Original Article

Physical-Functional Profile of Obese Individuals With or Without Metabolic Syndrome Classified by Cardiovascular Risk

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Abstract

Background: **Obesity is strongly associated with increased cardiovascular risk (CVR) and the development of metabolic syndrome (MS), conditions that negatively affect body composition, metabolic profile, and functional capacity. CVR stratification may contribute to a better understanding of these alterations and to the development of early intervention strategies.**

Objectives: **To evaluate the physical–functional profile of obese individuals with and without MS, classified according to CVR, and to compare biochemical, body composition, and functional parameters among these groups.**

Methods: **This cross-sectional study included 212 obese individuals allocated into four groups: control with low CVR (CLR, n = 63), control with intermediate/high CVR (CHR, n = 33), MS with low CVR (SLR, n = 55), and MS with intermediate/high CVR (SHR, n = 61). Body composition, blood metabolic parameters, and functional performance were assessed using sit-to-stand tests. Group comparisons were performed using one-way ANOVA or Kruskal–Wallis tests, followed by Tukey's or Dunn's post hoc tests, with significance set at $p < 0.05$.**

Results: **MS was present in 54.7% of the sample, and approximately 44% exhibited intermediate/high CVR. The CLR group showed lower visceral adiposity and waist circumference (WC) values ($p < 0.001$), as well as better functional performance in the 5-times sit-to-stand test (5TSTS; $p = 0.012$) and the 1-minute sit-to-stand test (1MSTS; $p = 0.002$). No significant differences in functional performance were observed among the CHR, SLR, and SHR groups ($p > 0.05$).**

Conclusions: **Individuals with lower CVR showed better sit-to-stand performance, while poorer performance was observed in participants with MS, particularly when associated with higher CVR. Sit-to-stand tests may provide useful complementary information for assessing physical performance in this population.**

Keywords: **Metabolic Syndrome; Heart Disease Risk Factors; Obesity.**

Introduction

Metabolic syndrome (MS) is a complex disorder represented by a set of cardiovascular risk (CVR) factors usually related to central adiposity accumulation and insulin resistance, which directly increase the risk of coronary artery disease (CAD), other forms of atherosclerotic cardiovascular disease (CVD), and type 2 diabetes mellitus (T2DM).[1] It is characterized by a set of metabolic and CVR factors, including abdominal obesity, atherogenic dyslipidemia (typically characterized by hypertriglyceridemia and/or reduced high-density lipoprotein cholesterol [HDL] cholesterol), systemic arterial hypertension, and changes in glucose metabolism, such as glucose intolerance or T2DM.[1,2] It is a significant public health problem both in Brazil and globally, with notable regional and demographic variations.[3]

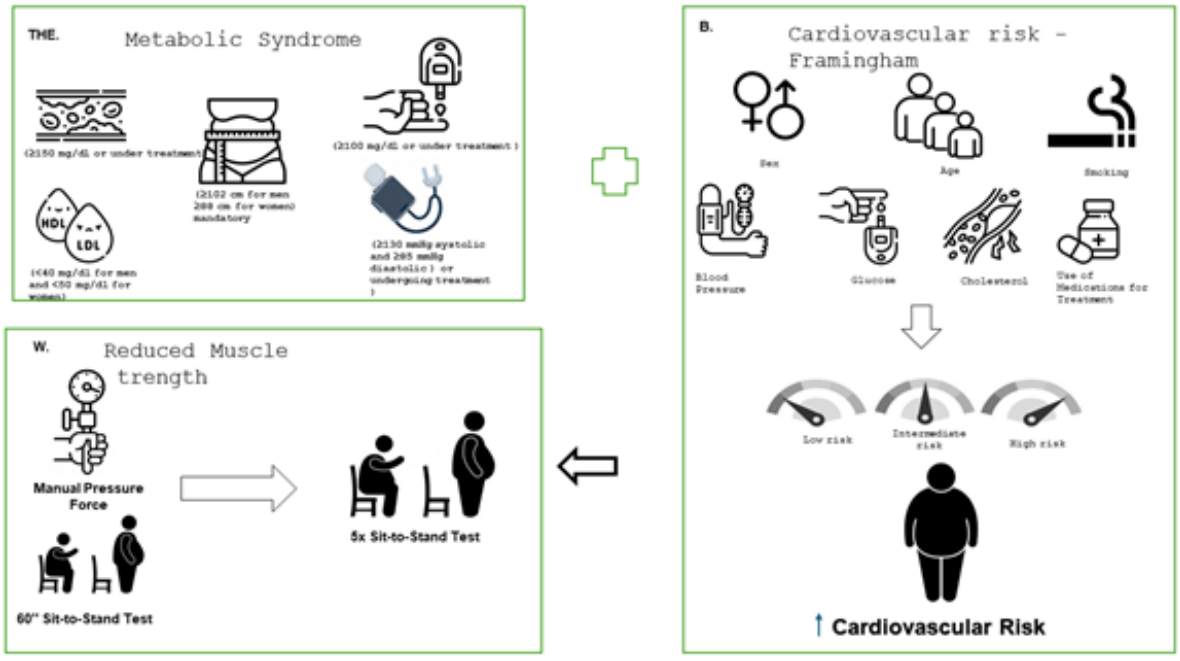
In a 2022 study, the authors evaluated 28 million individuals and found that the global prevalence of MS ranged from 12.5% to 31.4%, depending on the definition used.[4] One study showed that MS was present in 5% of normal-weight individuals, 22% of overweight individuals, and 60% of obese individuals.[5] In the Framingham Heart Study cohort, a weight gain of 2.25 kg or more over 16 years was associated with a 21% to 45% increased risk of

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Central Illustration: Physical-Functional Profile of Obese Individuals With or Without Metabolic Syndrome Classified by Cardiovascular Risk

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Interrelationship between Obesity, Metabolic Syndrome, and CVR. Schematic representation of the interrelationship between obesity, MS, and CVR, highlighting their effects on metabolic profile and functional capacity.

developing MS.[6] A large waist circumference (WC) alone identifies up to 46% of individuals who will develop MS within five years.[7] In Brazil, a 2022 meta-analysis indicated that the prevalence of MS among adults was approximately 33%, with higher rates in women, quilombolas, and rural populations.[8]

Previous studies have shown that individuals with MS may experience loss of skeletal muscle mass and/or lower muscle strength.[9,10] A prospective longitudinal study demonstrated that high cumulative muscle strength from youth reduces the risk of developing MS in midlife.[10] Mechanisms related to insulin resistance may explain the reduction in lean muscle mass and, when associated with the accumulation of intramuscular adiposity, may be responsible for impaired muscle contractile function and metabolic abnormalities.[11]

Most studies in the literature have found a relationship between handgrip strength (HGS) loss and the risk of MS and/or changes in its components (e.g., insulin resistance, systemic arterial hypertension, diabetes mellitus, etc.); however, the influence of the presence of MS on functional performance (specifically of the lower limbs) requires further investigation.[12] Gallardo-Alfaro, 2021, showed that participants with MS had lower functional fitness and lower functional fitness scores than their peers without MS, regardless of gender, age, body mass index (BMI), and WC, demonstrating a lower ability to perform daily activities safely and independently.[13]

The consensus is that MS is a complex association of multiple metabolic risk factors for CVD and diabetes mellitus.[14] (Central Illustration).

A 2017 meta-analysis indicates that MS is associated with an increased risk of CVD mortality and all-cause mortality in elderly populations.[15] In obese individuals, Freitas et al[16] observed that a higher risk of cardiovascular events was also associated with lower physical and functional performance, suggesting that there is a relationship between physical-functional performance and CVR. The San Antonio Heart Study (SAHS) has shown that individuals with MS are more insulin resistant and have a higher predicted risk of CVR compared to those without MS.[17] However, the responses of the MS interaction according to the classification of CVR levels in obese individuals, considering variables of body composition and physical-functional performance, still require a more in-depth description. An investigation that considers the profile of obese individuals with MS and CVR according to their specificities can help in the early management of the disease and in the intervention criteria.

Therefore, this study aims to evaluate the profiles of obese individuals with and without MS, classified into different levels of CVR, considering body composition and physical-functional status.

Methods

Study design and participants

This study is a cross-sectional, exploratory investigation approved by the institutional ethics committee and conducted in accordance with the Declaration of Helsinki and the STROBE recommendations. The sample was selected through an active search in the Basic Health Units, in partnership with the Faculty of Medicine and Physiotherapy of an institution, as well as through dissemination via leaflets and various communication channels (internet, radio, social media) throughout the city. All participants provided informed consent.

Participants were selected from May 2022 to October 2024, using the following inclusion criteria: adults aged 20 years or older, both sexes, and with obesity (BMI ≥ 30 kg/m^2). The exclusion criteria included physical or cognitive limitations that make it challenging to perform the physical test; histories of CVD such as angina, stroke, myocardial infarction, peripheral arterial disease, or heart failure; respiratory conditions that require oxygen therapy or frequent use of inhalation, documented dementia or clinically significant depression, surgery, chemotherapy or radiotherapy for cancer in the last six months, and severe illness or injury on the day of the clinical, functional assessment.

Sample size

An a priori analysis was performed to estimate the sample size using GPower 3.1. The sample size calculation considered four comparison groups, an effect size of 0.23, an α level of 0.05, and a power of 80%. The estimated sample size was 212 participants, already considering losses.

Criteria for the diagnosis of MS

According to the International Diabetes Federation (IDF), MS is diagnosed by the presence of central obesity, determined by elevated WC according to sex- and population-specific cutoff points, in addition to at least two metabolic abnormalities, including elevated triglycerides, reduced HDL-c, elevated blood pressure, or elevated fasting blood glucose.[18] In contrast, according to the American Heart Association/National Cholesterol Education Program Adult Treatment Panel III (AHA/NCEP ATP III), MS is defined by the presence of any three of the following five cardiometabolic abnormalities: elevated WC, elevated triglycerides, reduced HDL-c, elevated blood pressure, and elevated fasting blood glucose, without requiring central obesity as a mandatory criterion.[18-20]

In the present study, MS was defined according to harmonized AHA/IDF criteria, requiring the presence of elevated WC (WC ≥102 cm in men and ≥88 cm in women) associated with at least two of the following conditions: elevated triglycerides (TG ≥150 mg/dL [1.7 mmol/L]) and/or drug treatment for hypertriglyceridemia; reduced HDL (HDL-c <40 mg/dL [1.0 mmol/L] in men and <50 mg/dL [1.3 mmol/L] in women) and/or treatment for reduced HDL-c; elevated blood pressure (systolic ≥130 mmHg and/or diastolic ≥85 mmHg) and/or antihypertensive drug treatment; and elevated fasting blood glucose (≥100 mg/dL [5.6 mmol/L]) and/or pharmacological treatment for hyperglycemia.[18-20]

Laboratory tests used for the diagnosis of MS were obtained through blood sample collection performed by a trained laboratory technician, in partnership with a certified clinical analysis laboratory hired specifically for the biochemical assessments required for the study.

CVR Classification

To calculate CVR stratification in this study, we used the Framingham Risk Score, which estimates the risk of developing a coronary heart disease, cerebrovascular disease, peripheral arterial disease, or heart failure event at 10 years. This score was developed based on the Framingham studies and evaluates the following variables: gender, age, total cholesterol and HDL, systolic blood pressure, diabetes mellitus, smoking, and treatment for systemic arterial hypertension, in addition to classifying individuals as very high, high, intermediate, and low risk.[21,22]

According to the calculator: people classified as low risk have a probability of a cardiovascular event in the next 10 years less than 5%, those at intermediate risk have between 5% and 10% for women and between 5% and 20% for men, and those at high risk, 10% or more for women and 20% or more for men at risk of an event.[21,22]

People who already have a history of CVD (angina, stroke, myocardial infarction, peripheral artery disease, or heart failure) are classified as very high risk; This situation is identified as an exclusion criterion in the present study, which used only apparently healthy obese individuals. People with these health conditions may have outliers on physical function tests compared to a healthy person.

Access to the calculator is done through the link: FHS CVD (10-year risk) (https://www.framinghamheartstudy.org/fhs-rsk-functions/cardiovascular-disease-10-year-risk/).

Evaluation of anthropometric and body composition parameters

Weight and height were measured using an analog scale (Welmy, model 110, accuracy of 0.1 kg) with a stadiometer attached. BMI was calculated by dividing body mass (measured in kilograms) by the square of height (measured in meters), adopting the World Health Organization classification.[23] Waist and hip circumferences were measured using a flexible and non-elastic measuring tape with an accuracy of 0.1 cm, following standardized recommendations. WC was measured at the midpoint between the iliac crest and the last rib. Participants followed a standardized clinical protocol prior to assessment, including a 10–12-hour fast for solid foods, a 4-hour fast for liquids, abstinence from alcohol and physical exercise within the previous 24 hours, avoidance of caffeine, and bladder emptying before the measurements.[24] Body composition (bone mass, total body adiposity, visceral adiposity, lean mass) was assessed using dual-energy X-ray absorptiometry (DXA) (Lunar Radiation Corporation, Madison, Wisconsin, USA, DPX model).

Blood collection

Blood samples were collected in the morning, after a 12-hour overnight fast, and 8 ml of blood was extracted, 3 ml in a tube with fluoride anticoagulant for glucose and 5 ml in a tube without anticoagulant for analysis of the lipid profile. Serum levels of triglycerides (mg/dl), total cholesterol (mg/dl), HDL cholesterol (mg/dl), Low-density lipoprotein (LDL) cholesterol (mg/dl) and glucose (mg/dl) were analyzed.

Assessment of muscle strength and functional performance

HGS was assessed using a Jamar® dynamometer (kg), according to the American Society of Hand Therapists.[25,26] For this purpose, three measurements of the dominant hand were taken.[16,26]

The 5-times sit-to-stand test (5TSTS) and the 1-minute sit-to-stand test (1MSTS) are commonly used in the assessment of physical-functional performance.[27,28] 5TSTS is more closely related to lower limb strength, while 1MSTS refers to muscular endurance.[27,28] To perform the test, the volunteer sits with his arms crossed over his chest and his back resting on the chair, with the seat approximately 40 to 50 cm from the floor. The evaluator is next to the volunteer, giving instructions and ensuring safety. The person gets up and sits down as quickly as possible, using only the strength of the legs. Time is measured from the "let's go" sign to the end of the race using a digital stopwatch. Was allowed a one-minute interval between tests.[27]

Procedure

On the first day/year of assessments, participants were instructed to attend the collection site fasting, wear comfortable clothing, and maintain their usual use of medications. Blood pressure measurements were collected using a calibrated sphygmomanometer, along with anthropometric measurements and body composition assessments. Then, the blood sample was collected and sent for laboratory analysis. In the second stage (15 days later), a new blood pressure measurement was performed before the strength and functional performance tests.

Statistical analysis

Statistical analysis was performed using SPSS 22.0. Descriptive data were presented as mean ± standard deviation (SD) and 95% confidence intervals (95% CI) or median and interquartile interval (IQR) according to the normality of the data for continuous variables and as absolute (n) and relative (%) frequencies for categorical variables. Normality of the data was evaluated using the Kolmogorov–Smirnov test, while homogeneity of variances was assessed with Levene's test. Comparisons between the groups were performed using one-way ANOVA (for variables with normal distributions) or the Kruskal-Wallis test (for variables with non-normal distributions). Post-hoc comparisons were performed using Tukey's or Dunn's test. The graphs were created in GraphPad Prism 8.0. The level of significance adopted was $p < 0.05$.

This study employed rigorous methodologies to assess body composition, conduct physical testing, diagnose MS and CVR, and perform robust statistical analyses, ensuring clinical and scientific relevance.

Results

This study involved 221 individuals; However, nine were excluded because they did not complete the tests within the established deadline. Of the remaining 212 participants, the majority were women aged 20 to 75 years (average age 43), including 143 women and 69 men, with the majority being young women aged 30 to 49. Weight ranged from 68 to 183 kg, with a mean of 105.4 kg (95% CI: 93.7 – 117.2); BMI ranged from 30 to 54.8 kg/m², with a mean of 36.9 (95% CI: 36.3 – 37.7). In the CVR and intermediate/high CVR groups, we observed that 118 had low CVR, while 94 had intermediate/high CVR.

According to the MS criteria and CVR classifications, the sample was divided into four groups: CLR (control with low CVR; n = 63), CHR (control with intermediate/high CVR; n = 33), SLR (MS with low CVR; n = 55 participants), and SHR (MS with intermediate/high CVR; n = 61 participants). Data on general characteristics, such as demographic and anthropometric data, body composition, comorbidities/habits, and biochemistry, are presented in Table 1.

The SHR group had the highest mean age compared to the SLR group. On the other hand, participants in the CLR group were the youngest among the groups. In this sample, a higher prevalence of MS was observed in women; however, these findings should be interpreted with caution, as the sample size for men was significantly smaller. Analyzing only the group of women, a greater number of individuals were observed in the groups with lower CVR, both in the control group and in the group with MS. On the other hand, among men, the highest prevalence was found in the high/intermediate CVR group.

Some body composition data show significant differences between the groups; the percentage of body adiposity was higher in the CLR and SLR groups compared to the SHR group. The CLR group had lower visceral adiposity than all groups and a smaller WC than the SLR and SHR groups. There were no differences in weight, BMI, BMD, and appendicular muscle mass. When analyzing the presence or absence of systemic arterial hypertension, it becomes evident that most hypertensive individuals are in the high CVR group, which is not observed in the diabetic or smoking groups. Worse biochemical parameters were found in groups with MS with low and/or intermediate and high CVR.

No significant differences were found between the groups regarding HGS. Regarding 5TSTS and 1MSTS, we found differences between the CLR group and the other groups. The CLR group had better performance (shorter time spent) in the 5TSTS and (more repetitions) in the 1MSTS compared to the others (Figure 1).

Discussion

Several important findings are highlighted in our study. Individuals in the CLR group were younger, had lower body and visceral adiposity, and performed better on the sit-to-stand

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Table 1 – Demographic comparisons, body composition, medications, and biochemical variables between groups

Variables	CLR (cl) n=63	CHR (CH) n=33	SLR (SL) n=55	SHR (SH) n=61	F	Power	p-value	Post-hoc testing*.
Age	32.0 (15.0)	45.0 (15.0)	42.0 (19.0)	52.0 (16.0)	51.322	0.99	<0.001	cl<ch,sl,sh; sl<sh
Gender								
Women	50 (79.4%)	15 (45.5%)	44 (80.0%)	34 (55.7%)	-	-	<0.001	-
Men	13 (20.6%)	18 (54.5%)	11 (20.0%)	27 (44.3%)				
Body composition								
Weight	95.0 (19.9)	101.0 (34.4)	94.8 (27.3)	98.5 (23.0)	1.106	0.99	0.776	-
BMI	35.5 (5.5)	34.3 (5.5)	36.7 (8.9)	35.7 (5.9)	5.754	0.99	0.124	-
DMO	1.3 ± 0.11 (95%CI 1.2, 1.3)	1.2 ± 0.14 (95%CI 1.2, 1.3)	1.2 ± 0.15 (95%CI 1.2, 1.3)	1.2 ± 0.12 (95%CI 1.2, 1.3)	3.978	0.99	0.264	-
Total body adiposity (%)	47.0 (8.1)	43.1 (12.6)	47.8 (9.2)	45.0 (6.6)	12.853	0.99	0.005	cl> sh ;sl> sh
Visceral adiposity	1.1 (0.6)	1.5 (1.2)	1.7 (0.9)	2.0 (1.0)	33.458	0.99	<0.001	cl< ch, sl, sh
Appendicular muscle mass	22.4 (7.3)	28.2 (10.9)	22.0 (8.7)	25.5 (11.6)	7.091	0.99	0.069	-
WC	103.9 ± 9.8 (95%CI 101.5, 106.5)	107.9 ± 14.2 (95%CI 102.9, 112.9)	111.1± 11.7 (95%CI 107.9, 114.3)	111.1 ± 10.1 (95%CI 108.6, 113.7)	16.611	0.99	0.001	cl< sl, sh
Medication for Altered Blood Pressure/Systemic arterial hypertension								
Yes	7 (11.1%)	23 (69.7%)	22 (40.0%)	47 (77.0%)	-	-	<0.001	-
No	56 (88.9%)	10 (8.8%)	33 (29.2%)	14 (23.0%)				
Altered blood glucose/Diabetes mellitus								
Yes	1 (1.6%)	0 (0.0%)	8 (14.5%)	11 (18.0%)	-	-	0.001	-
No	62 (98.4%)	33 (100.0%)	47 (85.5%)	50 (82.0%)				
Smoking								
Yes	5 (7.9%)	2 (6.1%)	2 (3.6%)	5 (8.2%)	-	-	0.744	-
No	58 (92.1%)	31 (93.9%)	53 (96.4%)	56 (91.8%)				
Biochemistry Parameters								
Triglycerides	130.0 (40.0)	144.0 (26.0)	160.0 (53.0)	184.0 (91.0)	69.774	0.99	<0.001	sl > cl; sh > cl, ch
Total cholesterol	188.0 ± 46.0 (95%CI 179.8, 196.2)	198.9 ± 36.4 (95%CI 186.0, 211.8)	194.8 ± 33.9 (95%CI 185.7, 204.0)	210.9 ± 40.8 (95%CI 200.4, 221.3)	4.356	0.99	0.005	sh > cl
HDL	54.0 (16.0)	50.0 (21.0)	47.0 (20.0)	45.0 (11.0)	29.035	0.99	<0.001	cl > sl , sh ; ch > sh
LDL	102.4 (40.6)	107.4 (58.3)	108.0 (39.6)	123.6 (56.8)	1.575	0.99	0.196	-
Non-HDL	131.9 ± 43.2 (95%CI 123.8, 140.1)	146.8 ± 39.6 (95%CI 132.7, 160.8)	146.0 ± 32.2 (95%CI 137.1, 155.0)	164.9 ± 41.3 (95%CI 154.3, 175.5)	8.487	0.99	<0.001	sh > sl, cl
Blood glucose	84.0 (10.0)	88.0 (11.0)	91.0 (14.0)	94.0 (19.0)	33.825	0.99	<0.001	cl< sl, sh
Total HGS (Kg)	37.3 (11.3)	50.0 (25.5)	38.7 (12.6)	43.0 (21.5)	7.77	0.99	0.051	-
Women HGS (Kg)	36.3 ± 5.9 (95%CI 34.6, 38.0)	33.9 ± 5.7 (95%CI 30.7, 37.0)	35.5 ± 6.8 (95%CI 33.4, 37.6)	33.9 ± 7.9 (95%CI 31.1, 36.6)	1.098	0.99	0.35	-
Men HGS (Kg)	53.1 ± 7.6 (95%CI 48.5, 57.8)	58.0 ± 7.4 (95%CI 54.3, 61.7)	55.2 ± 8.8 (95%CI 49.2, 61.1)	54.7 ± 14.0 (95%CI 50.9, 58.5)	0.904	0.99	0.44	-

*CLR: Low cardiovascular risk control; CHR: Intermediate-high cardiovascular risk control; SLR: Low cardiovascular risk metabolic syndrome; SHR: Intermediate-high cardiovascular risk metabolic syndrome; BMI: Body mass index; BMD: Bone mineral density; HDL: High-density lipoprotein; LDL: Low-density lipoprotein; HGS: Handgrip strength; WC: waist circumference.. Data presented to mean ± SD (95% CI) or median (IQR) and n (%). * Tukey's or Dunn's post-hoc test, p-value for statistical significance < 0.05.*

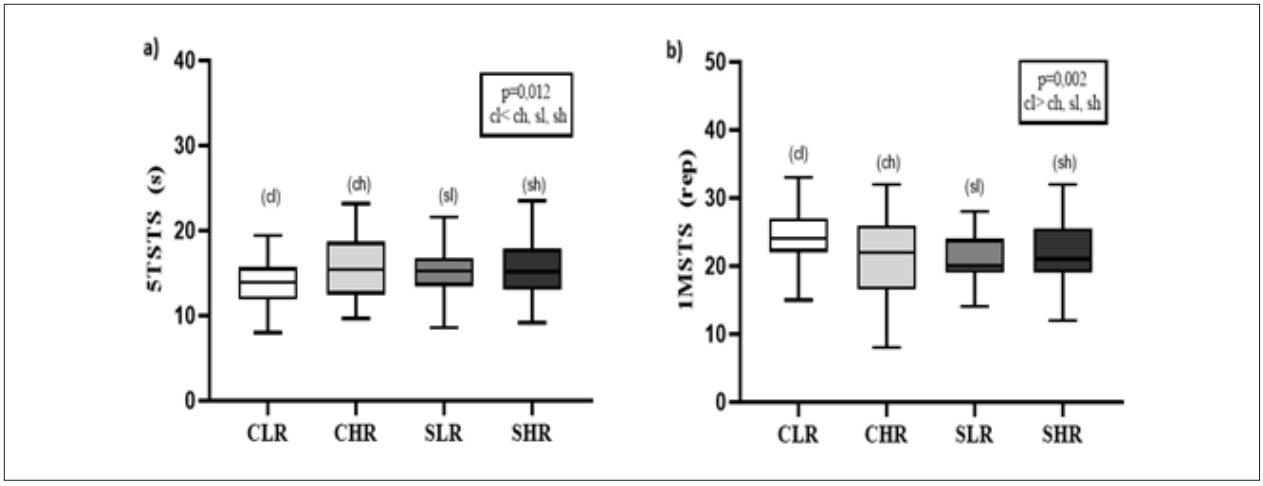


Figure 1 – *Comparison of test results (a) 5TSTS and (b) 1MSTS between groups. CLR: Low cardiovascular risk control; CHR: Intermediate-high cardiovascular risk control; SLR: Low cardiovascular risk metabolic syndrome; SHR: Intermediate-high cardiovascular risk metabolic syndrome; 5TSTS: 5-times sit-to-stand test; 1MSTS: 1-minute sit-to-stand test. Statistical significance: p-value < 0.05.*

tests. However, a notable point is the absence of differences between the CHR and SM groups. This result indicates that patients with high CVR may have similar characteristics of body composition and functional performance to patients with MS, regardless of the degree of CVR.

Age significantly influences both the onset and evolution of CVD and MS. Aging is associated with pathophysiological changes that increase susceptibility to cardiometabolic risk factors, contributing to the development of CVD and MS.[29,30] In addition, the earlier the onset of MS, the greater the subsequent risk of cardiovascular events. Individuals who develop MS before age 45 have a higher relative risk of CVD than those whose onset occurs at older ages, according to the Kailuan study.[30] The prevalence of MS increases progressively with age in both sexes, and this increase is more pronounced in postmenopausal women. According to data from the MORGAM study, the prevalence of MS can increase up to five times between 19-39 years and 60-78 years, while in men, this increase is approximately twofold.[31]

The relationship between body adiposity and MS is complex and involves the total amount, distribution, and function of adiposity. Obesity, especially central obesity (the accumulation of visceral adiposity), is a key component and risk factor for MS.[32] Studies show that increased visceral adiposity area is strongly associated with the risk of developing MS, being one of the best predictors for its appearance, regardless of BMI.[33]

Visceral adiposity is more strongly associated with cardiometabolic risks than subcutaneous adipose tissue. Lipid accumulation index (LAI) is a better predictor of diabetes mellitus than BMI, according to a study of older adults in Poland.[31] The present study corroborates this information, as it was possible to identify that the higher the visceral adiposity, the higher the CVR, both in individuals without and with different MS, when we analyzed the total adiposity percentile, which presents a higher number in individuals with low CVR than in individuals with intermediate/high CVR, regardless of whether they had MS. It also indicates that WC is higher in individuals with MS.

Although the present study found no significant differences in HGS between groups, recent evidence has shown that HGS is associated with cardiovascular conditions and may reflect broader cardiometabolic health. A recent cohort study using data from the Korean Genome and Epidemiology Study (KoGES) showed that higher relative HGS was inversely associated with incident coronary heart disease and CVD, with stronger associations observed in women.[34] In addition, the study conducted by Freitas in 2025,[16] demonstrates the association between HGS and CVR in menopausal women. HGS was evaluated, and no differences were found between the groups in the total sample or by sex. Therefore, the sample size or the CVR classification may have contributed to the absence of a difference in muscle strength.

This analysis reveals that individuals in the CLR group outperform those in the other groups on the sit-and-stand tests. The sit-and-stand test is a simple, fast, and commonly used measure of functional performance, reflecting the ability of the lower limb muscles to generate force. The 5TSTS test evaluates the time required for the individual to complete the test, which is related to lower limb strength and physical performance, and the 1MSTS test is a lower limb endurance test.[27,35]

In patients with obesity, performance on physical tests, including the sit-and-stand test, is associated with CVR.[27] The power generated during the sit-to-stand motion is an important determinant of physical function, which may be relevant to interventions aimed at improving health and quality of life in obese populations.[27] In addition, 1MSTS can be a valuable tool in the assessment of CVR and MS, especially in populations with heart disease or obesity, as it provides a measure of functional capacity correlated with the risk of cardiovascular events.[27,35]

A study conducted by Gallardo-Alfaro[13] evaluated functional fitness skills in individuals with and without MS syndrome,

showing that participants with MS had lower functional fitness and lower functional fitness scores than their non-MS peers, regardless of gender, age, BMI, and WC, demonstrating a lower ability to perform daily activities safely and independently.[13] The relationship between the sit-to-stand test 1MSTS and CVR and MS can be inferred from studies investigating functional capacity and CVR. The sit-and-stand test is a practical tool for assessing functional capacity in patients with heart conditions such as atrial fibrillation. It correlates well with other functional capacity tests, such as the six-minute walk test (6MWT).[35]

No studies were found in the literature that correlated the assessment of the physical profile of individuals with MS and high CVR; only MS was associated with CVR, showing that these individuals tend to be middle-aged or elderly adults, often men, with multiple aggregate risk factors, unfavorable metabolic profile, insulin resistance, and persistent exposure to MS components, which translates into a substantially increased risk of cardiovascular events and mortality.

One aspect of our data that deserves attention is the lack of differences in body composition and functional performance between people in the CHR group and those with MS, regardless of the degree of CVR. In the literature, MS is an important indicator of CVR, being associated with high mortality rates with a two- to five-fold increase in the risk of CAD.[36]

This study had a well-trained team committed to obtaining high-quality results, rigorously maintaining the veracity of the study data, an interdisciplinary approach, and partnerships with health units to search for participants actively. The limitations identified were: the higher number of participants with grade I obesity compared with the other obesity categories; the absence of participants with MS who were classified as overweight or normal weight; the lower proportion of men compared with women; and the heterogeneity of the sample regarding age, despite the predominance of younger participants, which may have influenced the muscle strength outcomes.

Thus, these data may guide the importance of a more specific approach for people with obesity who are at high CVR, encouraging early intervention, since our study demonstrated a metabolic and functional profile similar to that of individuals with MS. Additional studies should be encouraged to evaluate the influence of CVR levels associated with MS, as well as the predictive power of physical-functional tests for diagnosing MS across different age groups, while accounting for the potential impact of age-related heterogeneity on functional and muscle strength outcomes.

Conclusion

In conclusion, individuals with lower CVR showed better functional performance in the sit-to-stand tests, whereas the poorest performance was observed in the groups with MS, especially when associated with higher CVR. These findings suggest that MS may exert an additional negative impact on functional capacity beyond CVR alone, possibly related to greater visceral adiposity, unfavorable biochemical alterations, and associated metabolic dysfunctions.

Furthermore, although no significant differences in HGS were observed between groups, the sit-to-stand tests appeared to capture functional differences, suggesting greater sensitivity for identifying impairments in physical performance in this population. Thus, these results reinforce the importance of physical-functional assessment, particularly through simple tests that are applicable to clinical practice, as a complementary tool for investigating the functional impact of MS and CVR. Future studies with more robust analytical approaches, are warranted to further explore these findings.

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Author Contributions

Conception and design of the research: Moraes DB, Lage VKS, Freitas JPC, Esteves EA, Mendonça VA; acquisition of data: Moraes DB, Freitas JPC, Farnezi ACB, Gonçalves GT, Otoni MT, Cunha T, Silva TJ; analysis and interpretation of the data: Moraes DB, Lage VKS, Freitas JPC, Santos JNV, Esteves EA, Mendonça VA; statistical analysis: Lage VKS, Santos JNV; writing of the manuscript: Moraes DB, Lage VKS, Freitas JPC, Farnezi ACB, Santos JNV, Gonçalves GT, Otoni MT, Cunha T, Silva TJ, Esteves EA, Santos JM, Sartorio A, Taiar R, Lacerda ACR, Mendonça VA; critical revision of the manuscript for intellectual content: Moraes DB, Lage VKS, Freitas JPC, Santos JNV, Esteves EA, Santos JM, Sartorio A, Taiar R, Lacerda ACR, Mendonça VA.

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No potential conflict of interest relevant to this article was reported.

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Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of the Universidade Federal dos Vales do Jequitinhonha e Mucuri, under protocol number CAAE: 34095720.0.0000.5108 (approval date: 08/20/2020). All the procedures in this study were in accordance with the 1975 Helsinki Declaration, updated in 2013. Informed consent was obtained from all participants included in the study.

Use of Artificial Intelligence

During the preparation of this work, the author(s) used Grammarly and Google Tradutor for translating texts into different languages and correcting grammar, punctuation, and

style errors. After using this tool/service, the author(s) reviewed and edited the content as needed and take full responsibility for the content of the published article.

Availability of Research Data

All datasets supporting the results of this study are available upon request from the corresponding author.

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