



Originals

## Strength and adiposity as health markers: University sports as a modulator in Northeastern Brazilian students



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### ABSTRACT

**Introduction:** Physical fitness is a multidimensional health indicator, yet the impact of university sports participation on specific morphological and functional biomarkers remains insufficiently investigated in regional contexts such as Northeastern Brazil. **Objective:** To compare morphological and functional health indicators between student-athletes and non-athletes from the Federal Institute of Ceará and examine the role of sports participation in modulating key components of health-related physical fitness. **Methods:** A cross-sectional study was conducted with university students classified as student-athletes (n = 22) or non-athletes (n = 33). Physical fitness was assessed using the sit-and-reach test, as well as right/left handgrip, shoulder-girdle, and back-leg-chest dynamometry for muscular strength, and multifrequency bioelectrical impedance analysis for body composition and basal metabolic rate. **Results:** No significant differences in flexibility were observed between groups. Muscular strength was primarily influenced by biological sex (p < 0.0001), although student-athletes showed greater shoulder-girdle strength (40.83 ± 2.65 vs. 30.15 ± 2.22 kgf; p = 0.011) and back-leg-chest strength (114.3 ± 6.84 vs. 89.5 ± 7.41 kgf; p = 0.0192). Non-athlete women had a higher visceral fat index than women student-athletes (12.06 ± 1.04 vs. 5.16 ± 0.90; p = 0.013). Basal metabolic rate was higher in men because of their greater lean mass (p < 0.0001) but did not differ according to sports participation. **Conclusion:** University sports participation was associated with greater global muscular strength and lower visceral adiposity in women, supporting its role as a modulator of health-related physical fitness.

**Keywords:** muscle strength; health promotion; intra-abdominal fat; athletes; students.

## Força e adiposidade como marcadores de saúde: o esporte universitário como modulador em estudantes do Nordeste brasileiro

### RESUMO

**Introdução:** A aptidão física é um indicador multidimensional de saúde, mas o impacto da participação esportiva universitária em biomarcadores morfológicos e funcionais específicos permanece pouco investigado em contextos regionais como o Nordeste brasileiro. **Objetivo:** Comparar indicadores morfológicos e funcionais de saúde entre estudantes-atletas e não atletas do Instituto Federal do Ceará e examinar o papel da participação esportiva na modulação dos principais componentes da aptidão física relacionada à saúde. **Métodos:** Foi realizado um estudo transversal com estudantes universitários classificados como estudantes-atletas (n = 22) ou não atletas (n = 33). A aptidão física foi avaliada pelo teste de sentar e alcançar, dinamometria de preensão manual direita e esquerda, dinamometria escapular e dorsal-lombar e bioimpedância elétrica multifrequencial para composição corporal e taxa metabólica basal. **Resultados:** Não foram observadas diferenças significativas na flexibilidade entre os grupos. A força muscular foi influenciada principalmente pelo sexo biológico (p < 0,0001), embora os estudantes-atletas apresentassem maior força escapular (40,83 ± 2,65 vs. 30,15 ± 2,22 kgf; p = 0,011) e dorsal-lombar (114,3 ± 6,84 vs. 89,5 ± 7,41 kgf; p = 0,0192). Mulheres não atletas apresentaram maior índice de gordura visceral do que mulheres estudantes-atletas (12,06 ± 1,04 vs. 5,16 ± 0,90; p = 0,013). A taxa metabólica basal foi maior nos homens devido à maior massa magra (p < 0,0001), mas não diferiu segundo a participação esportiva. **Conclusão:** A participação esportiva universitária esteve associada a maior força muscular global e menor adiposidade visceral em mulheres, apoiando seu papel como modulador da aptidão física relacionada à saúde.

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<https://doi.org/10.33155/ramd.v19i1.1239>

ISSN-e: 1888-7546/ © 2026 Consejería de Turismo, Cultura y Deporte de la Junta de Andalucía.

*Palabras-chave:* força muscular; promoção da saúde; gordura intra-abdominal; atletas; estudantes.

## Fuerza y adiposidad como marcadores de salud: el deporte universitario como modulador en estudiantes del noreste brasileño

### RESUMEN

**Introducción:** La condición física es un indicador multidimensional de salud, pero el impacto de la participación deportiva universitaria sobre biomarcadores morfológicos y funcionales específicos sigue estando poco investigado en contextos regionales como el noreste brasileño. **Objetivo:** Comparar indicadores morfológicos y funcionales de salud entre estudiantes deportistas y no deportistas del Instituto Federal de Ceará y examinar el papel de la participación deportiva en la modulación de los principales componentes de la condición física relacionada con la salud. **Métodos:** Se realizó un estudio transversal con estudiantes universitarios clasificados como deportistas ( $n = 22$ ) o no deportistas ( $n = 33$ ). La condición física se evaluó mediante el test de sentarse y alcanzar, dinamometría de presión manual derecha e izquierda, dinamometría escapular y dorsolumbar y bioimpedancia eléctrica multifrecuencia para la composición corporal y la tasa metabólica basal. **Resultados:** No se observaron diferencias significativas en la flexibilidad entre los grupos. La fuerza muscular estuvo influida principalmente por el sexo biológico ( $p < 0,0001$ ), aunque los estudiantes deportistas presentaron mayor fuerza escapular ( $40,83 \pm 2,65$  vs.  $30,15 \pm 2,22$  kgf;  $p = 0,011$ ) y dorsolumbar ( $114,3 \pm 6,84$  vs.  $89,5 \pm 7,41$  kgf;  $p = 0,0192$ ). Las mujeres no deportistas presentaron un índice de grasa visceral mayor que las mujeres deportistas ( $12,06 \pm 1,04$  vs.  $5,16 \pm 0,90$ ;  $p = 0,013$ ). La tasa metabólica basal fue mayor en los hombres debido a su mayor masa magra ( $p < 0,0001$ ), pero no difirió según la participación deportiva. **Conclusión:** La participación deportiva universitaria se asoció con una mayor fuerza muscular global y una menor adiposidad visceral en las mujeres, lo que respalda su papel como modulador de la condición física relacionada con la salud.

*Palabras clave:* fuerza muscular; promoción de la salud; grasa intraabdominal; deportistas; estudiantes.

### INTRODUCTION

Physical inactivity and sedentary behavior within the educational context represent an urgent global public health challenge, severely affecting the metabolic and functional health of students.<sup>1</sup> Robust evidence indicates that prolonged periods of sedentary time trigger adverse metabolic changes, such as insulin resistance and systemic inflammation, while compromising cardiorespiratory fitness and quality of life in both the short and long term.<sup>2</sup> Beyond the clinical impact, physical inactivity imposes an alarming economic burden on healthcare systems. Projections suggest that if current prevalence rates remain unchanged, 499.2 million new cases of preventable non-communicable diseases will occur globally by 2030, incurring direct costs of US\$ 520 billion. The annual cost of physical inaction is estimated at approximately US\$ 47.6 billion, with 74% of new cases concentrated in low- and middle-income countries, although high-income nations absorb 63% of the economic costs.<sup>3</sup>

Replacing sedentary behavior with various forms of physical activity is an effective strategy to reduce all-cause and cause-specific mortality. Chang et al.<sup>4</sup> demonstrated that even minor shifts from sedentary time to light or moderate activities are associated with significant health benefits, while vigorous exercise further enhances risk reduction. In this context, the World Health Organization (WHO) guidelines reinforce that regular physical activity is essential across all age groups, establishing minimum thresholds for health maintenance. Adults should accumulate 150 to 300 minutes of moderate-intensity aerobic physical activity per week, or 75 to 150 minutes of vigorous activity. For children and adolescents aged 5 to 17, at least 60 minutes of daily moderate-to-vigorous activity is required, including exercises that strengthen muscles and bones.<sup>5</sup>

Within the educational framework, sports participation is a vital tool for mitigating the negative health outcomes affecting students, including high stress levels and comorbidities associated with hypokinesia.<sup>6,7</sup> It is well-documented that sports engagement develops the core components of health-related physical fitness: skeletal muscle strength, flexibility, cardiorespiratory endurance, and body composition. These elements are essential for quality of life, occupational performance, and longevity.<sup>8</sup> Therefore, the

stratification of these components can directly reflect the health status and quality of life of the student population.

In middle-income countries like Brazil, there is a historical challenge in addressing issues that hinder student well-being, such as mental illness, low socioeconomic status, and multi-causal morbidities.<sup>9,10</sup> These factors contribute to high dropout rates and low academic efficiency. In response, the Federal Institutes of Education—a public network of vocational and technological education spread across the country—have adopted sports policies to promote student-athlete development. A key initiative is the Games of the Federal Institutes (JIF), which foster school and university sports with significant regional representation.<sup>11</sup> The primary objectives of the JIF include combating attrition, increasing student retention, and reducing indicators of sedentary behavior and physical inactivity across diverse social contexts.

Despite the institutional importance of these programs, there is a historical lack of data reporting the efficiency of university sports in Brazil, particularly within the public network of the Northeast region and the state of Ceará. In this scenario, stratifying health-related physical fitness components serves as a valuable indicator of the impact of sports practice on organic health. Such data hold relevance beyond the socio-educational domain, directly affecting the physiological development of individuals in training. Thus, this study aimed to compare morphological and functional health indicators between student-athletes and non-athletes from the Brazilian Federal Education network. It is hypothesized that student-athletes exhibit superior physical fitness profiles compared to their non-athlete peers, supporting the role of sports as a health mediator in the public technological education system.

### METHODOLOGY

#### *Study Design and Ethical Considerations*

This is an observational, cross-sectional, and descriptive study with a quantitative approach, conducted with students from the Federal Institute of Education, Science, and Technology of Ceará.

**Table 1.** Sociodemographic and anthropometric characteristics of the study sample.

Variables	Student-athlete, % (n)	Non-athlete, % (n)
Women	10.91% (6)	30.91% (17)
Men	29.09% (16)	29.09% (16)
Single	38.18% (21)	52.73% (29)
Married	—	3.64% (2)
Other	1.82% (1)	3.64% (2)
Canindé Sertões	32.73% (18)	43.64% (24)
Fortaleza Metropolitan Region	7.27% (4)	16.36% (9)
Age (years)	23.45 ± 0.54	22.45 ± 0.47
Body mass (kg)	68.85 ± 2.89	71.61 ± 2.42

Values are presented as percentages and frequencies for categorical variables and as mean ± standard error of the mean for continuous variables. Student-athletes participated in the Games of the Federal Institute of Ceará; non-athletes had no history of participation in institutional sports competitions. No significant between-group differences were observed for age or body mass ( $p > 0.05$ ).

The experimental protocol was approved by the host institution's Human Research Ethics Committee (CAEE: 75209723.0.0000.5589). The sample was selected by convenience from the Canindé and Fortaleza campuses, comprising 55 men and women aged over 18 years.

#### Experimental Design and Groups

For comparative analysis, participants were stratified into two groups:

- i) Student-Athlete Group: Students who actively participated in the state-level stage of the Games of the Federal Institute of Ceará. Selection was based on participation in the most recent state stage held in Juazeiro do Norte, Ceará (n = 22; 16 men, 6 women).
- ii) Non-Athlete Group: Students with no history of participation in institutional sports competitions (n = 33; 16 men, 17 women).

Data collection was performed during the morning period to minimize circadian variations. The assessment flow followed a standardized sequence: (1) posterior chain flexibility, (2) static muscle strength, and (3) multifrequency bioelectrical impedance.

#### Flexibility Assessment

Posterior chain flexibility was verified using the Sit-and-Reach test on a Wells Bench.<sup>12</sup> Participants performed three trials of anterior trunk flexion with knees in full extension, and the best mark in centimeters (cm) was recorded. The bench (MDF) featured standardized dimensions of 20 cm (W) x 75 cm (L) x 34 cm (D).

#### Muscle Strength Assessment

Static strength was measured using Crown dynamometers (Filizola, Brazil), which were previously calibrated by the commercial supplier to ensure measurement precision.<sup>13</sup>

**Handgrip Strength:** Assessed with a handgrip dynamometer (100 kgf capacity), with three alternating measures between limbs and a one-minute rest interval. **Shoulder Girdle Strength:** Measured with a traction dynamometer (100 kgf) while the individual stood in an orthostatic position with shoulders abducted at 90°. **Back-leg-chest:** Evaluated with a dorsal dynamometer (200 kgf capacity), with knees slightly flexed and vertical traction applied. In all tests, the peak value in kilogram-force (kgf) was recorded for analysis.

#### Body Composition Assessment (Multifrequency Bioimpedance)

Morphometabolic analysis was performed via tetrapolar bioelectrical impedance analysis (BIA) using the InBody 120 multifrequency segmental analyzer (Biospace Co. Ltd., Seoul, Korea). The device uses an 8-point tactile electrode system (four for each hand and foot) and operates at frequencies of 20 kHz and 100 kHz, with an applied current of 150 A (+50 A). This technology allows for the direct impedance measurement of each of the body's five cylinders (arms, legs, and trunk), eliminating the need for empirical estimations based on age or sex for body composition calculations. Body fat mass, skeletal muscle mass, total body water, body fat percentage, and basal metabolic rate were determined. Participants were instructed to fast and maintain an empty bladder prior to the assessment.<sup>14</sup>

#### Statistical Analysis

Data are expressed as the mean ± standard error of the mean (SEM). After verifying data normality and homogeneity, a one-way Analysis of Variance (ANOVA) was applied, followed by Tukey's post hoc test for multiple comparisons. Inferential analyses and graphical representations were performed using GraphPad Prism 8.0 software, with a significance level set at  $p < 0.05$ .

## RESULTS

#### Sample Characteristics

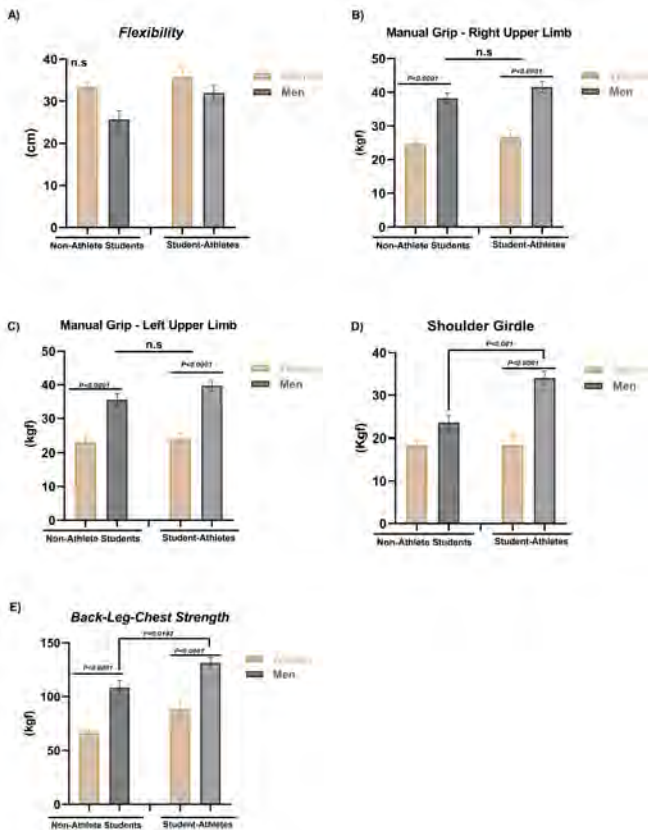
The demographic and anthropometric characteristics of the participants are summarized in Table 1. The total sample consisted of 55 students, with a higher prevalence of males (58.18%) compared to females (41.82%). Regarding marital status, the vast majority of the participants were single (90.91%). Geographically, most students were from the Canindé Sertões (76.36%), followed by the metropolitan region of Fortaleza (23.64%).

When comparing the groups, the Student-Athlete group showed a mean age of 23.45 ± 0.54 years and a body mass of 68.85 ± 2.89 kg. The Non-Student-Athlete group presented a mean age of 22.45 ± 0.47 years and a body mass of 71.61 ± 2.42 kg. Statistical analysis revealed no significant differences between groups for age or body mass, with p-values exceeding 0.05 for both anthropometric variables.

#### Flexibility and Muscular Strength

No statistically significant differences were observed in flexibility levels. Among non-athletes, females scored 33.32 ± 1.37 cm and males 25.72 ± 2.01 cm. In the athlete group, results were similar (35.67 ± 2.41 cm for females vs. 31.98 ± 1.97 cm for males) (Figure 1A).

Regarding muscular strength, biological sex was the primary determinant. Handgrip strength (HGS) in the right arm showed no significant difference by sports participation, but a marked difference by sex: men athletes reached  $41.56 \pm 1.59$  kgf compared to  $26.75 \pm 1.97$  kgf in females ( $p = 0.0001$ ). Similar patterns were found for the left arm. However, sports participation significantly enhanced specific dimensions: shoulder girdle strength was higher in men athletes ( $34.08 \pm 1.55$  kgf) compared to non-athletes ( $23.62 \pm 1.70$  kgf;  $p = 0.001$ ). For back-leg-chest strength, men athletes also excelled ( $131.3 \pm 4.88$  kgf vs.  $108.6 \pm 6.62$  kgf in non-athletes;  $p = 0.0192$ ) (Figure 1 B-E).

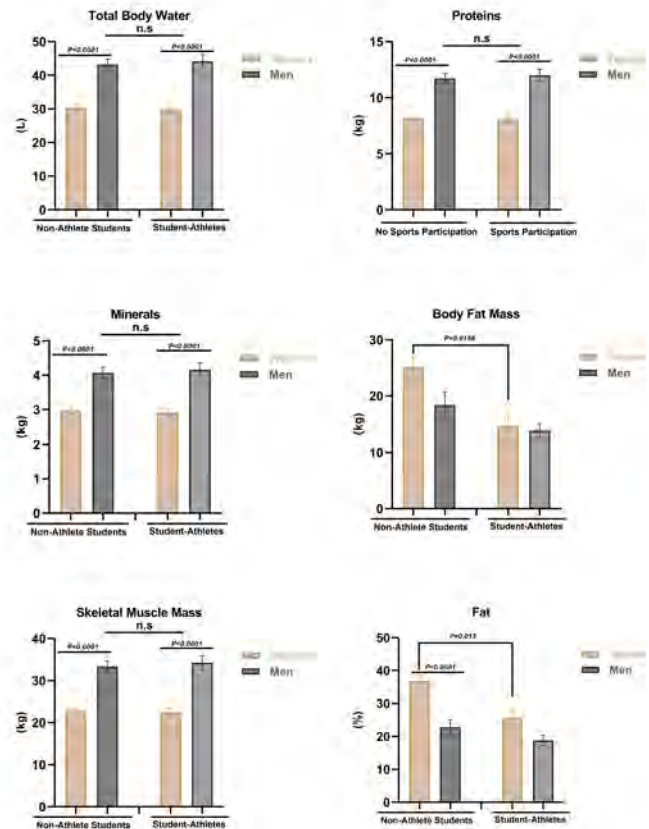


Panels show (A) flexibility, (B) right handgrip strength, (C) left handgrip strength, (D) shoulder-girdle strength, and (E) back-leg-chest strength. Values are mean  $\pm$  SEM. Group comparisons were performed using one-way ANOVA followed by Tukey's post hoc test. Statistical significance was set at  $p < 0.05$ ; n.s., not significant.

**Figure 1.** Flexibility and muscular strength according to biological sex and university sports participation.

**Body Composition and Metabolism**

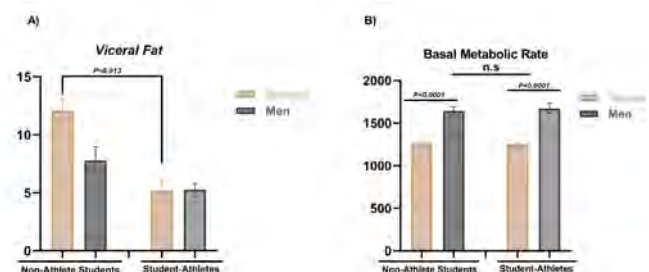
Figure 2 presents the interaction between biological sex and sports participation for structural and adiposity-related body-composition variables. Total body water, protein mass, mineral mass, and skeletal muscle mass were consistently higher in men than in women ( $p < 0.0001$ ), whereas no significant differences were observed between athletes and non-athletes within the same sex for these variables. In contrast, sports participation was associated with lower adiposity among women: women student-athletes had lower body fat mass than non-athlete women ( $p = 0.0156$ ) and a lower body fat percentage ( $25.57 \pm 2.48\%$  vs.  $36.83 \pm 1.79\%$ ;  $p = 0.013$ ). These differences were not statistically significant among men (Figure 2).



Comparative analysis of total body water, protein mass, mineral mass, skeletal muscle mass, body fat mass, and body fat percentage. Values are mean  $\pm$  SEM. Comparisons were performed using one-way ANOVA followed by Tukey's post hoc test. Statistical significance was set at  $p < 0.05$ ; n.s., not significant.

**Figure 2.** Interaction between biological sex and university sports participation for body-composition variables.

Figure 3 shows the visceral fat index and basal metabolic rate. Non-athlete women had a significantly higher visceral fat index than women student-athletes ( $12.06 \pm 1.04$  vs.  $5.16 \pm 0.90$ ;  $p = 0.013$ ). Among men, the visceral fat index was lower in student-athletes than in non-athletes ( $5.26 \pm 0.56$  vs.  $7.78 \pm 1.18$ ), although this difference was not statistically significant. Basal metabolic rate followed the pattern of skeletal muscle mass and was significantly higher in men than in women ( $p < 0.0001$ ), with no significant effect of sports participation (Figure 3).



Panels show (A) visceral fat index and (B) basal metabolic rate (kcal/day). Values are mean  $\pm$  SEM. Comparisons were performed using one-way ANOVA followed by Tukey's post hoc test. Statistical significance was set at  $p < 0.05$ ; n.s., not significant.

**Figure 3.** Visceral adiposity and basal metabolic rate according to biological sex and university sports participation.

## DISCUSSION

The present study highlights the impact of sports practice on health-related physical fitness components among university students. Our results indicate that participation in sports activities within an educational context is associated with superior morphofunctional health indicators. These findings are particularly noteworthy as they were measured in students participating and not participating in sports-based educational actions within the Brazilian federal education system. The analysis revealed significant structural and functional differences, specifically regarding strength patterns and body fat indices.

These findings reflect the influence of distinct socio-environmental and economic conditions between student-athletes and non-athletes, a disparity that underscores the urgent need for public policies focused on education and health. In this scenario, measuring physical fitness components emerges as a pivotal strategy, favored by the accuracy and non-invasive nature of the techniques, as well as their significant capacity to predict health outcomes within the formative environment.<sup>15</sup> Such a preventive approach becomes even more critical when laboratory clinical evaluations are unfeasible due to high costs and associated risks.<sup>16</sup>

Sports programs within educational and university institutions are essential. The Federal Institute Games (JIFs), designed for both educational and health-related contexts, serve as a strategic tool to consolidate the positive effects of physical exercise on student development, despite limited data on their specific health outcomes.<sup>17</sup> The present analysis highlights the cross-sectional behavior of health-related variables previously unexamined in studies regarding the Federal Institute of Ceará Games (JIFCE). Furthermore, evidence suggests that sports participation in competitions fosters motivation and discipline, which often translate into superior academic performance.<sup>18</sup> These factors are crucial for enhancing psycho-behavioral health, an aspect of paramount importance given the high prevalence of mental health disorders within educational networks.<sup>19</sup>

Beyond athletic performance, exercise in the educational-sporting context significantly contributes to combating sedentary behavior and cardiometabolic diseases, which often manifest silently during the student phase.<sup>20</sup> In this context, the American College of Sports Medicine (ACSM) guidelines recommend increasing physical activity levels to improve the five components of health-related physical fitness: muscular strength, flexibility, body composition, muscular endurance, and cardiorespiratory fitness.<sup>8</sup> Following these recommendations, this study evaluated flexibility levels, muscular strength, and body composition patterns, including the derivation of basal metabolic rate from body indices.

Historically, flexibility is a fundamental component of physical fitness and athletic performance, associated with joint mobility, movement efficiency, and injury prevention. It serves as a quality-of-life indicator by favoring functional autonomy, reinforcing its relevance in sports and rehabilitation.<sup>21</sup> Although no statistically significant difference was found, the investigated population showed a trend toward higher flexibility levels among student-athletes. Furthermore, a difference influenced by biological sex was noted, with women participants presenting higher values. Recent approaches confirm this component as fundamental for health and longevity.<sup>22</sup> According to Delgado Valdivia et al.,<sup>23</sup> flexibility is generally higher in women and tends to decrease progressively with age and educational trajectory, reinforcing the need for programs that maintain mobility throughout academic life.

The musculoskeletal structure is essential for daily activities; thus, measuring muscle mass and its capacity to generate force is clinically relevant.<sup>8</sup> In this study, a significant difference was detected between the strength levels of men and women during the dynamometry assays. Handgrip strength (HGS) should be integrated into clinical practice as a new "vital sign," as it reflects functional

status and global physiological reserve, allowing for the early identification of risks for cardiometabolic diseases and sarcopenia.<sup>24</sup>

Although no differences in distal strength were observed between athletes and non-athletes, this methodological application consolidates itself as a predictive health tool. Conversely, sporting experiences were associated with higher strength levels in multi-joint structures, such as the shoulder girdle and the back-leg-chest region. Muscular strength is a robust predictor of long-term survival, given that reduced levels are associated with a higher risk of all-cause mortality.<sup>25</sup> Thus, strength assessment serves as a functional indicator of general health and should be incorporated into clinical monitoring programs and health promotion policies. In educational environments, strength also relates to psychosocial aspects such as resilience and discipline, promoting integral well-being and academic performance.<sup>26</sup>

Body composition analysis complements functional variables.<sup>27</sup> Currently, metabolic alterations impact diseases such as obesity, which contributes to high mortality rates among university students.<sup>28</sup> It was found that male students showed similar body-composition profiles (total water, proteins, and minerals), but showed statistical differences compared to females. Skeletal muscle mass values differed primarily by biological sex rather than sports participation, which may justify the strength results found. These data reinforce that body composition analysis is an essential parameter for understanding the relationship between performance and health.<sup>8</sup>

Regarding fat morphology, a significant variation in fat mass distribution and percentage was documented between women athletes and non-athletes. Excess adiposity in university students is associated with increased chronic disease risk, often aggravated by inadequate dietary habits.<sup>29</sup> The present study detected elevated levels of visceral fat in non-athletes. Visceral fat, the primary determinant of abdominal obesity, represents a critical risk factor for mortality and intensifies systemic inflammatory processes.<sup>30</sup> This evidence highlights the necessity of continuous body composition monitoring and interventions aimed at reducing abdominal adiposity to promote health and better psycho-emotional balance.<sup>29</sup>

Finally, the BMR, assessed via bioelectrical impedance analysis (BIA), did not vary between athletes and non-athletes but was significantly higher in males due to greater muscle mass. Measuring BMR is essential for tailoring nutritional and training strategies; thus, biological sex must be considered to ensure precision in planning interventions aimed at holistic well-being (O'Neill et al., 2023).<sup>31</sup> In summary, the analyzed components showed better scores in students participating in university games. Despite limitations such as geographical distance and academic calendar interruptions, this study emphasizes the potential of these non-invasive methods for monitoring health in the formative context, enabling more robust future longitudinal research. Furthermore, the relevance of this investigation lies in the integration of body composition analysis — which quantifies and qualifies the distribution of different body tissues — with the assessment of muscular strength; this approach allows for the functional validation of the measured lean mass quality and its modulating role in student health.

## CONCLUSION

Physical fitness assessment revealed significant disparities between student-athletes and non-athletes, with muscle strength and visceral fat distribution emerging as the primary health markers. These findings suggest that institutional sports participation acts as a protective factor against metabolic risks in the academic environment. Furthermore, the use of non-invasive screening methods proves to be an effective strategy for monitoring student health, aligning educational institutions with global guidelines for health promotion and chronic disease prevention.

## Award id

PRH-00212-00058.01.00/23

## Funding

This research was supported by the Ceará Foundation for the Support of Scientific and Technological Development (FUNCAP) through the Pró-Humanidades programme (grant PRH-00212-00058.01.00/23).

Funded by: Ceará Foundation for the Support of Scientific and Technological Development (FUNCAP)

## DECLARATIONS

**Ethics approval and consent to participate:** The study was approved by the Human Research Ethics Committee of the Federal Institute of Education, Science and Technology of Ceará (CAAE: 75209723.0.0000.5589). All participants provided written informed consent before data collection.

**Conflicts of interest:** The authors declare no competing interests.

**Funding:** This research was supported by the Ceará Foundation for the Support of Scientific and Technological Development (FUNCAP) through the Pró-Humanidades programme (grant PRH-00212-00058.01.00/23).

**Acknowledgements:** The authors thank FUNCAP for the financial and institutional support provided throughout the project.

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