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Association between waist circumference (WC) values and hypertension, heart disease (HD) and diabetes, reported by the elderly – SABE survey: Health, wellness and aging, 2000 and 2006

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ABSTRACT

The positive association between WC and systemic arterial hypertension (SAH), diabetes mellitus (DM) and HD calls for investigation in the elderly. The objective of the present study was to identify WC values, so as better to determine the risk of these diseases. This was a longitudinal study using the data of 405 elderly participants of the SABE Survey: Health, Well-being and Aging, undertaken in São Paulo, in 2000 and 2006. The study variables were WC, sex, age group, ethnicity, and body mass index (BMI) (2000) and SAH, DM and HD (2006). The area under the Receiver Operating Caracteristics (ROC) curve (AUC) and confidence intervals of 95% was used to estimate the performance of WC values in correctly discriminating among the elderly, according to the reference or not to diseases associated with WC. WC critical values were identified by the highest positive likelihood ratio (PLR), and negative likelihood ratio (NLR) equal to zero. The AUC showed the satisfactory performance of WC critical values in discriminating between reports of DM in individuals of 60–74 years of age. The WC critical values identified were ≥87 cm for women and ≥99 cm for men, which presented a better performance in relation to the AUC value than to the WC values commonly used. The WC critical values identified in this study showed better discriminatory power of foretelling reference to DM than did the WC values commonly used.

1. Introduction

The increase in the proportion of elderly people in the population influences the prevalence of noncommunicable diseases (Wild, Roglic, Green, Sicree, & King, 2004; WHO, 2011). The most prevalent diseases among the elderly are (1) DM, which consists of an inability to produce insulin or a resistance to its action; (2) SAH, i.e. different degrees of increased systolic and diastolic blood pressure; and (3) dyslipidemias in which occur changes in plasma lipoprotein levels and which are related to the risk of HDs such as myocardial infarction, angina, coronary HD and congestive disease (Gonzalez-Campoy et al., 2013; Gravina, Rosa, Franken, Freitas, & Liberman, 2010; Mancia et al., 2013; Reiner et al., 2011).

Abdominal fat is, in the same way as aging, associated with metabolic alterations such as resistance to insulin and DM which are related to the risk of cardiovascular diseases (CVD) (Ferreira, Valente, Gonçalves-Silva, & Sichieri, 2006; WHO, 2000a). WC is considered to be the variable most closely related to abdominal fat and indicative of the risk of CVD, metabolic alterations and mortality (Picon et al., 2007; Roriz et al., 2011; Scafoglieri, Provyn, Bautman, Van Roy, & Clarys, 2011; WHO, 2000b).

According to the World Health Organization (WHO) and the International Diabetes Federation (IDF), the values of WC related to the metabolic risk of developing CVD and DM should be used only for the population in which they have been identified seeing that such variables depend on other risk factors such as the BMI, age and the ethnic characteristics of the location of body fat, to be used as indications of these diseases (Alberti, Zimmet, & Shaw, 2006; WHO, 2000b).

Due to the greater time of exposure to the risk variables during the lifetime, beyond the physiological, biochemical and hormonal alterations inherent in the process of aging, it is necessary to

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identify the values of WC specific to the elderly population and which make the correct detection of risk for the development of diseases possible (Matos, Giorelli, & Dias, 2011; Paula, Ribeiro, Rosado, Pereira, & Franceschini, 2010; Picon et al., 2007; Vasques, Priore, Rosado, & Franceschini, 2010; WHO, 2000b).

As has been done in similar studies in other parts of the world (Heim et al., 2011; Huang et al., 2005; Lim et al., 2012; Nilsson et al., 2008; Seo et al., 2009; Woo, Ho, Yu, & Sham, 2002), this study also seeks to meet this need in the scientific field, by identifying those WC values which better discriminate the risk of elderly people's resident in the municipality of São Paulo developing noncommunicable diseases.

2. Materials and methods

This is a longitudinal study of association, conducted in 2011 and 2012, using data of the SABE: Saúde, Bem-estar e Envelhecimento (Health, Well-being and Aging) Survey, a household-based study undertaken in the municipality of São Paulo in 2000 and 2006 (Lebrão & Duarte, 2008; Silva, 2003).

A total of 2 143 elderly people (≥60 years of age), of both sexes, selected by probabilistic sampling, participated in the SABE Survey in 2000. These elderly folk were reassessed in 2006 for the purpose of ascertaining the alterations in their health and living conditions that had occurred during that period. In this latter year, 1 115 elderly people, survivors from 2000, were again interviewed (Lebrão & Duarte, 2008).

In 2000, the SABE Survey was approved by the National Committee of Ethics in Research and by the Ethics in Research Committee of the Public Health School of the University of São Paulo (USP) and, in 2006, by the Ethics in Research Committee of the Public Health School of USP.

The population of this study consisted of elderly individuals who, in 2000, reported that they had never been diagnosed as having SAH, HD or DM, and who could be located and agreed to participate, in 2006. The elderly who were unable to respond to any of the three questions relating to the diseases under study, whether in 2000 or 2006, were considered "missing".

The elderly who, in 2000, were incapable of undergoing measurement of the WC, because they were bed-ridden, or had limited mobility (used wheel-chairs or crutches), or who were unable to stand without support (because of the amputation of the lower members) were excluded.

The variables of this study were the references to the selected diseases (SAH, HD and DM) in 2006 and, in 2000, WC, sex, age – classed in two groups: 60–74 and ≥75 years, ethnicity (Caucasian, for the reply "white" and non-Caucasian for all the other replies: mestizo, mulatto, negro, indigenous, Asiatic or other) and BMI. The elderly were classed as not overweight (BMI $< 28\ kg/m^2$) or overweight (BMI $\geq 28\ kg/m^2$) (PAHO, 2001).

The SAH, HD, DM, sex, age and ethnicity data were reported by the elderly themselves or some proxy or other informant. The measurements of WC, height and weight (for calculation of the BMI) were repeated in triplicate by trained interviewers and the average values were used for the analyses.

The measurement of the WC was undertaken with the use of an unstretchable tape-measure at the intermediate point between the lowest rib and the iliac crest with the abdomen relaxed, after breathing out, with the person standing erect with their arms relaxed and the abdominal region free of clothing.

2.1. Statistical methodology

The study population was selected by means of a complex sampling process, performed using the method of cluster sampling in two stages, census tracts being considered for the selection of the sample of the first stage, and segments residing in each census tract for the selection of the sample of the second stage, plus elderly residents in the districts where previous interviews had been conducted to compensate for the lower population density of patients aged 75 years and older, and a higher mortality rate for men. Statistical tests recommended for studies of the survey type were used in the analysis of the results.

Rao & Scott's test (Lee & Forthofer, 2006) and multiple logistic regression with a significance level of 5% were used for the analysis of the association between the reported incidence of SAH, HD and DM and the other variables, the magnitude being tested by the *odds ratio* (OR) values, the confidence interval being 95% (CI 95%). The variables age group, ethnicity and BMI were maintained for the adjustment of the multiple models, regardless of the level of significance, except for the male model, which it was not possible to stratify by ethnicity because all the men who reported DM in 2006 were Caucasian.

To avoid any inadequacy in the adjustment of the models, the multicolinearity between the variables was calculated in accordance with Variance Inflation Factor (VIF) values, and only non-colinear variables, with VIF values of between 0.19 and 5.30 (Hair, Anderson, Tatham, and Black, 1995), were kept in the final model.

The area under the ROC curve (AUC – area under the curve) and respective 95% CI were used to estimate the general performance of the critical WC values in discriminating correctly between the elderly, in accordance with the disease reported.

The likelihood ratios (LR), which combine sensitivity and specificity, were calculated for each WC value. The greater the PLR, the better the test, and the smaller the NLR, the better the test (Deeks & Altman, 2004; Massad, 2004).

In order to identify the critical values of WC with the best discriminatory power for the elderly, in accordance with the reference to the disease, the PLR was maximized and the NLR minimized, that is to say, they corresponded to the WC values with the greatest PLR value, when the NLR was kept at zero (Zou, O'Malley, & Mauri, 2007).

3. Results

A total of 405 elderly people participated in this study, 58.7% of whom were women and 87.2% were of between 60 and 74 years of age in 2000. The demographic and anthropometric characteristics of the study population are given in Table 1.

No statistically significant difference was observed between the average WC of those who reported and those who did not report SAH or HD, though the average WC of those who reported DM in 2006 was significantly greater than that of those who did not report it, both for women (99.0 cm and 89.9 cm; $p = 0.003$) and for men (107.4 cm and 93.3 cm; $p = 0.008$).

In the multiple regression models, the WC did not significantly increase the chance of reporting SAH (OR 1.03; 95% CI 0.99–1.07, for women, and OR 1.02; 95% CI 0.97–1.08, for men) or HD (OR 1.04; 95% CI 0.99–1.09, for women, and OR 1.03; 95% CI 0.96–1.11, for men), in 2006, independently of age group, ethnicity and BMI.

WC was associated with the mention of DM in the models adjusted for age group, ethnicity and BMI in the female group, and for age group and BMI in the male group. Each centimeter of increase in the WC increased the possibility of reporting DM by 8% among women and by 17% among men (Table 2).

The values of the area under the ROC curve: AUC: 0.751; CI 95% 0.618–0.884 for the women and AUC: 0.867; CI 95% 0.695–1.000 for the men showed discriminatory power, in terms of the critical values of WC in describing the elderly of 60–74 years whether or not they reported DM, but this was not possible in the elderly ≥75 years (AUC: 0.743; CI 95% 0.456–1.000, for women, and AUC: 0.446; IC 95% 0.020–0.871, for men). The WC value with the

Table 1
Percentage of elderly according to demographic and anthropometric characteristics, in 2000, and reported diseases, in 2006. SABE Survey, São Paulo, SP, 2000 and 2006.

Demographic and anthropometric characteristics	Women		p Value[a]	Men		p Value[a]
	Reported diseases			Reported diseases		
	Yes	No		Yes	No	
SAH						
Age group	n = 64	n = 174		n = 52	n = 115	
60–74	88.8	87.2	0.673	82.4	88.4	0.196
≥75	11.2	12.8		17.6	11.6	
Ethnicity	n = 64	n = 171		n = 51	n = 115	
Caucasian	75.8	70.4	0.503	62.6	79.7	0.734
Non-Caucasian	24.2	29.6		37.4	20.3	
BMI	n = 64	n = 174		n = 52	n = 115	
<28 kg/m^2	65.2	71.0	0.454	82.6	90.1	0.277
≥28 kg/m^2	34.8	29.0		17.4	9.9	
HD						
Age group	n = 23	n = 215		n = 23	n = 144	
60–74	91.7	87.1	0.394	68.2	88.4	0.015[b]
≥75	8.3	12.9		31.8	11.6	
Ethnicity	n = 22	n = 213		n = 23	n = 143	
Caucasian	66.3	72.4	0.609	87.2	72.5	0.204
Non-Caucasian	33.7	27.6		12.8	26.5	
BMI	n = 23	n = 215		n = 23	n = 144	
<28 kg/m^2	63.0	70.4	0.517	85.0	88.1	0.753
≥28 kg/m^2	37.0	29.7		15.0	11.9	
DM						
Age group	n = 11	n = 227		n = 6	n = 161	
60–74	91.2	87.4	0.645	85.4	86.7	0.008[b]
≥75	8.8	12.6		14.6	13.3	
Ethnicity	n = 11	n = 224		n = 6	n = 160	
Caucasian	74.5	71.6	0.849	100.0	73.9	0.251
Non-Caucasian	25.5	28.4		0.0	26.1	
BMI	n = 11	n = 227		n = 6	n = 161	
<28 kg/m^2	53.0	70.4	0.253	66.7	88.6	0.184
≥28 kg/m^2	47.0	29.6		33.3	11.4	

Source: SABE Survey, 2000 and 2006.
n: number.
[a] Rao & Scott's statistical test.
[b] $p < 0.05$.

greatest PLR (1.69), when NLR was kept at zero, occurred in the discrimination of the women of from 60 to 74 years of age, in accordance with the report of DM after 6 years, and was ≥87 cm (Table 3). For the men, of 60 to 74, this value was ≥99 cm (Table 4).

The WC value ≥87 cm presented the best performance for women in accordance with the AUC value (0.704; CI 95% 0.666–0.743), in comparison with the WC values ≥80 and < 88 cm and

Table 2
Association between demographic and anthropometric characteristics, in 2000, and reported DM, in 2006. SABE survey, São Paulo, SP, 2000 and 2006.

Demographic and anthropometric characteristics	OR	CI (95%)	p of the variable	p of the model
Female model[b]				
WC	1.08	1.03–1.13	0.002[a]	0.011[a]
Age group (≥75)	0.65	0.11–3.67	0.624	
Non-Caucasian	0.92	0.19–4.43	0.916	
BMI (≥28 kg/m^2)	0.62	0.13–3.03	0.554	
Male model[c]				
WC	1.17	1.05–1.31	0.005[a]	0.006[a]
Age group (≥75)	1.08	0.13–8.66	0.944	
BMI (≥28 kg/m^2)	0.40	0.04–4.49	0.452	

Source: SABE Survey, 2000 and 2006.
OR: odds ratio; CI (95%): confidence interval of 95%.
[a] $p < 0.05$.
[b] Model adjusted for age group, ethnicity and BMI, in accordance with multiple logistic analysis.
[c] Model adjusted for age group and BMI, in accordance with multiple logistic analysis.

Table 3
Indicators of the discriminatory power of WC, according to reports of DM, by women of 60–74 years of age, after a period of 6 years. SABE Survey, São Paulo, SP, 2000 and 2006.

WC values	PLR	NLR	SENS (%)	SPE (%)
≥48	1.00		100.0	0.0
≥61	1.01	0.00	100.0	0.6
≥65	1.01	0.00	100.0	1.3
≥66	1.03	0.00	100.0	2.5
≥71	1.03	0.00	100.0	3.1
≥72	1.06	0.00	100.0	5.7
≥73	1.07	0.00	100.0	6.3
≥74	1.10	0.00	100.0	9.4
≥75	1.11	0.00	100.0	10.1
≥76	1.12	0.00	100.0	11.3
≥77	1.15	0.00	100.0	13.2
≥78	1.19	0.00	100.0	15.7
≥79	1.22	0.00	100.0	18.2
≥80	1.24	0.00	100.0	19.5
≥81	1.28	0.00	100.0	22.0
≥82	1.33	0.00	100.0	24.5
≥83	1.37	0.00	100.0	27.0
≥84	1.45	0.00	100.0	30.8
≥85	1.54	0.00	100.0	35.2
≥86	1.61	0.00	100.0	37.7
≥87[a]	1.69	0.00	100.0	40.9
≥88	1.62	0.25	88.9	45.3

Source: SABE Survey, 2000 and 2006.
PLR: positive likelihood ratio; NLR: negative likelihood ratio; SENS: sensitivity; SPE: specificity
[a] The greater PLR and the smaller NLR.

Table 4
Indicators of the discriminatory power of WC, according to reports of DM, by men of 60–74 years of age, after a period of 6 years. SABE Survey, São Paulo, SP, 2000 and 2006.

WC values	PLR	NLR	SENS (%)	SPE (%)
≥66	1.00		100.0	0.0
≥69	1.01	0.00	100.0	1.1
≥70	1.02	0.00	100.0	2.2
≥74	1.03	0.00	100.0	3.2
≥79	1.06	0.00	100.0	5.4
≥80	1.07	0.00	100.0	6.5
≥81	1.09	0.00	100.0	8.6
≥82	1.11	0.00	100.0	9.7
≥83	1.12	0.00	100.0	10.8
≥84	1.15	0.00	100.0	12.9
≥85	1.17	0.00	100.0	15.1
≥86	1.22	0.00	100.0	18.3
≥87	1.27	0.00	100.0	21.5
≥88	1.35	0.00	100.0	25.8
≥89	1.41	0.00	100.0	29.0
≥90	1.48	0.00	100.0	32.3
≥91	1.50	0.00	100.0	33.3
≥92	1.60	0.00	100.0	37.6
≥93	1.75	0.00	100.0	43.0
≥94	1.90	0.00	100.0	47.3
≥95	1.98	0.00	100.0	49.5
≥96	2.38	0.00	100.0	58.1
≥97	2.74	0.00	100.0	63.4
≥98	3.00	0.00	100.0	66.7
≥99[a]	3.44	0.00	100.0	71.0
≥100	2.3	0.47	66.7	71.0

Source: SABE Survey, 2000 and 2006.
PLR: positive likelihood ratio; NLR: negative likelihood ratio; SENS: sensitivity; SPE: specificity
[a] The greater PLR and the smaller NLR.

≥88 cm proposed by Lean, Han, and Morrison (1995) and Han, van Leer, Seidell, and Lean (1995) (AUC 0.598; CI 95% 0.567–0.628, and AUC 0.671; CI 95% 0.555–0.786, respectively) (Fig. 1).

A similar superiority was observed when the WC value ≥99 cm for men of 60–74 years (AUC 0.855; CI 95% 0.808–0.901) was compared with the values proposed by Lean et al. (1995) and Han et al. (1995) of WC ≥94 and <102 cm (AUC 0.737; CI 95% 0.686–0.788) and WC ≥102 cm (AUC 0.720; CI 95% 0.391–1.000) (Fig. 2).

4. Discussion

According to the WHO's recommendation, the WC values which indicated risk of noncommunicable diseases should only be applied to the population in which they had been identified, by virtue of that population's specific characteristics as regards sex, age and ethnicity (WHO, 2000b).

Neither in clinical practice nor in the various studies of association or of prevalence related to the elderly population, has the WHO's recommendation been, in fact, adopted (Almeida, 2010; Barceló, Gregg, Pastor-Valero, & Robles, 2007; Girotto, Andrade, & Cabrera, 2010; Martins & Marinho, 2003; Munaretti, Barbosa, Marucci, & Lebrão, 2011; Tinoco et al., 2006), due to the lack of specific WC values for this age group in the various population studies, so this present study was undertaken with a view to filling this gap in scientific knowledge.

In this present study, WC presented the discriminatory power of the reference to DM among the elderly people of 60–74 years of age, ascertained by the value of the AUC (0.751; CI 95% 0.618–884, for women and 0.867; CI 95% 0.695–1.000, for men), which agrees with the result of the systematic revision undertaken by Browning, Hsieh, and Ashwell (2010) of studies including people of both sexes of from 18 years of age which indicated WC as foretelling DM (AUC 0.693).

It is speculated that the discriminatory power of WC for the elderly population ≥75 years, whether or not they reported DM, could be observed in the present study with the enlargement of the sample population of this age group. However, this may have occurred as a result of the reduction of the association between WC and noncommunicable diseases, due to the physiological changes related to aging. The result of a study of 37,697 women and 19,891 men, of 35–70 years of age, showed that the AUC of WC in the identification of two or more components of the metabolic syndrome (whether hypertension, hypercholesterolemia or hyperglycemia) tends to be lower in the older age groups (Wakabayashi & Daimon, 2012).

Various studies (Heim et al., 2011; Huang et al., 2005; Lim et al., 2012; Nilsson et al., 2008; Seo et al., 2009; Woo et al., 2002) have investigated the peculiarities of the relationship between localized fat, mainly in the abdominal region and noncommunicable

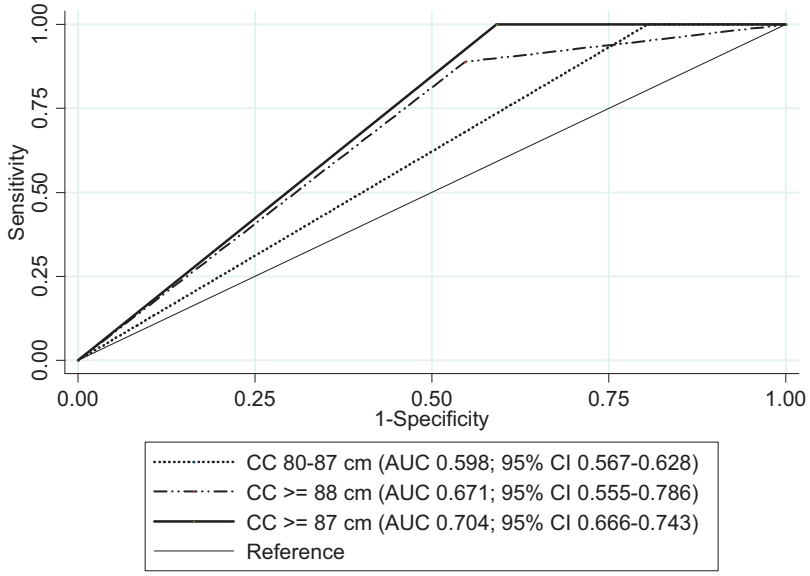

Fig. 1. ROC curve and the AUC for WC, according to reports of DM by women of 60–74 years of age, after a period of 6 years. SABE Survey, São Paulo, SP, 2000 and 2006.Source: SABE Survey, 2000 and 2006. CI (95%): confidence interval of 95%.

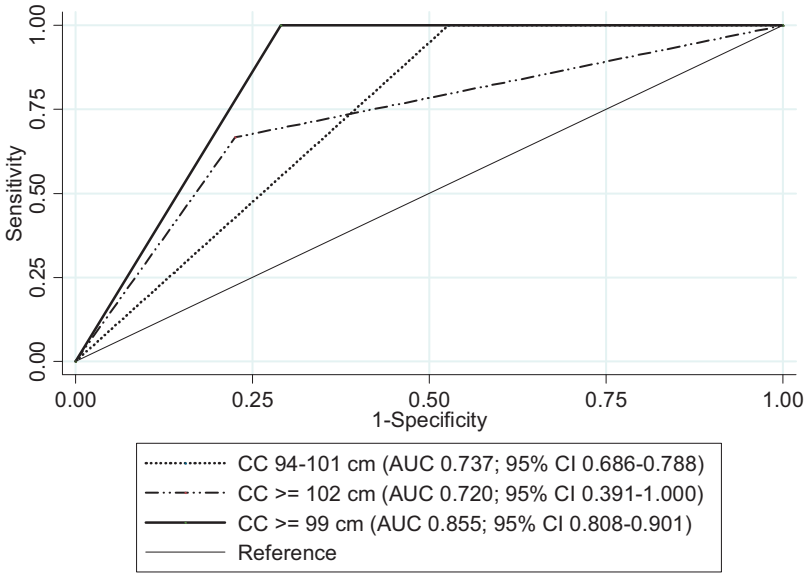

Fig. 2. ROC curve and the AUC for WC, according to reports of DM by men of 60–74 years of age, After a period of 6 years. SABE Survey, São Paulo, SP, 2000 and 2006.Source: SABE Survey, 2000 and 2006. CI (95%): confidence interval of 95%.

diseases in the elderly, and have identified critical values which permit the classification of this risk in their study samples, but no studies have been found which sought to identify the specific WC values for the elderly population and which used the LR, an index considered superior as regards sensitivity and specificity, as it is capable of demonstrating the probability of the disease under discussion (Akobeng, 2007).

In an observational, longitudinal study, lasting 36 months, of a random sample population of 2023 elderly Chinese (≥70 years of age, with an average age of 80.1 years), stratified by sex and age group, WC values ≥85.3 cm (Sens = 58.3%, and Spec = 54.6%), and ≥88.2 cm (Sens = 77.8%, and Spec = 66.8%) were identified for women and men, respectively, by means of ROC curves, as indicative of the risk of DM (Woo et al., 2002). On the basis of the sensitivity and specificity values of the WC values given by the study of Woo et al. (2002), we may calculate the PLR of 1.28 for the WC value ≥85.3 cm identified for women, and 2.34 for the WC value ≥88.2 cm identified for the men, and NLR values of 0.76 and 0.33, respectively, both indicators being inferior to the discriminating power of the WC identified in this present study.

Seo et al. (2009), using the ROC curve, identified a WC ≥86.5 cm as accurate for the identification of at least two of the components used to diagnose the metabolic syndrome, whether SAH, alteration of glycemia or dyslipidemia, in accordance with NCEP ATP III (National Cholesterol Education Program – Adult Treatment Panel III), for the elderly population (≥63 years of age) of South Korea, of both sexes. The values identified were 3.5 cm and 1.5 cm greater, respectively, than the 90 cm for the men and 85 cm for the women stipulated by the Korean Society for the Study of Obesity (Lee et al., 2007). Closely similar WC values were identified in another study of the South Korean population, in which WC ≥85 cm for the women and ≥87 cm for the men, of 65 years of age or above, were indicative of metabolic syndrome (Lim et al., 2012). Both these studies of the elderly population of South Korea identified lower WC values than those found in this present study.

Various other studies which sought to identify WC values specific for elderly populations have used the ROC curve for this purpose (Huang et al., 2005; Lim et al., 2012; Seo et al., 2009; Woo et al., 2002) and have found values lower than those of this present study (≥87 cm for the women and ≥99 cm for the men), but even so the WC values identified for the women are lower than those identified for the men, as also in this study, thus corroborating the internal consistency of these data.

Seeing that the fat located in the abdominal region is related to the risk of the development of disease, it is even more important that WC values be identified directly on the basis of the association with these outcomes, as has been done in this present study and others undertaken in various other countries (Feng et al., 2012; Heim et al., 2011; Huang et al., 2005; Lim et al., 2012; Nilsson et al., 2008; Seo et al., 2009; Woo et al., 2002), and not on the basis of the association with BMI values not specific for this age group (Heim et al., 2010; Roriz et al., 2011; Woo et al., 2002).

Many of the studies which propose WC values as related to the risk of certain diseases take cross-sectional delineations as their starting point (Heim et al., 2011; Lim et al., 2012; Nilsson et al., 2008; Seo et al., 2009), which limits the affirmation that a particular WC value may lead to certain outcomes and does not permit the identification of a cause and effect relationship. This is the reason for the choice of a longitudinal delineation in this study; however, the high prevalence of noncommunicable diseases, including SAH, HD and DM, in the elderly, resulted in a significant reduction in the size of the sample population when those elderly people who reported some of these diseases in 2000 were excluded from the study.

The increase in the proportion of elderly people in Brazil and in the world in general and the high prevalence of SAH, HD and DM in this section of the population highlight the importance of the identification of the risk of developing these diseases by means of WC, an inexpensive, non-invasive anthropometric variable which allows the adoption of actions which help in facing this challenging public health question.

As has been ascertained by this present study as well as by others with the same objective, the WC values normally used (Lean et al., 1995) might not coincide with those possessing the greatest discriminatory power to detect the risk of elderly people's developing CVD and/or DM. This fact has, further, been recognized by specialists in the field (Gravina et al., 2010), and thus led to the creation of criteria for the various anthropometric variables, specifically for the elderly population, on the basis of studies with representative samples from each country, which may also be used on the regional level.

Despite the superiority of the WC values identified in the present study, it is worth emphasizing that, in accordance with the

PLR and NLR values, the values given by Han et al. (1995), WC ≥80 and <88 cm, and ≥88 cm, for women, and WC ≥94 and <102 cm, and ≥102 cm, for men, also indicate a greater probability of reporting DM and little probability that individuals with WC values below those mentioned should report this disease. They are, further, values very close to those identified in this present study, thus supporting the recommendation of the II Cardiogeriatric Guideline (II Diretriz de Cardiogeriatria) (Gravina et al., 2010), which may be considered an advantage as these values (WC ≥88 cm, for women, and WC ≥102 cm, for men) are already widely known.

The small sample size, due to the high prevalence of noncommunicable chronic diseases in the elderly studied, limited the identification of WC values capable of discriminating only the risk of DM, but it is considered that, even so, it satisfies a demand that this study sought to meet, because DM, beyond being a disease in itself, constitutes a risk for other diseases such as SAH and increases the possibility of cardiovascular events, and thus WC values capable of foretelling DM may be considered harbingers of noncommunicable diseases in a general way. The use of the reported disease can be seen as a limitation, but it is accepted as a way to determine the prevalence of noncommunicable disease (Martin, Leff, Calonge, Garrett, & Nelson, 2000), even though it does not permit the identification of sub-clinical problems or of existing though as yet undiagnosed diseases. Further, it is unlikely that individuals who are willing to participate in a study of the inclusive nature of the SABE Survey should omit such information, and it is considered, therefore, that this does not constitute a limitation for this study.

The exclusion of the bed-ridden elderly, or of those with limited mobility or incapable of standing, such as make the measurement of the WC impracticable, could be held to affect the results obtained by this study; this was not, however, considered to be a limitation seeing that the critical WC values will only be applied to the elderly persons for whom it was possible to effect this measurement.

Noteworthy among the important aspects of this present study is the use of the LR which is superior to sensitivity and specificity in the assessment of diagnostic tests. Also the use of the comparison made between the AUC of the values identified and those given in the scientific literature, not specific for the elderly population but which precisely for that reason justified the undertaking of this research project, should be highlighted.

Despite the losses due to the reports of noncommunicable diseases at the baseline and the impossibility, in some cases, of undertaking the WC measurement, the sample population of the present study constitutes a representative sample, which suggests that these results may, therefore, be extrapolated to the whole of the elderly population resident in the municipality of São Paulo.

The recognition of WC values indicative of risk for the development of DM in the elderly of a particular population enables interventions to be adequately guided, thus being of great benefit to public health, especially in dealing with the possibility of the prevention of diseases highly prevalent in this age group.

5. Conclusions

WC has been associated with DM, regardless of sex, age group, ethnicity and BMI. The WC values with greatest discriminatory power as foretelling DM given in the present study performed better than those reported in the scientific literature.

However, as the previously published and customarily used values are very close to those identified in this study and also increased the probability of the occurrence of DM, it must be admitted that the values published in the literature present the advantage of already being widely known and used, both nationally and internationally.

Conflict of interest

The authors of this study declare themselves to be unaffected by any conflict of interest.

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References

Akobeng, A. K. (2007). Understanding diagnostic tests 2: Likelihood ratios, pre- and post-test probabilities and their use in clinical practice. *Acta Paediatrica, 96*, 487–491.

Alberti, K. G., Zimmet, P., & Shaw, J. (2006). Metabolic syndrome – A new world-wide definition. A Consensus statement from the International Diabetes Federation. *Diabetic Medicine, 23*, 469–480.

Almeida, M. F. (2010). *Diabete melito referida: incidência e preditores, em coorte de idosos domiciliados no município de São Paulo, Estudo SABE – Saúde, Bem-estar e Envelhecimento* (dissertation) Faculdade de Saúde Pública da Universidade de São Paulo.

Barceló, A., Gregg, E. W., Pastor-Valero, M., & Robles, S. C. (2007). Waist circumference, BMI and the prevalence of self-reported diabetes among the elderly of the United States and six cities of Latin America and the Caribbean. *Diabetes Research and Clinical Practice, 78*, 418–427.

Browning, L. M., Hsieh, S. D., & Ashwell, M. (2010). A systematic review of waist-to-height ratio as screening tool for the prediction of cardiovascular disease and diabetes: 0–5 could be a suitable global boundary value. *Nutrition Research Reviews, 23*, 247–269.

Deeks, J. J., & Altman, D. G. (2004). Diagnostic tests 4: Likelihood ratios. *British Medical Journal, 329*, 168–169.

Feng, R.-N., Zhao, C., Wang, C., Niu, Y.-C., Li, K., Guo, F.-C., et al. (2012). BMI is strongly associated with hypertension, and waist circumference is strongly associated with type 2 diabetes and dyslipidemia, in north Chinese adults. *Journal of Epidemiology, 22*, 317–323.

Ferreira, M. G., Valente, J. G., Gonçalves-Silva, R. M. V., & Sichieri, R. (2006). *Acurácia da circunferência da cintura e da relação cintura/quadril como preditores de dislipidemias em estudo transversal de doadores de sangue de Cuiabá, Mato Grosso* (vol. 22, pp. 307–314). Brazil: Cad Saúde Pública.

Girotto, E., Andrade, S. M., & Cabrera, M. A. S. (2010). Prevalence of abdominal obesity in hypertensive patients registered in a family health unit. *Arquivos Brasileiros de Cardiologia, 94*, 754–762.

Gonzalez-Campoy, J. M., St Jeor, S. T., Castorino, K., Ebrahim, A., Hurley, D., Jovanovic, L., et al. (2013). Clinical practice guidelines for healthy eating for the prevention and treatment of metabolic and endocrine diseases in adults: Cosponsored by The American Association of Clinical Endocrinologists/The American College of Endocrinology and The Obesity Society. *Endocrine Practice, 19*, 1–82.

Gravina, C. F., Rosa, R. F., Franken, R. A., Freitas, E. V., Liberman, A., et al. (2010). II Diretrizes Brasileiras em Cardiogeriatria. *Arquivos Brasileiros de Cardiologia, 95*, 1–112.

Hair, J. F. J., Anderson, R. E., Tatham, R. L., & Black, W. C. (1995). Multiple regression analysis. In J. F. J. Hair, R. E. Anderson, R. L. Tatham, & W. C. Black (Eds.), *Multivariate data analysis: with readings* (4th ed.). New Jersey: Prentice-Hall.

Han, T. S., van Leer, E. M. V., Seidell, J. C., & Lean, M. E. J. (1995). Waist circumference action levels in the identification of cardiovascular risk factors: Prevalence study in a random sample. *British Medical Journal, 311*, 1401–1405.

Heim, N., Snijder, M. B., Heymans, M. W., Deeg, D. J. H., Seidell, J. C., & Visser, M. (2010). Exploring cut-off values for large waist circumference in older adults: A new methodological approach. *Journal of Nutrition Health and Aging, 14*, 272–277.

Heim, N., Snijder, M. B., Heymans, M. W., Deeg, D. J. H., Seidell, J. C., & Visser, M. (2011). Optimal cutoff values for high-risk waist circumference in older adults based on related health outcomes. *American Journal of Epidemiology, 174*, 479–489.

Huang, K.-C., Lee, M.-S., Lee, S.-D., Chang, Y.-H., Lin, Y.-C., Tu, S.-H., et al. (2005). Obesity in the elderly and its relationship with cardiovascular risk factors in Taiwan. *Obesity Research, 13*, 170–178.

Lean, M. E. J., Han, T. S., & Morrison, C. E. (1995). Waist circumference as a measure for indicating need for weight management. *British Medical Journal, 311*, 158–161.

Lebrão, M. L., & Duarte, Y. A. O. (2008). Estudo SABE 2000 e 2006. In *Estudo SABE [CD-ROM]*. São Paulo: Universidade de São Paulo.

Lee, E. S., & Forthofer, R. N. (2006). Conducting durvey data analysis. In E. S. Lee & R. N. Forthofer (Eds.), *Analyzing complex survey data*. Bervely Hills: Sage.

Lee, S. Y., Park, H. S., Kim, D. J., Han, J. H., Kim, S. M., Cho, G. J., et al. (2007). Appropriate waist circumference cutoff points for central obesity in Korean adults. *Diabetes Research and Clinical Practice, 75*, 72–80.

Lim, S., Kim, J. H., Yoon, J. W., Kang, S. M., Choi, S. H., Park, Y. J., et al. (2012). Optimal cut points of waist circumference (WC) and visceral fat area (VFA) predicting for metabolic syndrome (MetS) in elderly population in the Korean Longitudinal Study on Health and Aging (KLoSHA). *Archives of Gerontology and Geriatrics, 54*, e29–e34.

Mancia, G., Fagard, R., Narkiewicz, K., Redón, J., Zanchetti, A., Böhm, M., et al. (2013). ESH/ESC guidelines for the management of arterial hypertension. *Journal of Hypertension, 31*, 1281–1357.

Martin, L. M., Leff, M., Calonge, N., Garrett, C., & Nelson, D. E. (2000). Validation of self-reported chronic conditions and health services in a managed care population. *American Journal of Preventive Medicine, 18*, 215–218.

Martins, I. S., & Marinho, S. P. (2003). O potencial diagnóstico dos indicadores da obesidade centralizada. *Revista de Saúde Pública, 37*, 760–767.

Massad, E. (2004). A teoria bayesiana no diagnóstico médico. In E. Massad, R. X. Menezes, P. S. P. Silveira, & N. R. S. Ortega (Eds.), *Métodos Quantitativos em Medicina* (first ed.). Barueri: Manole.

Matos, L. N., Giorelli, G. V., & Dias, C. B. (2011). Correlation of anthropometric indicators for identifying insulin sensitivity and resistance. *Sao Paulo Medical Journal, 129*, 30–35.

Munaretti, D. B., Barbosa, A. R., Marucci, M. F. N., & Lebrão, M. L. (2011). Self-rated hypertension and anthropometric indicators of body fat in elderly. *Revista da Associação Médica Brasileira, 57*, 25–30.

Nilsson, G., Hedberg, P., Jonason, T., Lönnberg, I., Tenerz, A., Forberg, R., et al. (2008). Waist circumference alone predicts insulin resistance as good as the metabolic syndrome in elderly women. *European Journal of Internal Medicine, 19*, 520–526.

PAHO – Pan American Health Organization. (2001) XXXVI Reunión del comitê asesor de investigaciones em salud – Encuesta Multicêntrica – Salud, Bienestar y Envejecimiento (SABE) en America Latina y el Caribe. Informe preliminar.

Paula, H. A. A., Ribeiro, R. C. L., Rosado, L.E.F.P.L., Pereira, R. S. F., & Franceschini, S. C. C. (2010). Comparison of the different definition criteria for the diagnosis of the metabolic syndrome in elderly women. *Arquivos Brasileiros de Cardiologia, 95*, 346–353.

Picon, P. X., Leitão, C. B., Gerchman, F., Azevedo, M. J., Silveiro, S. P., Gross, J. L., et al. (2007). Medida da cintura e razão cintura/quadril e identificação de situações de risco cardiovascular: estudo multicêntrico em pacientes com diabetes melito tipo 2. *Arquivos Brasileiros de Endocrinologia & Metabologia, 51*, 443–449.

Reiner, Z., Catapano, A. L., Backer, G. D., Graham, I., Taskinen, M.-R., Wiklund, O., et al. (2011). ESC/EAS guidelines for the management of dyslipidaemias. *European Heart Journal, 32*, 1769–1818.

Roriz, A. K., Oliveira, C. C., Moreira, P. A., Eickemberg, M., Medeiros, J. M. B., & Sampaio, L. R. (2011). Methods of predicting visceral fat in Brazilian adults and older adults: A comparison between anthropometry and computerized tomography. *Archivos Latinoamericanos de Nutrición, 61*, 5–12.

Scafoglieri, A., Provyn, S., Bautman, I., Van Roy, P., & Clarys, J. P. (2011). Direct relationship of body mass index and waist circumference with body tissue distribution in elderly persons. *Journal of Nutrition Health and Aging, 15*, 924–931.

Seo, J. A., Kim, B. G., Cho, H., Kim, H. S., Park, J., Baik, S. H., et al. (2009). The cutoff values of visceral fat area and waist circumference for identifying subjects at risk for metabolic syndrome in elderly Koreans: Ansan Geriatric (AGE) cohort study. *BMC Public Health, 9*, 443–451.

Silva, N. N. (2003). Aspectos metodológicos: processo de amostragem. In M. L. Lebrão & Y. A. O. Duarte (Eds.), *O projeto SABE no município de São Paulo: uma abordagem inicial* (pp. 45–71). Brasília: Organização Pan-Americana de Saúde.

Tinoco, A. L. A., Brito, L. F., Sant'Anna, M. S. L., Abreu, W. C., Mello, A. C., Silva, M. M. S., et al. (2006). Sobrepeso e obesidade medidos pelo índice de massa corporal (IMC), circunferência da cintura (CC) e relação cintura/quadril (RCQ), de idosos de um município da Zona da Mata Mineira. *Revista Brasileira de Geriatria e Gerontologia*. Available at: http://revista.unati.uerj.br/scielo.php?script=sci_arttext&-pid=S1809-98232006000200006&lng=pt&nrm=iso&tlng=pt Accessed 20.10.12.

Vasques, A. C. J., Priore, S. E., Rosado, L.E.F.P.L., & Franceschini, S. C. C. (2010). Utilização de medidas antropométricas para a avaliação do acúmulo de gordura visceral. *Revista de Nutrição, 23*, 107–118.

Wakabayashi, I., & Daimon, T. (2012). Receiver-operated characteristics (ROCs) of the relationships between obesity indices and multiple risk factors (MRFs) for atherosclerosis at different ages in men and women. *Archives of Gerontology and Geriatrics, 55*, 96–100.

WHO – World Health Organization. (2000a). The health consequences of overweight and obesity in adults and children. In *Obesity: Preventing and managing the global epidemic* (pp. 43–72). Geneva: World Health Organization WHO Technical Report Series 894.

WHO – World Health Organization. (2000b). Defining the problem of overweight and obesity. In *Obesity: Preventing and managing the global epidemic* (pp. 7–16). Geneva: World Health Organization – WHO WHO Technical Report Series 894.

WHO – World Health Organization (2011). Diabetes. Fact sheet N° 312 (online). Available at: http://www.who.int/mediacentre/factsheets/fs312/en/ Accessed 19.08.11.

Wild, S., Roglic, G., Green, A., Sicree, R., & King, H. (2004). Global prevalence of diabetes: Estimates for the year 2000 and projections for 2030. *Diabetes Care, 27*, 1047–1053.

Woo, J., Ho, S. C., Yu, A. L. M., & Sham, A. (2002). Is waist circumference a useful measure in predicting health outcomes in the elderly? *International Journal of Obesity, 26*, 1349–1355.

Zou, K. H., O'Malley, A. J., & Mauri, L. (2007). Receiver-operating characteristic analysis for evaluating diagnostic tests and predictive models. *Circulation, 115*, 654–657.