Diagnostic property of anthropometric indicators in the prediction of high body fat estimated by DXA in hypertensive women

Propriedade diagnóstica dos indicadores antropométricos na predição do excesso de gordura corporal estimado por meio do DXA em mulheres hipertensas

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Abstract – Excess body fat is an important risk factor for the development of arterial hypertension. The aim of this study was to verify the diagnostic performance of anthropometric indicators in the prediction of excess body fat estimated by Dual-energy Radiometric Absorptiometry (DXA) in hypertensive women. A cross-sectional study with 71 hypertensive women (57.9 ± 10.1 years; 77.8 ± 15.1 kg; 156.8 ± 5.2 cm) was carried out. The anthropometric indicators analyzed were: Body Mass Index (BMI), Waist Circumference (WC), Waist-to-Hip Ratio (WHR), Waist-to-Height Ratio (WHtR) and Conicity Index (C Index). Body fat measured by DXA was used as the reference method. Descriptive statistics and ROC curve were used for data analysis. Comparing the anthropometric indicators with the percentage of total fat estimated by DXA, significant differences were observed in BMI, WC and WHR (P <0.05). In relation to the percentage of trunk fat, a difference was identified in BMI and WC (P <0.05). Among the anthropometric indicators analyzed, BMI (0.83), WC (0.79) and WHtR (0.80) had the largest areas under the ROC curve in relation to excess body fat determined by DXA. The cutoff points were conservative in relation to those suggested in literature. Anthropometric indicators BMI (24.72 kg/m²), WC (87.81 cm) and WHtR (0.55) can be adopted in the evaluation of excess body fat in hypertensive women, since they demonstrated to be good predictors when confronted with DXA.

Key words: Anthropometry; Body fat distribution; Sensitivity and specificity; Women.

Resumo – *O excesso de gordura corporal é importante fator de risco para o desenvolvimento e agravamento da hipertensão arterial. Objetivou-se verificar o desempenho diagnóstico dos indicadores antropométricos na predição de excesso de gordura corporal estimado por meio do absortometria radiológica de dupla energia (DXA) em mulheres hipertensas. Realizou-se estudo transversal com 71 mulheres hipertensas (57,9 ± 10,1 anos; 77,8 ± 15,1 kg; 156,8 ± 5,2 cm). Os indicadores antropométricos analisados foram: Índice de Massa Corporal (IMC), Circunferência da Cintura (CC), Relação Cintura-Quadril (RCQ), Relação Cintura-Estatura (RCEst) e Índice de Conicidade (IC). A gordura corporal mensurada por meio da DXA foi utilizada como método de referência. Utilizou-se estatística descritiva e curva ROC para a análise dos dados. Comparando os indicadores antropométricos com o percentual de gordura total estimado pelo DXA, observou-se diferenças significativas no IMC, na CC e na RCEst (P < 0,05). Em relação ao percentual de gordura de tronco, identificou-se diferença no IMC e na CC (P < 0,05). Dos indicadores antropométricos estudados, o IMC (0,83), a CC (0,79) e a RCEst (0,80) tiveram as maiores áreas sob a curva ROC quando comparados a RCQ (0,50) e ao IC (0,55). Os pontos de corte se mostraram conservadores em relação àqueles sugeridos pela literatura. Os indicadores antropométricos IMC (24,72 kg/m²), CC (87,81 cm) e RCEst (0,55) podem ser adotados na avaliação do excesso de gordura corporal em mulheres hipertensas, uma vez que demonstraram ser bons preditores quando confrontados com DXA.*

Palavras-chave: *Antropometria; Distribuição da gordura corporal; Sensibilidade e especificidade; Mulheres.*

INTRODUCTION

Excess body fat is an important risk factor for the development and progression of several chronic non-communicable diseases, including arterial hypertension[1]. Increased body fat stimulates the renin-angiotensin-aldosterone system and sympathetic nerve activity, in addition to a physical compression in kidneys, causing changes in intrarenal hemodynamic behavior and impairments in sodium excretion, which together contribute to increase blood pressure[2].

In this context, accurate control of excess body fat becomes important among hypertensive individuals, since disease control and the success of pharmacological or non-pharmacological interventions can be mediated by changes in this variable[3]. This may be even more relevant in women who are naturally more prone to accumulation of fat in certain body regions due to hormonal issues[4]. In addition, the reduction in estrogen production observed in women with advancing age increases the sympathetic nervous activity and impairs endothelial function, hindering blood hypertension control[5].

Dual-energy radiological abortometry (DXA) evaluates the amount and distribution of body fat with high degree of accuracy, objectivity and reproducibility when all the measurement procedures recommended by the manufacturer are adopted[6,7]. However, it is not always accessible in middle- and low-income countries. Thus, simpler procedures, involving more accessible techniques and measures, with lower operational costs, such as anthropometric indicators[8], may be more applicable and, therefore, it is important to evaluate whether such measures are sensitive and specific in the prediction of excess body fat when compared to DXA, which has been used as an alternative in the validation of diagnostic methods of excess body fat in population studies based on doubly indirect techniques, such as anthropometric indicators[9]. In apparently healthy women, Body Mass Index (BMI) in conjunction with Waist Circumference (WC) and Conicity Index (CI) appear to be the best anthropometric indicators in predicting excess body fat[10], but it is still unclear if this method applies to hypertensive women.

Therefore, the aim of this study was to verify the diagnostic performance of anthropometric indicators [(Body Mass Index (BMI), Waist Circumference (WC), Waist-to-Hip Ratio (WHR), Waist-to-Height Ratio (WHtR) and Conicity Index (C Index)] in the prediction of excess body fat estimated by DXA in hypertensive women.

METHODOLOGICAL PROCEDURES

Recruitment

Women diagnosed with high blood pressure were recruited for a possible participation in a Randomized Clinical Trial (NCT02257268) linked to a behavior change program. The analyses of this cross-sectional study involved part of the baseline assessments performed for the clinical trial.

Participants were recruited through advertisements in local media, distribution of leaflets in hospitals and in the vicinities of the University of Pernambuco, Recife, Brazil, in 2014.

The study was approved by the Committee of Ethics in Research with Human Beings of the Federal University of Santa Catarina under protocol No. 811,266. After being informed about the aims and procedures of the study, all participants signed the free and informed consent form (TCLE) in compliance with Resolution 466/12 of the National Health Council.

Screening

As inclusion criteria, the following requirements were observed: age equal to or greater than 40 years, report of medical diagnosis of blood hypertension (systolic / diastolic blood pressure ≥ 140/90 mmHg) controlled by the use of antihypertensive medication for at least three months prior to the start of the study, not having diabetes and other cardiovascular diseases, physical limitations, and not being regularly enrolled in any physical activity program.

Demographic and Clinical Data

By means of a face-to-face individual interview, adopting an anamnesis form prepared by the researchers, demographic information (age and income) and those related to the use of antihypertensive drugs were collected.

Anthropometric measurements

Body weight (BW) was measured with barefoot participants, dressed in light clothing, using a digital scale (Welmy®, São Paulo, Brazil) with precision of 0.1 kg. Height (HEI) was obtained by means of a stadiometer connected to the scale, with accuracy of 0.1 cm.

WC was measured using an inelastic tape measure (Sanny®, São Paulo, Brazil), with precision of 0.1 cm, at the point of the smallest circumference between thorax and hip. Using the same tape measure, the hip circumference (Q) was measured in the widest area of the hips and in the largest protrusion of the buttocks. For all anthropometric measurements, the procedures described by the International Society for the Advancement of Kinanthropometry (ISAK)[11] were used.

From BW, HEI, WC and Q scores, BMI (BMI = BW (kg) / HEI² (m)), WHR [WHR = WC (cm) / Q (cm)], WHtR (WHtR = WC (cm) / HEI (cm)] and CI [CI = WC (m) / 0.109 $\sqrt{}$ BW (kg) / HEI (m)] were calculated[12-16].

In order to classify participants according to anthropometric indicators, the cutoff points proposed in literature were considered: adequate BMI <25 kg / m2 and inadequate ≥ 25 kg / m², adequate WC <88 cm and inadequate ≥ 88 cm[13], adequate WHR <0.85 cm and inadequate ≥0.85 cm[14], adequate WHtR ≤ 0.50 and inadequate ≤ 0.5015 and adequate CI <1.18 and inadequate ≥ 1.18[16].

Body Fat Measured through DXA

DXA with full-body scanner (Lunar Prodigy DXA, model NRL 41990, GE® Lunar, Madison, WI) was used to evaluate total body and trunk fat (% F_{DXA}) (criterion method). The participant was asked to lie down on the table in dorsal decubitus position, along a standard longitudinal line, remaining motionless during the measurement. The procedure lasted about five to 10 minutes for each participant and was performed by the same evaluator, with experience in this type of measurement, who previously calibrated the device according to manufacturer's recommendations.

Participants were recommended to follow the routine procedures before the evaluation in order not to cause measurement errors: to maintain the diet of the last days, not to smoke, to not drink alcohol in the 24 hours before the test, to maintain the routine medication and not to change the hydration standard[17].

We chose to categorize $\%F_{DXA}$ by performing distribution into percentiles. The final quartile (75th percentile) was used as the reference value to classify excess body fat, i.e., women who presented value equal or greater to the 75th percentile ($\%F_{DXA} \geq 47.6$) were diagnosed with excess body fat, and women who presented values below the 25th percentile ($\%F_{DXA} < 42$) were considered without excess body fat.

Statistical analysis

Variables were expressed as mean, standard deviation, minimum value and maximum value. After categorizing participants according to the cutoff points suggested for each one of the anthropometric indicators, the Student's t test for independent samples was used to compare the fat percentage estimated by DXA between groups. Receiver Operator Characteristic Curve (ROC) analysis was performed to calculate the sensitivity and specificity among anthropometric indicators (BMI, WC, WHR, WHtR, CI) in relation to the criterion measure ($\%F_{DXA}$) and for comparison of the area under the curve, in the identification of excess body fat, considering a 95% confidence interval. Sensitivity and specificity values not less than 60% and area under the ROC curve not less than 50% were criteria used for selection of cutoff points[18]. Analyses were performed using the SPSS software (Statistical Package for Social Sciences) version 22.0.

RESULTS

The general characteristics of the sample, composed of 71 hypertensive women, were presented in Table 1.

Table 2 shows the comparison of the total and trunk fat percentage estimated by DXA according to the classification of participants based on the cutoff points proposed for each of the anthropometric indicators (BMI[12], WC[13], WHR[14], WHtR[15], and Conicity Index[16]). Comparing the total fat percentage estimated by DXA, a statistically significant difference was observed between groups classified according to BMI, WC and WHtR (P <0.05).

In relation to the trunk fat percentage, a difference was identified between groups classified according to BMI and WC (P <0.05). The group of women classified with inadequate BMI and WC presented higher total and trunk fat percentage in comparison to the group with adequate indicators. In addition, the total fat percentage was higher for the group with inadequate WHtR in relation to the group with this indicator within criterion considered adequate.

Table 1. General characteristics, body fat and anthropometric indicators of hypertensive women (n = 71).

Variables	Mean ± SD	95% CI	Minimum	Maximum
Age (years)	57.93 ± 10.18	55.52; 60.34	41.00	86.00
Income (mw*)	1.35 ± 1.48	1.00; 1.70	0.00	9.00
Antihypertensive drugs	2.09 ± 0.84	1.85; 2.28	1.00	4.00
BW (kg)	77.79 ± 15.08	74.23; 81.36	47.40	116.20
HEI (cm)	156.78 ± 5.23	155.54; 158.02	144.00	169.00
Total F_{DXA} (%)	44.52 ± 4.50	43.46; 45.59	29.2	54.5
BMI (kg/m²)	31.49 ± 5.59	30.16; 32.81	19.77	48.98
WC (cm)	98.13 ± 11.13	95.47; 100.78	72.37	135.93
WHR (cm)	0.92 ± 0.07	0.90; 0.93	0.74	1.25
WHtR	0.63 ± 0.07	0.61; 0.64	0.49	0.88
Conicity Index	1.28 ± 0.06	1.27; 1.30	1.13	1.43

SD = standard deviation. 95% CI = confidence interval. mw = minimum wages (R$ 724,00). BW = body weight. HEI= height. %FDXA = relative body fat. BMI = Body Mass Index. WC = Waist Circumference. WHR = Waist-to-Hip Ratio. WHtR = Waist-to-Height Ratio.

Table 2. Total and trunk fat percentage estimated by DXA according to the classification of participants based on cutoff points proposed for the anthropometric indicators (n = 71).

	Adequate[†] Mean ± SD (95%CI)	Inadequate[††] Mean ± SD (95%CI)	P*
Total fat (%)			
BMI (kg/m²)	36.35 ± 4.47 (31.65; 41.04)	45.28 ± 3.72 (44.36; 46.20)	0.00
WC (cm)	39.77 ± 5.26 (35.72; 43.81)	45.22 ± 3.98 (44.20; 46.23)	0.00
WHR (cm)	44.99 ± 2.88 (42.58; 47.39)	44.34 ± 4.62 (43.17; 45.52)	0.70
WHtR	32.20 ± 4.24 (-5.92; 70.32)	44.88 ± 4.01 (43.92; 45.84)	0.00
Conicity Index	41.90 ± 7.01 (34.54; 49.25)	44.77 ± 4.20 (43.72; 45.8)	0.13
Trunk fat (%)			
BMI (kg/m²)	35.55 ± 6.86 (28.35; 42.74)	45.63 ± 4.18 (44.59; 46.66)	0.00
WC (cm)	39.08 ± 6.65 (33.97; 44.19)	45.61 ± 4.48 (44.47; 46.74)	0.00
WHR (cm)	45.56 ± 3.15 (42.93; 48.19)	44.64 ± 5.48 (43.25; 46.03)	0.64
WHtR	31.05 ± 11.10 (-68.69; 130.79)	45.18 ± 4.54 (44.08; 46.26)	0.32
Conicity Index	39.58 ± 8.98 (30.16; 49.01)	45.26 ± 4.56 (44.13; 46.39)	0.18

† BMI <25 kg / m²; WC ≤ 88 cm; WHR <0.85 cm; WHtR ≤0.50 and; CI <1.18. †† BMI ≥ 25 kg / m², WC ≥ 88 cm, WHR ≥ 0.85 cm, WHtR ≥0.50; and CI ≥ 1.18. SD = standard deviation. 95% CI = confidence interval. BMI = Body Mass Index. WC = Waist Circumference. WHR = Waist-to-Hip Ratio. WHtR = Waist-to-Height Ratio. * T test for independent samples (adequate vs. inadequate).

In the analysis of the areas under the ROC curve, it was observed that BMI, WC and WHR were more sensitive and specific in the identification of women with excess body fat when compared to the other anthropometric indicators. When the areas under the ROC curves were compared with one another, a statistically significant difference (P <0.05) was observed in anthropometric indicators BMI, WC and WHR, respectively (Table 3).

Table 3. Diagnostic properties of anthropometric indicators to detect excess body fat in relation to the criterion measure (%F$_{DXA}$).

Comparison	ROC curve (CI 95%)	Cutoff point †	Sensitivity	Specificity
BMI vs %F$_{DXA}$	0.83 (0.72-0.93)*	24.72	1.00	0.89
WC vs %F$_{DXA}$	0.79 (0.68-0.90)*	87.81	1.00	0.83
WHR vs %F$_{DXA}$	0.50 (0.33-0.66)	0.88	0.80	0.80
WHtR vs %F$_{DXA}$	0.80 (0.70-0.91)*	0.55	1.00	0.83
CI vs %F$_{DXA}$	0.55 (0.39-0.71)	1.27	0.60	0.60

95% CI = confidence interval. BMI = Body Mass Index. WC = Waist Circumference. WHR = Waist-to-Hip Ratio. WHtR = Waist-to-height Ratio. CI = Conicity Index. %F$_{DXA}$ = relative body fat. Vs = versus. * Significant ROC curve (P <0.05). † Cutoff points obtained from the ROC curve analysis.

Through the analysis of the ROC curve, two of the anthropometric indicators are below the reference line (WHR and CI), that is, they are indicators with low discriminatory power for excess body fat estimated by means of DXA (Figure 1).
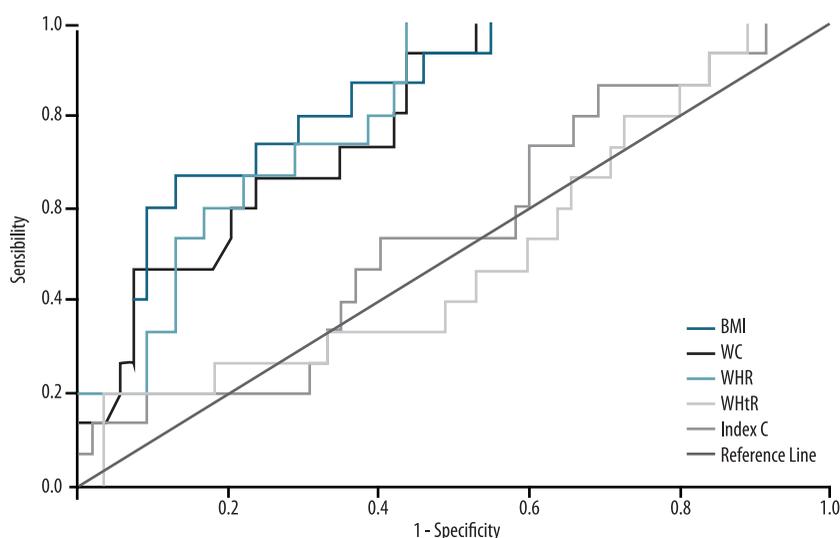

Figure 1. Area under the ROC curve of anthropometric indicators to predict excess body fat in hypertensive women

DISCUSSION

The main findings of the present study indicated that BMI, WC and WHtR were more discriminatory in measuring excess body fat compared to WHR and CI in hypertensive women. These results show that not only the indicator of generalized obesity (BMI), but also indicators of central

obesity (WC, WHtR), can be used to diagnose excess body fat in hypertensive women. In women not diagnosed with chronic diseases, BMI and WC also proved to be good predictors of excess body fat[10].

In addition, in comparing the fat percentage estimated by DXA according to groups classified based on cutoff points recommended in literature for each of the anthropometric indicators, it was identified that, in fact, when classification was based on BMI[12], WC[13] and WHtR[15], groups (adequate and inadequate) significantly differed for total fat percentage. Regarding the trunk fat percentage, there was also a difference between groups when analyzed according to BMI and WC classification. These indicators have been accepted as simple measures used to evaluate the amount and distribution of body fat and also as useful indicators to provide important information to predict the presence of blood hypertension[19,20].

BMI consists of an anthropometric indicator widely used in the general population to identify obesity and related health risks[12], corroborating the findings of the present study that identified higher specificity and sensitivity values, as well as greater area under the ROC curve for this indicator. In the present study, the best cutoff point for BMI to diagnose excess body fat was 24.7 kg / m2, close to the cutoff point proposed by the World Health Organization[12], which is ≥ 25.0 kg / m2.

However, there are controversies about using the same cutoff point for adults and older individuals in order to detect excess body fat, since changes in body composition due to the aging process should be considered[21,22].

WC is mainly correlated with the distribution of visceral adipose tissue and, therefore, such an anthropometric indicator has been recommended for the specific evaluation of abdominal obesity[23]. Recent studies have highlighted the increase in abdominal obesity in the Brazilian female population[24,25]. In this study, it was observed that the best cutoff point for predicting excess body fat was 87.8 cm. This finding is in line with the proposal of the United States National Institute of Health[26], and by the World Health Organization[13], used in most western countries recommends for women WC ≥ 88 cm as the best cutoff point for identifying health risks.

The literature has shown that WHtR is a good discriminator of abdominal obesity related to cardiovascular risk factors[16]. In the present study, the best cutoff point for the detection of excess body fat in women was 0.55, similarly to the recommendation of literature, which suggests values equal to or higher than 0.5 for both sexes[16,27]. The study by Rodrigues et al.[28] determined cutoff points for WHtR in Brazilians and the cutoff point suggested for women (0.54) was close to that found in the present study.

The above results indicate that the cutoff points for BMI, WC and WHtR were conservative in relation to the cutoff points adopted in literature. The cutoff points found for WHR and CI, as well as the area of the ROC curve, suggest that both anthropometric indicators are not the most adequate for diagnosing excess body fat in hypertensive women due to their low sensitivity and specificity. On the other hand, according to literature, WHR is an anthropometric indicator that is also associated with visceral

fat, being an acceptable index of intra-abdominal fat[29]. The cutoff point for this indicator suggested in this study was 0.88 cm. A study conducted with Brazilian women over 50 years reported the same cutoff point[29], differing from the cutoff point recommended in literature, 0.85[15]. In turn, CI is another anthropometric option that provides information on body fat distribution. A study comparing CI to other anthropometric indicators found that it is a good predictor for the identification of visceral fat[30], which, to a certain extent, contradicts the findings of the present study. In addition, the value of 1.18 is recommended in studies[17,29] as the best cutoff point in the prediction of excess body fat; however, in the present study, the cutoff point found was 1.27.

The discrepancy among studies may be related to the population in question, since, in the present study, only hypertensive women were analyzed. Gomes et al.[10] suggest, for example, that CI is a good indicator for preliminary diagnosis of health risks in populations not yet diagnosed with any chronic disease.

This study presents some limitations that should be considered in the interpretation of results, for example the sample heterogeneity regarding age and the fact that the sample is not representative, which limits the possibility of extrapolation of results. However, the use of DXA as a reference standard is a strong point of the study. Another point to be emphasized is that other studies involving hypertensive populations have assessed "the power" of anthropometric indicators in predicting cardiovascular risk or blood hypertension, but few have proposed to investigate whether these indicators are, in fact, sensitive in the prediction of overweight.

CONCLUSION

Based on the above results, it was concluded that anthropometric indicators BMI, WC and WHtR can be used to diagnose excess body fat in hypertensive women, being thus important measures of the effect of pharmacological and non-pharmacological interventions in this population. In addition, due to their high sensitivity and specificity, simplicity and low operating costs, these methods are more affordable for the monitoring of the health status of hypertensive women.

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