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Relationship between waist circumference and supine abdominal height measured at different anatomical sites and cardiometabolic risk factors in older women

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Abstract

Objectives: To measure waist circumference (WC) and supine abdominal height (SAH) at different anatomic sites and to assess the relationship with cardiometabolic risk factors in women aged >60 years.
Methods: The present study included 113 women from Viçosa, Minas Gerais, Brazil. The evaluations comprised anthropometric, biochemical and haemodynamic measurements. Different anatomical sites were used to measure WC: (i) the midpoint between the last rib and iliac crest; (ii) umbilical level; (iii) immediately above the iliac crests; and (iv) the narrowest point between the last rib and the iliac crest. Measurements were also taken at different anatomic sites for SAH: (i) the midpoint between the iliac crests; (ii) umbilical level; (iii) higher abdominal diameter; and (iv) the narrowest point between the last rib and the iliac crest.
Results: It was found that 35.4% of women were overweight, and the area (SE) body mass index was 25.8 (4.2) kg/m^2. WC at the umbilical level [area (SE) area under the curve (AUC) = 0.694 (0.079)] and SAH at the midpoint between the iliac crests [AUC = 0.747 (0.076)] showed the largest areas under the receiver operating characteristic curve ($P < 0.05$) with respect to the identification of cardiometabolic risk factors associated with the metabolic syndrome (MS) where, of the two measures, SAH showed the greatest predictive potential.
Conclusions: The results obtained in the present study suggest that, for the assessment of older women, the umbilical level and the midpoint between the iliac crests should used to measure WC and SAH, respectively. SAH showed the greatest predictive power for cardiometabolic risk factors associated with the MS in older women.

Introduction

Abdominal fat has been associated with risk markers for the metabolic syndrome (MS) (Sampaio, 2004). Waist circumference (WC) and supine abdominal height (SAH) are measurements that are strongly correlated with total and central obesity, as well as visceral fat deposits, compared to direct imaging techniques (Zamboni *et al.*, 1998; Harris *et al.*, 2000; Duarte Pimentel *et al.*, 2010). However, studies have observed a variety of different descriptions with respect to the anatomical site adopted for these anthropometric measurements (Nilsson *et al.*, 2008; Duarte Pimentel *et al.*, 2010). It is noteworthy that a consensus regarding the best location to be used has not yet been established, and discrepancies in the mode of taking these measurements can lead to differing results (Turcato *et al.*, 2000; Wang *et al.*, 2003).

The objectives of the present study were two-fold: (i) to measure WC and SAH in different anatomic sites of the abdomen and (ii) to assess the relationship of these measurements with cardiometabolic risk factors in women aged >60 years.

Materials and methods

The cross-sectional study included women aged >60 years attending the Family Health Program/FHP of Viçosa, Minas Gerais, Brazil, because this comprises the cut-off classification for elderly individuals in Brazil. The Family Health Program is a strategy for reorienting the care model, operationalised through the implementation of multidisciplinary teams in primary health. These teams are responsible for monitoring a number of families, located in a defined geographical area. The teams act to promote health, prevention, recovery, and rehabilitation of frequent diseases and disorders, as well as to maintain the health of this community (Ministry of Health, 2001).

The present study was conducted after receiving approval from the Ethics Committee on Human Research of the Federal University of Viçosa and all participants provided their written informed consent. Inclusion criteria were: no previous coronary event and no use of any drugs that could interfere with glucose homeostasis, blood pressure and lipid metabolism.

The factors evaluated were fasting blood glucose (glucose oxidase method), total cholesterol, high-density lipoprotein cholesterol (HDL-c), triglycerides (enzymatic colorimetric method) and low-density lipoprotein cholesterol (LDL-c) as estimated using the formula proposed by Friedewald *et al.* (1972). Blood samples were collected by venipuncture, centrifuged for 10 min at $2123 \times \mathbf{g}$, and assayed in an automatic biochemical Cobas Mira Plus analyzer (Roche Diagnostic, Basel, Switzerland).

The metabolic risk factors considered were: (i) fasting plasma glucose ≥110 mg dL^{-1}; (ii) triglycerides; ≥150 mg dL^{-1}; (iii) serum HDL-c <50 mg dL^{-1}; and (iv) blood pressure ≥130/85 mmHg, in accordance with the National Cholesterol Education Program (National Institutes of Health, 2002). The MS was characterised by the existence of three or more of these conditions. Although the NCEP-ATPIII includes measurement of WC as one of the components of the MS, it was not included in the diagnosis in the present study because this measurement was compared with other similar measurements (Wannamethee *et al.*, 2005). Total cholesterol and LDL-c were included in the correlation analysis aiming to supplement the assessment of overall cardiovascular risk.

Blood pressure was measured with a mercury sphygmomanometer by a single skilled professional and the entire procedure was performed in accordance with recommendations of the US Department of Health and Human Services (National Institutes of Health, 2004).

Weight, height, WC and SAH were measured and the body mass index (BMI) was derived from the ratio of weight (kg) by height squared (m^2), for which the criteria for classification were those proposed by Lipschitz (1994): <22 kg/m^2 – low weight; 22–27 kg/m^2 – normal weight; and >27 kg/m^2 – overweight. In accordance with procedures recommended by the World Health Organization (WHO) (1995), the older individuals were weighed using digital electronic scales with a capacity of 200 kg and a sensitivity of 100 g when wearing light clothing (previously targeted) and without shoes; height was obtained using a vertical stadiometer, with a length of 2.2 m and scale of 0.1 cm. WC was taken with a flexible, inelastic tape measure, with an accuracy of 0.1 cm, without compressing the tissue. During the measuring process, the participant remained in the standing position, with body weight distributed evenly on both feet. Measurements were obtained in triplicate using the mean of the two closest values taken at the end of a normal expiration. Different anatomical sites were used to measure WC: (i) the midpoint between the last rib and iliac crest – WCMP (WHO, 1995); (ii) umbilical level – WCU (Gomes *et al.*, 2006); (iii) immediately above the iliac crests – WCIC (Kullberg *et al.*, 2007); and (iv) the narrowest point between the last rib and the iliac crest – WCNP (Santos & Sichieri, 2005).

The supine abdominal height, commonly referred to as the sagittal abdominal diameter is a simple, non-invasive measurement based on the fact that, for individuals in the supine position, any increase in accumulation of visceral fat maintains the height of the abdomen in the sagittal direction, whereas subcutaneous fat reduces the height of the abdomen as a result of the force of gravity (Kvist *et al.*, 1988). It was measured by means of an abdominal caliper (Holtain-Kahn Abdominal Caliper®; Holtain Ltd., Dyfed, Wales, UK) with a mobile stem and precision of 0.1 cm. With the volunteer lying on her back with knees bent, the measurements were obtained in triplicate using the mean between the two closest values taken at the end of a normal expiration, with the shaft of the divide on the abdomen being uncompressed (Mukuddem-Petersen *et al.*, 2006).

The Kolmogorov–Smirnov test was used to verify whether the variables were normally distributed. Analysis of variance was used to evaluate the difference between WC and SAH measured at four different anatomic sites. The test procedure was complemented by Tukey's multiple comparison, which identifies groups that differ, maintaining a controlled level of significance for the test. Where the variables were not normally distributed, the Kruskal–Wallis procedure was used followed by Dunn's multiple comparisons to identify groups that were statistically different.

To assess the correlation between anthropometric measures of abdominal adiposity and changes in the MS, Pearson's and Spearman's (where the variables were not normally distributed) correlations were used. Correlations of anthropometric measurements adjusted for age and BMI were examined using Pearson's partial correlation. For variables presenting a non-normal distribution, data were log-transformed.

Receiver operating characteristic (ROC) curves were constructed to assess the ability of different WC and SAH measurements to predict the presence of the MS and its characteristic abnormalities. For this purpose, the area under the curve is an indicator of how well the measure of adiposity can detect a positive result. The area under the curve varies from 0 to 1, with 0.5 indicating no predictive potential and 1 indicating perfect predictive potential (Wannamethee *et al.*, 2005). $P < 0.05$ was considered statistically significant. Data were stored in an EXCEL (Microsoft Corp., Redmond, WA, USA) spreadsheet, and statistical analysis was performed using SPSS, version 15.0 (SPSS Inc., Chicago, IL, USA), SIGMA STATISTIC, version 2.03 (SPSS Inc.) and MEDCALC, version 9.3 (MedCalc Software, Mariakerke, Belgium).

Results

This cross-sectional, analytical study involved 113 older women. The median age was 65 years and the mean (SD) BMI was 25.8 (4.2) kg/m^2. The majority were physically inactive (79.8%). According to the BMI, 16.8% were underweight, 47.8% had normal weight and 35.4% were overweight. The MS was diagnosed in 13.3% (n = 15) of volunteers, and high blood pressure (54.9%), low HDL-c (35.4%) and hypertriglyceridaemia (30.1%) were the most frequent risk markers (Table 1).

Positive correlations were found for fasting glucose versus WCMP, WCU, WCNP, SAH (all) and age; triglycerides versus WC (all) and SAH (all); and diastolic blood pressure versus BMI. Negative correlations were observed between HDL-c versus WC (all) and SAH (all). The main correlations were between fasting glucose, triglycerides and HDL-c versus WCMP, WCU, WCNP and SAH – umbilical level (SAHU), SAH – largest abdominal diameter (SAHL), SAH – midpoint between the iliac crests (SAHMP) and SAH – narrowest point between the last rib and the iliac crest (SAHNP) (data not shown).

Table 1 Measurements of central tendency and variability of the biochemical parameters and blood pressure with respect to the occurrence of metabolic disorders in older women (n = 113) in Viçosa in 2008

Variables	Value, mean (SD) or median (minimum – maximum)
Age (years)	65 (60.0–84.0)*
Weight (kg)	58.05 (41.85–95.5)*
Stature (m)	153.43 (5.68)†
Body mass index (kg/m^2)	25.4 (17.9–37.5)*
Blood pressure and biochemical parameters	
Systolic blood pressure (mmHg)	133.13 (18.98)†
Diastolic blood pressure (mmHg)	78.00 (58.00–112.00)*
Fasting glucose (mg dL^{-1})	93.00 (73.00–135.00)*
Triglycerides (mg dL^{-1})	120.00 (49.00–355.00)*
HDL-c (mg dL^{-1})	55.47 (14.06)†
LDL-c (mg dL^{-1})	141.14 (41.46)†
Total cholesterol (mg dL^{-1})	223.47 (42.88)†
Metabolic disorders, n (%)	
Elevated blood pressure	62 (54.9)
Hyperglyacemia	12 (10.6)
Hypertriglyceridaemia	34 (30.1)
Low HDL-c levels	40 (35.4)
Waist circumference (cm)	
WCMP	87.92 (9.60)†
WCU	91.90 (10.77)†
WCIC	94.31 (9.59)†
WCNP	82.37 (9.54)†
Supine abdominal height (cm)	
SAHMP	19.95 (14.2–32.40)*
SAHU	19.45 (13.85–32.25)*
SAHL	20.35 (14.3–32.35)*
SAHNP	19.65 (13.85–30.30)*

WC, waist circumference; WCNP, narrowest point between the last rib and the iliac crest; WCIC, immediately above the iliac crests; WCU, umbilical level; WCMP, midpoint between the last rib and the iliac crest; SAH, supine abdominal height; SAHNP, narrowest point between the last rib and the iliac crest; SAHL, largest abdominal diameter; SAHU, umbilical level; SAHMP, midpoint between the iliac crests. HDL-c, high-density lipoprotein cholesterol; LDL-c, low-density lipoprotein cholesterol.

†Symmetric variables.

*Asymmetric variables.

After determining the partial correlations adjusted for age and BMI (Table 2), it was verified that the correlations remained significant for triglycerides and all SAH measurements (especially SAHL), as well as HDL-c and WC (WCU and WCNP).

The distribution of areas under the ROC curve for detection of cardiometabolic risk factors characteristic of the MS is shown in Table 3. The results indicate that, for the identification of an increased triglyceride concentration, WCU and SAHMP ($P < 0.05$) were those with the largest areas. For detection of high blood

Table 2 Partial correlations between waist circumference (WC), supine abdominal height (SAH), measured at different anatomical sites, with biochemical and clinical factors, adjusted for age and body mass index in older women (n = 113) in Viçosa, in 2008

	Ln FG	Ln TG	TC	LDL-c	HDL-c	SBP	Ln DPB
Waist circumference							
WCMP	0.119	0.171	0.102	0.096	−0.166	−0.146	−0.106
WCU	0.079	0.279**	0.030	0.008	−0.211*	−0.137	−0.082
WCIC	0.045	0.174	0.084	0.062	−0.1057	−0.124	−0.071
WCNP†	0.104	0.208*	0.071	0.085	−0.253**	−0.121	−0.084
Supine abdominal height							
SAHMP†	0.168	0.317**	0.181	0.123	−0.123	−0.024	−0.068
SAHU†	0.119	0.295**	0.185	0.126	−0.098	0.011	−0.033
SAHL	0.128	0.337**	0.175	0.116	−0.136	−0.048	−0.079
SAHNP†	0.147	0.263**	0.159	0.109	−0.097	−0.015	−0.062

FG, fasting glucose; TG, triglycerides; TC, total cholesterol; LDL-c, low-density lipoprotein; HDL-c, high-density lipoprotein; SBP, systolic blood pressure; DBP, diastolic blood pressure; WCNP, narrowest point between the last rib and the iliac crest; WCIC, immediately above the iliac crests; WCU, umbilical level; WCMP, midpoint between the last rib and the iliac crest; SAHNP, narrowest point between the last rib and the iliac crest; SAHL, largest abdominal diameter; SAHU, umbilical level; SAHMP, midpoint between the iliac crests.
†Asymmetric variables subjected to logarithmic transformation.
*$P < 0.05$; **$P < 0.01$.

Table 3 Distribution of areas under the receiver operating characteristic (ROC) curve stratified by waist circumference (WC) and supine abdominal height (SAH), measured at different anatomical sites, in the detection of components of the metabolic syndrome (MS) in older women (n = 113) in Viçosa in 2008

	Alterations in the MS*: area (SE) area under the ROC curve (95% CI)			
Anthropometric measurements	Hypertriglyceridaemia (≥150 mg dL^{-1})	Elevated blood pressure (≥130/85 mmHg)	Hyperglycaemia (≥110 mg dL^{-1})	Reduced HDL-c (<50 mg dL^{-1})
Waist circumference				
WCMP	0.532 (0.059) (0.436–0.626)	0.531 (0.055) (0.435–0.626)	0.585 (0.091) (0.489–0.677)	0.652 (0.055)** (0.557–0.739)
WCU	0.579 (0.059) (0.482–0.671)	0.543 (0.054) (0.446–0.637)	0.598 (0.091) (0.502–0.689)	0.668 (0.055)** (0.574–0.754)
WCIC	0.542 (0.059) (0.446–0.636)	0.540 (0.055) (0.444–0.634)	0.552 (0.090) (0.456–0.646)	0.663 (0.055)** (0.568–0.749)
WCNP	0.568 (0.059) (0.471–0.661)	0.551 (0.054) (0.454–0.645)	0.584 (0.091) (0.488–0.676)	0.642 (0.056)** (0.547–0.730)
Supine abdominal height				
SAHMP	0.628 (0.059)** (0.532–0.717)	0.579 (0.054) (0.483–0.672)	0.582 (0.091) (0.486–0.674)	0.626 (0.056)** (0.530–0.716)
SAHU	0.622 (0.059)** (0.526–0.712)	0.596 (0.053) (0.500–0.687)	0.581 (0.091) (0.484–0.673)	0.615 (0.056)** (0.518–0.705)
SAHL	0.624 (0.059)** (0.528–0.714)	0.576 (0.054) (0.479–0.668)	0.587 (0.091) (0.491–0.679)	0.621 (0.056)** (0.525–0.710)
SAHNP	0.602 (0.059) (0.506–0.693)	0.584 (0.054) (0.487–0.676)	0.611 (0.091) (0.514–0.701)	0.621 (0.056)** (0.525–0.711)

WCNP, narrowest point between the last rib and the iliac crest; WCIC, immediately above the iliac crests; WCU, umbilical level; WCMP, midpoint between the last rib and the iliac crest; SAHNP, narrowest point between the last rib and the iliac crest; SAHL, largest abdominal diameter; SAHU, umbilical level; SAHMP, midpoint between the iliac crests; CI, confidence interval; HDL-c, high-density lipoprotein cholesterol; SE, standard error.
*In accordance with NCEP-ATPIII (2002).**$P < 0.05$.

pressure, WCNP and SAHU showed the largest areas ($P > 0.05$); fasting hyperglycaemia was best predicted by WCU and SAHNP ($P > 0.05$), whereas low HDL-c was identified by WCU and SAHMP ($P < 0.05$). In the detection of alterations with respect to this last metabolic factor, it was found that areas under the ROC curve referring to all measures of WC and SAH were significant ($P < 0.05$).

When examining the predictive ability of different WC and SAH measurements for the MS, it was observed that

Table 4 Distribution of the areas under the receiver operating characteristic (ROC) curve stratified by waist circumference (WC) and supine abdominal height (SAH), measured at different anatomical sites, in the detection of the risk of the metabolic syndrome (MS) in older women (n = 113) in Viçosa, in 2008

	MS*
Anthropometric measurements	Area (SE) area under the ROC curve (95% CI)
Waist circumference	
WCMP	0.635 (0.018) (0.540–0.724)
WCU	0.694 (0.079)** (0.600–0.777)
WCIC	0.676 (0.081)** (0.581–0.761)
WCNP	0.662 (0.081)** (0.567–0.748)
Supine abdominal height	
SAHMP	0.747 (0.076)** (0.656–0.824)
SAHU	0.722 (0.078)** (0.630–0.802)
SAHL	0.736 (0.077)** (0.645–0.814)
SAHNP	0.710 (0.079)** (0.617–0.791)

WCNP, narrowest point between the last rib and the iliac crest; WCIC, immediately above the iliac crests; WCU, umbilical level; WCMP, midpoint between the last rib and the iliac crest; SAHNP, narrowest point between the last rib and the iliac crest; SAHL, largest abdominal diameter; SAHU, umbilical level; SAHMP, midpoint between the iliac crests; CI, confidence interval; SE, standard error.
*In accordance with NCEP-ATPIII (2002). $^{**}P < 0.05$.

WCU and SAHMP showed significantly higher areas under the ROC curve (Table 4).

Discussion

To date, no studies are available in the literature examining and comparing (in older women) different methods of WC and SAH measurement, their respective relationships with the MS and the factors that characterise this condition.

The correlations, independent of age variation and overall adiposity, showed that SAH and WC, with an emphasis on SAHL and WCNP, remained significantly correlated only with high-level triglycerides and low-level HDL-c. By linking the cardiometabolic risk factors to predict the MS, greater areas under the ROC curve for both WC and for SAH were observed, most notably SAHMP and WCU. It is noteworthy that although the correlations are not strong, they indicate the need to monitor physiological changes triggered by ageing, especially in relation to anthropometry, using measurements of the anatomical sites that best correlated with the cardiometabolic risk factors of the present study.

In nutritional evaluation, WC is a very common measure (Snijder *et al.*, 2002) and SAH is a relatively new parameter, as used to identify patients with intra-abdominal adiposity and high cardiometabolic risk (Sampaio *et al.*, 2007; Duarte Pimentel *et al.*, 2010).

In a study performed by Turcato *et al.* (2000), WC and SAH were identified as the measurements that best correlate with cardiometabolic risk factors (fasting glucose, systolic blood pressure and diastolic blood pressure) in older individuals. In the present study, SAH showed higher areas under the ROC curve for predicting the clinical and biochemistry alterations under investigation compared to WC. Consistent with this finding, some studies have shown that WC in older individuals is not a good predictor of cardiometabolic risk factors and mortality (Woo *et al.*, 2002; Cabrera *et al.*, 2005) because this measurement is more related to total fat than abdominal fat in older individuals (Harris *et al.*, 2000). By contrast, other studies revealed the possible superiority of SAH in the prediction of visceral adipose tissue in older patients compared to other anthropometric measurements, including WC (Zamboni *et al.*, 1998; Snijder *et al.*, 2002), which possibly explains the better predictive power of SAH to detect metabolic changes.

Conclusions

For the evaluation of older women, it is suggested that the umbilical level and the midpoint between the iliac crests represent the points at which to measure WC and SAH, respectively. Between these two measurements, SAH showed the greatest predictive power for cardiometabolic risk factors associated with the MS in the study sample.

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Conflict of interest, source of funding and authorship

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