Original Article

Association of Waist-Stature Ratio with Hypertension and Metabolic Syndrome: Population-Based Study

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Abstract

Background: **Hypertension and metabolic syndrome are cardiovascular risk factors associated with increased adiposity. In a previous study, waist-to-stature ratio (WSR) was identified as the best obesity index associated with left ventricular hypertrophy.**

Objective: **In this study we compared the ability of this index to identify hypertension and metabolic syndrome with other obesity indexes (body mass index - BMI; waist circumference - WC; and waist-to-hip ratio - WHR) by receiver operating characteristic (ROC) curve analyses.**

Methods: **1,655 (45.8% men) participants of the MONICA-WHO/Vitória Project, mean age 45 ± 11 y were investigated. Metabolic syndrome prevalence (ATP-III criteria) was 32.9%, hypertension was 42.4% and obesity was 19.2%.**

Results: **Regarding the ability to identify hypertension, there was a significant WSR superiority in relation to BMI and WC ($p < 0.05$) regardless of gender, but WHR ($p > 0.05$). In relation to the ability to identify metabolic syndrome, there was a significant WSR superiority in relation to WHR in men ($p < 0.001$), but BMI and WC ($p = 0.16$ and $p = 0.9$), respectively. However, in women WSR was significantly superior in relation to WHR ($p < 0.001$) and BMI ($p = 0.025$), but WC ($p = 0.8$). The optimal WSR cutoffs are 0.52 and 0.53 for hypertension and 0.53 and 0.54 for metabolic syndrome, for men and women, respectively.**

Conclusion: **Abdominal obesity, identified by WSR as a surrogate, and not overall obesity (BMI as surrogate), is the simplest and best applicable obesity index associated to hypertension and metabolic syndrome in our population. (Arq Bras Cardiol 2010; 95(2): 186-191)**

Key words: **Hypertension; metabolic syndrome; epidemiologic studies; risk factors; body mass index.**

Introduction

Metabolic risk factors, including visceral obesity, glucose intolerance, and dyslipidemia, often cluster in some individuals[1], a construct called metabolic syndrome. Elevated blood pressure is the risk component most commonly associated with metabolic syndrome, regardless of the diagnostic criteria used[2] and the greatest single contributor to cardiovascular risk worldwide[3].

Recent emphasis has been placed on the importance of understanding the progression of cardiovascular disease and its natural history[4,5], as well as whether cardiovascular risk is influenced by physical characteristics that can be modified by lifestyle behaviors. Increased body fatness is of particular interest in this area, as the prevalence of cardiovascular disease has been partly attributable to a largely overweight/obese population[6], now affecting nearly 70% of United States adult population[7].

In a population-based study involving 641 subjects of the MONICA-WHO/Vitória Project, abdominal obesity - identified by waist-to-stature ratio (WSR = 0.56, regardless of gender) as surrogate and not body mass index (BMI), was the best obesity index associated with left ventricular hypertrophy determined by echocardiography, an important predictor of cardiac death[8]. Therefore, our aim was to test, in a large population-based study, the association between WSR (a method of easy interpretation that could be used in health promotion programs) with arterial hypertension and metabolic syndrome. In addition, the performance of the WSR index was compared to other classical obesity indexes, by receiver operating characteristics (ROC) curve analysis.

Methods

Study design and population

A cross-sectional, population-based study to determine the prevalence and severity of cardiovascular risk factors was carried out in an urban population in the city of Vitória, state of Espírito Santo, Brazil (1999 to 2001). Data were collected according to the general guidelines of the MONICA-WHO Project[9]. A total of 1,662 individuals (25 to 64 years) were

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Manuscript received July 02, 2009; revised manuscript received October 09, 2009; accepted November 24, 2009.

selected among the eligible population and attended at the University Hospital to be submitted to clinical and laboratory examinations. The design and sampling of this survey were described elsewhere[10]. The project was approved by the institutional ethic committee and all participants gave their informed written consent.

Procedures

Blood pressure was measured in fasting individuals during the morning period (7 to 9 am) in the sitting position using a standard mercury sphygmomanometer on the left arm after a 5 to 10 minute rest period. The first and fifth phases of Korotkoff sounds were used to indicate systolic and diastolic blood pressures, respectively. The mean values of the systolic and diastolic blood pressures were calculated from two measurements carried out by two independent trained examiners, with a minimal interval of 10 min between the two readings. For biochemical analysis, blood samples were collected soon after blood pressure measurements to determine glucose, triglycerides, total cholesterol and HDL-cholesterol lipoprotein, by using validated commercial analytical kits.

Anthropometric parameters were obtained by trained technicians, using standard methods. Body weight was measured on a calibrated scale, to the nearest 0.1 kg. Height was measured using a wall-mounted stadiometer, to the nearest 0.5 cm. BMI was calculated as body weight (kg) divided by the squared height (m^2). Waist circumference (WC) was measured at the mean point between the lowest rib margin and the iliac crest with the subject standing and at the maximum point of normal expiration. Hip circumference was measured to the nearest 0.1 cm around the thighs, at the height of the greater trochanter, in the standing position.

Subjects were considered hypertensive in the presence of systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg or those using anti-hypertensive drugs, including diuretics. According to ATP III criteria[11], metabolic syndrome was defined when any three of five following diagnostic criteria were present: WC > 102 cm in men and > 88 cm in women; type II diabetes mellitus or fasting glucose ≥ 110 mg/dl; HDL-cholesterol < 40 mg/dl in men and < 50 mg/dl in women; triglycerides ≥ 150 mg/dl; systolic blood pressure ≥ 130 mmHg and/or diastolic blood pressure ≥ 85 mmHg. Diabetes was defined when a positive history was present or fasting blood glucose was ≥ 126 mg/dl.

Statistical analysis

Statistical analysis was carried out using the SPSS 13.0 statistical package. Data are described as means ± standard deviations and medians for continuous variables. Proportions are used to express dichotomous variables. The goodness-of-fit for normal distribution was evaluated using the Kolmogorov-Smirnov test. The unpaired Student *t* test and Chi-square test were used to compare continuous and categorical variables, respectively. Correlation analyses (Pearson) were performed to estimate associations between anthropometric indexes and clinical variables. Triglycerides were analyzed after log transformation. The ability of anthropometric measures to identify hypertension and metabolic syndrome, as well as sensitivities and specificities of the indexes were analyzed by ROC curves[12]. Differences of the areas under the ROC curve (AUC) were compared using a previously described method[13]. Optimal cutoffs were defined by the points representing the highest concomitant sensitivity and specificity[14]. Statistical significance was set at $p<0.05$ for proportions and means, unless stated otherwise.

Results

Seven individuals were excluded from the analysis due to the lack of data to diagnose metabolic syndrome. Therefore, data are reported on 1,655 subjects (759 men and 896 women). The prevalence of metabolic syndrome was 32.9% (251 men and 294 women) and 42.4% of the subjects had hypertension (47.5% in men). It is worth mentioning that around 71% of subjects with metabolic syndrome had associated blood pressure levels ≥ 140/90 mmHg. Conversely, among subjects with hypertension, 50% did not meet the criteria for the diagnosis of metabolic syndrome.

The general clinical characteristics of the sample according to gender are shown in Table 1. All variables were higher in men, except age, WSR, fasting glucose, diabetes mellitus and metabolic syndrome prevalence, which did not show any differences. BMI, HDL-cholesterol, obesity prevalence and use of antihypertensive drugs were lower in men compared to women. Table 2 depicts the correlation coefficients between the anthropometric indexes and the studied variables. All correlations are significant with $p < 0.01$, regardless of gender.

Figure 1 shows ROC curves of BMI (0.665), WC (0.668), WHR (0.686) and WSR (0.700) for men (top) and BMI (0.726), WC (0.749), WHR (0.738) and WSR (0.762) for women (bottom), regarding the ability to identify hypertension. There was a significant WSR superiority in relation to BMI and WC ($p < 0.05$) regardless of gender, but WHR ($p > 0.05$).

In relation to the ability to identify metabolic syndrome, Figure 2 shows ROC curves of BMI (0.759), WC (0.775), WHR (0.730) and WSR (0.774) for men (top) and BMI (0.813), WC (0.835), WHR (0.779) and WSR (0.836) for women (bottom). There was a significant WSR superiority in relation to WHR in men ($p < 0.001$), but BMI and WC ($p = 0.16$ and $p = 0.9$), respectively. In women WSR was significantly superior in relation to WHR ($p < 0.001$) and BMI ($p = 0.025$), but WC ($p = 0.8$).

AUC values and optimal anthropometric indexes partition points according to the highest sensibility and specificity to identify hypertension are shown in Table 3. There was roughly the same BMI cutoff (around 26 kg/m^2), a 0.01 difference in WSR (0.52 and 0.53), a 0.09 difference in WHR (0.92 and 0.83) and a 5 cm difference in WC (88.75 and 83.75) for men and women, respectively. It is noteworthy that WSR showed the highest combined sensitivity and specificity, with values > 65% and > 70% for men and women, respectively.

Table 4 shows AUC values and optimal anthropometric indexes partition points according to the highest sensibility and specificity to identify metabolic syndrome. There was a 0.8 kg/m^2 difference in the BMI cutoffs (26.0 kg/m^2 and 26.8 kg/m^2), a 0.01 difference in WSR (0.53 and 0.54), a 0.08 difference

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Table 1 - Baseline characteristics of the sample according to gender

Variables	All subjects (1,655)	Male (759)	Female (896)	P
Age, years	45±11	45±11	45±11	0.90
SBP, mmHg	128±22	130±20	126±23	<0.001
DBP, mmHg	84±14	87±14	82±14	<0.001
BMI, kg/m^2	26.2±5	25.8±4	26.5	<0.003
Waist circumference, cm	86±12	89±11	84±13	<0.001
Waist-stature ratio	0.53±0.07	0.52±0.06	0.53±0.08	0.06
Waist-hip ratio	0.87±0.08	0.92±0.07	0.83±0.08	<0.001
Triglycerides, mg/dl	139±137	164±176	119±86	<0.001
HDL-C, mg/dl	45±12	42±12	48±12	<0.001
Glucose, mg/dl	105±31	105±28	104±34	0.39
Current smoke, %	27.3	30.8	24.3	0.02
Diabetes mellitus, %	7.7	7.0	8.3	0.58
Obesity, %	19.2	16	21.9	<0.001
Hypertensive, %	42.6	47.5	38.3	<0.001
Use of AH drugs, %	16.3	11.4	20.4	<0.001
Metabolic syndrome, %	32.8	33	32.7	0.58

Data are shown as mean ± SD, or percentage (%). SBP - systolic blood pressure; DBP - diastolic blood pressure; BMI - body mass index; HDL-c - HDL-cholesterol; AH - anti hypertensive. P is relative to Student t test when comparing differences between males and females.

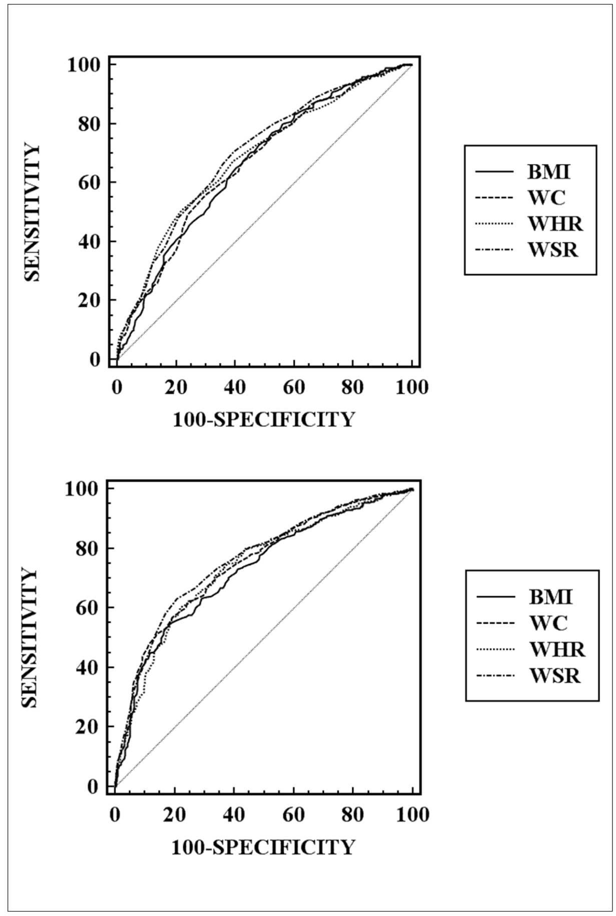

***Figure 1** - ROC curve of anthropometric indexes regarding the ability to identify hypertension in men (top) and women (bottom).*

Table 2 - Correlation coefficients between anthropometric indexes and clinical variables

	Age	SBP	DBP	Triglycerides	HDL-C	Glucose	WC	WHR	WSR
Men									
BMI	0.11	0.30	0.32	0.20	-0.20	0.22	0.90	0.59	0.90
WHR	0.46	0.29	0.31	0.24	-0.16	0.23	0.79		0.83
WSR	0.34	0.34	0.35	0.24	-0.20	0.26	0.94		
WC	0.26	0.29	0.32	0.23	-0.21	0.23			
Women									
BMI	0.18	0.35	0.40	0.25	-0.23	0.26	0.89	0.45	0.89
WHR	0.38	0.35	0.37	0.39	-0.22	0.30	0.74		0.76
WSR	0.34	0.41	0.44	0.34	-0.25	0.32	0.97		
WC	0.30	0.39	0.43	0.34	-0.24	0.30	1.00		

SBP - systolic blood pressure; DBP - diastolic blood pressure; WC - waist circumference; WHR - waist-to-hip ratio; WSR - waist-to-stature ratio; BMI - body mass index. All correlations are statistically significant with $p < 0.01$.

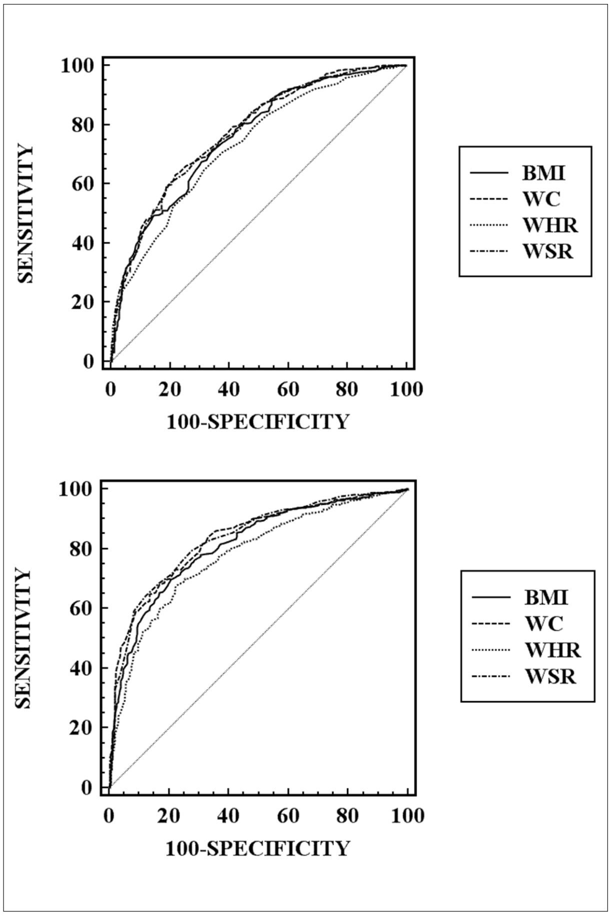

Figure 2 - ROC curve of anthropometric indexes regarding the ability to identify metabolic syndrome in men (top) and women (bottom).

in WHR (0.92 and 0.84) and a 5 cm difference in WC (90.25 and 80.25) for men and women, respectively. Again, WSR showed the highest combined sensitivity and specificity, with values around 69% and 75% for men and women, respectively.

It is noteworthy that WSR was the only anthropometric index exclusively capable of efficiently identifying both hypertension and metabolic syndrome, regardless of gender.

Discussion

Our study shows that WSR and WHR have comparable prediction ability to identify hypertensive subjects, regardless of gender. However, regarding the ability to identity metabolic syndrome, in men WSR performed as good as WC and BMI, and significantly better than WHR. Conversely, in women, WSR showed a significantly better ability than the other indexes, but WC. Therefore, in general, our main finding is that WSR is the best isolated anthropometric index to identify hypertension and metabolic syndrome in the general population, regardless of gender. The optimal cutoff points are 0.52 and 0.53 for hypertension and 0.53 and 0.54 for metabolic syndrome, for men and women, respectively.

The debate over how to best define obesity is complicated by observations suggesting that BMI, WC, or WHR may each perform better in predicting cardiovascular risk in specific populations, depending on gender, age, and ethnicity[15]. Therefore, mainly in developing countries, every effort should be made to develop cost-efficient, easily interpreted and applicable criteria to identify subclinical conditions recognized as risk factors for cardiovascular disease.

BMI has been used as obesity index in most studies to date. However, its ability to predict or to be associated with hypertension, metabolic syndrome and left ventricular hypertrophy has been questioned[16,17]. Conversely, anthropometric measures of abdominal obesity have been shown to be strongly and positively associated with cardiovascular and all-cause mortality, regardless of BMI[18].

Measures of WC may correspond to different proportions of visceral adiposity, which are frame-size dependent. Some normalizations have been investigated regarding the power to best indicate higher cardiovascular risk, such as correction for height (or its exponentials)[19,20] or for hip circumference[21].

Table 3 - Areas under the ROC curves (AUC), cutoffs, sensitivity and specificity of anthropometric indexes in relation to the ability to identify hypertension

	AUC	95% CI	p	Cut off	Sensitivity	Specificity
Men						
WC	0.668	0.633 to 0.702	0.7*, 0.2&, 0.001#	88.75	0.62	0.62
WHR	0.686	0.652 to 0.719	0.3#	0.92	0.64	0.64
WSR	0.700	0.666 to 0.733	0.001*, 0.3&	0.52	0.66	0.66
BMI	0.665	0.630 to 0.699	0.3&	25.6	0.62	0.62
Women						
WC	0.749	0.719 to 0.777	0.02*, 0.001#, 0.4#	83.75	0.68	0.67
WHR	0.738	0.708 to 0.767	0.5*	0.83	0.68	0.67
WSR	0.762	0.733 to 0.790	0.001*, 0.08&	0.53	0.70	0.70
BMI	0.726	0.695 to 0.755	0.5#	26.2	0.65	0.65

AURC - area under the ROC curve; WC - waist circumference; BMI - body mass index; WHR - waist to hip ratio; WSR - waist to stature ratio. p value in relation to BMI, to WHR &, and WSR#.*

Table 4 - Areas under the ROC curves (AUC), cutoffs, sensitivity and specificity of anthropometric indexes in relation to the ability to identify metabolic syndrome

	AUC	95% CI	P	Cut off	Sensitivity	Specificity
Men						
WC	0.778	0.743 to 0.804	0.1*, 0.03&, 0.9#	90.25	0.70	0.69
WHR	0.730	0.696 to 0.761	0.16*	0.92	0.67	0.67
WSR	0.774	0.743 to 0.804	0.001&, 0.16*	0.53	0.69	0.69
BMI	0.759	0.727 to 0.789	0.16&	26.0	0.68	0.68
Women						
WC	0.835	0.809 to 0.859	0.03*, 0.001&, 0.8#	85.25	0.74	0.75
WHR	0.779	0.750 to 0.806	0.09*	0.84	0.71	0.71
WSR	0.836	0.810 to 0.859	0.025*,<0.001&	0.54	0.75	0.76
BMI	0.813	0.786 to 0.838	0.09&	26.8	0.74	0.74

AUC - area under the ROC curve; WC - waist circumference; BMI - body mass index; WHR - waist to hip ratio; WSR - waist to stature ratio. p value in relation to BMI, to WHR&, and WSR#.*

Data from Brazilians studies point toward visceral adiposity, as opposed to BMI, as a risk factor for hypertension, which was better identified by measurements of WC[22] or WHR[23]. However, WHR requires measurements of both waist and hip circumferences and its ratio reflects an abstract concept, which is more difficult for the population to understand and interpret it. Moreover, subjects with fat increments in the hip area or in both circumferences could have as a result, low or normal WHR. Indeed, in our sample 27% of obese men and 43% of obese women (according to BMI ≥ 30 kg/m^2) had normal WHR values. This finding probably explains the lower correlation between WHR and BMI (r = 0.59 and r = 0.45, for men and women, respectively), compared to WSR and BMI (r = 0.90 and r = 0.89 for males and females, respectively. Multiple biological mechanisms have been implicated in the mediation of the adverse health effects of excess adiposity; however, the exact pathways are still unknown. In addition to mechanisms involving secretion of adipokines and other vasoactive substances, visceral fat seem to be more sensitive to lipolysis, compared with subcutaneous fat, thereby preferentially increasing circulating free fatty acid levels, which may contribute to its role in risk factor manifestation[24].

Accordingly, our data favors abdominal adiposity as an imperative cardiovascular risk factor. Therefore, our study suggests that WC, after being corrected for height, may be more appropriate and practical, in contrast with abstract concepts (BMI and WHR) or fixed and gender-specific WC partition points currently being used. Moreover, asking subjects to multiply their stature (in cm) by a predetermined value (according to the risk factor to be identified, that is, around 0.52 for hypertension, 0.54 for metabolic and 0.56 for left ventricular hypertrophy, regardless of gender) and the recommendation to keep the waist girth below the resultant maximal measurement, could achieve an important goal in health education and disease prevention in our community.

A limitation of our study is its cross-sectional design, which does not allow us to draw conclusions in terms of causality.

In conclusion, in general, our main finding is that WSR is the simplest and best applicable obesity index to identify hypertension and metabolic syndrome in our population.

Acknowledgements

The study was supported by grants from *Conselho Nacional de Desenvolvimento Científico e Tecnológico* (CNPq, 304248/2005-3) and *Fundação de Amparo à Pesquisa do Espírito Santo* (FAPES, 35884886/2006).

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Sources of Funding

This study was funded by CNPq and FAPES.

Study Association

This study is not associated with any post-graduation program.

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