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Anthropometric Indicators as Predictors of Adiposity and Cardiometabolic Diseases

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Abstract

Objective: To evaluate the ability of anthropometric indicators to identify adiposity and metabolic syndrome (MS) in patients with arterial hypertension (AH). Materials and Methods: Cross-sectional study with patients of both sexes, age? 20 years, with AH and overweight, and in outpatient care. Lifestyle, clinical, and anthropometric data were collected, and the following indicators were calculated: body mass index, waist-to-height ratio (WHtR), and conicity index (CI). Results: A total of 181 patients (53.3±12.6 years) participated. There was a predominance of women (69.6

Index terms—

Introduction n recent decades there has been an increase in chronic non-communicable diseases (CNCDs), such as cardiovascular diseases (CVD), cancer, diabetes, and chronic respiratory diseases, being the leading causes of death today, responsible for just over 70% of deaths worldwide. Among the main risk factors, these share behaviors that can be modifiable, such as tobacco use, physical inactivity, poor diet, and harmful alcohol consumption, which in turn contribute to overweight, increased blood pressure, altered plasma lipids, and, finally, diseases (1). Moreover, CVD is the leading cause of death in Brazil and worldwide, accounting for about one-third of these deaths (2).

The association between blood pressure and weight gain has been reported, with a higher prevalence of arterial hypertension (AH) in obesity, representing a public health problem. Another consideration involving overweight is the arrangement of fat cells that, when concentrated in the abdominal region, has a vast association with cardiovascular events, and abdominal adiposity measurements can be used as a complementary approach to determine the risk of premature death (3).

It is also noteworthy that the presence of abdominal adiposity implies the development of metabolic alterations, among them, glucose intolerance and hypertriglyceridemia, considered important factors in the emergence of metabolic syndrome (MS). These increase morbidity and mortality due to atherosclerotic disease and its consequences, such as coronary artery disease (4).

The evaluation of adiposity is necessary for cardiometabolic risk assessment and prevention of obesity comorbidities. Although the diagnostic imaging technique is the most efficient method to evaluate adiposity, it becomes limited due to its high cost and methodological difficulties, which justifies the use of alternative, low-cost methods with greater clinical applicability. In this context, anthropometry stands out, in which adiposity is evaluated by means of isolated measurements, such as waist circumference (WC), or associated, from the construction of other anthropometric indicators such as body mass index (BMI), waist-to-height ratio (WHtR) and conicity index (CI) (5).

The anthropometric indicators of adiposity can establish important relationships with cardiometabolic diseases, namely, the AH and MS (6). Both anthropometric indicators of total obesity (BMI) and central obesity (WHtR and CI) are predictors of AH (7), but in metabolic abnormalities, the indicators of abdominal obesity stand out, such as a classic measure, WC (8). The correlation between the anthropometric indicators is also observed, such as between WC and BMI, these being the indicators that were most associated with the other anthropometric variables and also with alterations in plasma lipids (9).

Studies aiming to understand and diagnose more easily and reliably the possible relations of adiposity indicators with health problems are of utmost importance. Moreover, CVD and metabolic diseases are of great concern in developing countries. Considering the importance of adiposity in cardiometabolic risk and the verification of the accuracy of anthropometric indicators in this context, the objective of this study was to evaluate the capacity of anthropometric indicators in the identification of adiposity and MS in patients with AH.

1 II.

2 Materials and Methods

3 a) Study design

This is a cross-sectional study, with nonprobability sampling design and convenience sampling, with patients seen at the nutrition, cardiology, endocrinology, and metabolism outpatient clinics of the University Hospital of the Federal University of Grande Dourados, in the state of Mato Grosso do Sul, Midwest region of Brazil.

Patients who attended the outpatient units in that period and met the selection criteria for the study were invited to participate, and were included upon agreement and signing of an informed consent form. The individuals who were not participating in the study had ample and unrestricted access to care. The present study was approved by the Research Ethics Committee for human beings of Anhanguera-Uniderp, opinion number 838.813 (CAAE 35187214.8.0000.5161), according to Resolution No. 466/2012 of the Health Council -Ministry of Health.

4 b) Sample

Inclusion criteria were age ? 20 years, overweight, BMI ? 25 kg/m^2 in adults (10) and ? 28 kg/m 2 in the elderly (age ? 60 years) (11), diagnosis of AH under drug treatment. Pregnant and puerperal women, indigenous patients, those whose anthropometric measurements were not possible, patients unable to communicate verbally, and those who did not present complete medical records with the data necessary for the study were excluded.

Initially 313 patients were selected in the research period, and after checking the eligibility criteria, 208 patients were invited to participate, with refusal of 27 patients. In total, 181 patients aged between 20 and 80 years were evaluated.

5 c) Data collection

Data was collected through personal interview and from electronic medical records of outpatient care. Sociodemographic (age, gender, marital status, education, race/color), economic (monthly income), lifestyle (physical activity, tobacco and alcohol use), clinical (diagnosis of chronic diseases and medication use) and anthropometric (weight, height and waist circumference) data were collected. The practice of physical activity was assessed according to personal reports: "no physical activity" (no/sedentary), "physical activity" (yes), when individuals exercised, according to recommendations of the Institute of Medicine/Food and Nutrition Board (12).

To collect anthropometric measurements we used the methodology recommended by the Food and Nutrition Surveillance System -SISVAN (13), which is an information system that aims to monitor the nutrition and feeding conditions of the Brazilian population. For the measurement of height (m), the patient was positioned barefoot and with head free of adornments, in the center of the equipment (stadiometer). He stood upright, with arms extended along his body, head up, looking at a fixed point at eye height. The individual placed his heels, calves, buttocks, scapulae, and the back of his head (occipital region) against the Alturexata® precision multifunctional portable stadiometer, whose maximum height is 200 cm, with a 0.5 cm interval.

To measure the weight (kg), the individual was standing in the center of the base of the scale, barefoot and with minimal clothing. Balmak Actilife® digital scales were used, with a capacity of up to 200 kg. The WC (cm) was measured with the individual standing, with the tape positioned at the midpoint between the last rib and the iliac crest. For this measurement the Sanny "Starret"® tape measure was used, inelastic and flexible, with an accuracy of 0.1 cm.

6 d) Anthropometric indicators of adiposity and metabolic syndrome classification

The anthropometric indicators analyzed were BMI, WC, WHtR, and CI. BMI, obtained by dividing weight by squared height (kg/m^2), was classified for the adult population (20-59 years) into pre-obesity (BMI between 25 and 29.9 kg/m 2) and obesity (BMI ? 30kg/m 2) (10). For the elderly (60-80 years) different BMI cut-off points were used, and in this population the values proposed by the Pan American Organization were considered (11): pre-obesity (BMI ?28 and < 30 kg/m 2) and obesity (BMI ? 30 kg/m 2). WC was classified as high when greater than 80 cm for women and greater than 90 cm for men (14).

To calculate the WHtR, we used the WC divided by height -both in centimeters -with a result ranging from values close to zero (0) to one (1). The cut point considered was 0.5, a single cut point for both sexes, used in the evaluation of excess abdominal fat and risk of obesity comorbidities (15).

The CI was determined by means of weight, height and WC measurements, expressed in meters, using the following mathematical equation: CI= waist circumference 0.109????????? ??? ???????? ??? 38 Year 2023

The cut-off point considered was 1.25 for men and 1.18 for women, which configures a high risk for CVD and metabolic diseases (16).

The presence of two or more of the following components was considered for the diagnosis of MS: WC (>90 cm for men and >80 cm for women); triglycerides ? 150mg/dL and/or men HDL -c < 40mg/dL and women HDL-c < 50 mg/dL or use of hypolipemiants; blood pressure ? 130/ 85 mmHg or use of anti-hypertensives; serum glucose > 100 mg/dL (including type 2 diabetes mellitus (DM), as suggested by the International Diabetes Federation (IDF) (14).

7 e) Statistical Analysis

The IBM SPSS (Statistical Package for the Social Science) Statistics®, version 22 and MedCalc Statistical®, version 17.4, software was used for statistical analysis. To test the best fit for normal distribution the Kolmogorov-Smirnov test was applied. Categorical data in percentages were analyzed by the chi-square test or Fisher's exact test. Continuous data were described as mean and standard deviation and analyzed by the t-student or Mann-Whitney test. The capacity of anthropometric indicators in the identification of adiposity, as well as their sensitivity and specificity, was evaluated by the ROC curve (Receiver Operating Characteristic), using BMI as the test index. Furthermore, the ROC curve was applied to analyze the capacity of anthropometric indicators in predicting MS, applied to the groups of patients with and without MS. The predictive power of anthropometric indicators regarding adiposity and MS was tested in subgroups consisting of gender (men/women), age (adults/elderly) and race/color (white and non-white individuals). Significant differences were considered to be values of p?0.05.

8 III.

9 Results

A total of 181 patients were evaluated, most of them female (69.6%), with a mean age of 53.3±12.6 years. As for socio-demographic characteristics, patients were predominantly adults (69.1%), non-white (58.6%), had attended elementary school or were not literate (67.9%), had a monthly income of 1 to 3 minimum wages (80.1%), and had a partner (65.2%). Regarding lifestyle habits, most were nonsmokers (61.3%), did not consume alcoholic beverages (75.7%), and did not practice physical exercise (79.0%) (Table 1). When assessing the presence of diseases, 47% had DM, 44.2% had dyslipidemia, and 71.8% had MS. MS was associated with increasing age (p=0.003) and male gender (p=0.002) (Table 1).

The mean BMI was 36±6.4kg/m2, 81.2% were classified as obese, and all patients had increased WC and WHtR. The mean values of WC (p=0.014), WHtR (p=0.047) and CI (p<0.001) were higher in the group of patients with MS, while the BMI value (p=0.721) did not differ between these groups. High cardiometabolic risk, according to the CI, was observed in 93.9% of patients, being present in 97.7% of those with MS (p=0.001) (Table 2).

The AUC values, cutoff points, sensitivity, specificity, and positive and negative predictive values of the anthropometric indicators (WC, WHtR, CI) evaluated in the identification of adiposity in patients with AH are shown in Table 3. Among the indicators, WC was a good discriminator both in men (AUC 0.92; 95%CI 0.82-0.98; p<0.001) and in women (AUC 0.91; 95%CI 0.85-0.95; p<0.001), with cutoff points of 111 cm for men and 98 cm for women. It was possible to observe that WC showed 100% specificity in men, while in women CC showed higher sensitivity (87.4%). The positive predictive values were 80.0% and 81.8% for men and women, respectively. The WHtR showed AUC of 0.84 (men) and 0.90 (women), therefore a good discriminator, especially in women.

Considering only the adults, the WHtR (AUC 0.93; 95%CI 0.87-0.97; p<0.001) followed by WC (AUC 0.92; 95%CI 0.86-0.96; p<0.001) were good discriminators. In the elderly, WC (AUC 0.82; 95%CI 0.82-0.98; p<0.001) was the best discriminator, with 100% specificity and 63.3% sensitivity, and a positive predictive value of 87.5%. As for race/color, in whites, WC and WHtR were the best predictors of adiposity, with similar results for sensitivity and specificity, but in non-whites, the sensitivity of WC was higher. Figure 1 shows the ROC curve in relation to the ability to identify adiposity in the subgroups evaluated.

The areas under the ROC curve to evaluate the capacity of anthropometric indicators (BMI, WC, WHtR, CI) to identify MS, as well as cutoff points, sensitivity, specificity of the indicators and positive and negative predictive values are shown in table 4. In men, BMI and WHtR showed higher values for sensitivity, 64.6% and 60.4%, respectively, with a positive predictive value of 87.3%, and WC had the highest AUC and specificity. In women, CI had an AUC of 0.71 (95% CI; 0.63-0.79; p<0.001), and was also the most specific indicator (81.8%), while BMI was more sensitive (97.6%). In both adults and the elderly, WC was more sensitive (84.3% and 93.6%, respectively), but in adults, CI had an AUC of 0.70 (95%CI; 0.61-0.78; p<0.001), being the best discriminator of MS in this subgroup. When analyzing race/color, both groups showed CI with better AUC. Figure 2 shows the ROC curve of the anthropometric indicators able to identify MS in the subgroups studied.

IV.

10 Discussion

The findings of this study show that WC showed the best discriminatory power of adiposity in patients with AH of both sexes, which reinforces the role of WC in the identification of obesity in this population. WC is a traditional anthropometric measurement, with a simple measurement technique and low cost, which provides clinical practicality in its use, besides the solid association with cardiometabolic abnormalities, as observed in the study by Domínguez-Reyes et al. (8), who also elected WC as the best discriminator of adiposity for both sexes in a Latin American population.

Anthropometric indicators are presented in a clear, objective and easy-to-apply way, however they suffer some influences such as gender, age and race (17), being extremely relevant the evaluation of the indicators behavior in the identification of adiposity in different subgroups of patients, as presented in this work.

Another point that draws attention in the current investigation is that only patients diagnosed with AH participated, but the majority presented MS, an undiagnosed and consequently untreated disorder in this population. MS configures the presence of combined cardiometabolic risk factors that are responsible for worsening the health of patients with AH (4). It is also noteworthy that, differently from women, who presented as the best indicator to discriminate MS the CI, in men the WC had the highest AUC. This may be explained by the larger number of female participants or by the distribution of abdominal fat in this population.

The study by Camhi et al. (18) makes it evident that fat distribution between men and women is different. Study only with women, the clinically useful indicators to discriminate coronary risk were WC, WHtR and CI (19). Another study brought that the CI has contributed to the stratification of cardiovascular risk in women (20), data that are similar to the current study, since the CI was the best predictor of MS in this group.

With the aim of having some anthropometric indicator capable of easily and quickly notifying MS in clinical/outpatient care, in order to promote treatment to this subclinical portion of patients, the most sensitive indicators in the identification of MS in this study were obtained as BMI (according to sex) and WC (age, race/color), but the best discriminators of MS were WC (men) and HF (other subgroups), and in other studies, BMI, WC and WHtR, besides attributing the strong relationship of these indicators with visceral fat deposition (21, 22).

Studies report that, among the indicators, WC is a good parameter of visceral fat and can be used as an alternative marker. The WHtR is an index to measure obesity and predict metabolic risks, being more sensitive than BMI, especially in the older population. Another good predictor of metabolic disorders is the CI (23-25), which in the current study was the anthropometric indicator that best identified MS, except in men, whose best discriminator was WC. That said, and in view of the vast literature on alternative methods and indicators to predict or diagnose metabolic disorders, this study has as a weak point the failure to explore a method that has been much commented on in the current literature, the neck circumference and abdominal volume index, which has proven to be very accurate in relation to **??**MI (26, **??**7).

Results obtained from a systematic review indicate that WHtR is the best anthropometric index when used alone, while WHtR and WC showed better discriminatory power in predicting cardiovascular risk factors compared to the other indices (28).

The WHtR has shown to be efficient in the discrimination of adiposity in most subgroups (women, adults, whites and non-whites), and it has been placed as a practical advantage the use of a single cut point, and even though there is still no consensus about the best cut point, the most commonly used is the value of 0.5 (15). In the present study, the cutoff point for WHtR was 0.62 in men and 0.64 in women, agreeing with the findings of Rezende et al. (7), regarding a cutoff point higher than 0.5 and different between genders, and Oguoma et al. (2021) (21), who identified in the presence of cardiometabolic diseases a higher cutoff point for WHtR.

The possible relationship between abdominal adiposity and MS was evident, because all anthropometric parameters of fat tissue deposition were increased in patients with MS. Moreover, it is clear the importance of comparing the anthropometric methods, especially because in the present study there was no difference in BMI between patients with and without MS, corroborating the statements that BMI may not be a good indicator to determine cardiometabolic risk by not considering the distribution of body fat **??**29).

In this study it was observed that among the anthropometric indicators, WC and WHtR were the best discriminators of adiposity in the presence of AH. These results converge with other studies, such as Milagres et al. (30), who conclude that the increase in body fat, diastolic blood pressure, triglycerides, glycemia, and the reduction in HDL-cholesterol are associated with an increase in the cutoff points of these anthropometric indices, with a greater association of WHtR with cardiometabolic risk factors.

Moreover, studies with the Brazilian population also suggest that anthropometric indicators of total (BMI) and central (WC and WHtR) obesity are predictors of hypertension, as well as the CI (31, 7). And for other populations, both WHtR and WC were the best predictors of MS (32-34). It is worth emphasizing the need for population-specific cut-off points, given the existence of differences in an individual's body composition due to sex, age, race, and the occurrence of height loss in the elderly (35).

A limiting factor of the study was the larger number of women (69.6%) and adults (69.1%) in the sample, besides the significant number of patients with MS (71.8%), which may have impaired the identification of anthropometric indicators that predict MS in the subgroups, especially in men and the elderly.

In conclusion, this research allowed us to warn about the need to evaluate anthropometric indicators in overweight patients in the presence of comorbidities, such as hypertension, the most prevalent condition associated with obesity today. Adiposity in the studied population was better discriminated by WC and WHtR, considering the different subgroups, culminating in the identification of greater abdominal accumulation of body fat, which in itself already predicts risk in the development of cardiometabolic diseases. The high prevalence of MS in this population portrays an undiagnosed condition, which in the light of anthropometric indicators of adiposity can be identified in a practical and fast way by the CI, especially in adult, female patients of different races (white and non-white).

11 Sponsorship

This [1]

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Figure 1: Figure 1 :

2

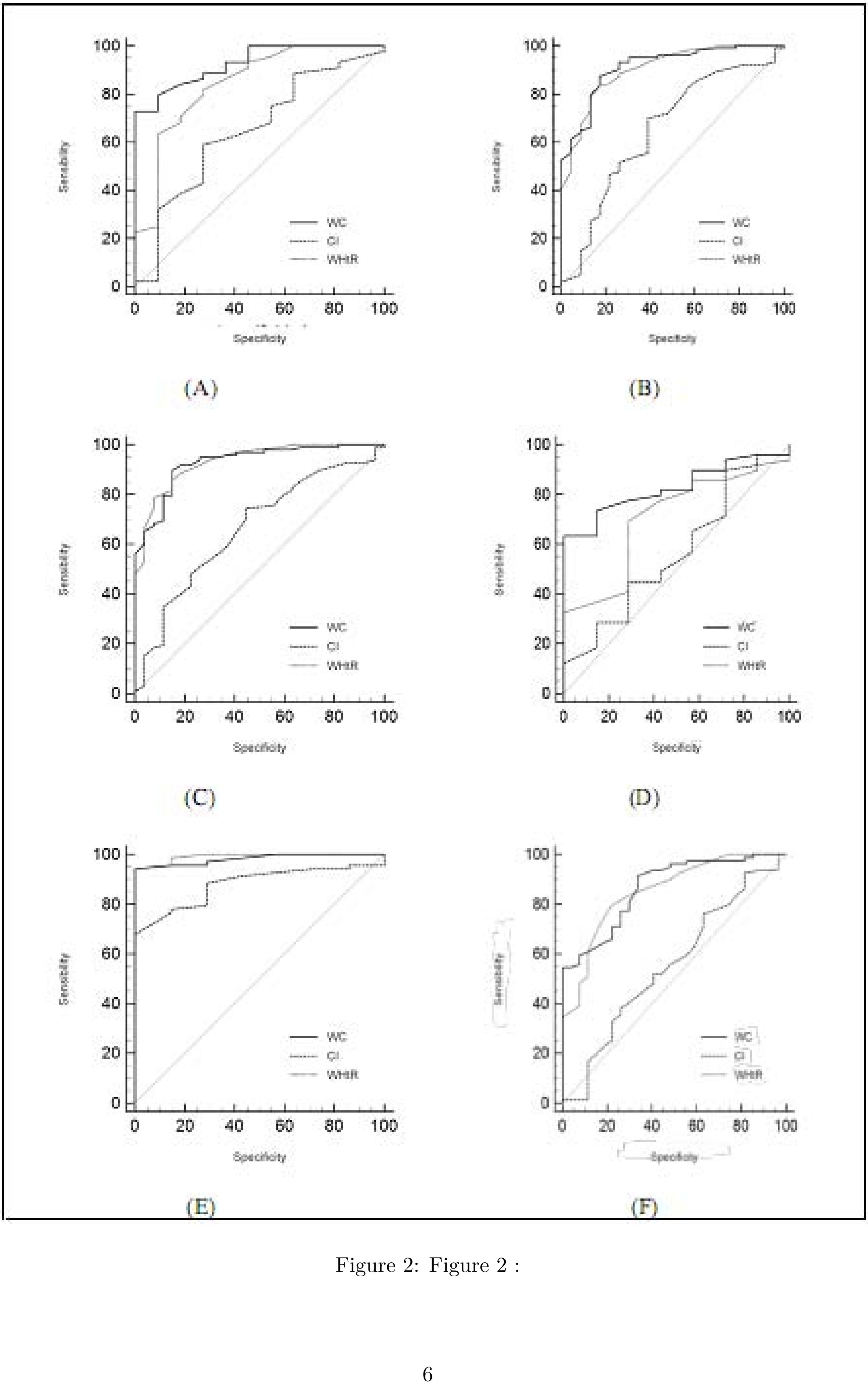

Figure 2: Figure 2 :

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Figure 3: Table 1 :

2

Variables	Total n= 181	WITH MS n=130	WITHOUT MS n=51	P
BMI (kg/m 2 ; mean±SD)	36.0±6.4	35.9±6.2	36.3±6.8	0.721*
WC (cm; mean±SD)	110.0±13.7	111.6±12.8	106.0±15.3	0.014*
WHtR (mean±SD)	0.69±0.09	0.70±0.08	0.67±0.09	0.047*
CI (median, min-max)	1.34 (1.07-1.96)	1.35 (1.11-1.60)	1.29 (1.07-1.96)	<0.001*
BMI				
Pre-obesity	34 (18.8)	25 (19.2)	9 (17.6)	0.806 ?
Obesity	147 (81.2)	105 (80.8)	42 (82.4)	
CI				
Hih CR	170 (93.9)	127 (97.7)	43 (84.3)	0.001 ?
Low CR	11 (6.1)	3 (2.3)	8 (15.7)	

SD -standard deviation; MS -metabolic syndrome; (*) Student's t-test; (?) Chi-square or Fischer's exact tes index; WC: waist circumference; WHtR: waist-to-height ratio. CI: conicity index; CR: cardiometabolic risk. p?0.05.

Figure 4: Table 2 :

3

	AUC	95%CI	P	Cut-off point	Sensibility %	Specificity %	PV + %	PV -%
Homens								
WC (cm)	0.92	0.82-0.98	<0.001*	111	72.7	100.0		
CI	0.65	0.50-0.77	0.12	1.36	59.1	72.7	80.0	20.0
WHtR	0.84	0.72-0.92	<0.001*	0.62	81.8	72.7		
Women								
WC (cm)	0.91	0.85-0.95	<0.001*	98	87.4	82.6		
CI	0.65	0.56-0.73	0.02*	1.27	69.9	60.9	81.8	18.2
WHtR	0.90	0.83-0.94	<0.001*	0.64	83.5	82.6		
Adults								
WC (cm)	0.92	0.86-0.96	<0.001*	98	89.8	85.2		
CI	0.66	0.57-0.74	0.005*	1.27	74.5	55.6	78.4	21.6
WHtR	0.93	0.87-0.97	<0.001*	0.64	78.6	92.6		
Elderly								
WC (cm)	0.82	0.70-0.91	<0.001*	111	63.3	100.0		
CI	0.56	0.42-0.69	0.582	1.47	89.8	28.6	87.5	12.5
WHtR	0.70	0.56-0.81	0.041*	0.67	69.4	71.4		
White								
WC (cm)	0.98	0.92-0.99	<0.001*	95	94.1	100		
CI	0.87	0.78-0.94	<0.001*	1.29	67.6	100	90.7	9.3
WHtR	0.99	0.93-1.00	<0.001*	0.60	94.1	100		
Non-white								
WC (cm)	0.86	0.78-0.92	<0.001*	98	91.1	66.7		
CI	0.55	0.45-0.65	0.417	1.27	75.9	37.0	74.5	25.5
WHtR	0.85	0.77-0.91	<0.001*	0.64	79.7	77.7		

*[Note: AUC: Area under the ROC curve; 95%CI: Confidence Interval; PV: predictive value; *statistically significant; WC: Waist circumference; CI: conicity index; BMI: Body mass index; WHtR: Waist-to-height ratio. p value in relation to body mass index.]*

Figure 5: Table 3 :

4

	AUC	95%CI		P	Cut-off point	Sensibility %	Specificity %	PV + %	PV - %
Homens									
BMI	0.51	0.38-0.65		0.861	30.9	64.6	14.3		
WC (cm)	0.53	0.39-0.67	0.37-	0.782	113.8	58.3 31.2	57.1 42.9	87.3	12.7
CI	0.51	0.65		0.910	1.34				
WHtR	0.50	0.36-0.63		0.990	0.69	60.4	14.3		
Women									
BMI	0.51	0.42-0.60		0.822	27.6	97.6	13.6		
WC (cm)	0.63	0.54-0.71	0.63-	0.015*	101 1.33	74.4 54.9	50.0 81.8	65.0	34.9
CI	0.71	0.79		<0.001*					
WHtR	0.63	0.54-0.72		0.008*	0.7	54.9	68.2		
Adults									
BMI	0.51	0.42-0.60		0.799	37.7	62.7	47.6		
WC (cm)	0.62	0.53-0.71	0.61-	0.016*	97 1.33	84.3 51.8	38.1 81.0	66.4	33.6
CI	0.70	0.78		<0.001*					
WHtR	0.57	0.48-0.66		0.159	0.7	43.4	73.8		
Elderly									
BMI	0.55	0.42-0.69		0.635	33.2	68.1	66.7		
WC (cm)	0.50	0.37-0.64	0.51-	0.952	99 1.34	93.6 70.2	33.3 66.7	83.9	16.0
CI	0.65	0.77		0.209					
WHtR	0.56	0.42-0.69		0.621	0.62	87.2	33.3		
White									
BMI	0.50	0.38-0.62		0.977	36.9	45.5	45.0		
WC (cm)	0.61	0.49-0.72	0.58-	0.136	107.5	76.4 61.8	45.0 75.0	73.3	26.7
CI	0.70	0.80		0.005*	1.33				
WHtR	0.59	0.47-0.70		0.198	0.7	54.5	65.0		

*[Note: AUC: Area under the ROC curve; 95%CI: Confidence Interval; PV: predictive value; *Statistically significant; WC: Waist circumference; CI: conicity index; BMI: Body mass index; WHtR: Waist-to-height ratio. p value in relation to body mass index.]*

Figure 6: Table 4 :

.1 Acknowledgments

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