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Research Article

Discriminatory Ability of New and Traditional Anthropometric Indices for Hypertension and Diabetes in the Elderly

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Abstract

Purpose: To investigate the association and discriminatory ability of new and traditional anthropometric indices for diabetes and hypertension in elderly.

Materials and methods: We conducted a cross-sectional population-based study of 62 elderly aged 60 years or more. Body Mass Index (BMI), Waist Circumference (WC), Hip Circumference (HC), Waist to Hip Ratio (WHR), Waist to Height Ratio (WHtR), Conicity Index (CI), Waist to Calf Ratio (WCR), Waist to Hip to Height Ratio (WHHR), Body Adiposity Index (BAI), A Body Shape Index (ABSI) and Body Roundness Index (BRI) were obtained. The outcomes were hypertension and diabetes. Poisson regression with robust variance estimator was used to estimate the prevalence ratios. Adjustors were age, sex, income, level educational, alcohol consumption, smoking status, physical activity and diet quality score. To assess discriminatory ability was used receiver operating characteristic curve.

Results: Most of the anthropometric indices were positively associated with both diabetes and hypertension. The prevalence of diabetes were increased more than 1.5-fold per SD increase for WCR and WHR (P <0.0001). Hip circumference showed an inverse association with diabetes. The areas under the curve were significantly greater than 0.5 (P <0.05). WCR (AUC: 0.67, 95% CI: 0.62-0.72), WHtR (AUC: 0.66, 95% CI: 0.61-0.72) and BRI (AUC: 0.66, 95% CI: 0.6z-0.72) showed discriminatory ability slightly higher for diabetes.

Conclusion: New anthropometric indices did not show stronger associations or better discriminatory ability than the traditional anthropometric indices for hypertension or diabetes in elderly individuals.

Keywords: Ability; Aging; Anthropometry; Cardiovascular risk factor; Discriminatory

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Introduction

Global estimates have recently shown higher prevalence of hypertension and type 2 diabetes in older adults, with projection of a large increase in the prevalence of diabetes in the developing countries over the next decades [1,2]. Obesity is recognized to be a significant modifiable risk factor for type 2 diabetes and hypertension [3] and the Body Mass Index (BMI) is simple index commonly used to classify overweight and obesity. Aging is normally accompanied by an increase in body fat, especially visceral [4], however still it remains unclear which anthropometric indices are associated with cardiovascular risk factors in the elderly [5]. Studies in adults have demonstrated that the central adiposity indicators are more reliable predictors of hypertension and type 2 diabetes than BMI [6,7].

Anthropometric measurements are often used as proxies for total body fat and abdominal visceral adipose tissue in population studies [7,8]. Classically, waist circumference, waist to hip ratio and waist to height ratio are measures used to estimate the risk cardiometabolic related to central obesity [9]. Recently others indices, such as the waist to calf ratio [10], waist to hip to height ratio [11], body roundness index [12] and a body shape index [13] have been proposed as risk predictors, but these have not been studied in elderly.

The aim of this study was to investigate the association of new and classic anthropometric indices with diabetes and hypertension as well as their discriminatory ability.

Material and Methods

Data collection

The study was conducted in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) and was approved by the Ethics Committee on Human Research of the Federal University of Viçosa, Minas Gerais, Brazil. All participants gave written informed consent before data collection. Face-to-face interviews were conducted by interviews trained at the elderly's home using a standard questionnaire to obtain information.

Study population

This study was a community population-based, cross-sectional of non-institutionalized older individual residents in Southeast Brazil, in the city of Viçosa (Minas Gerais) in 2009. The calculation of the size of the sample was determined considering the reference population of 7,980 elderly people, 95% confidence level, 50% estimated prevalence for different outcomes, 4% estimation error and 20% losses. Of the 670 randomly selected elderly, 7.3% (n=49) were excluded from the study due to refusal (n=24), death (n=9) and address not found (n=16). Thus, 621 elderly were interviewed and 84 of these were excluded from the analysis due to the impossibility of anthropometric measurements by physical limitations (wheelchair and/or presence of limb amputation), totaling a final sample of 537 elderly.

Definition of diabetes and hypertension

Diabetes and hypertension were defined based on self-reported physician-diagnosed or self-reported current use of antidiabetic or antihypertensive medication during the 15 days prior to the interview, which was coded according to the Anatomical Therapeutic Chemical Classification system [14].

Anthropometric data

The anthropometric assessment followed recommended calibration procedures by the World Health Organization [15]. Weight was measured on a portable class III electronic balance (Marte® LC200-PS), with a maximum capacity of 199.95kg, minimum capacity of 1kg and precision of 50g. Height was measured using a vertical stadiometer (Altura Exata®) with a bilateral numerical scale from 35-213cm with 0.1cm divisions. Circumferences were obtained with the help of inelastic measuring tape, flexible, with a capacity of 1.80m and 0.1mm of accuracy. The table 1 shows how the anthropometric indices were calculated.

Anthropometric indices	Formulas
A body shape index ($m^{11/6}$. $kg^{-2/3}$) [13]	WC (m) ÷ (BMI (kg/m^2)$^{2/3}$ x Height (m)$^{1/2}$)
Body roundness index [12]	364.2 - (365.5 x ε), where ε = $\sqrt{1-\left[\frac{[WC(m)\div(2\times\Pi)]^2}{[0.5\times heignt(m)]^2}\right]}$
Body adiposity index [16] (%)	HC (cm) ÷ Height (m)1.5 - 18
Conicity index [17]	WC (m) ÷ (0.109 x $\sqrt{Weight(kg)\div Height(m)}$
Body mass index (kg/m^2) [15]	Weight (kg) ÷ Height $(m)^2$
Waist to height ratio [18]	WC (cm) ÷ Height (cm)
Waist to calf ratio [10]	WC (cm) ÷ CC (cm)
Waist to hip ratio [15]	WC (cm) ÷ HC (cm)
Waist to hip to height ratio [11]	WC (cm) ÷ HC (cm) ÷ Height (cm)

Table 1: Formulas for anthropometric indices calculation.

ε: Eccentricity; BMI: Body Mass Index; CC: Calf Circumference; HC: Hip Circumference; WC: Waist Circumference.

Measurements of covariates

Data of behavior factors, such as smoking, alcohol consumption and physical activity, diet quality, as well as on socioeconomic data was collected during the household interview. The elderly income was estimated by the sum of remuneration for the activity performed, retirement benefit and financial assistance from third parties; measured in reais and converted into US dollar by adopting the average quote in the current period of data collection (June-December 2009: US$ 1.00 = R$ 1.8234). The minimum wage in the year of the study was R$ 465.00 (US$ 255.00). Income was categorized according to the median and the educational level was classified in <8 years and ≥8 years of schooling.

Food consumption was obtained through habitual dietary intake recall by the method of multiple passages [19]. Overall diet quality was assessed using Brazilian Healthy Eating Index Revised (BHEI-R). BHEI-R was measured from 12 components based on food groups totaling a maximum score of 100 points and a higher score represents a better dietary quality [20,21]. Physical activity was categorized in 'yes' or 'no'; current smoking status in 'smoker', 'ex-smoker' or 'never-smoker' and alcohol consumption was dichotomized in 'non-drinker', 'ex-drinker' and 'current drinker'.

Data analysis

Statistical analyses were performed using the software Stata version 13.0 [22]. Hypertension and diabetes were analyzed as dichotomous outcomes (0 = 'no' and 1 = 'yes'). The independent variables were new anthropometric indices: ABSI, BRI, BAI, WCR, WHHR and classic anthropometric indices: BMI, WC HC, WHR WHtR and IC. Despite the use of different scales, the anthropometric indices were standardized to a mean of 0 and a Standard-Deviation (SD) of 1, before estimating the association of the diverse indices and prevalence of diabetes and hypertension Prevalence Ratios (PR) and 95% Confidence Intervals (CIs) were estimated by applying Poisson regression model with robust variance. Analyses were adjusted for a number of confounders (sex, age, level educational, income, diet quality, physical activity, current smoking status and alcohol consumption) that were selected using directed acyclic graphs [23].

In addition, we calculated the area under the Receiver Operating Characteristic (ROC) curve and 95% Confidence Intervals (CIs) to evaluate the discriminatory ability of anthropometric indices to identify elderly with diabetes and hypertension. In this study was observed that the prevalence of hypertension and diabetes was of 92.6% and 37.7% in obese elderly and 76.1% and 19.0% in non-obese elderly, respectively. Assuming $\alpha = 0.05$, the statistical power in all analyses was >97,3% for hypertension and >98,8% for diabetes [24] (OpenEpi24: www.OpenEpi.com).

Results

Enrollment and screening began on June, 2009 and ended on December, 2009. The mean age (SD) of 537 participants was 69.7 (7.38) years with a range of 60-91 years and 50.1% (n=269) were females. Table 2 shows the characteristics of the study population.

The most anthropometric variables were positively associated with both diabetes and hypertension, while the hip circumference showed an inverse association with diabetes. The prevalence of diabetes was increased more than 1.5-fold per SD increase for WCR and WHR (Table 3).

The Areas Under the Curve (AUCs) for each anthropometric measure were significantly greater than 0.5, but the discriminatory ability was lower for hypertension compared with diabetes. The indices that show discriminatory ability slightly higher were the WCR, WHtR and BRI for diabetes (Table 4).

Variables	Values
Population size (n)	537
Age (mean ± SD)	69.7 ± 7.38
Female (%)	50.1
Income (US$) (median, IQR)	382.50 (255.00 - 877.50)
Level educational <8 years (%)	78.2
Current smokers (%)	11.9
Physical inactivity (%)	67.6
Current drinkers (%)	37.4
Diet quality (BHEI-R) (mean ± SD)	64.2 ±11.2
Hypertension (%)	79.9
Diabetes (%)	23.9
BMI ≥ 30 kg/m² (%)	22.7

Table 2: Characteristics of the study population.

SD: Standard Deviation; IQR: Interquartile Range; BHEI-R: Brazilian Healthy Eating Index Revised; BMI: Body Mass Index

Anthropometric indices (n=537)	Prevalence ratios and 95% confidence interval	
	Hypertension[1]	Diabetes[2]
Bodymass Index (BMI)	1.09 (1.05 - 1.13)	1.31 (1.16 - 1.47)
Waist Circumference (WC)	1.09 (1.04 - 1.13)	1.38 (1.22 - 1.56)
Hip Circumference (HC)3	0.96 (0.89 - 1.03)	0.64 (0.50 - 0.84)
Waist to Hip Ratio (WHR)	1.08 (1.03 - 1.13)	1.55 (1.32 - 1.82)
Waist to Height Ratio (WHtR)	1.09 (1.05 - 1.14)	1.41 (1.24 - 1.60)
Waist to Calf Ratio (WCR)	1.07 (1.03 - 1.11)	1.52 (1.33 - 1.75)
Waist to Hip To Height Ratio (WHHR)	1.07 (1.02 - 1.11)	1.46 (1.26 - 1.68)
Conicity Index (CI)	1.07 (1.03 - 1.12)	1.39 (1.22 - 1.59)
Body Adiposity Index (BAI)	1.08 (1.04 - 1.12)	1.23 (1.07 - 1.40)
A Body Shape Index (ABSI)	1.03 (0.98 - 1.07)	1.22 (1.06 - 1.40)
Body Roundness Index (BRI)	1.08 (1.05 – 1.13)	1.34 (1.20 - 1.50)

Table 3: Prevalence ratios and 95% confidence interval for hypertension and diabetes to one standard deviation§ increment in anthropometric indices in elderly.

§Standard Deviation (SD): BMI: 5.09 kg/m²; WC: 12.39 cm; HC: 10.04 cm; WHR: 0.07; WHtR: 0.08; WCR: 0.24; WHHR: 0.05; CI: 0.07; BAI: 6.7%; ABSI: 0.004 $m^{11/6}.kg^{-2/3}$ and BRI: 1.89.

[1]Model 1: Adjusted for age, sex, median income, level educational (<8 or ≥8 years), drinking status, smoking status, physical activity and diet quality score.

[2]Model 2: First model additionally for hypertension.

[3]Model 1 and 2: Additionally adjusted for waist circumference.

Anthropometric indices (n=537)	AUC (95% CI)	
	Hypertension	Diabetes
Bodymass index	0.61 (0.56 - 0.68)	0.63 (0.57 - 0.70)
Waist circumference	0.62 (0.56 - 0.68)	0.64 (0.58 - 0.69)
Waist to hip ratio	0.58 (0.51 - 0.64)	0.60 (0.55 - 0.66)
Waist to height ratio	0.64 (0.59 - 0.70)	0.66 (0.61 - 0.72)
Waist to calf ratio	0.61 (0.55 - 0.67)	0.67 (0.61 - 0.72)
Waist to hip to height ratio	0.62 (0.56 - 0.68)	0.65 (0.59 - 0.70)
Conicity index	0.61 (0.55 - 0.67)	0.63 (0.58 - 0.68)
Body adiposity index	0.62 (0.56 - 0.67)	0.61 (0.55 - 0.67)
A body shape index	0.55 (0.49 - 0.61)	0.57 (0.51 - 0.62)
Body roundness index	0.64 (0.59 - 0.70)	0.66 (0.61 - 0.72)

Table 4: Area Under the receiver operating Characteristic Curve (AUC) of anthropometric indices to discriminate elderly individuals with hypertension and diabetes.

Discussion

This population-based study of elderly individuals simultaneously compared the association and discriminatory ability of new and classic anthropometric indices for diabetes and hypertension. We found a positive association between anthropometric indices with diabetes and hypertension as has been demonstrated in previous studies [4,7,8]. In our study, the most recently proposed adiposity indices such as BRI, ABSI and WHHR did not show stronger associations or better discriminatory ability for hypertension or diabetes than the traditional anthropometric indices (BMI, WC, WHR and WHtR). Recent studies, study involving samples from the elderly, have also shown that CI, BAI, ABSI and BRI do not have a better discriminatory ability than BMI, WC, WHR and WHtR for outcomes related to the greater cardiometabolic risk, such as hypertension [25], diabetes [25,26], metabolic syndrome [27] and cardiovascular diseases [28].

The combination of excess body fat, mainly abdominal, with reduced muscle mass may produce more negative health outcomes and the sarcopenia phenotype or sarcopenic obesity are common in the older population [29]. In view of this, WCR could predict sarcopenic obesity since it is an index that assesses the disproportion between abdominal fat and leg muscle mass [10], but further studies are needed to verify this. In our study, hip circumference was inversely associated with diabetes. This is also supported in other studies with adults [30,31] and elderly [32]. There is evidence that a visceral and gluteofemoral adipose tissue has distinct intrinsic characteristics. Thigh and hip fat deposits have been positively linked with increased lipoprotein lipase, serum leptin and adiponectin activities, and negatively with the proinflammatory cytokines. As possible mechanisms to explain the 'protective effect' of gluteofemoral fat is a more passive metabolic activity that leads to visceral fat and fatty acids being stored for long time spans revealed by a lower concentration in the circulation [33].

The comparability of our results with those found in other studies is limited, because in our literature review, we did not find any study that compared the discriminatory ability of new and traditional anthropometric indices in the elderly population. Only a few studies [34-37] had investigated the association and discriminatory ability of BMI, WC, WHR and/or WHtR for cardiometabolic risk factors in the elderly population and the results were inconsistent. Corroborating findings from other studies [36,38,39], anthropometric indicators showed low discriminant power to diabetes and hypertension in the elderly.

There are a few limitations to our study. Firstly, the study has a cross-sectional design, so it limits to establish temporality between the predictors and the outcome. Secondly, the prevalence of diabetes and hypertension in the population might be underestimated in this study because the majority of study participants were of low education level. However, to minimize bias additionally medication records were considered to define chronic diseases. This study demonstrated that the recently proposed anthropometric indices showed no higher discriminatory ability than the indices traditionally used in population studies and in clinical practice. WCR seems to be a promising index in the evaluation of the elderly, but more studies are needed.

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Conflict of Interest

The authors declare no conflict of interest

Authors Contribution

FACR, AQR, SEP and SCCF conceived and designed the study; AQR performed the study; FACR, AQR and PFP contributed to the statistical analysis; FACR wrote the paper. All authors contributed to the critical revision of the manuscript. All authors read and approved the final manuscript.

Ethical Standards Disclosure

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects/patients were approved by the Ethics Committee on Human Research of the Federal University of Viçosa, Minas Gerais, Brazil. Written informed consent was obtained from all subjects/patients.

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