Original Article

WAIST/HEIGHT RATIO COMPARED WITH OTHER ANTHROPOMETRIC INDICATORS OF OBESITY AS A PREDICTOR OF HIGH CORONARY RISK

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ABSTRACT
Objective. this study compares the performance of the waist-height ratio with other anthropometric indicators of obesity: waist circumference (WC), waist-to-hip ratio (WHR), conicity index (C Index), and body mass index (BMI) for discriminating the level of coronary risk (HCR).
Methods. a cross-sectional study of a subset of the participants enrolled on the "Monitoring Cardiovascular Diseases and Diabetes in Brazil" project (MONIT) was carried out in Salvador, Brazil (2000). The total sample comprised 968 people (391 men and 577 women) aged 30 to 74. First, the total area was calculated under the ROC curves between the C Index, WHR, waist/height ratio, WC, BMI and HCR at a 95% confidence interval. Sensitivity and specificity were then calculated. Analyses were carried out using STATA 7.0.
Results. Areas under the ROC curves used as indicators of obesity were C Index 0.80, WHR 0.76, waist/height ratio 0.76, WC 0.73, and BMI 0.64 for men and Index C 0.75, WHR 0.75, waist/height ratio 0.69, WC 0.66 and BMI 0.59 for women.
Conclusion. Indicators of abdominal obesity are better at discriminating HCR than the usual obesity indicator (BMI). The waist/height ratios are closer to the results of other studies. Furthermore, the waist/height ratio whose statistical significance justifies its use.

Key words: Obesity. Body Fat Distribution. Anthropometry.

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Introduction

Obesity, and in particular abdominal obesity, predisposes people to a series of cardiovascular risk factors. It is very often associated with conditions such as dyslipidemia, arterial hypertension, insulin resistance and diabetes, which make the occurrence of cardiovascular events more likely, particularly coronary ones. [1,2] The countless ills associated with obesity have meant that it is now defined as a non-transmissible chronic progressive and recurrent disease. [3] The disease is now becoming a global epidemic, [4] affecting practically all ages and socioeconomic groups and threatens both developed countries and underdeveloped countries. [5]

Obesity or even overweight are not generally difficult to recognize, but correct diagnosis demands that levels of risk be identified and this, in turn, makes some form of quantification necessary.

Imaging techniques such as magnetic resonance, [6] computerized tomography [7] and dual emission X-ray absorptiometry (DEXA) [8] are options that offer greater precision when assessing the accumulation of fat. However, very often the high cost of the equipment, methodological sophistication and the difficulty of involving those being assessed in the measurement protocols mean that their use in population studies or for clinical diagnosis has been limited.

Therefore, the simplicity of application and the relative ease of interpretation have made anthropometric methods popular instruments for assessing excess body fat. Many different anthropometric indices have been proposed to determine the association between overweight and cardiovascular risk factors.

The body mass index (BMI) is, possibly, the method that has been most widely publicized within the population.

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Specialists and laypeople know the BMI cutoffs. While BMI is a good indicator, it is not completely correlated with the distribution of body fat.

Waist circumference (WC) and the waist/hip ratio (WHR) are the indicators most often used to gauge centralized distribution of adipose tissues, both for assessing individual patients and groups of people, but the differences in body composition between different age groups and races make it difficult to define universal cutoff points. [5] Determination of these cutoff points is useful for detecting the risk of developing diseases, whether for health surveillance or populational diagnosis.

Other indicators that have demonstrated good correlations with cardiovascular risk factors are conicity index (C Index) and the waist/height ratio. The C Index is determined from weight, height and waist circumference[9] and has an association with cardiovascular risk factors. Other authors have demonstrated that the waist/height ratio is strongly associated with many cardiovascular risk factors and have identified the closest cutoff points for this anthropometric indicator of obesity for discriminating coronary risk in a number of different populations, [10,11] suggesting that it can be used for population studies.

In Brazil, studies have not yet been conducted to compare the waist/height ratio with other indicators of obesity (BMI, WC, WHR, C Index) for predicting high coronary risk (HCR).

Methods

This was a quantitative cross-sectional study of a sample of 968 adults less than 30 years old, which was a subset of 2,297 adults who took part in the "Monitoring Cardiovascular Diseases and Diabetes in Brazil" project (MONIT), project undertaken in the Brazilian city of Salvador in the year 2000 undertaken by the nontransmissible chronic diseases team at the collective health department (ISC) of the *Universidade Federal da Bahia* (UFBA) and financed by the Brazilian Ministry of Health. [12] Data collection was in the form of a household census carried out by the Bahia Blue project, run by investigators from ISC-UFBA with different objectives. [13]

Sample

According to MONIT, three-stage cluster sampling was used. The first step was to group census sectors from eight of the city's 10 hydrographic basins, with similar sociodemographic characteristics, into 108 survey areas, which were then classified by socio-economic status as high, mixed or low. The entire area contained 16,592 households, with approximately 83,000 inhabitants over the age of 20. Thirty-seven of these areas were chosen by probabilistic sample, in proportion to the number of sectors of each socioeconomic status. A second stage was to select 1540 households by systematic sampling (interval = 10). Of these, 1258 families (81.7%), living in 63 census sectors, agreed to take part. The third stage was to select participants, a maximum of two per household, one of each sex. A total of 2476 interview appointments were made, with 2.9% refusals (72) and an irrecoverable loss of 4.3% (107) of completed questionnaires. The final sample was therefore 2297 adults aged from 20 to 74 years. Since the model used to calculate a coronary risk indicator for the study described here was built on the basis of a population aged 30 to 74, the sample was reduced to 1654 adults, 711 men and 943 women. However, only 968 people from this age subset completed the entire protocol of measurements and were analyzed (391 men and 577 women, which is the equivalent of 55% of the men and 61% of the women).

A study has already been published analyzing differences between the entire sample and the sample used here, reporting that, despite losses, the only variable with a statistically significant difference between the groups, in both sexes, was blood pressure, although when proportions were analyzed it was observed that the prevalence of high blood pressure did not differ between the two groups. In our analysis the only statistically significant difference between those enrolled and those lost was the variable educational level of females. [17]

Data collection

All participants were interviewed at home to obtain demographic data and systolic blood pressure (PAS) and diastolic blood pressure (PAD) were measured six times; the first three, consecutively, 30 minutes after starting the interview and the second three after a 20 minute interval, with the subject seated, with an empty bladder, not having smoked or drunk coffee or alcohol during the 30 minutes prior to measurement. The first of the six PAS and PAD measurements was discarded and the mean of the other five used for analysis.

Waist circumference was measured with the subject in the exposition, with as little clothing as possible, at the midpoint between the last floating rib and the iliac crest. Weight and height were measured by the staff at each neighborhood's Health Centre, where blood was also taken for biochemical tests after 12 hours' fasting. The following were assayed: total cholesterol (Trinder enzymatic method), high density lipoprotein (HDL-C) (Labtest method) and glycemia (Trinder enzymatic method). The techniques and methods used for biochemical tests follow the standard procedures adopted by the *Sociedade Brasileira de Patologia Clínica.*

Ten fieldwork interviewers and two supervisors, both nutritionists, were duly trained for all stages of the work. In order to test and correct instruments and techniques, including the dynamics of the fieldwork, 50 households (100 people) were visited and interviews and tests carried out following the entire methodology proposed. The test group is not included in the sample. Intra-investigator and inter-investigator comparisons were made of means, standard deviations and coefficients of variation for circumference, weight and height, in order to verify techniques and instruments.

Instruments used

An Omron HEM 705 CP sphygmomanometer, tested and approved by the British Hypertension Society, was used to take blood pressure. Height was measured with an English "Leicesters" stadiometer made by the Child Growth Foundation and which has a base and can be used to measure height in the field. Body weight was measured using Filizola " bathroom " scales with a maximum capacity of 150 kg and calibrated by the *Instituto Nacional de Metrologia* (INMETRO), certified to have a margin of error of ± 100 g. Waist circumference was measured with a Starrett flexible metal measuring tape accurate to 0.1 cm.

Study variables

The following variables were used to construct the HCR indicator representing a group of cardiovascular risk factors analyzed simultaneously: age, sex, PAS, PAD, total cholesterol, HDL-C, smoking and diabetes. The variables weight, height and waist circumference were used to calculate the anthropometric indicators of obesity.

Construction of the coronary risk indicator

Framingham, Wilson et al., [14] constructed an algorithm for measuring coronary risk on the basis of 12 years' follow-up of a cohort of 2,489 men and 2,856 women aged 30 to 74 years. Their algorithm is used as the model for the study described here. During the follow-up period, 383 men and 227 women in the cohort developed CAD. Using Cox regression modeling the authors constructed a points table (algorithm) including the variables they had chosen (age, PAS, PAD, total cholesterol, HDL-C, smoking and diabetes). For each variable the score could be positive, when considered a risk factor, or negative when considered a protective factor, as has been described in an article published by Pitanga and Lessa (2005).

The scores were calculated using the beta coefficient of the Cox regression model. [14] Each member of the sample in our study had their scores calculated using the algorithm. In order to identify HCR, scores were summed and put in ascending order and percentiles were calculated, with the score equating to the 80th percentile chosen as the cutoff for high coronary risk. The cutoff for men was eight points and for women it was 10 points.

Analysis procedure

Receiver Operating Characteristic (ROC) curves were used for analysis. Initially the total area under the ROC curve was determined for BMI, WC, WHR, C Index, waist/height ratio and HCR. The confidence interval was set at 95%. The greater the area under the ROC curve, the greater the discriminatory power of the obesity indicator for identifying HCR. The confidence interval determines whether the predictive capacity of the obesity indicator is due to chance and its bottom limit must never be less than 0.50. [16]

Sensitivity and specificity were then calculated for each of the arithmetic indicators for HCR. The figures indicated by the ROC curve cutoff points which should produce the best equilibrium between sensitivity and specificity for the measurements chosen to discriminate HCR.

Data were analyzed using the statistical programme "STATA", version 7.0. The project was approved without reservations by the Ethics Committee of the Bahia Regional Medical Council *(Conselho Regional de Medicina do Estado da Bahia)*. All people who participated in the study or their guardians signed a consent form agreeing to take part.

Results

The majority of the characteristics of the sample were similar between subsets, with statistically significant differences between men and women for the variables body weight, height, waist circumference, PAS, PAD, total cholesterol and HDL-C (Table 1).

For both sexes, the areas under ROC curves used to identify the predictive power of the anthropometric indices identified the C Index as the best discriminant of HCR (Table 2). The waist/height ratio had an area under the ROC curve of 0.76 and a cutoff point of 0.52 for men (95%CI = 0.70 - 0.82) with sensitivity of 68% and specificity of 64% and a cutoff point for women of 0.53 (95%CI = 0.64 - 0.75) with sensitivity of 67% and specificity of 58% (Table 2).

Waist circumference had less predictive power than the waist/height ratio, with an area under the ROC curve of 0.73 for men (95%CI = 0.67 - 0.79) and 0.66 for women (95%CI = 0.60 - 0.71). The cutoff points of 0.88 for men and 0.83 for women provided the best equilibrium between sensitivity (men = 65% and women = 64%) and specificity (men = 67% and women = 62%) Table 2).

The areas under the ROC curves for C Index and WHR were similar for women, with statistically significant differences between the other obesity indicators in terms of HCR discrimination (Table 2).

Comparing the discriminatory power of the waist/

height ratio with the other obesity indicators, a statistical significance between areas under the ROC curves was observed. The comparisons of C Index (p = 0.0440), WC (p = 0.0104) and BMI (p = 0.0000) for men all detected statistically significant differences. When compared with WHR, the difference did not reach statistical significance (p = 0.7859). For women, the analysis demonstrated statistically significant differences between the area under the ROC curve for waist/height ratio and all other obesity indicators (Table 3).

Discussion

Several studies have demonstrated that the waist/height ratio is good at discriminating abdominal obesity that is related to cardiovascular risk factors, and also HCR. 10, 18

Analysis of sensitivity and specificity using ROC curves is recommended in epidemiological studies for determining cutoff points. 15 This type of analysis does not only make it possible to identify the best cutoff point but also provides the area under the curve, which translates to an indicator's discriminatory power for a given outcome. In this study, all of the anthropometric indicators analyzed exhibited predictive capacity for HCR. Nevertheless, it is notable that the waist/height ratio has good discriminatory power for HCR, with the second largest area under the ROC curve for this outcome, in both sexes.

In contrast with WHO recommendations, this study

Table 1 - Means, standard deviations and percentages of study variables

	Men (n=391)	Women (n=577)	p
Age (years)	45.34±10.44	45.73±11.64	0.59
Weight (kg)	68.91±12.30	64.20±13.84	< 0.001
Height (stature) (m)	1.68±0.07	1.55±0.07	< 0.001
Waist (cm)	85.64±10.11	82.68±12.19	< 0.001
Hips (cm)	93.73±7.46	99.72±10.00	< 0.001
PAS (mmHg)	130.6±22.8	124.8±24.6	< 0.001
PAD (mmHg)	81.1±14.6	78.2±13.2	< 0.001
Total cholesterol (mg/dl)	220.6±52.0	232.3±52.5	< 0.001
HDL-C (mg/dl)	48.5±13.1	51.5±13.5	< 0.001
Glycemia (mg/dl)	90.5±29.2	92.0±34.4	0.48
C Index	1.23±0.07	1.18±0.09	< 0.001
WHR	0.91±0.07	0.83±0.08	< 0.001
waist/height ratio	0.51±0.06	0.53±0.08	< 0.001
WC (cm)	85.6±10.1	82.7±12.2	< 0.001
BMI (kg/m2)	24.4±3.85	26.54±5.39	< 0.001
Coronary risk			
Not high	76%	79%	
High	24%	21%	0.61
Educational level			
Low	50%	54%	
Medium/High	50%	46%	0.57
Skin color			
White	24%	26%	
Black and others	76%	74%	0.74

Continuous variables were compared using Student's t test for independent samples and percentages with the Chi-square test; PAS = systolic blood pressure; PAD = diastolic blood pressure; HDL-C = high-density lipoprotein.

Table 2 - Comparison of the HCR cutoff points and areas under ROC curves for the anthropometric indicators of obesity

Obesity indicators	Cutoff point	Sensitivity	Specificity	Area at 95%CI	p
Men					
C Index	1.25	74%	75%	0.80 (0.74-0.85)	
WHR	0.92	74%	65%	0.76 (0.71-0.82)	
waist/height ratio	0.52	68%	64%	0.76 (0.70-0.82)	
WC	0.88	65%	67%	0.73 (0.67-0.79)	
BMI	24.0	67%	53%	0.64 (0.57-0.71)	0.0013
Women					
C Index	1.18	73%	61%	0.75 (0.70-0.80)	
WHR	0.83	73%	63%	0.75 (0.70-0.80)	
waist/height ratio	0.53	67%	58%	0.69 (0.64-0.75)	
WC	0.83	64%	62%	0.66 (0.60-0.71)	
BMI	26.0	62%	53%	0.59 (0.53-0.65)	< 0.001

C Index = conicity index; HCR = high coronary risk; BMI = body mass index; WHR = waist/hip ratio; WC = waist circumference.

suggests that WC was not the best predictor of HCR, although it was more accurate than BMI for both sexes. Furthermore, the best cutoff points, defined by means of ROC curve analysis, for WC, WHR and BMI, were different from those provided by the WHO. Other studies conducted in Brazil have also found different cutoff points from those proposed by the WHO, confirming that these universal cutoff points for WC are not effective for our population. [5, 19, 20]

Fat distribution and body composition patterns vary greatly between different population groups. [21] Over recent years, a large number of publications have provided evidence of the inappropriateness of applying cutoff points defined for Caucasian populations to other racial groups. One very clear example is given by the results that are being observed in Asian populations. Studies that have assessed the indicators of fat distribution among Chinese and Japanese populations have clearly demonstrated that the best cutoff points for a range of chronic diseases are below those recommended by the WHO. [22,23] Furthermore, high body fat percentages have been observed in these populations, despite BMI being within normal limits . [23] The waist/height ratio is also proving to have a strong association with cardiovascular risk factors in Asian populations. [24]

With relation to the C Index, Pitanga and Lessa [19] proposed cutoff points of 1.25 for men and 1.18 for women. Despite this information, few studies could be located that used this measurement as a reference. The same authors, in another publication, mentioned that one limitation of using the C Index in population studies is the difficulty of calculating the denominator of the equation proposed for calculating the index. [17] The scarcity of the scientific information available about the C Index in different populations around the world and in different age groups is another factor that prevents this indicator from being adopted as a reference for population studies.

In a cohort study undertaken in Thailand, resulting from 17 years' follow-up with a total sample of 2,536 men aged 35 to 59, BMI, WC, WHR and the waist/height ratio were compared in terms of discriminatory power for coronary artery disease (CAD). They used the same Cox regression models we used in this study. The waist/height ratio was the best of the four indices analyzed, for predicting CAD in men from this population. The cutoff point suggested in that study (0.51) [18] was very similar to the one we arrived at (0.52).

Recent research designed to determine cutoffs for the waist/height ratio in different populations indicated that a cutoff point of 0.5 is the best figure for both sexes and all

Table 3 - Comparison of the significance level of the waist/height ratio and all other indicators			
	Area under the ROC curve at 95% confidence interval		p
Men			
waist/height ratio and C Index	0.76 (0.70-0.82)	0.80 (0.74-0.85)	0.0440
waist/height ratio and WHR	0.76 (0.70-0.82)	0.76 (0.71-0.82)	0.7859
waist/height ratio and WC	0.76 (0.70-0.82)	0.73 (0.67-0.79)	0.0104
waist/height ratio and BMI	0.76 (0.70-0.82)	0.64 (0.57-0.71)	< 0.001
Women			
waist/height ratio and C Index	0.69 (0.64-0.75)	0.75 (0.70-0.80)	0.0063
waist/height ratio and WHR	0.69 (0.64-0.75)	0.75 (0.70-0.80)	0.0050
waist/height ratio and WC	0.69 (0.64-0.75)	0.66 (0.60-0.71)	< 0.001
waist/height ratio and BMI	0.69 (0.64-0.75)	0.59 (0.53-0.65)	< 0.001

C Index = conicity index; BMI = body mass index; WHR = waist/hip ratio; WC = waist circumference.

different ages and populations. [10, 22, 25]

Several different studies have demonstrated that the waist/height ratio is also a better indicator of the health of children and adolescents than anthropometric indicators. The 0.5 cutoff point that is proposed is similar to that recommended for adults. [26, 27]

It should not be forgotten that body composition changes as the aging process progresses, which could alter the cutoff points of other anthropometric measurements. Since the waist/height ratio has a direct relationship between growth and waist circumference, this may be the greatest advantage of the measure and may explain the fact that the cutoff point is the same irrespective of age. One other factor that appears to be a positive attribute of this measure is its ease of application, since a simple tape measure is sufficient to calculate the waist/height ratio by applying simple division to the height and waist measurements.

Considering that excess fat in the central part of the body is associated with cardiovascular diseases, diabetes and mortality, the definition of cutoff points for indicators that stand out for their operational simplicity and accuracy allows at-risk people to be identified, making such indicators of great use to health-care services, in addition to making it possible to determine the situation that different population groups are in with relation to these risks, when used in epidemiological research.

The population-based approach to health risk would be much simpler if the same anthropometric index and the same public health message could be used for all populations. Considering that the cutoff points for waist/height ratio found in many different populations are close to 0.50, the population message suggested is that waist circumference should be less than half a person's height.

One limitation of this study is that HCR was defined using the algorithm modeled on the cohort followed by Framinghan, [14] which meant that people under 30 years of age were removed from the sample. Furthermore, the choice to base HCR cutoff points on the 80th percentile was arbitrary.

Conclusions

The results observed suggest that the waist/height ratio is a simple measure with good predictive power for HCR and that its cutoff point is very similar to those found in several different populations. It would be interesting to conduct studies in Brazil relating the waist/height ratio to a range of outcomes in both sexes.

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