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Anthropometric indicators of obesity for the prediction of metabolic syndrome in the older adults

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ABSTRACT

Introduction: The anthropometric indicators of obesity may be important in predicting metabolic syndrome (MS). **Objective:** To evaluate the anthropometric indicators as predictors of MS and verify the association of these indicators with MS in older adult individuals of both sexes. **Methods:** Cross-sectional epidemiological study was carried out with 222 individuals aged 60 years or older residents in the urban area of Aiquara, Bahia state, Brazil. Older adults were measured for anthropometric indicators: body mass index (BMI), waist-to-height ratio (WHtR), waist circumference, conicity index, the sum of skinfolds; blood pressure; biochemical variables: fasting glucose, triglycerides, total cholesterol, and fractions. For the diagnosis of MS, the definition of the International Diabetes Federation was used. Descriptive and inferential data analysis was tested using correlation, the Poisson regression technique, and the Receiver Operating Characteristic (ROC) curve. **Results:** The prevalence of MS was 62.3%. There was a correlation of all anthropometric indicators with MS in both sexes. The indicators of visceral fat had a strong association in that these indicators had an area under the ROC curve higher than 0.76 (CI95% 0.66–0.85). Thus, most results showed a weak correlation. **Conclusion:** All anthropometric indicators can be used to predict MS in older adults for both sexes, however, BMI and WHtR showed the best predictions.

Keywords: anthropometry; metabolic syndrome; health of the elderly; ROC curve; obesity.

INTRODUCTION

Several risk factors can, together, characterize the metabolic syndrome (MS), such as arterial hypertension, dyslipidemia, hyperglycemia, and abdominal obesity, and consequently, offer a higher risk of developing cardiovascular diseases and type 2 diabetes. These risk factors tend to be more prevalent in the aging process, due to individual physiological changes that contribute to increasing the MS incidence[1].

There is a variation in the prevalence of MS in the literature due to some characteristics, such as age, sex, race/ethnicity, and criteria used to diagnose MS[2]. However, the high prevalence of this syndrome in the older adult population has been a relevant phenomenon, justified by the association with chronic non-communicable diseases, increasing morbidity and mortality, and the impact on the health system[3].

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Although there is no consensus on the etiology and determinants of MS, it is known that it is composed of a set of genetic, environmental, and behavioral characteristics. Among all the mechanisms of MS pathophysiology suggested, visceral adiposity has been considered as the conduction for the genesis, progression, and transition processes for cardiovascular diseases, through the systemic alterations that the adipose tissue induces in the physiological and metabolic profile for these diseases[2,4].

Anthropometric indicators of obesity have been used in epidemiological studies to verify health outcomes. Thus, they can indicate, for example, overweight and body fat in middle-aged adults and the older adults[5-7] and identify MS in the older adults[8].

However, there is still a requirement for methods more practical, with lower costs, more accurate, and adequate to track the metabolic syndrome in the older adult population, due to several heterogeneous methods and cut-off points/percentile for gender, age group, and ethical groups found in the literature[8].

Thus, the use of anthropometric methods for the identification and application of new parameters enables the earlier diagnosis of MS in older adults. In addition, these methods are easy to apply, non-invasive, and inexpensive. In this way, these methods can contribute to the screening and risk stratification to control the incidence of MS on an epidemiological scale, mainly, highlighting the sum of the skinfolds. Thus, these procedures can provide positive effects on individual/ collective health and, consequently, reduce public spending on this health problem.

Based on the literature, this study was aimed to evaluate the anthropometric indicators as a predictor of metabolic syndrome, as well as to verify the association of these indicators with MS in older adult individuals of both sexes.

METHODS

Source of data

This research is characterized by epidemiological, cross-sectional, and is part of the home-based study entitled "Health conditions and lifestyle of older adult people living in small municipalities". The location chosen for the study was the municipality of Aiquara, located in the south-central region of the State of Bahia, Brazil, composed of 4,725 inhabitants[9] of which 618 are ≥60 years old (approximately 13% of the total population).

As this is a population-based study, 351 older adults living in the urban area were identified in the census of the evaluated municipality, according to the data from the Brazilian primary care information system in 2012[10], with the population eligible for the study. This choice by this population segment was made by the researchers, and it happened due to the ease of access, such as the identification of the elderly who used the information from the integrated primary care system with information from the elderly in the urban area.

The study included older adults for each area/micro area of the family health strategy, aged 60 years or older, of both sexes, who reported sleeping in the same home for three nights or more, not being institutionalized; residents in the urban area and who consent to participate in the research after authorizing their participation. In the present study, 129 older adults were excluded, as they were not located after three visits on different shifts, with cognitive impairment and without a companion to assist in the responses, who refused to participate in the study, and without blood samples collected. Thus, the study population was 222 older adults. Data collection took place in four stages between January and August 2015.

First, a home interview was assessed, followed by anthropometric and blood data collection which were performed in an educational institution of the mentioned town. The interviews and anthropometric measurements were carried out by teachers and students previously trained to have standardization.

The main data used in this study were: (a) socio-demographic characteristics (age, sex); (b) blood pressure (systolic and diastolic blood pressure); (c) biochemical variables (fasting glucose, triglycerides, total cholesterol, and fractions); (d) anthropometry (body mass, height, waist circumference, hip perimeter and skinfolds) e) behaviors variables [physical activity (International Physical Activity Questionnaire, long version); active (≥150 minutes per week) or physically inactive (<150 minutes per week); currently smokes (yes or no) and alcohol use (yes or no)]. The choice of adjustment variables was due to reasons of influence on body composition and close relationship with the 5 factors of the metabolic syndrome.

The study was approved by the Ethics Committee, under the number CAEE 56017816.2.0000.0055, the participation was voluntary with written informed consent obtained from all participants.

Metabolic syndrome

Metabolic syndrome was defined according to the International Diabetes Federation[11]. The criteria considered the presence of at least three metabolic risk factors among the following five: a) waist circumference ≥80 and ≥90 for women and men respectively; b) triglycerides ≥150 mg/dL; c) systolic blood pressure (SBP) ≥130 mmHg and diastolic blood pressure ≥85 mmHg; d) HDL-cholesterol for men ≤ 40 mg/dL and women ≤50 mg/dL; e) Fasting glycemia ≥100 mg/dL. The outcome (MS) was categorized as follows: yes, 3 or more MS risk factors; no, <3 MS risk factors.

Anthropometric indicators of obesity

The individual's body mass was measured with barefoot and light clothes and height was measured according to the established technique[12]. The waist circumference was measured with an anthropometric chart, according to the standard procedure described by Callaway *et al.*[13]. The skinfolds measures were performed using a Lange caliper and evaluated in the right hemisphere, being considered the following sites: triceps, subscapular, supra iliac, abdomen, thigh, and calf[14-16]. Except for the measurement of body mass, the other anthropometric measurements were obtained in three measurements and the mean value was recorded in the analyzes.

The blood sample was collected by trained professionals (nurses) using disposable materials by appointment. At the end of the collection, the blood samples were sent to the Public Health Laboratory of the Reference Center for Endemic Diseases Pirajá da Silva in the municipality of Jequié/BA, Brazil, where they were processed and analyzed.

The measures were calculated as follows: Body Mass Index [BMI=body mass (Kg)/height (m)2]; waist-to-height ratio [WHtR=waist circumference (cm)/height (cm)]; waist circumference (cm)15; conicity index [CI=Waist Perimeter (m)/(0.109√(Body Mass/Height (m))16; sum of skinfolds [sum of mean skinfolds: tricipital (mm), abdominal (mm), thigh (mm), calf (mm), subscapular (mm), supra-iliac (mm)] and waist circumference (cm).

Statistical analysis

A descriptive analysis of the data was performed, for this, it was calculated: the distribution of frequencies, means or medians, and standard deviations or interquartile intervals. The tests used were the Kolmogorov-Smirnov test, to verify the normality of the data; and the chi-square and U tests of the Mann-Whitney or Student tests, to compare the differences between genders. The correlation between the anthropometric indicators and the biochemical and hemodynamic variables was tested using the Pearson and Spearman correlation. To verify the association of the outcome with the other variables, Poisson regression was used. We adjusted robust models to estimate the prevalence ratios (PR), with their respective 95% confidence intervals (95%CI). The power of diagnosis of the metabolic syndrome of the anthropometric indicators of obesity and the identification of the best cut-offs were evaluated using the parameters provided by the Receiver Operating Characteristic (ROC) curve: area under the ROC curve (parameter considered adequate above 70%), sensitivity (proportion of true positives) and specificity (proportion of false positives), positive predictive value (PPV) and negative predictive value (NPV). All these values are provided by the statistical program.

In the analysis, the level of statistical significance used was 5% (α=0.05). Statistical Package for the Social Sciences for Windows (IBM-SPSS version 20.0) and MedCalc (version 9.1.0.1, 2006) was used for data analysis.

RESULTS

The present study considered the population of 222 older adults applying the inclusion and exclusion criteria. The participants were of mean age of 71.8±7.69 years (60-95 years). The prevalence of metabolic syndrome was 62.3%, with no significant difference between prevalence among women (67.5%) and men (55.2%) (p>0.05).

The characteristics of the sample are presented in Table 1, as well as the comparison between sexes. There was a significant difference in height, body mass, body mass index, waist-to-height ratio, and waist circumference, and on biochemical variables, there were only significant differences in total cholesterol and HDL-c. The female group had shown higher values than the male group in all general variables, except for body mass and height (Table 1).

Table 2 shows the correlation of anthropometric indicators (BMI, WHrt, WC, CI, sum of skinfolds) with the levels of systolic blood

Table 1: Characteristics of the sample, values expressed as mean and (±) standard deviation. Aiquara, Bahia, Brazil (N=222).

Variables	Total	Men	Women
N	222	94	128
Age (years) §	71.80±7.69	72.56±8.44	71.23±7.07
Height (m) §	1.55±0.08	1.62±0.06	1.50±0.06**
Body Mass (kg) §	63.77±13.87	66.57±12.58	61.71±14.46**
Anthropometric indicators			
Body mass index (kg/m²) §	26.42±5.39	25.18±4.26	27.33±5.95*
Waist-to-Height Ratio (AU) ¥	0.60±0.09	0.57±0.07	0.63±0.09**
Waist Circumference (cm) ¥	96.14±12.98	93.57±11.76	98.04±13.54
Conicity index (AU) ¥	1.34±0.09	1.33±0.08	1.35±0.09
Σ Skinfolds (mm) ¥	158.00±64.28	118.08±45.17	187.32±60.41**
Blood pressure			
Systolic (mmHg) §	155.74±23.13	157.78±22.59	154.24±23.48
Diastolic (mmHg) §	88.28±13.61	88.69±13.68	87.98±11.80
Biochemical Indicators			
Glycemia (mg/dL) §	113.75±45.66	115.95±48.67	112.13±43.43
Total cholesterol (mg/dL) ¥	211.15±46.34	201.71±42.17	218.04±48.16*
HDL-c (mg / dL) §	48.69±15.13	44.55±8.80	51.71±17.86**
LDL-c (mg / dL) ¥	131.39±41.33	126.35±35.83	135.02±44.67
Triglycerides (mg / dL) §	148.62±90.63	147.88±91.03	149.16±90.69

AU. Arbitrary unit, * <0.05; ** <0.01; §Mann-Whitney U test; ¥Independent T test.

pressure (SBP) and biochemical indicators (HDL-c, Glycemia, Triglycerides). Importantly, HDL-c was the only parameter that showed a negative correlation with anthropometric indicators. The others (SBP, Glycemia, Triglycerides) showed a positive correlation (Table 2). Thus, most results showed a weak correlation[17].

Table 3 introduces the PR for metabolic syndrome with the increase in obesity indicators. For both sexes, all indicators of obesity were associated with metabolic syndrome. In females, BMI and WHtR showed high strength of association, thus, by increasing each unit in BMI and WHtR, it corresponds to an approximate increase of 5% and 3%, respectively, the probability of them presenting the outcome. The indicators of obesity, BMI, and WHtR, with better correlations, were the same in both sexes. In males, reaching each increment of one unit in these indicators can increase approximately 11% and 6%, respectively, the probability of older adult men presenting metabolic syndrome (Table 3).

Table 4 describes the diagnostic properties of anthropometric indicators of obesity to detect metabolic syndrome in older adults according to sex. There was a statistical difference in the percentage under the ROC curve only in females (Table 4).

The areas under the ROC curve are shown in Figure 1. The comparison of the areas under the ROC curve among the indicators in females and males can be also observed in Figure 1.

Table 2: Correlation between anthropometric indicators, and biochemical and blood pressures variables for older adults. Aiquara, Bahia, Brazil (N=222).

Variables	BMI	WHtR	WC	CI	Σ Skin Fold
Males					
SBP§	0.231*	0.281**	0.267**	0.239*	0.149
DBP¥	0.059	0.088	0.078	0.108	0.104
Glucose¥	0.246*	0.296*	0.284*	0.236*	0.163
Total Cholesterol§	-0.002	-0.050	0.015	-0.078	0.039
HDL-c§	-0.345**	-0.399**	-0.357**	-0.332**	-0.314**
LDL-c§	-0.033	-0.064	-0.026	-0.088	0.020
Triglycerides¥	0.269*	0.265*	0.307*	0.175	0.214**
Females					
SBP§	-0.030	0.141	0.019	0.141	-0.064
DBP§	0.018	0.017	0.012	-0.023	0.000
Glucose¥	0.273**	0.325**	0.304**	0.231**	0.238**
Total Cholesterol§	0.013	0.046	0.050	0.082	0.042
HDL-c¥	-0.238**	-0.310**	-0.315**	-0.300**	-0.261**
LDL-c§	-0.021	0.003	0.018	0.082	-0.011
Triglycerides¥	0.223**	0.298**	0.307**	0.324**	0.231**

BMI, body mass index; WHtR, waist-to-height ratio; WC, waist circumference; CI, Conicity Index. Σ, sum, SBP, systolic blood pressure; DBP, diastolic blood pressure; *p<0.05; **p<0.01; §Pearson correlation; ¥Spearman correlation.

DISCUSSION

All the anthropometric indicators presented the capacity of prediction for metabolic syndrome in older adults of both sexes, all of them presented an elevated area under the ROC curve and a lower limit of 95% above 0.60. These results may show that anthropometric indicators of generalized obesity, central obesity, and body fat can diagnose metabolic syndrome, highlighting the indicators of central obesity which had greater discriminative power.

The established BMI cut-off point to predict MS was 26.8 kg/m^2 for men and 26.4 kg/m^2 for women. A similar result was observed by Gadelha *et al.*[18] in females. Following female results, males showed resemblant cut-off values, however; it was slightly lower than those found by Gharipour *et al.*[19]. Although BMI is an indicator with limitations, since it does not differentiate the fat mass from the fat-free mass, this indicator is one of the most used in epidemiological studies as cardiovascular risk.

In the ROC curve analysis, all indicators showed good predictive capacity values of the area under the ROC curve above 0.7[20]. Regarding the waist-to-height ratio and waist circumference indicators, an indicator of central fat presented similar values of prediction of MS. The values established for the first indicator were 0.55 for men and 0.63 for women. The same was observed by Oliveira *et al.*[8] for males (0.55), and for females, higher and lower values were found[21,22]. Considering waist circumference (WC), values for the discrimination of MS were 89.3 cm and 92.6 cm for men and women, respectively. These values are consistent with those suggested by The International Diabetes Federation[11] for South American populations, and Oliveira *et al.*[8] who analyzed a representative sample of older adult individuals with similar characteristics, proposing cut-off points for WC. These two indicators are the ones that are most associated with cardiovascular risk factors because they are associated with visceral fat.

Table 3: Prevalence ratio for metabolic syndrome with increased indicators of obesity in older adults. Aiquara, Bahia, Brazil (N=222).

Variables	Female			Male		
	PR†	CI95%	p-valor	PR†	CI95%	p-valor
BMI (kg/m^2)	1.048	1.027 - 1.069	<0.001	1.108	1.057 - 1.160	<0.001
WC (cm)	1.024	1.014 - 1.035	<0.001	1.033	1.018 - 1.049	<0.001
Σ Skin Fold	1.005	1.003 - 1.008	0.002	1.009	1.005 - 1.013	<0.001
WHtR	1.033	1.018 - 1.049	<0.001	1.058	1.031 - 1.086	<0.001
Conicity Index	1.029	1.013 - 1.046	0.001	1.046	1.020 - 1.071	<0.001

PR. prevalence ratio; CI95%, confidence interval; BMI. body mass index; WHtR. waist-to-height ratio; WC, waist circumference; CI, Conicity index. Σ, sum, † Adjusted for age, smoking, alcohol intake, and physical activity.

Table 4: Area under ROC curve, cut-off points, sensibility, and specificity of the predictive obesity indicators for metabolic syndrome in Older Adults according to sex for the older adults. Aiquara, Bahia, Brazil. (N=222).

Anthropometric indicators	ROC Curve (CI 95%)	Cut off point	Sensitivity %	Specificity %	Positive predictive value	Negative predictive value
Male						
BMI	0.81 (0.71-0.88)	26.8	56.2	92.3	89.9	63.1
WHtR	0.82 (0.73-0.90)	0.55	83.3	69.2	76.9	77.0
WC	0.84 (0.75-0.91)	89.3	89.6	69.2	78.1	84.3
CI	0.76 (0.66-0.85)	1.34	72.9	74.4	77.8	69.0
Σ Skin Fold	0.80 (0.70-0.88)	123.6	64.6	87.2	86.1	66.6
Female						
BMI	0.80 (0.71-0.87)	26.4	65.4	82.1	88.3	53.3
WHtR	0.84 (0.76-0.90)	0.63	67.5	92.3	94.8	57.7
WC	0.80 (0.72-0.87)	92.6	81.5	66.7	83.5	63.4
CI	0.77 (0.68-0.84)	1.32	76.2	66.7	82.6	57.4
Σ Skin Fold	0.78 (0.70-0.85)	162	86.4	66.7	84.3	70.2

CI 95%, confidence interval; BMI, body mass index; WHtR, waist-to-height ratio; WC, Waist Circumference; CI, Conicity Index. Σ, sum.

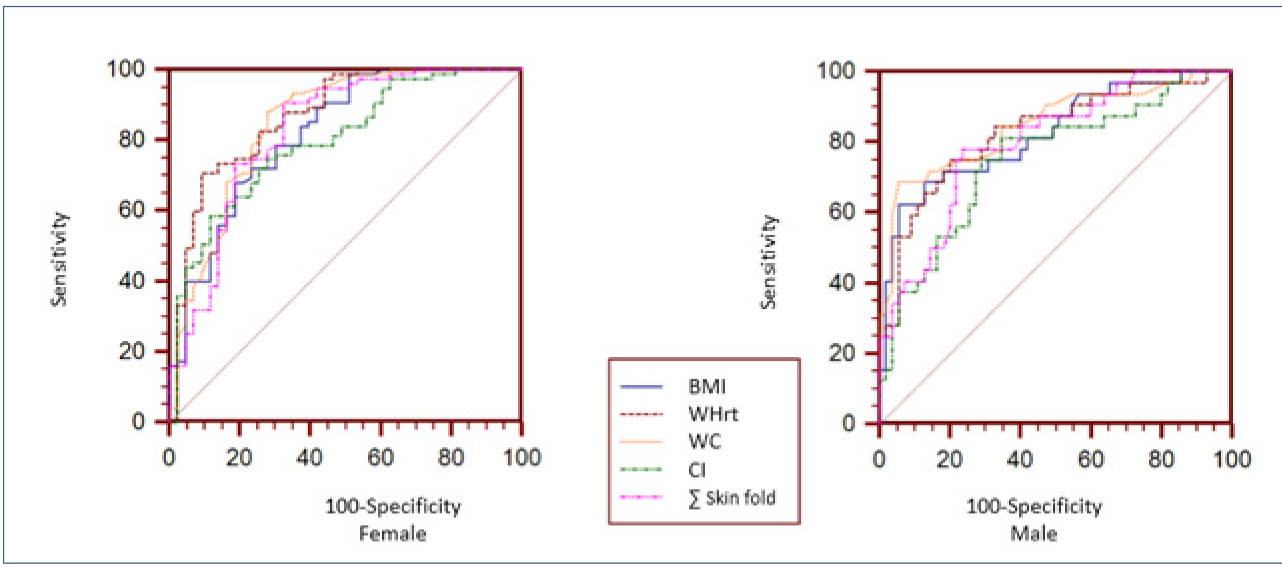

Figure 1: Area under the ROC curve of anthropometric indicators to predict metabolic syndrome in older adults. Aiquara, Bahia, Brazil (N=222).

The best cut-off point for the conicity index, which is also an indicator of central fat, was the indicator that demonstrated the smallest area under the ROC curve, presenting cut-off points of 1.34 for men and 1.36 for women. According to Gadelha *et al.*[18], the cut-off point for this indicator was lower for females and in the study by Abulmeaty *et al.*[23]. These central fat indicators (WHtR, WC, and CI) are directly associated with visceral fat which is an important indicator of various metabolic alterations, such as hypertension, HDL-c, and insulin resistance[24,25].

The sum of skinfolds presented a cut-off point for both sexes with values higher than 120 mm. Nevertheless, to the best of our knowledge, there is no information in the literature about the prediction of MS through the sum of skinfolds, even though few studies have already shown an association between the percentage of body fat and MS[18,26].

There were some limitations of our research, as it is a cross-sectional study, which may restrict the inferences of causality. Furthermore, the sample is classified as small, despite calculations, were performed to represent the older adult population in that city. Another limitation to be considered is that, with the aging process, there is a redistribution of body fat with a reduction in subcutaneous fat and an increase in visceral fat, which may have interfered with the results of the sum of the skin folds.

In conclusion, such anthropometric indicators can be used to perform a screening for factors that are related to metabolic syndrome in older adults of both sexes, since it represents a non-invasive method with low complexity and cost. Among the indicators evaluated, BMI and WHtR presented the best predictions. According to these results, it is possible to monitor and evaluate the health conditions of this specific group, as well as assist in reducing the public costs derived from these health hazards.

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