

Risk assessment of metabolic syndrome in a higher education institution

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ABSTRACT

Background

Metabolic syndrome is an emerging health problem among young adults, including college students, and is associated with high mortality and morbidity rates. Physical activity is one of the main factors in preventing this syndrome.

Objectives

This study aimed to evaluate the influence of physical activity levels on the prevalence of metabolic syndrome in college students.

Method and Materials

The sample included 95 students from a higher education institution, aged between 18 and 45 years. The IPAQ questionnaire was initially used, followed by assessments of body composition by bioimpedance, in addition to measurements of blood pressure, heart rate and blood glucose. For statistical analysis, associations between metabolic syndrome risk factors and physical activity levels were examined using SPSS software.

Result

The results indicated that individuals classified as very active had greater lean mass, lower body fat percentage, higher bone mineral density and lower resting heart rate compared to sedentary and irregularly active individuals. **Conclusion:** We conclude that regular physical activity can reduce the risk of metabolic syndrome and promote better health indicators in college students.

Keywords

Metabolic syndrome; health; college students; physical activity level; body composition

INTRODUCTION

Adopting healthy habits early in life and sustaining them throughout adulthood is fundamental for long-term health. In contemporary perspectives, health is understood not only as the absence of disease but as the pursuit of a balanced and sustainable lifestyle¹. Nevertheless, many young individuals still engage in behaviors that compromise their health, raising concerns about the potential impact on future outcomes. Determinants such as adequate nutrition, regular physical activity (PA), sleep quality, stress control, and the avoidance of risk behaviors including smoking, excessive alcohol and drug consumption—together with inherent factors

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such as age and genetic predisposition, play a decisive role. When neglected, these elements contribute to the development of chronic conditions, among which metabolic syndrome (MS) stands out, characterized by the coexistence of hypertension, obesity, insulin resistance, and dyslipidemia²⁻⁶.

Globally, the prevalence of MS is high, affecting approximately one-quarter of the population, which reinforces its importance as a public health issue^{4,7,8}. In Portugal, for example, a survey involving 16,856 individuals reported a prevalence of 27.5%, strongly associated with aging. The same study found that 42.6% of participants presented hypertension, although only 25.5% were under effective control, and 14.89% had type 2 diabetes, with only 51.7% achieving adequate glycemic management⁹.

Lifestyle factors such as physical inactivity, poor dietary patterns, and genetic predispositions are among the primary contributors to the development of MS and other chronic diseases^{10,11}. Conversely, regular PA has been shown to reduce cardiovascular risk, improve blood pressure regulation, enhance insulin sensitivity, and lower MS prevalence¹². Therefore, encouraging healthy eating habits in combination with regular PA represents a central strategy for the prevention and management of MS, with substantial benefits for population health.

Since the World Health Organization (WHO) first defined MS in 1998—initially emphasizing insulin resistance as a central feature¹³ the concept has evolved to encompass a broader set of cardiovascular risk factors, including abdominal obesity, dyslipidemia, and hypertension, with diagnostic criteria adjusted for age¹⁴. Given its multifactorial nature, MS requires an interdisciplinary approach, drawing on expertise from endocrinology, cardiology, nutrition, and epidemiology to advance understanding of its mechanisms and progression¹⁵.

The rising incidence of MS in younger populations is particularly alarming, as the condition has historically been more prevalent in older adults^{16,14}. Sedentary lifestyles and inadequate dietary patterns are key drivers of this trend, underscoring the importance of evaluating PA levels among young individuals and their association with MS. Although prevalence remains lower in this age group, those with irregular PA patterns or sedentary behaviors face a substantially higher risk⁸. In this context, the present study aimed to examine the

influence of PA levels on the prevalence of MS among university students.

MATERIAL AND METHODS

Sample

The study adopted a cross-sectional design, with a descriptive and inferential approach. The sample consisted of 95 students from a higher education institution, 63 men and 32 women, aged between 18 and 45 years.

Study design

To carry out this study, initial contact was made with the management of the higher education institution, presenting the research proposal and requesting the necessary authorization for its conduct. After approval by the management, all volunteers were informed about the objectives and procedures and were required to sign the Free and Informed Consent Form. The study was previously approved by the Ethics Committee for Research with Human Beings of ISCE Douro - Instituto Superior de Ciências Educativas do Douro.

Procedures

Data collection consisted of physical assessments performed using bioimpedance and a questionnaire was also applied to assess the participants' physical activity levels, including information on the frequency, duration and intensity of the activities performed.

Instruments

Anthropometry and body composition

Body composition was assessed using a Tanita bioimpedance scale (BC-601), while height was measured with a portable ADE stadiometer, with a capacity to measure from 15 to 210 cm. Waist circumference was measured at the height of the iliac line, using an ADE perimeter measuring tape, with a scale of 50 to 150 cm, printed on both sides to facilitate the measurement of length and width.

Blood glucose

Blood glucose concentration (mg/dL) was measured using the Freestyle Libre device. Assessments were performed with participants fasting, approximately one hour after waking up. Blood was collected using a lancet, with which individuals were pricked to extract a capillary sample. The collected blood was then applied to a strip compatible with the Freestyle device, which

then provided a reading of blood glucose levels.

Blood pressure and heart rate

Systolic and diastolic blood pressure, as well as heart rate, were measured using a digital sphygmomanometer (OMRON M2 HEM-7143-E) equipped with a 22-32 cm Easy cuff. Participants were instructed to remain seated with their upper limbs semi-flexed. Blood pressure measurements were performed three times, and the mean value of the measurements was recorded. Resting heart rate was obtained after participants had been lying down for five minutes without any activity. Three measurements were also performed, and the mean value was recorded for analysis.

Physical activity levels

To assess participants' physical activity levels, the International Physical Activity Questionnaire (IPAQ) was used, as described by Craig et al.¹⁸ This instrument is essential for identifying the PA pattern, allowing individuals to be classified into four groups. The first group, "very active," includes those who meet the physical activity guidelines: (a) vigorous activity on 5 days per week, with 30 minutes per session; or (b) vigorous activity on 3 days per week, with 20 minutes per session, combined with moderate activity or walking on 5 days per week and 30 minutes per session. The second group, "active," includes individuals who meet one of the following recommendations: (a) vigorous activity on 3 days per week, with 20 minutes per session; or (b) moderate activity or walking on 5 days per week, with 30 minutes per session; or (c) any combination totaling 150 minutes per week. The third group, "irregularly active," includes those who do not perform enough PA to be considered active, divided into: irregularly active A, who meets at least one recommendation criterion; and irregularly active B, who does not meet any criterion. Finally, the "sedentary" group is made up of individuals who do not practice PA for at least 10 continuous minutes per week. This categorization facilitates the analysis of PA levels and the identification of strategies to promote a more active lifestyle.

Statistical analysis

Descriptive statistics were presented as means and standard deviations, while exploratory analyses were conducted using the Kolmogorov-Smirnov and Levene tests, which assessed the normality and homogeneity of the distributions, respectively. The significance level was set at $p \leq 0.05$. Comparisons between different

levels of physical activity were performed using one-way ANOVA, complemented by the Bonferroni test, allowing a detailed analysis of variables between PA groups. Data were analyzed using IBM SPSS Statistics, version 28.0, for Microsoft Windows (IBM Corp., Armonk, NY, USA).

RESULTS

Table 1 presents the characteristics of the sample, with relevant variables for the analysis. The average height was 1.70 ± 0.091 m and the weight was 70.32 ± 11.26 kg, resulting in a BMI of 24.1 ± 3.26 . The average systolic and diastolic blood pressures were 112.8 ± 11.5 mmHg and 66.52 ± 10.1 mmHg, respectively. Regarding body composition, the average muscle mass (MM) was 51.95 ± 10.98 kg, with a fat percentage (FM) of $22.12 \pm 10.94\%$ and water percentage (H₂O) of $56.34 \pm 8.87\%$. The bone mineral density (BMD) was 2.76 ± 0.53 g/cm², glucose level was 78.84 ± 9.56 mg/dL, resting heart rate (Rest HR) was 72.51 ± 12.38 bpm, and the waist circumference was 84.37 ± 7.00 cm.

Table 1. Risk factors for metabolic syndrome and body composition.

Variables	Total
	Mean \pm DP
Height (m)	1,70 \pm 0,091
Weight (kg)	70,32 \pm 11,26
BMI (kg/m ²)	24,1 \pm 3,26
SBP (mmHg)	112,8 \pm 11,5
DBP(mmHg)	66,52 \pm 10,1
MM (kg)	51,95 \pm 10,98
% BF	22,12 \pm 10,94
% H ₂ O	56,34 \pm 8,87
BMD (%)	2,76 \pm 0,53
VF (%)	3,18 \pm 2,55
RHR (bpm)	72,51 \pm 12,38
WC (cm)	84,37 \pm 7,00
BG (mg/dL)	78,84 \pm 9,56

Table 2 presents the means and standard deviations of the variables analyzed by group, as well as comparisons between different levels of physical activity (PA). The group classified as very active showed higher MM, higher

BMD, and lower body fat percentage (%BF) compared to the irregularly active and sedentary groups. Additionally, the very active group exhibited a lower resting heart rate (RHR) compared to the sedentary group.

Table 2- Mean, standard deviation and comparisons between PA levels.

Variables	Very active (M=39; F=8) Mean±SD	Active (M=8; F=4) Mean±SD	Irregularly active (M=3; F=7) Mean±SD	Sedentary (M=12; F=14) Mean±SD
SBP (mmHg)	112.96±10.53	116.92±14.15	116.0±6.092	109.5±13.07
DBP(mmHg)	64.83±10.44	66.92±10.07	70.20±9.138	67.96±9.77
MM (kg)	57.10±9.27	49.55±11.10	45.38±10.38*	46.28±9.943*
% BF	17.29±7.33	25.91±16.52	27.85±6.81*	26.91±11.27*
% H2O	58.48±9.94	56.40±5.81	52.14±4.82	54.04±8.348
BMD (%)	2.99±0.453	2.81±0.500	2.42±0.524*	2.46±0.496*
VF (%)	2.72±2.456	3.50±2.611	4.30±2.359	3.42±2.71
RHR (bpm)	68.26±12.45	75.83±9.46	77.10±15.60	76.88±9.80*
WC (cm)	83.7±7.154	86.50±6.82	86.6±6.328	83.73±7.05
BG (mg/dL)	77.70±10.01	76.67±6.853	82.90±9.893	80.35±9.46

Legend: (SBP) Systolic blood pressure; (DBP) Diastolic blood pressure; (MM) total body muscle mass; (BF) body fat mass; (H2O) body water; (BMD) bone mineral density; (VF) visceral fat; (RHR) Resting heart rate; (WC) Waist circumference; (BG) blood glucose. *P < 0,05 vs. Very active.

DISCUSSION

The present study aimed to examine the prevalence of MS among university students in relation to their PA levels. The findings demonstrated that students classified as “very active” exhibited greater muscle mass (MM), lower body fat percentage (%BF), higher bone mineral density (BMD), and reduced resting heart rate (RHR) compared with sedentary or irregularly active peers. These results suggest that regular PA plays a central role in improving body composition and metabolic parameters, acting as a protective factor against MS.

Evidence consistently supports the association between PA and MS, emphasizing the role of exercise in preventing obesity, hypertension, and dyslipidemia, which represent core diagnostic components of the syndrome¹⁹⁻²³. The lower %BF and higher MM observed among more active participants are particularly relevant, as they contribute to enhanced insulin sensitivity and

reduced systemic inflammation, two key mechanisms in MS prevention and management^{24,25}. These results reinforce the idea that regular engagement in PA can modulate metabolic risk factors and mitigate disease progression.

A further noteworthy finding was the reduced RHR among active students. A lower RHR reflects superior cardiovascular fitness, which is strongly linked to improved autonomic regulation, lower blood pressure, and a reduced likelihood of cardiovascular complications²⁶⁻²⁹. This highlights the importance of fostering active lifestyles in the university setting, where academic and social demands often promote sedentary behaviors. In addition, the observation of higher BMD among physically active individuals underscores the positive impact of exercise on skeletal health. Regular activity is known to stimulate bone formation and preserve bone integrity³⁰⁻³², making it a critical factor not only for MS prevention but also for

long-term musculoskeletal well-being.

Despite these promising results, some limitations must be acknowledged. First, body composition was assessed using bioelectrical impedance, a method influenced by hydration status and food intake, which may introduce measurement variability. Second, PA levels were determined through the International Physical Activity Questionnaire (IPAQ), a self-reported tool that is subject to recall bias and misreporting. Finally, the relatively small sample size limits the generalizability of the findings. Larger studies are warranted to provide more robust and reliable evidence regarding the interplay between PA, body composition, and MS in young adults.

CONCLUSION

We conclude that highly active university students exhibit greater MM, lower %BF, BMD, and lower

RHR, suggesting that regular PA is essential for the prevention of MS and the promotion of overall health.

Author's contributions

Pedro A. Gomes: Acquisition of data, data analysis, interpretation of results and writing-original draft, Joana Ribeiro, Nelson Valente and Andreia Teixeira: involved in writing, reviewing, Luis Branquinho, Pedro Afonso, Joana Silva, Victor Neiva Lavorato: supervision and writing-review, Luciano Bernardes Leite: supervision, writing-review and submitting manuscript, Pedro Forte: interpretation of results, writing-original draft, reviewing and editing. All authors have read and agreed on the final version of the manuscript.

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