased risk for developing severe clinical conditions.[4,5] In an attempt to contain viral transmission, governments worldwide imposed quarantine and lockdown measures as a primary strategy to mitigate the spread of COVID-19. Evidence from previous outbreaks of severe acute respiratory syndrome had already demonstrated the effectiveness of timely quarantine and isolation measures.[6,7]

Conversely, individuals began to experience chronically increased sympathetic nervous system activity, leading to persistent detrimental effects on the heart and blood vessels. The wide range of neurological manifestations and associated disorders linked to SARS-CoV-2 infection is consistent with multiple pathogenic pathways. Social isolation and loneliness have been associated with an increased risk of mortality and the development of major chronic diseases.[8] Specifically, social isolation is associated with a higher risk of mortality among patients with cardiovascular disease (CVD), affecting young people, adults, and the elderly with CVD in Brazil. In addition to disease-related factors, clinical and sociodemographic characteristics, as well as the presence of signs and symptoms, also contribute to mortality risk.[9]

Limited physical activity and the inability to engage in regular outdoor activities as a consequence of collective quarantine may induce several metabolic effects that increase cardiovascular risk. Moreover, chronic diseases preceding social isolation have been shown to influence physical activity levels by increasing sedentary time during the COVID-19 pandemic. Consequently, many beneficial metabolic and cardiovascular adaptations induced by regular physical exercise can be lost within as little as two weeks of inactivity, impairing aerobic capacity, reducing physical fitness, and/or increasing blood pressure (BP).[10]

BP is considered a relevant indicator of cardiovascular and metabolic health in humans. Children with elevated BP levels have a higher likelihood of becoming hypertensive adults; however, early monitoring and improved management of pediatric hypertension can reduce the risk of cardiovascular disease later in life.[11] Early diagnosis is, therefore, essential to prevent the progression of cardiovascular diseases caused by abnormal BP values.[12] Although it remains unclear whether uncontrolled BP increases susceptibility to COVID-19 or whether controlled BP reduces risk among hypertensive patients, several scientific organizations emphasize that BP control remains a crucial component for minimizing complications associated with the disease, regardless of its influence on viral susceptibility.[13]

Recent evidence shows that certain cardiovascular risk factors—such as hypertension—have become increasingly prevalent among adolescents, accompanying the rising rates of overweight, sedentary behavior, and inadequate dietary habits in this population. These conditions may also be influenced by genetic, epigenetic, environmental, and social factors.[14]

In this context, the present study aims to evaluate blood pressure and health-related physical fitness among middle school students from São João dos Patos, Maranhão, contributing to the prevention of deleterious effects associated with COVID-19.[15,16]

METHOD

This is a cross-sectional, quantitative study, with no possibility of inferring causality, conducted among middle school students of both sexes enrolled in public and private schools in the municipality of São João dos Patos, Maranhão, Brazil.

The target population consisted of students regularly enrolled in the selected schools during the data collection period. Recruitment was carried out through direct contact with school administrators, followed by informational meetings with students and parents or legal guardians. Eligible students were invited to participate after receiving detailed information about the study objectives, procedures, risks, and benefits.

Inclusion criteria comprised students who were officially enrolled in the participating schools and who returned both the Informed Assent Form and the Informed Consent Form (TALE/TCLE), duly signed by their parents or legal guardians.

Exclusion criteria included the use of medications acting on the central nervous or cardiovascular systems, and the presence of physical or mental disabilities that could interfere with the proposed assessments.

A schematic representation of the recruitment and inclusion process is recommended (Figure 1), including:

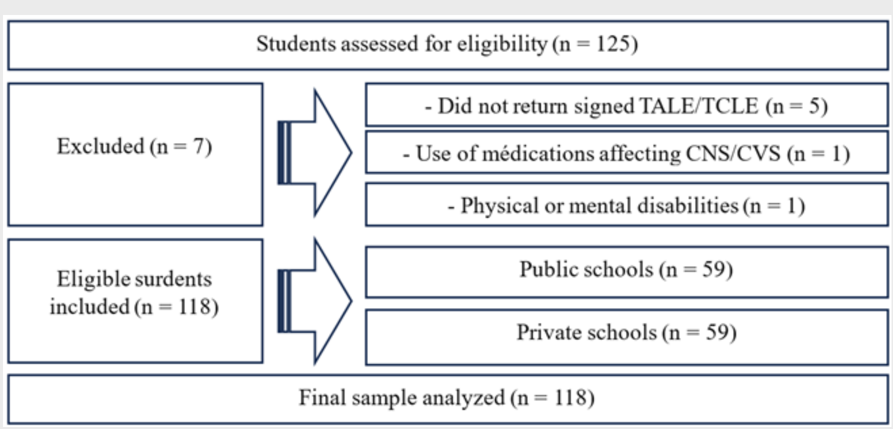

Figure 1. Flowchart of participant recruitment and inclusion (STROBE)

Ethical Considerations

The informed consent and assent forms clearly described the study objectives, justification, potential risks and benefits, and all procedures, in accordance with the ethical principles established by the Brazilian National Health Council. Participants were assured of their right to withdraw from the study at any time without penalty or consequences.

This investigation is part of a broader research project entitled *"Study of Blood Pressure and Health-Related Physical Fitness in Schoolchildren from São João dos Patos, Maranhão: Prevention of Deleterious Effects Associated with COVID-19"*, which was approved by the Research Ethics Committee under protocol number 4.372.043.

Data Collection Procedures

Physical fitness was assessed using the PROESP-BR physical fitness test battery, which includes measurements of Body Mass Index (BMI), flexibility, abdominal muscular endurance, and cardiorespiratory endurance.

Blood pressure and heart rate were measured using a professional arm-type oscillometric blood pressure monitor (HBP-1100, OMRON, USA), validated by the British Hypertension Society (BHS) and the European Society of Hypertension (ESH) for use in children and adolescents. An appropriately sized cuff was selected according to each participant's arm circumference, following manufacturer recommendations.

Participants rested for 5 minutes in a quiet environment, with legs uncrossed and the arm supported at heart level. All measurements were conducted in the morning, and no extreme values were observed in the sample.

Statistical Analysis

Data distribution was assessed using the Kolmogorov–Smirnov test for normality. Continuous variables were expressed as mean ± standard deviation. Comparisons between groups were performed using the chi-square test or Fisher exact test when appropriate, and Pearson's correlation coefficient was applied to examine associations between variables. A significance level of 5% ($p < 0.05$) was adopted. All statistical analyses were conducted using Sigma software (version 2010).

RESULTS

The study sample consisted of 118 children and/or adolescents, 67 males and 51 females, aged 10 to 15 years. Table 1 presents the sample characteristics according to sex and the variables analyzed. Both groups exhibited a similar age range; however, males demonstrated higher values of body weight, height, BMI, CR, flexibility, AE, and SBP, whereas females presented slightly higher DBP and heart rate HR when compared with males.

Table 1: Characterization of Study Variables

Variables	Male	Female
Sex (n)	67	51
Age (years)	12 ± 1.33	12 ± 1.28
Body weight (kg)	52.9 ± 15.31	48.0 ± 9.02
Height (m)	1.59 ± 0.11	1.55 ± 0.05
BMI (kg/m²)	20.6 ± 4.30	20.0 ± 3.13
CR (m)	734 ± 197.85	672 ± 122.41
Flexibility (cm)	36 ± 9.99	35 ± 8.96
AE (reps)	26 ± 8.43	23 ± 9.76
SBP (mmHg)	116 ± 14.91	113 ± 13.34
DBP (mmHg)	68 ± 10.07	69 ± 7.63
HR (bpm)	82 ± 13.43	91 ± 14.43

Data presented as mean ± standard deviation; BMI = Body Mass Index; kg = kilograms; m = meters; kg/m² = kilograms per square meter; CR = cardiorespiratory endurance; AE = abdominal endurance; SBP = systolic blood pressure; DBP = diastolic blood pressure; HR = heart rate; mmHg = millimeters of mercury; bpm = beats per minute; reps = repetitions; cm = centimeters.

Figure 2 illustrates the distribution of BMI classification by sex. Most boys (73.1%) and girls (76.5%) were classified within the healthy zone, compared with 26.9% and 23.5%, respectively, categorized in the risk zone. Notably, the proportion of girls in the healthy zone was slightly higher, whereas boys exhibited a slightly higher proportion in the risk category, however, no statistically significant differences were observed with p=0,90.

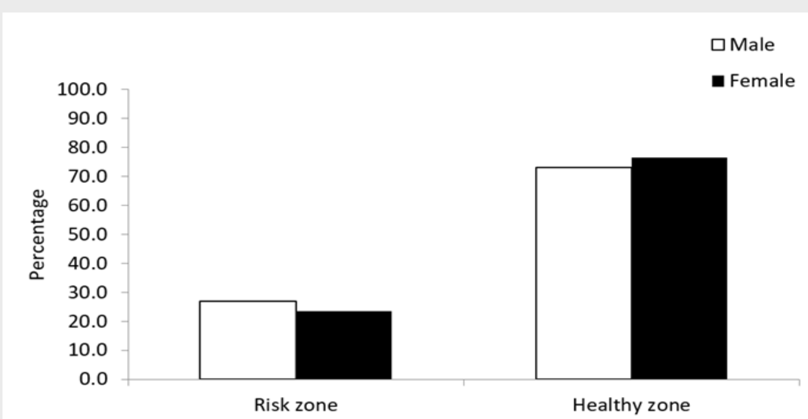

Figure 2. Classification of body mass index for both sexes. Fisher test evaluate group differences, with a significance level of $p > 0.05$.

As presented in Table 2, the majority of participants exhibited poor cardiorespiratory endurance, with 52 males (78%) and 36 females (70%), with no statistically significant difference between sexes ($p = 0.25$).

Data are presented as frequencies and percentages. Statistical analyses were performed using the chi-square test for flexibility and Fisher's exact test for cardiorespiratory endurance and abdominal endurance; all tests were applied to evaluate differences between groups.

Regarding flexibility, 18 males (27%) were classified as having fair flexibility, whereas 19 females (37%) demonstrated good flexibility, with a statistically significant difference between sexes ($p < 0.001$). With respect to abdominal endurance, the majority of males (44; 67%) and females (26; 51%) were again classified as having poor performance, with no statistically significant difference between groups ($p = 0.28$). Notably, none of the participants achieved an excellent classification in any of the three physical fitness components evaluated.

Figure 3 presents blood pressure classification, showing that boys had a higher prevalence of elevated blood pressure (19.4%) compared with girls (15.7%). In contrast, girls exhibited higher prevalences of stage I and stage II hypertension (19.6% and 7.8%, respectively). However, no statistically significant differences were observed between sexes ($p = 0.89$).

Table 2: Classification of cardiorespiratory resistance, flexibility and abdominal resistance of participants.

Classification	Cardiorespiratory endurance		Flexibility		Abdominal resistance	
	Male n (%)	Female n (%)	Male n (%)	Female n (%)	Male n (%)	Female n (%)
Poor	52 (78)	36 (70)	17 (25)	10 (20)	44 (67)	26 (51)
Fair	6 (9)	10 (20)	18 (27)	16 (31)	13 (19)	16 (31)
Good	8 (12)	4 (8)	16 (24)	19 (37)	7 (10)	5 (10)
Very Good	1 (1)	1 (2)	16 (24)	6 (12)	3 (4)	2 (4)
Excellent	-	-	-	-	-	2 (4)

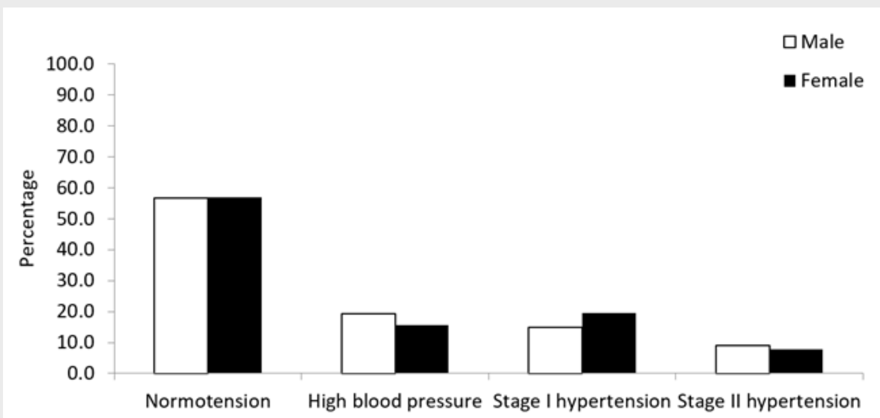

Figure 3. Distribution of Systolic and Diastolic Blood Pressure in the Sample. Data presented as frequency and percentage. Statistical analysis performed using the chi-square test evaluate sexes differences ($p > 0.05$).

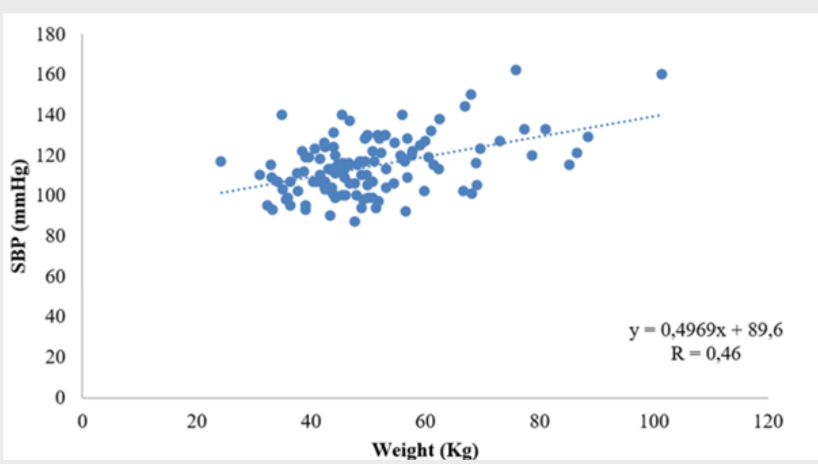

Figure 4. Relationship between participants' systolic blood pressure (SBP) and their weight.

Figure 4 shows the relationship between systolic blood pressure and body weight. Pearson's correlation indicated a positive but weak association between these variables (r = 0.46).

DISCUSSION

The present study found highly relevant results. Regarding BMI, 26.9% of male participants and 23.5% of female participants were classified in the risk zone. These findings are comparable to those reported by Oliveira et al.[17] in Campo Grande, MS, which indicated a concerning scenario: obesity prevalence was 22.2% among adolescents (15.8% and 29.4% in males and females, respectively) and 27.8% among young adults (27.3% and 28.6% for males and females, respectively). The prevalence of overweight was 38.9% among young adults and 13.9% among adolescents.[17]

In the analysis of cardiorespiratory endurance, 78% of boys and 70% of girls in the present study were classified as poor. In contrast, more positive results were reported by Peixoto, Borges, and Reichert,[18] who demonstrated an association between physical activity levels and cardiorespiratory fitness (CRF) across different time thresholds, indicating that accumulating at least 150 minutes of physical activity per week was sufficient to promote adequate CRF among adolescents.[18]

Based on the analyzed data, girls tended to exhibit lower values for cardiorespiratory aptitude. This may be explained by multiple factors, including motivation, cultural aspects related to movement practices, ethnic and psychological characteristics, and primarily physiological differences.

Additionally, 52% of boys exhibited poor or fair flexibility levels. However, Lima et al.,[19] in a study conducted in southern Santa Catarina, reported that for every additional centimeter of flexibility among girls, boys demonstrated 2.94 cm less. In that study, 54.2% of girls achieved positive flexibility performance.[19]

Recent studies have highlighted flexibility as an important component influencing quality of life in children and adolescents. Although girls generally demonstrate superior flexibility compared with boys, both sexes tend to reach satisfactory health-related classifications.

Another particularly relevant and concerning variable in this study is abdominal endurance. A total of 67% of boys and 51% of girls were classified as poor, which contrasts with the findings of Corrêa et al.[20], in which boys demonstrated significantly higher values than girls in the abdominal endurance test.[20] Similarly, Jesus et al.[21] found that fewer than half of Brazilian adolescents of both sexes exhibited adequate abdominal muscle endurance for health. The authors emphasize the importance of considering sex differences when evaluating lifestyle and physical fitness among adolescents.[22] They also highlight the need for research focused on investigating possible causes and consequences of low abdominal endurance, as this information can support public health strategies aimed at prevention and health promotion among children and adolescents.

Furthermore, the present study revealed that more than 35% of both male and female students had elevated blood pressure. However, in a cross-sectional epidemiological study conducted by Reuter et al.[22], only 16.2% of adolescents were classified as having elevated BP. These discrepancies may be related to age-specific characteristics, as older children tend to have greater height, which can contribute to increased BP levels.

Correlations between systolic blood pressure and body weight, as well as between diastolic blood pressure and weight, were positive but weak. In the study by Melo et al.[23], the prevalence of elevated BP was 48.8%, particularly among male adolescents, suggesting an association between excess weight and elevated BP.[23] In the same study, systolic BP demonstrated a strong correlation with BMI and waist circumference in male participants, while diastolic BP showed a weak correlation with these variables. These anthropometric parameters indicate that elevated BP is related to excess body weight and/or increased body fat.

Some limitations should be acknowledged. Blood pressure was measured only once and during a single period, which may have influenced results, as participants could have exhibited temporarily elevated BP due to the assessment context. Additionally, body composition was evaluated using BMI, which, although recommended for large populations by the World Health Organization, has several limitations.

Based on the results, it can be concluded that participants demonstrated low levels of physical fitness across both sexes. Abdominal endurance was particularly low among boys, which is concerning for this group. Regarding cardiorespiratory endurance and flexibility, male students presented higher frequencies in the "poor" classification compared with female students. Moreover, a higher percentage of boys exhibited elevated BP and stage II hypertension than girls.

Overall, the sample demonstrated a high prevalence of low physical fitness and an increased risk of developing hypertension, especially considering the positive association between BP and body weight. Therefore, these individuals may be more susceptible to severe stages of COVID-19.

CONCLUSION

In summary, the findings of the present investigation describe a high prevalence of low physical fitness across multiple components, including cardiorespiratory endurance, abdominal endurance, and flexibility, in the assessed population. Given the cross-sectional nature of the study, causal relationships cannot be inferred. Nevertheless, the observed distributions of physical fitness levels and blood pressure measurements may indicate potential associations with increased cardiometabolic risk. The relationship identified between blood pressure and body weight should be interpreted as an association rather than a direct effect. These results underscore the relevance of monitoring physical fitness and cardiovascular indicators in school-aged populations and may inform preventive and health-promotion strategies, while highlighting the need for longitudinal and interventional studies to confirm these associations.

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CONFLICTS OF INTEREST

All authors declare that they have no conflicts of interest.

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