Diabetes & Metabolic Syndrome: Clinical Research & Reviews 10 (2016) 143–148

Contents lists available at ScienceDirect

Diabetes & Metabolic Syndrome: Clinical Research & Reviews

journal homepage: www.elsevier.com/locate/dsx

Original Article

Comparison of adiposity indices and cut-off values in the prediction of metabolic syndrome in postmenopausal women

André B. Gadelha [a], Jonathan Myers [b,c], Sérgio Moreira [d], Maurílio T. Dutra [a], Marisete P. Safons [a], Ricardo M. Lima [a,*]

[a] University of Brasília, Brasília, Brazil
[b] Division of Cardiology, Veterans Affairs Palo Alto Health Care System, Palo Alto, CA, USA
[c] Stanford University, Stanford, CA, USA
[d] Federal University of Vale do São Francisco, Petrolina, Brazil

ARTICLE INFO

Keywords:
Metabolic syndrome
Obesity
Aging
Menopause

SUMMARY

Aims: To compare adiposity indices and to assess their various cut-off values for the prediction of metabolic syndrome (MetS) in postmenopausal women.
Methods: One hundred forty nine volunteers (67.17 ± 6.12 years) underwent body composition assessment using DXA and had 5 anthropometric indices measured (Waist Circumference, WC; Waist-to-Height Ratio, WHtR; Body Mass Index, BMI; Body Adiposity Index, BAI; and Conicity Index). Blood pressure was assessed using an oscillometric device and fasting blood samples were collected. MetS was classified according NCEP-ATP III. Cut-off values to predict MetS were obtained using Receiver Operating Characteristic (ROC) curve analyses and odds ratios were also calculated.
Results: MetS prevalence was 29.5% and subjects who were classified with MetS showed worse cardiometabolic outcomes and higher anthropometric indices values ($p < 0.05$). With the exception of total- and LDL-cholesterol, all remaining variables were significantly correlated with at least one of the adiposity indices, with the strongest relationships observed for the indices reflecting central body fat. The cut-off values were 88 cm, 0.57 cm/cm, 26.85 kg/m^2, 43.7%, 36.34%, and 1.24 units for WC, WHtR, BMI, DXA-derived body fat percentage, BAI, and conicity index, respectively. Significant greater risks for MetS were found for volunteers who had WHtR (odds = 9.08; CI: 1.81–45.47) or WC (odds = 5.20; CI: 1.30–20.73) measurements above cut-off values.
Conclusion: Adiposity indices are associated with MetS in postmenopausal women in different degrees. Indices which consider central adiposity such as WC and WHtR have a stronger relationship with MetS compared to DXA-derived body fat percentage, which is considered a gold standard.

1. Introduction

The aging process is associated with a decline in most physiological functions; thus, there exists a need for research related to maintaining physical function as the World's population ages [1]. Important changes that occur with advancing age include fat mass accumulation, which has been consistently linked with impaired cardiometabolic health in older individuals [2]. Moreover, the prevalence of obesity is greater in women, with adiposity accumulation peaking around the fifth decade of life [1,3], coinciding with menopause. Menopause is also associated with reductions in muscle mass and strength, particularly among sedentary women [4], contributing further to increased cardio-metabolic risk. Taken together, the postmenopausal period itself is an independent risk factor for the development of metabolic disorders [5].

The clustering of cardiometabolic risk factors has been referred to as metabolic syndrome (MetS), a complex disorder that is considered a worldwide epidemic [6,7]. The prevalence of MetS has increased and is dependent on sex and age, with a higher incidence reported in postmenopausal women [8]. MetS negatively impacts quality of life, is a major risk factor for cardiovascular disease and has important health care costs implications. Thus, measurement strategies with high predictive accuracy for the identification of MetS are critical to optimally define this syndrome. In this regard, although a variety of adiposity indices have been associated with

* Corresponding author at: Universidade de Brasília (UnB), Campus Universitário Darcy Ribeiro, Faculdade de Educação Física, Brasília, Distrito Federal 70910-900, Brasil. Tel.: +55 61 84908490; fax: +55 61 31072500.
E-mail address: ricardomoreno@unb.br (R.M. Lima).

http://dx.doi.org/10.1016/j.dsx.2016.01.005
1871-4021/

cardiometabolic risk [9–11], optimal definitions and cutpoints for the detection of MetS in postmenopausal women have not been fully explored. Gold standard equipment to assess body composition such as dual-energy X-ray absorptiometry (DXA) is not widely accessible for large populations [12]. Therefore, low cost measurements of adiposity for the prediction of MetS merits attention and would provide important practical applications.

In an effort to improve upon commonly used methods to estimate percent body fat, Bergman et al. [13] recently proposed the body adiposity index (BAI), which was strongly associated ($r = 0.85$) with DXA-derived body fat percentage. However, its significance for diagnosing obesity-related conditions is unclear. Several other adiposity indices are commonly used to identify cardiometabolic risk, but further studies are necessary in the context of predicting MetS. Even though body mass index (BMI) has been the most widely used measurement to classify obesity, it has been criticized because it lacks consideration of fat distribution [14]. In this regard, it is well known that excessive intra-abdominal fat accumulation is an independent risk factor for developing MetS, so that waist circumference (WC) is considered a criterion for its definition [9–11]. Other indices in addition to WC have been used to estimate central adiposity such as waist-to height ratio (WHtR), and the conicity index [15,16]. All of these indices have demonstrated significant relationships with cardiometabolic risk. However, when compared to one another, indices that consider abdominal adiposity have consistently been shown to be superior predictors of metabolic risk and adverse outcomes [16–21]. Noteworthy, none of these studies used a gold standard for body composition analysis.

An improvement in cut-off points above which individuals would be at greater risk for MetS would be an important advance. Such an improvement in classification would be helpful for the earlier and more accurate identification of MetS, permitting an implementation of early preventive strategies during the aging process. Recently, Mora-García et al. [15] suggested cutpoints for identifying MetS using anthropometric variables among adult-Colombian women. These authors proposed cut-off values for WC, BMI, BAI, Waist to hip ratio, and WHtR. However, cut-off values for indices of adiposity in postmenopausal women have not been clearly defined. Such cutpoints are important given that the prevalence of MetS is expected to increase as the population ages worldwide. Thus, the aim of the present study was to compare adiposity indices and to assess their various cut-off values for the prediction of MetS in postmenopausal women.

2. Material and methods

2.1. Experimental approach

To compare the ability of adiposity indices to predict MetS and determine optimal cut-off values in postmenopausal women, a representative sample of postmenopausal women from Brazil took part in this cross-sectional study. Volunteers underwent blood pressure measurements, blood sample analyses, anthropometric measurements, and body composition assessments using DXA. MetS was identified according to the NCEP-ATP III definition. In addition, correlations between indices of adiposity, body composition, and MetS-phenotypes were examined. Cut-off values with the highest sensitivity and specificity were proposed and odds ratios for predicting MetS were calculated.

2.2. Subjects

We considered MetS prevalence, 95% confidence intervals and a study error of 8%, to derive an appropriate sample size of 144 postmenopausal women. Thus, a representative sample of older women was recruited by visits to leisure and physical activity centers for elderly people, phone calls, and advertisements. Initially, 200 volunteers answered an in-person questionnaire addressing medical history, years of post-menopause, medication use, and co-morbidities. After exclusion criteria were applied, 149 women (67.17 ± 6.12 years; 16.65 ± 8.17 post-menopause years) took part in the present cross-sectional study. Exclusion criteria included those unable to walk without assistance, metallic prosthesis implants, and pacemaker use.

All volunteers were informed about the study procedures and voluntarily signed an informed consent form. The authors declare that all experiments on human subjects were conducted in accordance with the Declaration of Helsinki and the study protocol was previously approved by the Ethics Committee from the University under Registration 001/13.

2.3. Anthropometric measurements and calculations

All anthropometric measurements were conducted in the morning, after an overnight fast. Body mass was evaluated with 0.1 kg precision on a physician's digital balance beam scale and height was measured to the nearest 0.1 cm using a wall stadiometer. Waist circumference was assessed at the level of umbilicus and hip circumference was determined at the level of the maximum extension of the buttocks posteriorly in a horizontal plane. An anthropometric tape (Sanny Anthropometric Medical) was used to measure both waist and hip circumferences. All measurements were carried out by the same experienced researcher. BMI was calculated as weight (kg) divided by height squared (m^2). WHtR was calculated as waist divided by height in centimeters and BAI was calculated as [(hip circumference)/((height)$^{1.5}$) − 18)]. Lastly, conicity index was determined according to the following equation: conicity index = waist circumference (m)/0.109$\sqrt{}$(total body mass (kg)/height (m)).

2.4. Body composition assessments

Body composition was measured using DXA (lunar model 8743, GE Medical Systems, USA) according to procedures specified elsewhere [22]. Body fat percentage was registered and considered for subsequent analyses. All measurements were carried out by the same trained technician and the equipment was calibrated daily according to manufacturer specifications. The DXA equipment has been demonstrated to a coefficient of variation of 1.9% with 6 measurements on consecutive days.

2.5. Metabolic syndrome

Blood pressure was measured twice following 5 and 10 min of rest using an oscillometric automated device (BP 3AC1- 1PC, Microlife, Switzerland) with volunteers in the seated position. The mean values of systolic and diastolic blood pressure from the two measurements were considered for analyses. Within-subject coefficient of variation for the device was 6.0% and 5.7% for systolic and diastolic blood pressure, respectively.

Blood was collected following an overnight fast of at least 12 h. Samples were immediately moved to a laboratory for analysis for glucose, lipid profile, and insulin. Triglycerides, cholesterol and sub-fractions as well as blood glucose were measured using an enzymatic colorimetric method, processed in an Autohumalyzer A5 (Human-2004). Plasma insulin concentration was assayed using the Automated Chemiluminescence System ACS-180 (Ciba-Corning Diagnostic Corp., 1995, United States). Inter- and intra-assay coefficients of variation for blood variables determination did not exceed 4.5%.

MetS was defined according to the National Cholesterol Education Program Adult Treatment Panel III recommendation [9]. This criterion is based on the presence of at least three of the following five risk factors: (1) waist circumference $\geq$ 88 cm; (2) serum triglycerides $\geq$ 150 mg/dL; (3) high-density lipoprotein cholesterol $\leq$ 50 mg/dL; (4) systolic and/or diastolic blood pressure $\geq$ 130 or 85 mm Hg, respectively; and (5) fasting glucose $\geq$ 110 mg/dL. Of note, volunteers under treatment for diabetes, hypertension, and/or dyslipidemia were classified as positive for these risk factors. To avoid bias, MetS criteria was adapted for those variables which have considered abdominal obesity in their calculations (i.e., WC, WHtR, and conicity index); thus, the central obesity requirement for this definition was omitted [23] (i.e., excluding WC criteria). Hence, MetS-adjusted criteria were determined as at least three of the four instead five risk factors.

2.6. Statistical analysis

Descriptive data are expressed as mean and standard deviation. The normal distribution of data was examined using the Kolmogorov–Smirnov test. Pearson correlation coefficients were performed to examine the relationship between variables. All adiposity and cardiometabolic risk factors between groups with and without MetS were compared using an independent *t*-test. Categorical data were expressed as frequencies and chi-square analyses were performed for compare categorical variables (e.g. smoking and hormone replacement therapy). The cut-off points for each adiposity indices to predict MetS were obtained using Receiver Operating Characteristic (ROC) curve analyses. Areas under the ROC curves and the confidence intervals were used to compare the ability of each adiposity index to predict MetS. Odds ratios and confidence intervals (95%) for the presence of MetS considering the identified cut-off points for each adiposity index were calculated with adjustments for age, hormone replacement therapy, physical activity, and smoking status. The significance level was set at $p \leq 0.05$, and all analyses were conducted using the Statistical Package for Social Sciences (SPSS 20.0).

3. Results

MetS prevalence was 29.5% for the study sample. Table 1 shows comparisons between Non-MetS and MetS groups. No differences were observed for age, height or years of menopause between groups. However, in addition to increased body weight ($p < 0.001$), those classified with MetS had higher systolic, diastolic and mean blood pressure, triglycerides, fasting glucose, and lower HDL cholesterol levels. Moreover, all the examined adiposity indices were greater among those classified as having MetS. The prevalence of hormone replacement therapy, high physical activity level, and smoking were 18.8%, 21%, and 1.3%, respectively, with no differences between groups.

Table 2 shows the associations between adiposity indices and blood pressure, glycemic status and lipid profiles. With the exception of total- and LDL-cholesterol, all remaining variables were significantly correlated with at least one of the adiposity indices, with the strongest relationships observed for the indices reflecting central body fat. Fig. 1 shows ROC curves and optimal cut-off points for each adiposity index, which were considered those values with the highest balance of sensitivity and specifity in the diagnosis of MetS. The cut-off values were as follows: WC = 88 cm; WHtR = 0.57 cm/cm; BMI = 26.85 kg/m^2; fat mass = 43.7%; BAI = 36.34%; conicity index = 1.24 units.

Odds ratios for the presence of MetS considering postmenopausal women with measurements above the identified cut-off values are shown in Table 3. Odds ratios (95% confidence intervals) for WC, WHtR, and C index were 18.62 (6.71–51.69), 10.57 (4.28–26.11), and 8.59 (3.50–21.10), respectively. However, since WC is a criterion for MetS identification, a second criteria was adopted for these variables excluding central obesity, which provided odds ratios of 5.52 (1.93–15.72), 10.16 (2.88–35.85), and 4.39 (1.54–12.49), for WC, WHtR, and conicity index, respectively. Odds ratios for percent body fat, BMI, and BAI were 2.97 (1.24–7.11), 3.93 (1.61–9.60), and 2.21 (0.92–5.39), respectively. After adjustments for hormone replacement therapy, physical activity, smoking, and age, the odds ratios for BAI and conicity index were no longer statistically significant.

Table 1
Comparison among age, menopause years, adiposity indices, and metabolic syndrome-phenotypes regarding both groups, Non-MetS and MetS. Data are expressed as mean and standard error.

Variable	Non-MetS	MetS
N	105	44
Age (years)	67.04 ± 0.57	67.50 ± 1.01
Menopause (years)	15.9 ± 1.02	18.16 ± 1.46
Height (m)	1.54 ± 0.57	1.56 ± 0.01
Body mass (kg)	61.6 ± 1.05	71.80 ± 1.60**
Adiposity indices		
Body mass index (kg/m^2)	25.84 ± 0.39	29.69 ± 0.62**
Fat mass (%)	41.44 ± 0.67	44.14 ± 0.76*
Waist circumference (cm)	84.62 ± 1.05	96.28 ± 1.18**
Waist-to-height ratio (cm/cm)	54.9 ± 0.70	61.99 ± 0.80**
Conicity index (AU)	123.1 ± 0.87	130.47 ± 1.18**
Body adiposity index (%)	33.91 ± 0.45	36.55 ± 0.99*
Blood pressure		
Systolic (mm Hg)	134.2 ± 1.63	145.60 ± 2.67**
Diastolic (mm Hg)	77.04 ± 0.85	80.76 ± 1.50*
Mean (mm Hg)	96.09 ± 1.00	102.38 ± 1.66**
Biochemical indicators		
HDL (mg/dL)	59.19 ± 0.86	50.05 ± 1.70**
LDL (mg/dL)	123.40 ± 3.10	123.93 ± 5.67
Total Cholesterol (mg/dL)	205.14 ± 5.88	212.50 ± 6.65
Triglycerides (mg/dL)	112.85 ± 3.56	195.20 ± 11.54**
Fasting glucose (mg/dL)	87.98 ± 1.34	105.45 ± 3.95**

MetS, metabolic syndrome; AU, arbitrary units.
* 0.05.
** 0.001.

4. Discussion

Consistent with literature [18,20,24], the present results demonstrate that adiposity indices were associated with MetS-related phenotypes, with stronger associations observed for those indices that reflect central adiposity (i.e., WC and WHtR), despite the fact that the gold standard (DXA) evaluation was used for measuring body composition. Our main objectives however, were to compare the ability of adiposity indices to predict MetS, and to determine optimal cut-off values for these indices in the diagnoses of MetS among postmenopausal women. To reach this aim, DXA and anthropometric measures were performed to determine adiposity, and MetS was identified according to the NCEP-ATP III definition [9]. Sensitivity and specificity of each adiposity measure was calculated using ROC curves. We observed that central fat-based indices exhibited greater areas under the curves when compared to BMI or DXA-derived percent body fat; subjects with values above the proposed cut-offs exhibited a markedly higher likelihood ratio of having MetS. The relationships between MetS-related phenotypes and different adiposity indices have been previously studied [17,18,20,24]; however, to our knowledge no studies have focused specifically on postmenopausal women. Expanding upon previous observations, the present investigation included a gold standard evaluation of body composition (DXA) [25].

Table 2
Correlation among body mass index, fat (%), waist circumference, conicity index, waist-to-height ratio, and body adiposity index with cardiometabolic variables.

Variable	BMI	Fat (%)	WC	C index	WHtR	BAI
Systolic blood pressure	0.20*	0.01	0.24**	0.25**	0.30**	0.22**
Diastolic blood pressure	0.21**	0.01	0.24**	0.21*	0.26**	0.17*
Mean arterial pressure	0.23**	0.01	0.26**	0.26**	0.31**	0.22**
Serum glucose	0.23**	0.16	0.16	0.01	0.14	0.15
Total cholesterol	0.01	−0.05	0.02	0.05	0.04	0.12
High density lipoprotein	−0.12	−0.05	−0.19*	−0.19*	−0.17*	0.08
Low density lipoprotein	−0.01	−0.05	−0.02	−0.01	−0.01	0.08
Triglycerides	0.14	0.02	0.27**	0.34**	0.28**	0.07

BMI, body mass index; WC, waist circumference; WHtR, waist-to-height ratio; C index, conicity index; BAI, body adiposity index.
* $p < 0.05$.
** $p < 0.01$.

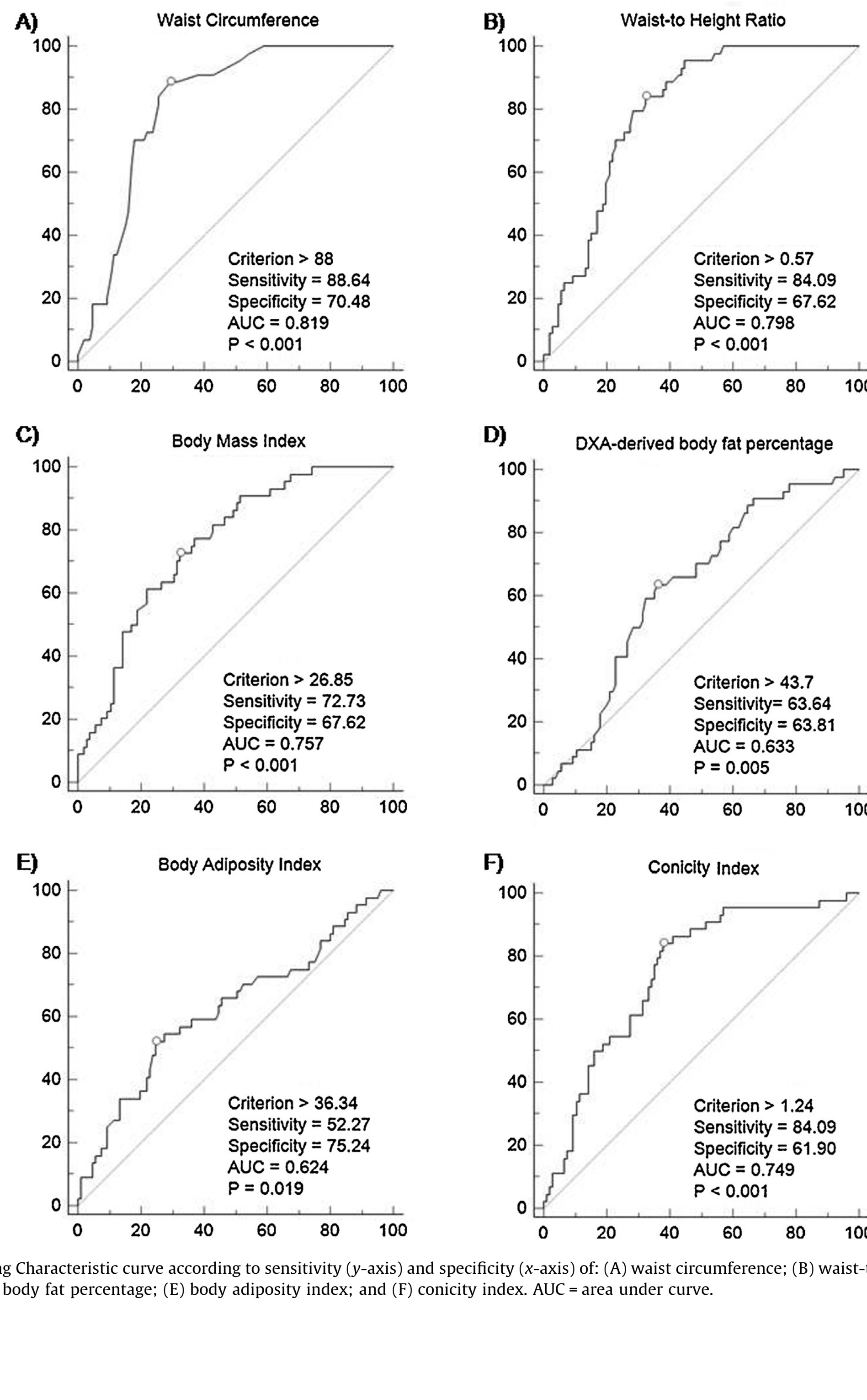

Fig. 1. Receiver Operating Characteristic curve according to sensitivity (*y*-axis) and specificity (*x*-axis) of: (A) waist circumference; (B) waist-to height ratio; (C) body mass index; (D) DXA-derived body fat percentage; (E) body adiposity index; and (F) conicity index. AUC = area under curve.

Table 3
Odds ratio (confidence interval = 95%) for metabolic syndrome.

Indices	Metabolic syndrome	
	Odds ratio (CI = 95%)	#Adjusted (CI = 95%)
Waist circumference[α]	5.51 (1.93–15.72)**	5.20 (1.30–20.73)**
Fat percentage	3.09 (1.48–6.42)**	2.97 (1.24–7.11)*
Body mass index	5.57 (2.55–12.14)**	3.93 (1.61–9.60)**
Body adiposity index	3.33 (1.59–6.97)**	2.21 (0.92–5.39)
Waist-to-height ratio[α]	10.16 (2.88–35.85)**	9.08 (1.81–45.47)**
Conicity index[α]	4.39 (1.54–12.49)**	2.19 (0.67–7.15)

α Metabolic syndrome criteria adapted.
* $p < 0.05$.
** $p \leq 0.01$.
\# Odds ratio adjusted for hormonal replacement, smoking, physical activity, and age.

In agreement with the present findings, Menke et al. [17] assessed the association between measures of adiposity and cardiovascular risk factors among 12,608 North Americans. The best predictor of cardiovascular risk was WC, which notably was the only adiposity index that considered abdominal fat distribution. Furthermore, central obesity had explained the strongest performance of WC in a previous study with similar design [17], Knowles et al. [18] added a specific index of visceral fat, but did not observe any advantage in terms of predicting MetS-related phenotypes when compared with four other indices of adiposity. Among women ($n = 952$), WC had the strongest association with glucose intolerance (area under ROC curve ≥ 0.72). However, among women the best determinants of elevated triglycerides and high blood pressure were waist-to-hip ratio (area under ROC curve: 0.65) and WHtR (area under ROC curve: 0.70), respectively. In addition, elevated WC and BMI were associated with significantly higher risk for uncontrolled fasting glucose, high blood pressure, low HDL-cholesterol, and high triglycerides (odds ratios = 4.34; 3.40; 2.64; and 6.47, respectively; all $p < 0.01$).

More recently, Zhang et al. [20] compared the ability of different adiposity indices to identify cardiometabolic risk in women aged 37–74 years from Asia. Each of the following indices was compared: BMI, WC, waist-to-hip ratio, WHtR, and bioelectrical impedance-derived body fat percentage. In agreement with the present findings, the authors concluded that abdominal obesity was an important anthropometric parameter to identify metabolic risk. Notably, WHtR showed the strongest association when compared to the other evaluated indices [20]. Zhang et al. [23] compared determinants of adiposity and cardiovascular risk factors of Chinese women. They observed that BAI was the weakest predictor of adiposity and cardiovascular risk when compared to WC, BMI, and percent body fat [23]. These results concur with the present observations and indicate that central adiposity is more harmful to cardiometabolic health when compared to hip circumference, which is used for the BAI calculation. Although BAI has been studied in samples composed of men and women [13], Zhang et al. [23] suggested that BAI is gender dependent; thus, it may be important to examine this parameter in samples composed only of women. Therefore, there is no apparent reason to adopt indices that require more complex calculations than WHtR and WC, since these indices appear to strongly predict cardiometabolic conditions.

There is a lack of cut-off values in the literature regarding the determination of MetS in postmenopausal women. Thus, the present study was designed to better define MetS in a sample of postmenopausal women from Brazil. To our knowledge only one previous study has addressed this issue among women. Mora-García et al. [15] estimated anthropometric cut-off points and identified its association with MetS in a sample of Colombian women, and reported optimal cut-off values for WC, BMI, BAI, Waist to hip ratio, and WHtR of 85 cm, 28 kg/m^2, 39%, 0.80 and 56, respectively. However, the study was conducted in a wide age range (from 20 to 80 years), and thus results specific for postmenopausal women remain to be further defined. When compared to the present findings, there were notable differences in cut-off values; whereas we observed lower values for BMI and BAI indices, and the optimal cut-off for WC was higher. In agreement to the present findings, Mora-Garcia et al. [15] reported a higher risk of MetS among women with WHtR measurements above the cut-off point and that this was the only variable associated with MetS.

Although DXA has been considered a gold standard assessment for body composition [25], we observed that several standard anthropometric indices were better predictors of MetS. Among the indices examined, WC, conicity index, and WHtR have been suggested to be superior because they consider regional fat distribution and are better reflections of vascular anatomy and metabolic activity [17]. Probably, WHtR was likely the best determinant of MetS because it can reflects the ratio between WC and height, reducing the chance of overestimating or underestimating central obesity. Importantly, we adapted the MetS criterion for the variables that considered abdominal obesity (i.e., excluding WC of criteria) to avoid bias; thus, MetS was determined by at least three out of four instead five risk factors [23]. Of note, even with such approach, individuals with measurements above the WHtR cut-off value were those that exhibited the higher chance to have MetS, even after adjustments for hormonal replacement therapy, smoking, physical activity, and age.

We recognize several limitations in our study. First, it is limited by its cross-sectional design, which precludes cause–effect inferences. Further longitudinal studies are needed to establish temporal relationships between determinants of MetS and causality. Second, the number of volunteers participating in the study was relatively small; however, sample size calculations were designed to represent postmenopausal women from a region of Brazil that is inhabited by people from the different regions of the country (i.e., representative of the whole country). We used the gold standard assessment of body composition (DXA), which made difficult to expand the sample size given its expense and low accessibility in large populations [12]. Finally, caution should be considered when extrapolating our results to the general population and other ethnic groups.

5. Conclusion

Consistent with previous reports, various adiposity indices are associated with MetS-related phenotypes in postmenopausal women in different degrees. We observed that indices which consider central adiposity such as WC and WHtR have a stronger relationship to MetS compared to DXA-derived percent body fat, which is considered a gold standard evaluation. In practical terms, given that WC and WHtR are accurate, simple to measure, and have minimal cost, they should be routinely employed in the assessment of older adults at high risk for MetS.

Conflicts of interest

The authors report no conflicts of interest in this work.

Acknowledgments

We thank the participants of the study and the Sabin Laboratory, which allowed analyses of blood variables. This work was supported by National Council for Scientific and Technological Development grants 487622/2012-0 and 307630/2013-7 by University of Brasília.

References

[1] Organization WH. Obesity: prevention and managing the global epidemic: report of a WHO consultation. WHO Tech Rep Ser 2000;894.
[2] Canning KL, Brown RE, Jamnik VK, Kuk JL. Relationship between obesity and obesity-related morbidities weakens with aging. J Gerontol Ser A: Biol Sci Med Sci 2014;69:87–92.
[3] Perissinotto E, Pisent C, Sergi G, Grigoletto F, Enzi G. Anthropometric measurements in the elderly: age and gender differences. Br J Nutr 2002;87: 177–186.
[4] Vianna LC, Oliveira RB, Araújo CGS. Age-related decline in handgrip strength differs according to gender. J Strength Condition Res 2007;21:1310–4.
[5] Cho GJ, Lee JH, Park HT, Shin JH, Hong SC, Kim T, et al. Postmenopausal status according to years since menopause as an independent risk factor for the metabolic syndrome. Menopause 2008;15:524–9.
[6] Ford ES, Li C, Zhao G, Pearson WS, Mokdad AH. Prevalence of the metabolic syndrome among U.S. adolescents using the definition from the International Diabetes Federation. Diab Care 2008;31:587–9.
[7] Kassi E, Pervanidou P, Kaltsas G, Chrousos G. Metabolic syndrome: definitions and controversies. BMC Med 2011;9:48.
[8] Oliveira PFA, Gadelha AB, Gauche R, Paiva FML, Bottaro M, Vianna LC, et al. resistance training improves isokinetic strength and metabolic syndrome-related phenotypes in postmenopausal women. Clin Intervent Aging 2015;10:1299.
[9] Expert Panel on Detection E. Executive summary of the third report of the National Cholesterol Education Program (NCEP) expert panel on Detection, Evaluation, and Treatment of high blood cholesterol in adults (Adult Treatment Panel III). JAMA 2001;285:2486.
[10] Alberti K, Eckel RH, Grundy SM, Zimmet PZ, Cleeman JI, Donato KA, et al. Harmonizing the metabolic syndrome a joint interim statement of the International Diabetes Federation Task Force on epidemiology and prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity. Circulation 2009;120:1640–5.
[11] Alberti K, Zimmet P, Shaw J. Metabolic syndrome—a new world-wide definition. A consensus statement from the international diabetes federation. Diab Med 2006;23:469–80.
[12] Villareal DT, Apovian CM, Kushner RF, Klein S. Obesity in older adults: technical review and position statement of the American Society for Nutrition and NAASO. The Obesity Society. Obesity Res 2005;13:1849–63.
[13] Bergman RN, Stefanovski D, Buchanan TA, Sumner AE, Reynolds JC, Sebring NG, et al. A better index of body adiposity. Obesity 2011;19:1083–9.
[14] Müller M, Lagerpusch M, Enderle J, Schautz B, Heller M, Bosy-Westphal A. Beyond the body mass index: tracking body composition in the pathogenesis of obesity and the metabolic syndrome. Obesity Rev 2012;13:6–13.
[15] Mora-García GJ, Gómez-Camargo D, Mazenett E, Alario Á, Fortich Á, Gómez-Alegría C. Anthropometric parameters' cut-off points and predictive value for metabolic syndrome in women from Cartagena, Colombia. salud pública de méxico 2014;56:146–53.
[16] Shidfar F, Alborzi F, Salehi M, Nojomi M. Association of waist circumference, body mass index and conicity index with cardiovascular risk factors in postmenopausal women: cardiovascular topic. Cardiovasc J Afr 2012;23:442–5.
[17] Menke A, Muntner P, Wildman RP, Reynolds K, He J. Measures of adiposity and cardiovascular disease risk factors. Obesity 2007;15:785–95.
[18] Knowles K, Paiva L, Sanchez S, Revilla L, Lopez T, Yasuda M, et al. Waist circumference, body mass index, and other measures of adiposity in predicting cardiovascular disease risk factors among Peruvian adults. Int J Hypertension 2011;2011.
[19] Wai WS, Dhami RS, Gelaye B, Girma B, Lemma S, Berhane Y, et al. Comparison of measures of adiposity in identifying cardiovascular disease risk among Ethiopian adults. Obesity 2012;20:1887–95.
[20] Zhang Z-Q, Deng J, He L-P, Ling W-H, Su Y-X, Chen Y-M. Comparison of various anthropometric and body fat indices in identifying cardiometabolic disturbances in chinese men and women. PloS One 2013;8:e70893.
[21] Bennasar-Veny M, Lopez-Gonzalez AA, Tauler P, Cespedes ML, Vicente-Herrero T, Yañez A, et al. Body adiposity index and cardiovascular health risk factors in Caucasians: a comparison with the body mass index and others. PloS One 2013;8:e63999.
[22] Lima RM, Bezerra LM, Rabelo HT, Silva MA, Silva AJ, Bottaro M, et al. Fat-free mass, strength, and sarcopenia are related to bone mineral density in older women. J Clin Densitom 2009;12:35–41.
[23] Zhang ZQ, Liu YH, Xu Y, Dai XW, Ling Wh, Su YX, et al. The validity of the body adiposity index in predicting percentage body fat and cardiovascular risk factors among Chinese. Clin Endocrinol 2014;81:356–62.
[24] dos Santos EP, Gadelha AB, Safons MP, Nóbrega OT, Oliveira RJ, Lima RM. Sarcopenia and sarcopenic obesity classifications and cardiometabolic risks in older women. Arch Gerontol Geriatr 2014;59:56–61.
[25] Cornier M-A, Després J-P, Davis N, Grossniklaus DA, Klein S, Lamarche B, et al. Assessing adiposity a scientific statement from the American Heart Association. Circulation 2011;124:1996–2019.