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ARTICLE

"A body shape index" and its association with arterial hypertension and diabetes mellitus among Brazilian older adults: *National Health Survey* (2013)

"*A body shape index*" e a associação com hipertensão arterial e diabetes mellitus entre idosos brasileiros: a *Pesquisa Nacional de Saúde* (2013)

"*A body shape index*" y su asociación con la hipertensión arterial y diabetes mellitus entre adultos mayores brasileños: *Encuesta Nacional de Salud* (2013)

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Abstract

The aim was to evaluate the separate and joint association of abdominal adiposity indicators (a body shape index – ABSI, waist circumference – WC, waist-to-height ratio – WHtR) and body mass index (BMI) with arterial hypertension and diabetes mellitus, in Brazilian older adults. Data from the 2013 Brazilian National Health Survey *(PNS 2013) were used for the population aged 60 years or older (10,537 older adults). Arterial hypertension and diabetes mellitus outcomes were self-reported and the following anthropometric indices were evaluated by direct measurement: a ABSI, BMI, WC and WHtR. Associations were assessed by logistic regression, with adjustments for confounding factors. The results of this study evidenced a higher strength of association between the report of arterial hypertension and diabetes mellitus with BMI, WC and WHtR in the Brazilian population of older adults in separate analyses, when compared to ABSI. When adjusted for BMI, ABSI showed a greater strength of association with the outcomes, but it was not superior to the performance of WC and WHtR. Considering the lower strength of association, in separate and joint analyses, between the new index (ABSI) and the chronic conditions assessed, BMI, WC and WHtR probably remain as useful indices in public health, at least in relation to arterial hypertension and diabetes mellitus in Brazilian older adults.*

Aging; Anthropometry; Diabetes Mellitus; Hypertension; Obesity

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Introduction

Among the main risk factors for the occurrence of chronic noncommunicable diseases (NCD), excess weight can be highlighted, especially as a determinant of cerebrovascular diseases, arterial hypertension and diabetes mellitus [1,2]. Epidemiological studies suggest that an increase in the prevalence of arterial hypertension and diabetes mellitus is associated with increased body weight [3,4] however, the importance of abdominal fat in determining cardiovascular and metabolic events should be highlighted [5,6,7,8].

In this sense, several anthropometric indicators have been proposed to identify the population with the highest risk of cardiovascular events, and the body mass index (BMI) is the most used to evaluate excess weight in epidemiological studies. However, its use has been questioned because it does not distinguish between the accumulation of lean and fat body mass, nor the concentration of peripheral and abdominal fat [9,10]. In addition, waist circumference (WC) has been used to complement BMI assessment, but this indicator has limitations to adequately estimate body fat distribution, as it does not take height into account; also, taller individuals have a larger waist circumference, but not necessarily a greater accumulation of abdominal fat [11,12]. Consequently, researchers proposed waist-to-height ratio (WHtR) as an alternative to WC [1]. However, due to the high correlation between WC and WHtR, it is unlikely that these two measures would produce different results regarding the association with health outcomes [13]. Due to the limitations of WC, new measures to evaluate abdominal adiposity were proposed to complement BMI, such as "a body shape index" (ABSI), which is based on WC, adjusted for height and BMI. This index was able to adequately predict risk of death from all causes in the USA population, with a better performance than WC. However, the authors emphasized that ABSI's predictive power for all-cause mortality differed among ethnicities, with lower power among Latinos compared to Caucasians and African-Americans [14].

Regarding morbidity, ABSI was a weak predictor of risk of cardiovascular diseases and metabolic syndrome in Iranian adults [15] and risk of stroke among Spanish men [16], when compared to WHtR. However, little is known about its association with morbidity and mortality in Brazil [17], especially in population of older adults, which is rapidly growing in the country, with a high NCD burden [18]. In addition, due to the miscegenation of the Brazilian population [19], ABSI may have a different performance in terms of understanding the risks of important diseases present in this population.

In this context, this study aimed to evaluate the separate and joint association of indicators of abdominal adiposity (ABSI, WC, WHtR) and BMI with arterial hypertension and diabetes mellitus, in Brazilian older adults.

Methodology

Study population

This is a cross-sectional, household-based study that used data from the *Brazilian National Health Survey* (PNS), conducted in 2013, with a representative sample of the Brazilian adult population, by the Brazilian Institute of Geography and Statistics (IBGE) and the Ministry of Health. The PNS was approved by the National Committee for Ethics in Research (CONEP) in 2013, regulation number 328,159, and all participants signed an informed consent form [20].

The sample selection was carried out in three stages, with census tracts, households and residents aged 18 years or over as primary, secondary and tertiary units, respectively. For each selected household, an interview was conducted with one adult aged 18 years or more, who was selected using an equiprobability method among all adults living in the household. The interviews were conducted in more than 64 thousand households (response rate = 94%) [21]. For the present study, participants aged 60 or over who had complete information for all variables of interest were selected, which resulted in a sample of 10,537 older adults (94.3% of the older adults PNS respondents). Data collection was carried out using structured questionnaires and performed at the selected household, along with a physical examination to collect anthropometric measurements.

Variables and collection procedures

The dependent variables were self-reported arterial hypertension and diabetes mellitus, which were defined by answering the following questions: "Has a doctor ever diagnosed you with arterial hypertension (high blood pressure)?" and "Has a doctor ever diagnosed you with diabetes?". The main exposure variables were anthropometric indices, evaluated by direct measurements. Weight and height were measured according to techniques recommended by the literature, with the participants in light clothing and without shoes. A portable digital scale and a portable stadiometer were used to measure weight and height, respectively, with the individuals in an upright position. WC was measured using a flexible and inelastic tape measure, at the midpoint between the last rib and the iliac crest, with the interviewee standing and at the end of a normal expiration [22]. WHtR was calculated by dividing the waist circumference (cm) by height (cm). BMI was calculated dividing the individual's weight in kilograms by the square of the height in meters. ABSI was calculated using the following formula: WC (m) ÷ ($BMI^{2/3}$ × height $(m)^{1/2}$) [14].

The potential confounding variables included: age in years (continuous), sex (male and female), self-reported skin color (white and non-white) and education, categorized as low (without education/basic education), medium (high school) and high (higher education). Health behaviors included smoking (never smoked, ex-smoker and current smoker), alcohol consumption (no consumption, moderate consumption – between 1 and 7 doses/week for women and 1 to 14 doses/week for men, and at-risk consumption – more than 7 doses/week for women and more than 14 doses/week for men) [23] and physical activity in leisure time (active and non-active). Smoking was assessed based on the following questions: "Do you currently smoke any tobacco products?" and "In the past, did you smoke any tobacco products?". Two questions were used to evaluate alcohol consumption: "How many days a week do you usually drink alcohol?" and "In general, on the days you drink, how many doses of alcohol do you consume? (1 serving of alcohol is equivalent to 1 can of beer, 1 glass of wine or 1 dose of rum, whiskey or other distilled alcohol)". Physical activity in leisure time was evaluated based on the answers to questions about frequency and duration. Older adults who did at least 150 minutes of moderate-intensity or 75 minutes of vigorous exercise per week were considered physically active [24].

Statistical analyses

Rao-Scott test (categorical variables) and Wald test (continuous variables) were used to compare the distribution of all dependent variables for men and women. All variables used in this study were compared between hypertensive and normotensive, diabetic and non-diabetic, using the Rao–Scott test (categorical variables) and Wald test (continuous variables). All anthropometric measurements were converted to Z score using the following equation:

$$\text{Z score} = \frac{\textit{individual anthropometric value} - \textit{mean anthropometric value}}{\textit{standard deviation}}$$

As no significant interaction between the anthropometric indicators and sex ($p < 0.05$) was observed, multiple regression analysis results were presented for the whole sample. Logistic regression analysis was used to evaluate the association between arterial hypertension, diabetes mellitus and transformed anthropometric indices (Z score), with estimated odds ratio (OR) and respective 95% confidence intervals (95%CI). To evaluate the association between the anthropometric indicators and the outcomes of interest, the following models were constructed:

Model 1: unadjusted model.

Model 2: evaluates the separate association of each anthropometric indicator adjusted by confounding factors.

Model 3: evaluates the association of each abdominal adiposity indicator adjusted by BMI (continuous) and confounding factors.

Model 4: evaluates the association of BMI adjusted by ABSI (continuous) and confounding factors.

Analyses were performed using Stata software version 13.0 (https://www.stata.com), incorporating the effect of the sample design and individual probability weights.

Results

A total of 10,537 individuals participated in this study (66.7% women), with a mean age of 69.8 years (95%CI: 69.5-70.1 years). Considering the total study population, the prevalence of arterial hypertension was 52.3% (95%CI: 50.5-54.1), 55.8% among women and 47.6% among men ($p < 0.001$). The prevalence of diabetes mellitus was 19% (95%CI: 17.9-20.4) in the total population and 20.4% among women and 17.3% among men ($p = 0.047$). Men had a higher proportion of smokers, former smokers and alcohol consumption than women. Regarding anthropometric indices, the mean values of ABSI and WC were higher among men ($0.0859m^{11/6}kg^{-2/3}$ and 97.7cm, respectively), while women had higher mean BMI and WHtR ($27.5kg/m^2$ and 0.61, respectively). The other variables showed no significant difference between sexes.

Table 1 shows the characteristics of the sample according to reports of arterial hypertension and diabetes mellitus. Older adults who reported arterial hypertension and diabetes mellitus had similar characteristics: they were older, mostly women, had lower education, higher proportion of former smoker and lower proportion of current smoker and alcohol consumption, except for diabetics who had a higher proportion of physical inactivity compared to non-diabetics.

Table 2 presents the mean values (and standard deviations) of the anthropometric indices according to the diagnosis of arterial hypertension and diabetes mellitus. It was verified that the diseases studied were associated with higher values of all anthropometric indicators considered in the study.

Table 1

Sociodemographic characteristics and health behaviors among Brazilian older adults, according to reports of arterial hypertension and diabetes mellitus. *Brazilian National Health Survey*, 2013.

Variables	Hypertension			Diabetes		
	No	Yes	p-value	No	Yes	p-value
Age, mean (SD)	69.2 (8.2)	70.4 (7.9)	< 0.001	69.7 (8.2)	70.3 (7.4)	0.049
Sex			< 0.001			0.047
Male	46.9	38.8		43.6	38.7	
Female	53.1	61.2		56.4	61.3	
Skin color			0.291			0.384
White	55.7	53.9		54.9	53.9	
Non-white	44.3	46.1		45.1	46.1	
Education			< 0.001			0.002
Higher education	12.4	9.1		11.4	7.6	
High school	14.4	11.0		13.0	11.0	
Without education/Basic education	73.2	79.9		75.6	81.4	
Smoking			< 0.001			< 0.001
Never smoked	57.0	57.1		57.0	57.0	
Ex-smoker	28.8	33.1		30.1	35.2	
Current smoker	14.2	9.8		12.9	7.8	
Alcohol consumption (doses per week)			< 0.001			< 0.001
No consumption	83.2	88.5		84.7	91.3	
Moderate	11.0	8.1		10.4	5.4	
At-risk	5.8	3.4		4.9	3.3	
Physical activity in leisure time			0.274			0.021
Active	14.8	13.5		14.8	11.3	
Non-active	85.2	86.5		85.2	88.7	

SD: standard deviation.

Note: values expressed as percentage, unless otherwise specified. p-value: Rao-Scott test or Wald test.

Table 2

Anthropometric indices among Brazilian older adults, according to report of arterial hypertension and diabetes mellitus. *Brazilian National Health Survey*, 2013.

Indices	Hypertension			Diabetes		
	No	Yes	p-value	No	Yes	p-value
ABSI	0.084 (0.007)	0.086 (0.007)	< 0.001	0.085 (0.007)	0.086 (0.007)	< 0.001
BMI	26.07 (4.68)	27.81 (5.18)	< 0.001	26.69 (5.00)	28.19 (5.00)	< 0.001
WC	93.43 (12.58)	98.36 (12.62)	< 0.001	95.11 (12.85)	99.82 (12.13)	< 0.001
WHtR	0.58 (0.08)	0.62 (0.08)	< 0.001	0.60 (0.08)	0.63 (0.08)	< 0.001

ABSI: a body shape index ($m^{11/6}kg^{-2/3}$); BMI: body mass index (kg/m^2); WC: waist circumference (cm); WHtR: waist-to-height ratio.
Notes: values expressed as mean (standard deviation). p-value: F-test (linear regression).

Table 3 presents OR estimates and 95%CI for the association between arterial hypertension, diabetes mellitus and the anthropometric indicators for the unadjusted model and the model adjusted for potential confounding factors. All indices were associated with reports of hypertension and diabetes mellitus among older adults. For both hypertension and diabetes, ABSI had a weaker association with the analyzed outcomes when compared to WC and WHtR, after adjusting for confounding factors (model 2). Adding BMI as an adjustment variable in the ABSI, WC and WHtR models showed an increase in the strength of association only for the ABSI model (model 3). Regarding BMI, the addition of ABSI as an adjustment variable in the model already containing the confounding variables included in the study increased the magnitude of association for hypertension and diabetes (model 4). However, the overlap in confidence intervals should be considered, showing that none of the indicators had superior performance in the association with the outcomes evaluated, when adjusted by other indicators.

Discussion

The results of this study showed significant association between the report of arterial hypertension and diabetes mellitus with higher values of BMI, WC and WHtR in the older Brazilian population in separate analyses when compared to ABSI. When adjusted for BMI, ABSI showed a greater strength of association with the outcomes, but it was not superior to the performance of WC and WHtR in models 2 and 3. It is worth mentioning that this is the first study to evaluate the performance of ABSI, a recently proposed index, in the Brazilian population of older adults, compared to the indices commonly used in the literature.

The use of anthropometric measurements has been useful in public health and in the clinical management of problems related to overweight, mainly because it requires no technological sophistication, uses low-cost tools and is associated with cardiovascular and metabolic outcomes. These advantages also allow the use of these indices in population studies, which involve large-scale evaluations [25]. ABSI is a recently proposed index based on WC, independent of BMI, which can better evaluate the relative contribution of WC to abdominal obesity and clinical outcomes [26], which makes it potentially useful in the evaluation of populations at risk for cardiometabolic diseases, generating a growing international interest in its performance.

The results of our study are in line with those observed in studies of different populations. Studies conducted in adult rural populations in China [27] and adults and older people in Indonesia [28] showed that ABSI presented a weak association with arterial hypertension when compared to other anthropometric indices. Similarly, in a longitudinal study with Iranians, WHtR and WC were superior in identifying risk of arterial hypertension compared to ABSI [13]. Among Japanese adults, a retrospective cohort study found that compared to WC, ABSI was not a better predictor of diabetes mellitus, hypertension, and dyslipidemia [29].

Table 3

Association between anthropometric indices and report of arterial hypertension and diabetes mellitus among Brazilian older adults. *Brazilian National Health Survey*, 2013.

Indices (Z-score)	Odds ratio (95%CI)			
	Model 1	Model 2	Model 3	Model 4
Hypertension				
ABSI	1.19 (1.10-1.27)	1.17 (1.10-1.27)	1.30 (1.21-1.40)	-
WC	1.45 (1.40-1.61)	1.57 (1.46-1.69)	1.47 (1.31-1.64)	-
WHtR	1.50 (1.40-1.61)	1.58 (1.47-1.70)	1.48 (1.32-1.65)	-
BMI	1.43 (1.34-1.54)	1.42 (1.36-1.58)	-	1.55 (1.44-1.67)
Diabetes				
ABSI	1.18 (1.09-1.28)	1.17 (1.09-1.28)	1.29 (1.18-1.41)	-
WC	1.46 (1.34-1.59)	1.48 (1.36-1.62)	1.50 (1.32-1.72)	-
WHtR	1.51 (1.39-1.65)	1.47 (1.35-1.61)	1.48 (1.30-1.68)	-
BMI	1.33 (1.23-1.44)	1.33 (1.23-1.44)	-	1.41 (1.30-1.54)

95%CI: 95% confidence intervals; ABSI: a body shape index ($m^{11/6}kg^{-2/3}$); BMI: body mass index (kg/m^2), WC: waist circumference (cm); WHtR: waist-to-height ratio.
Model 1: non-adjusted; Model 2: adjusted for age (continuous), sex, skin color, education, smoking, alcohol consumption and physical exercise in leisure time; Model 3: adjusted for BMI (continuous), age (continuous), sex, skin color, education, smoking, alcohol consumption and physical exercise in leisure time; Model 4: adjusted for ABSI (continuous), age (continuous), sex, skin color, education, smoking, alcohol consumption and physical exercise in leisure time.

In China, ABSI was associated with a higher risk of diabetes mellitus, but WC had a better discriminatory power than BMI and ABSI [30]. Additionally, in a study conducted in 14 European countries, BMI and ABSI were weaker discriminators than other anthropometric measures to predict cardiovascular disease mortality among European adults and older people [31]. Our results corroborate these studies, also showing a weak association of ABSI with arterial hypertension and diabetes mellitus in a highly mixed population of Latin American older adults, in comparison WC and WHtR, even when adjusted for BMI. ABSI was proposed as an alternative measure to WC and complementary to BMI, allowing the separate contribution of BMI and adjusted WC to diseases to be determined [26]. However, after adjusting for ABSI, BMI (model 4) did not appear to have a higher association with the outcomes evaluated when compared to the results from the models containing only WC and WHtR and confounding factors (model 2), or the models adjusted by BMI and confounding factors (model 3).

The possible explanations for the weaker association between the diagnoses of arterial hypertension and diabetes mellitus and ABSI in comparison to the other indices have not been clearly established. However, as suggested by other studies [28,29,32], possible reasons for these results are related to ethnic and sex differences, which influence the evaluation of body composition in different populations [33]. Thus, it can be assumed that the regression coefficients for ABSI can be specific to each population group, not having the same performance in other populations. In this sense, Krakauer & Krakauer [14] verified that ABSI was strongly correlated with age and sex, which was confirmed by later studies. Confirming this result, among Chinese adolescents the appropriate exponents to standardize WC in relation to BMI and height, in the ABSI calculation, were different from those proposed in the original formula (0.45 and 0.55, respectively) [34]. In an adult and older Indonesian population, the exponents for the men were similar to those reported for the American population [14], but for the women these exponents were lower, suggesting that appropriate exponents should be modified, for example, according to sex. However, even using this adaptation, ABSI calculated with these new exponents did not show a greater association with hypertension, when compared to BMI, WHtR and WC [28], similar to what was observed in the example of our study.

The results of our study on the association of the chronic conditions evaluated with WC and WHtR measurements, even when adjusted for BMI, are consistent with that observed in other populations, which tend to present associations of greater magnitude, in comparison to BMI and ABSI. Previous studies have shown that these measurements were superior to BMI because they had a higher correlation with intra-abdominal fat, as well as better risk indicators for mortality, cardiometabolic risk factors and cardiovascular diseases, including arterial hypertension and diabetes mellitus [1,35,36,37,38,39,40]. These results are further corroborated by the evidence that, even though they were classified as having a normal BMI, adult individuals from a cohort of European and Chinese origin with a higher WC had increased risk of cardiovascular disease and premature death [41]. These results seem to demonstrate that the new index does not overcome the limitation observed for WC, regarding the non-inclusion of the individual's height in the estimate. Thus, it is not shown as an adequate predictor of fat concentration in the abdominal region, at least in terms of the association with arterial hypertension and diabetes mellitus.

Among the limitations of this study, its cross-sectional nature should be emphasized because it does not allow the establishment of a temporal relationship between variables, which may have led to skewed interpretations, especially in cases where the existence of chronic conditions may have altered lifestyle habits and, consequently, the body composition of older adults. Another aspect that should be highlighted is the use of self-reported information for chronic conditions, which may have introduced information bias in the study, although previous research has already demonstrated the validity of this method [42,43,44,45]. In addition, the comparability of our results with other studies should consider that only the population of older adults was included, with a higher prevalence of the investigated chronic diseases, while the majority of studies conducted to date included the adult population. Another aspect to be considered is that WC measurements in this study were made at the midpoint between the last rib and the iliac crest, which was different from Krakauer & Krakauer [14], who measured WC immediately above the iliac crest. However, the association of WC with health outcomes seems to be independent of the measurement protocol [46], although these differences may still influence the results in some way.

However, even considering these limitations, it should be noted that this analysis was conducted in a large national sample, using standardized procedures for data collection, ensuring its internal validity [47]. This analysis demonstrated ABSI performance, widely discussed in the literature, in a highly mixed population of older adults, contributing to the knowledge of its association with important chronic conditions known to be related to abdominal fat concentration.

Conclusions

In summary, this study quantified, for the first time, the magnitude of the association between the report of arterial hypertension and diabetes mellitus with four different anthropometric indices among Brazilian older adults, including a recently proposed index. Considering the lower strength of association between the new index (ABSI) and the chronic conditions assessed, even after adjustment for BMI and confounding factors, WC and WHtR probably remain as useful indices in public health, at least in relation to arterial hypertension and diabetes mellitus in Brazilian older adults. Additionally, BMI was associated with these conditions, when analyzed alone or adjusted by ABSI, and remains as an index that could be used in the context of these diseases, despite its known limitations.

Contributors

M. A. Nascimento-Souza contributed in the study conception, data analysis and interpretation, and writing of the article. M. F. Lima-Costa and S. V. Peixoto contributed in the data analysis and interpretation and revision of the manuscript

Additional informations

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Resumo

*O estudo teve como objetivo avaliar a associação isolada e conjunta dos indicadores de adiposidade abdominal (*a body shape index *– ABSI, circunferência da cintura – CC, razão cintura-estatura – RCE) e índice de massa corporal (IMC) com a hipertensão arterial e o diabetes mellitus em idosos brasileiros. Foram usados dados da* Pesquisa Nacional de Saúde *(PNS 2013) para a população com 60 anos ou mais (10.537 idosos). A hipertensão arterial e o diabetes mellitus foram auto-relatados, e os seguintes índices antropométricos foram avaliados através da aferição direta: índice de formato corporal ABSI, IMC, CC e RCE. As associações foram avaliadas por regressão logística, com ajustes para fatores de confusão. Os resultados do estudo evidenciaram uma associação mais forte entre o relato de hipertensão arterial e diabetes mellitus em análises separadas com IMC, CC e RCE na população idosa brasileira, quando comparado ao ABSI. Quando ajustado para IMC, o ABSI mostrou uma associação mais forte com os desfechos, mas não foi superior ao desempenho da CC ou da RCE. Considerando a associação mais fraca nas análises separadas e conjuntas entre o novo índice (ABSI) e as doenças crônicas avaliadas, o IMC, CC e RCE ainda são índices úteis na saúde pública, pelo menos em relação à hipertensão arterial e ao diabetes mellitus em idosos brasileiros.*

Envelhecimento; Antropometria; Diabetes Mellitus; Hipertensão; Obesidade

Resumen

*El objetivo de este estudio fue evaluar la asociación independiente y conjunta de los indicadores de adiposidad abdominal (*a body shape index *– ABSI, circunferencia de cintura – CC, proporción cintura-altura – ICA) y el índice de masa corporal (IMC) con la hipertensión arterial y la diabetes mellitus, en ancianos brasileños. Los datos procedieron de la* Encuesta Nacional de Salud *de 2013 (PNS 2013) pertenecientes a una población con 60 años o más (10.537 ancianos). Los resultados de hipertensión arterial y diabetes mellitus fueron autoinformados y se evaluaron los siguientes índices antropométricos mediante medición directa: ABSI, IMC, CC y ICA. Las asociaciones se evaluaron mediante regresión logística, con ajustes por factores de confusión. Los resultados del presente estudio evidenciaron una fuerza de asociación más alta entre el reporte de hipertensión arterial y la diabetes mellitus con el IMC, CC e ICA en la población anciana brasileña en los análisis por separado, cuando se compararon con el ABSI. Cuando se ajustó al IMC, el ABSI mostró una fortaleza mayor de asociación con los resultados, pero no fue superior al desempeño de la CC e ICA. Considerando una fortaleza de asociación más baja, en los análisis por separado y conjuntos, entre el nuevo índice (ABSI) y las condiciones crónicas de salud evaluadas, IMC, CC e ICA probablemente siguen siendo índices útiles en salud pública, al menos en relación con la hipertensión arterial y la diabetes mellitus en ancianos brasileños.*

Envejecimiento; Antropometría; Diabetes Mellitus; Hipertensión; Obesidad

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