Nutrición Hospitalaria

Trabajo Original

Is relative fat mass a better indicator of high blood pressure levels when compared to other anthropometric indexes?

¿Es la masa grasa relativa un mejor indicador de los niveles de presión arterial alta en comparación con otros índices antropométricos?

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Abstract

Background: relative fat mass (RFM) has been proposed recently, and the effectiveness in relation to other anthropometric indexes already consolidated regarding the predictive capacity of high blood pressure levels (HBPL) has not been investigated yet.

Objectives: the objective was to analyze the predictive capacity of RFM for HBPL, and to compare it with others indexes.

Methods: a cross-sectional study was conducted with 896 individuals. Weight, height, hip, waist circumference (WC), and neck circumference measurements were evaluated, and RFM, body mass index (BMI), body adiposity index, waist/hip ratio, and waist/height ratio were calculated. Systolic (SBP) and diastolic (DBP) blood pressures were measured on one occasion. Descriptive statistics, Pearson's correlation, a logistic regression model, and the analysis of the receiver operating characteristic (ROC) curves were used.

Results: HBPL proportion was higher in men (34.68 %, p < 0.01). There was a positive correlation (p < 0.01) between all anthropometric measurements and SBP and DBP. WC in males (OR, 3.66; p < 0.01) and BMI in females (OR, 5.06; p < 0.01) showed the greatest associations with HBPL. There was no statistical difference (p > 0.05) in the area under the curve.

Conclusions: the findings of our study suggest that RFM is not the best index for predicting HBPL, although it has shown positive associations.

Keywords:

Hypertension. Adiposity. Anthropometric indicators.

Resumen

Introducción: se ha propuesto recientemente la medida de la masa grasa relativa (RFM) como predictor de la hipertensión arterial (HBPL), aunque su valor predictivo y la comparación con otros índices antropométricos está por evaluar.

Objetivos: el objetivo fue analizar la capacidad predictiva de la RFM para el HBPL y compararlo con otros índices.

Métodos: se realizó un estudio transversal con 896 individuos. Se evaluaron las medidas de peso, talla, cadera, circunferencia de la cadera (CC) y circunferencia del cuello, y se calcularon la RFM, el índice de masa corporal (IMC), el índice de adiposidad corporal, la relación cintura/cadera y la relación cintura/estatura. En una ocasión se midió la presión arterial sistólica (PAS) y diastólica (PAD); se utilizaron la estadística descriptiva, la correlación de Pearson, un modelo de regresión logística y el análisis de las curvas *Receiver Operating Characteristic* (ROC).

Resultados: la proporción de HBPL fue mayor en los hombres (34,68 %; p < 0,01). Hubo una correlación positiva (p < 0.01) entre todas las medidas antropométricas y PAS y PAD. La CC en los hombres (OR: 3,66; p < 0,01) y el IMC en las mujeres (OR: 5,06; p < 0,01) mostraron las mayores asociaciones con los HBPL. No hubo diferencia estadística (p > 0.05) en el área bajo la curva.

Conclusiones: los hallazgos de nuestro estudio sugieren que la RFM no es el mejor índice para predecir el HBPL, aunque ha mostrado asociaciones positivas.

Palabras clave:

Hipertensión. Adiposidad. Indicadores antropométricos.

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INTRODUCTION

Systemic arterial hypertension (SAH) has a high worldwide prevalence (1). In Brazil, a study conducted with adults in Brazilian capitals reported SAH in 24.50 % in 2019 (2). There is evidence in the literature that SAH prevention, as well as diabetes, considerably reduces the risk of developing cardiovascular diseases (CVD) (3). Thus, a simple and low-cost method, such as anthropometric measurements and indices, could be used as an important cost-effective strategy for screening SAH in primary care.

As obesity plays an important role in the etiology of SAH, the use of body adiposity indicators can assist in its identification in individuals with excess body adiposity (4). Among the various measures described in the literature, body mass index (BMI) and waist circumference (WC) are well documented as SAH indicators (5,6). Nevertheless, some limitations must be considered regarding the use of these measures, such as the inability of BMI to discriminate body composition differences taking into account sex and ethnicity (7), since body adiposity degree may not be the same in different individuals (8), and the fact that WC does not consider height, since there is evidence of an inverse association between height and health risk (9).

Other indicators have been used to verify the predictive capacity of SAH compared to BMI and WC (4,10-13), such as the waist-to-height ratio (WHtR) (4,11), waist-to-hip ratio (WHR) (4,11), body adiposity index (BAI) (11,14), and neck circumference (NC) (12), among others. Despite the wide use of these indicators, some limitations should be highlighted: for example, the fact that WHR has specific cutoff points for different ethnic groups and sex (15). On the other hand, a meta-analysis published in 2012 (10) showed that WHtR is better for the identification of cardiometabolic risks when compared to BMI and WC, despite being questioned for having a single cutoff point to classify different groups (16).

Due to the limitations presented by body adiposity indicators, new indexes have been proposed seeking to identify a simple and easy-to-use equation for clinical and epidemiological purposes. In this sense, a new equation has been recently proposed to assess body fat, namely Relative Fat Mass (RFM) (17). This equation was based on the height/waist ratio, creating a linear equation as a way to estimate fat percentage in adult individuals of both sexes. The validation of RFM was performed for the American population and did not involve its relationship with cardiovascular diseases, which reinforces the need to verify the response of this indicator in other populations, and its predictive capacity in comparison to other indicators of body adiposity for SAH.

Thus, the need to verify the response of new body adiposity indicators is justified, as well as the need to compare their effectiveness in relation to indicators already consolidated in the literature. According to the World Health Organization (18) there is a constant need to monitor risk factors for chronic non-communicable diseases, especially those that have a greater impact on morbidity and mortality from chronic diseases worldwide, and that can be modified in primary health care. Therefore, the aim of this study was to analyze the predictive capacity of the new body adiposity index, RFM, for high blood pressure levels and to compare it with indicators already consolidated in the literature such as BMI, BAI, WC, NC, WHR and WHtR.

METHODS

STUDY POPULATION

This is a cross-sectional study based on the "Cardiovascular Risk Factors In University Students" study, developed in a private higher education institution. All students regularly enrolled in the institution in 2017 and the first semester of 2018 were eligible.

The sample size was calculated using the Epi-Info software, considering: reference population of 1,800 college students; estimated prevalence of 24.50 % (2), expected sampling error of 3.50 %; effect of study design estimated at 1.6, to which was added 10 % relating to losses or refusals and 10 % for the control of confounding factors, yielding a final sample of 845 individuals. The final data included 896 subjects in the age group of 18-40 years.

MEASUREMENTS

Assessment of blood pressure

Blood pressure was measured on a single occasion with two measurements, with a 10-minute interval between measurements, with the individual sitting for at least 5 minutes and according to Brazilian recommendations (19). When the difference between the first and second measurements showed values greater than 10 mmHg, a third measurement was performed and the average of the two closest values was recorded. An automatic wrist sphygmomanometer (Omron HEM 629), duly calibrated, was used. Values obtained after the two measurements were summed up and the average of the readings was recorded. Individuals with systolic blood pressure (SBP) greater than 140 mmHg and/or diastolic blood pressure (DBP) greater than 90 mmHg or known to be hypertensive were classified as having high blood pressure levels (1,19).

Anthropometric data

To evaluate height, a metal stadiometer (Welmy®, in-wall, Santa Bárbara D'Oeste, SP, Brazil), with an accuracy of 1 cm was used. Body mass was obtained using a TANITA digital scale (model Iron Man BC-554®) with a capacity of 200 kg and an accuracy of 100 g. Subjects were wearing as little clothing as possible, barefoot, and had no metal objects on, according to the procedures described by the manufacturer. WC was measured with an inelastic measuring tape (Sanny®, São Paulo, SP, Brazil) with an accuracy of 0.1 mm, at the midpoint between the last rib and the iliac crest. The cutoff points proposed by the World Health Organization (18) for WC were adopted. To perform these measurements the subject was asked to be barefoot, with arms along the body and head in the horizontal plane of Frankfurt.

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NC was measured immediately below the laryngeal prominence, using cutoff points proposed for the Brazilian population (20). Hip circumference was measured at the level of the maximum posterior extension of the gluteus in a horizontal plane. Circumference measures were taken with subjects in orthostatic position using a Sanny® inelastic measuring tape (São Paulo, SP, Brazil) with 0.1-cm accuracy.

RFM was calculated based on height and waist circumference using the following equation (17):

$$RFM = 64 - (20 \times [height\ in\ meters\ /\ waist\ in\ meters]) + (12 \times sex)$$

Where: male sex = 0; female sex = 1.

After anthropometric measurements, BMI (body mass/height^2) (18), BAI (hip circumference / height x √height - 18) (21,22), WHR (18) and WHtR (23) were calculated. BMI was classified according to the WHO scoring system (18). Percentage body fat values estimated by BAI and RFM above 25 % for men and 35 % for women were considered as excess body adiposity (24). For WHR, cutoff points of 0.85 for women and 0.90 for men (18) were adopted, while for WHtR a cutoff point of 0.50 was used for both sexes (23).

DATA COLLECTION AND ETHICAL PROCEDURES

Data collection took place in a private room and all evaluators were trained to perform measurements. Participants were informed about the data collection procedures and study objectives, and signed an informed consent form. The project was approved by the Ethics Committee for Research with Humans of the Federal University of Viçosa (58964616.4.0000.5153).

STATISTICAL ANALYSIS

Descriptive statistics were used to characterize data, and counts and proportions were used for categorical variables. Due to the differences between sexes described in the literature, analyses were performed with stratification by sex. Differences in proportions were identified using the Chi-square test. Pearson's correlation between anthropometric indexes and SBP and DBP were calculated to identify relationships between variables. A logistic regression model was used to verify the association between high blood pressure levels and anthropometric variables. Receiver-operating characteristic (ROC) curve analysis was adopted for each adiposity index to assess the ability to correctly discriminate high blood pressure levels. The significance level adopted was 5 % (p < 0.05). Data were entered twice and analyzed using the Stata 13.1 software.

RESULTS

This study involved 896 individuals, 421 men (46.99 %) and 475 women (53.01 %) with a mean age of 22.16 years (SD, 4.01).

The proportion of high blood pressure levels was 21.32 %, this being significantly higher in men (34.68 %, p < 0.01). Table I describes the proportion of individuals with increased values. Compared to women, men had a higher proportion of increased BMI (p < 0.01), BAI (p < 0.01), WHtR (p = 0.03), SBP (p < 0.01) and DBP (p < 0.01), while women had a higher proportion of increased RFM (p < 0.01) and WC (p < 0.01).

Bivariate correlation coefficients between anthropometric variables and SBP and DBP were analyzed. Pearson's correlation coefficients revealed positive and significant associations (p < 0.01) between anthropometric measurements and SBP and DBP (Table II). Table II shows the correlation matrixes stratified by sex. In males and in females, correlations between RFM and SBP and RFM and DBP were higher only among those observed between BAI and SBP, BAI and DBP, WHR and SBP, and WHR and DBP (p < 0.01 for all).

In males, all anthropometric parameters were associated with high blood pressure levels, with WC showing a greater association in the unadjusted analysis (OR, 3.66; 95 % CI, 2.29 to 5.83). After controlling for age, it was observed that all parameters remained positively associated (Table III), with WC remaining as the indicator with the greatest strength (OR, 3.66; 95 % CI, 2.28 to 5.08). In females (Table III), BMI was the indicator that showed the greatest association with high blood pressure levels (OR, 5.08; 95 % CI, 2.69 to 9.61). Although it lost strength in the association after adjustment for age, BMI was still the marker with the highest association for high blood pressure levels (OR, 5.06; 95 % CI, 2.67 to 9.59).

The use of the ROC curve to assess areas under the curve (AUC) and 95 % confidence intervals in the prediction of high blood pressure levels is shown in table IV. Although BMI showed an area under the upper curve in males (0.69; 95 % CI, 0.63 to 0.74), in females BMI (0.75; 95 % CI, 0.67 to 0.82) showed an area under the curve similar to NC (0.75; 95 % CI, 0.67 to 0.82); this was not statistically different from all other anthropometric indicators.

DISCUSSION

Some studies with Brazilian adults aimed to verify the predictive capacity of anthropometric indicators for predicting SAH (4,11,13), but this study included in its analysis the recent RFM index and compared its predictive capacity with other indicators already used in clinical practice in young Brazilian adults. RFM is one of the most recently proposed indicators and has been compared to more than 250 anthropometric measurements (17) to verify its ability to estimate fat percentage. Recently, a study conducted in a Chinese population (25) verified the predictive capacity of RFM when compared to other indicators to predict incident SAH, and RFM proved to be an indicator capable of predicting incident SAH, although it did not replace indicators such as BMI, WC, and WHtR, results that are similar to those observed in our study. In general, in our study, all indicators were associated with high blood pressure levels in both sexes, with WC in males (OR, 3.66; 95 % CI, 2.28 to 5.08) and BMI in females (OR, 5.06;

Table I. Description of anthropometric indexes and systolic and diastolic blood pressure in university students, according to sex. Brazil, 2017/2018 (n = 896)

Anthropometric indicators	Men (n = 421)		Women (n = 475)		p-value
	n	%	n	%	
RFM					
Normal	302	71.73	304	50.17	0.01
Increased	119	28.27	171	36.00	
BMI					
Normal	254	60,33	350	73.68	< 0.01
Overweight	167	39.67	125	26.32	
BAI					
Normal	237	56.29	422	88.84	< 0.01
Increased	184	43.71	53	11.16	
WC					
Normal	321	76,25	297	62.53	< 0.01
Increased	100	23.75	178	37.47	
NC					
Normal	292	69.36	347	73.05	0.22
Increased	129	30.64	128	26.95	
WHR					
Normal	346	82.19	421	54.89	< 0.01
Increased	75	17.81	54	11.37	
WHtR					
Normal	266	63.18	332	69.89	0.03
Increased	155	36.82	143	30.11	
SBP					
Normal	300	71.26	458	96.42	< 0.01
Increased	121	28.74	17	3.58	
DBP					
Normal	364	86.46	448	94.32	< 0.01
Increased	57	13.54	27	5.68	

RFM: relative fat mass; BMI: body mass index; BAI: body adiposity index; WC: waist circumference; NC: neck circumference; WHR: waist-to-hip ratio; WHtR: waist-to-height ratio; SBP: systolic blood pressure; DBP: diastolic blood pressure. p-value obtained from the Chi-squared test.

Table II. Correlation matrix between the anthropometric indexes and systolic and diastolic blood pressure in university students, according to sex. Brazil, 2017/2018 (n = 896)

	Men (n = 421)								
	RFM	BMI	BAI	WC	NC	WHR	WHtR	SBP	DBP
RFM	1								
BMI	0.90*	1							
BAI	0.84*	0.84*	1						
WC	0.94*	0.91*	0.72*	1					
NC	0.64*	0.75*	0.48*	0.71*	1				
WHR	0.79*	0.61*	0.38*	0.80*	0.52*	1			
WHtR	0.98*	0.92*	0.84*	0.96*	0.65*	0.80*	1		
SBP	0.23*	0.32*	0.17*	0.29*	0.32*	0.17*	0.24*	1	
DBP	0.23*	0.27*	0.19*	0.27*	0.29*	0.19*	0.25*	0.63*	1
	Women (n = 475)								
	RFM	BMI	BAI	WC	NC	WHR	WHtR	SBP	DBP
RFM	1								
BMI	0.88*	1							
BAI	0.80*	0.86*	1						
WC	0.94*	0.88*	0.70*	1					
NC	0.61*	0.67*	0.43*	0.68*	1				
WHR	0.69*	0.41*	0.16*	0.68*	0.44*	1			
WHtR	0.98*	0.89*	0.81*	0.96*	0.62*	0.69*	1		
SBP	0.38*	0.44*	0.34*	0.39*	0.41*	0.18*	0.38*	1	
DBP	0.22*	0.27*	0.21*	0.23*	0.24*	0.12*	0.23*	0.71*	1

*RFM: relative fat mass; BMI: body mass index; BAI: body adiposity index; WC: waist circumference; NC: neck circumference; WHR: waist-to-hip ratio; WHtR: waist-to-height ratio; SBP: systolic blood pressure; DBP: diastolic blood pressure. *p-value < 0.01, obtained from Pearson's correlation test.*

4 95 % CI, 2.67 to 9.59) being those with the highest association strength.

In our study, using a sample of university students, RFM was not the best indicator of high blood pressure levels. Although RFM had a high and significant OR in men (OR, 2.44; p < 0.01) and in women (OR, 3.67; p < 0.01), it was only higher than the association found for BAI (OR, 1.88; p < 0.01 and OR, 3.43; p < 0.01, respectively) and WHR (OR, 2.42; p < 0.01 and 2.88; p < 0.01, respectively) with high blood pressure levels. Although RFM is easy to apply, it involves a greater number of mathematical calculations when compared to other indicators, which can be a limiting factor for its use. In addition, WC measurement, used in the calculation of RFM, involves professional training and

is scarcely used in clinical practice (26), which, in addition to the low association with high blood pressure levels, limits the use of RFM in relation to other indicators.

As already mentioned, RFM was recently proposed, so its consistency as a body adiposity indicator and its possible association with cardiometabolic risks indicators need further investigations. Among the few studies found, RFM was not able to overcome WC and WHR in predicting the risk of general mortality in a population-based cohort, and the authors highlighted that RFM can be a good tool to estimate body adiposity percentage, not being better than methods already established in the literature (27). In another study conducted in a Korean population to validate the diagnostic capacity of RFM as an indicator of body adiposity percentage,

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Table III. Logistic regression, unadjusted and adjusted for high blood pressure levels with anthropometric indexes in university students, according to sex. Brazil, 2017/2018 (n = 896)

	Unadjusted OR (95 % CI)	p-value	Model 1* OR (95 % CI)	p-value
Men (n = 421)				
RFM	2.43 (1.57-3.76)	< 0.01	2.44 (1.56-3.83)	< 0.01
BMI	3.30 (2.16-4.78)	< 0.01	3.34 (2.17-5.13)	< 0.01
BAI	1.91 (1.27-2.87)	< 0.01	1.88 (1.25-2.84)	0.03
WC	3.66 (2.29-5.83)	< 0.01	3.66 (2.28-5.08)	< 0.01
NC	2.69 (1.72-4.06)	< 0.01	2.64 (1.71-4.08)	< 0.01
WHR	2.42 (1.46-4.02)	< 0.01	2.42 (1.43-4.08)	< 0.01
WHtR	2.46 (1.62-3.73)	< 0.01	2.55 (1.64-3.94)	< 0.01
Women (n = 475)				
RFM	3.68 (1.93-5.99)	< 0.01	3.67 (1.92-7.00)	< 0.01
BMI	5.08 (2.69-9.61)	< 0.01	5.06 (2.67-9.59)	< 0.01
BAI	3.45 (1.65-7.19)	< 0.01	3.43 (1.65-7.17)	< 0.01
WC	4.78 (2.43-9.40)	< 0.01	4.82 (2.44-9.50)	< 0.01
NC	4.89 (2.58-9.24)	< 0.01	4.87 (2.58-9.21)	< 0.01
WHR	2.91 (1.38-6.12)	< 0.01	2.88 (1.35-6.15)	< 0.01
WHtR	4.51 (2.38-8.55)	< 0.01	4.50 (2.36-8.53)	< 0.01

AUC: area under the ROC curve; SE: standard error; CI: confidence interval; RFM: relative fat mass; BMI: body mass index; BAI: body adiposity index; WC: waist circumference; NC: neck circumference; WHR: waist-to-hip ratio; WHtR: waist-to-height ratio. *Adjusted for age.

Table IV. Area-under-the-curve analysis of high blood pressure levels and anthropometric indexes in university students, Brazil, 2017-2018 (n = 896)

	Men (n = 421)			Women (n = 475)		
	AUC	SE	(95 % CI)	AUC	SE	(95 % CI)
RFM	0.64	0.03	0.58-0.70	0.71	0.04	0.62-0.80
BMI	0.69	0.03	0.63-0.74	0.75	0.04	0.67-0.82
BAI	0.61	0.03	0.56-0.67	0.69	0.04	0.62-0.78
WC	0.66	0.03	0.60-0.71	0.73	0.04	0.64-0.81
NC	0.67	0.03	0.62-0.72	0.75	0.05	0.67-0.82
WHR	0.59	0.03	0.53-0.65	0.62	0.04	0.52-0.72
WHtR	0.64	0.03	0.58-0.70	0.71	0.1	0.62-0.80

AUC: area under the ROC curve; SE: standard error; CI: confidence interval; RFM: relative fat mass; BMI: body mass index; BAI: body adiposity index; WC: waist circumference; NC: neck circumference; WHR: waist-to-hip ratio; WHtR: waist-to-height ratio.

it was observed that the accuracy of this index is comparable to BMI, but RFM presented an incorrect classification rate lower than BMI for women (26). These data, as well as the results of our study, indicate that RFM seems to be able to estimate body adiposity percentage and, consequently, its association with CVD, but it does not seem to be better than other already consolidated indicators.

Regarding the best indicator for estimating high blood pressure levels, divergences in results require further studies involving new indexes such as RFM. For example, in a follow-up study (2.8 years) with the Korean population, it was observed that the increase in the baseline WHtR value was positively associated with the development of SAH (28). In a study with primary data from a cohort of adults from South Asia, it was found that WC and WHtR were the best indicators to identify adults with prevalent SAH (29). In male employees of a hospital in Argentina, BMI showed a greater predictive capacity for SAH when compared to WC and WHtR (30). In a large sample of Peruvian adults, WC was the best indicator of body adiposity to estimate high blood pressure in males (31). These variations in anthropometric indicators capable of predicting SAH can be attributed to the distinct characteristics of each population regarding sample selection and size, cutoff points, and body adiposity assessment (32). In our study, WC and BMI were, as the indicators with the highest association with high blood pressure levels, consistent with other studies. However, it is important to highlight that, in females, the strength of the association and the area under the NC curve was superior to those of the other indicators.

Some studies with Brazilian adults have been conducted to analyze the capacity of anthropometric indicators to predict blood pressure. In adults in the city of Vitória, state of Espírito Santo, Brazil, it was found that WHtR was the best applicable obesity index to identify hypertension (33). In another study with Brazilians residing in the Federal District, the conicity index, WHR and WHtR had a greater relationship with hypertension when compared to BMI in men, while in the female gender WHR and WHtR showed better results, although, after adjustment, no measure remained associated with high blood pressure values in women (11). In our analyses, all anthropometric indicators were associated with high blood pressure levels; however, WC in men and BMI in women showed better associations. Taking into account the simplicity of application and their low cost, these indicators seem to be a good alternative to identify high blood pressure levels.

In another study conducted with Brazilian adults to verify which indicator was more strongly associated with SAH, WC and BMI were also the primary associated indicators in men and women, respectively (34). Unlike our analysis, this study used only 4 anthropometric indicators, among them the visceral adiposity index (VAI), which estimates visceral fat dysfunctions with cardiometabolic risks (35). Although this index assesses visceral fat, which is more strongly associated with cardiometabolic diseases than other adipose tissue compartments (36), it was not superior to the other parameters evaluated (34). In addition, the measurement to be used in a screening should be the simplest and least expensive possible, and allow a reliable risk estimate, which is not the case with VAI, which requires the use of biochemical markers

for its calculation, not always being accessible in clinical practice. In this sense, the findings of our study are relevant because they show the relationship of indicators that are easy to use and that do not require equipment and/or refined techniques for their application, allowing the use of these indicators in studies with large samples, in places where assessment resources are limited, and as screening tools.

Unlike the analyses carried out in Brazilian populations (11,34) and other studies (5,6,28), in addition to including the recent RFM index in our analysis, NC was included, which is a parameter that is easy to measure and requires only a measuring tape. Studies have shown correlation of NC with weight, BMI, and WC (37), and with visceral adipose tissue as assessed by means of computed tomography (38). Data from 2,732 individuals in the Framingham cohort also indicated that NC was associated with SAH (39). In our study, NC was one of the indicators with the highest association with high blood pressure levels, the third with the greatest association strength in males (OR, 2.64; 95 % CI, 1.71 to 4.08) and the second in females (OR, 4.87; 95 % CI, 2.58 to 9.21), surpassing RFM and other indicators already consolidated. NC can be a good alternative for use as a screening instrument since it only requires a measuring tape and the anatomical reference point is easy to locate.

When analyzing the predictive capacity of anthropometric indicators for high blood pressure levels, it was observed that BMI and NC were those that presented the largest area under the ROC curve in both sexes, but they were not significantly different from the other indicators. In addition, all indicators in males and BAI and WHR in females showed areas under the curve below 0.7, which is indicative of a low predictive capacity (40). The search for a measure that can adequately estimate body fat percentage and, especially, its association with cardiometabolic parameters requires further investigation.

Some strengths and limitations should be highlighted in order to interpret the results of this study. Methodological rigor was maintained, guaranteeing the internal validity of the study; in relation to SAH, this is the first known study that included RFM and compared its predictive capacity for high blood pressure levels with other anthropometric indicators already consolidated in the literature. In addition, the use of several low-cost and easy-to-use body fat indicators in large samples at the detriment of expensive and difficult-to-access equipment should be highlighted, as it allows a greater external validity. Despite these strengths, some limitations should be highlighted. As the population of this study was restricted to university students, the extrapolation of data to other groups should be performed with caution; however, it is important to highlight that the early identification of changes in blood pressure values can contribute to its control and prevention. The cross-sectional design requires care in inferring results, limiting the capacity to establish causal relationship between variables. Although the analyses have been adjusted by age, it is still possible that unmeasured variables may influence associations.

In conclusion, the findings of our study suggest that RFM is not the best indicator for predicting high blood pressure levels in university students, although it has shown positive associations.

WC in men and BMI in women showed the best associations. This reinforces the idea of maintaining and using simple methods, applicable in daily practice, such as circumference measures, to the detriment of more complex approaches.

REFERENCES

1. World Health Organization. Hypertension - Key facts [Internet]. WHO; 2019 [cited 2020 Apr 3]. Available from: https://www.who.int/news-room/fact-sheets/detail/hypertension
2. Brasil. Ministério da Saúde. Departamento de Análise de Situação de Saúde, Secretaria de Vigilância em Saúde. Vigilância de fatores de risco e proteção para doenças crônicas por inquérito telefônico: Vigitel 2019. Ministério da Saúde; 2012.
3. Chung IH, Park S, Park MJ, Yoo E-G. Waist-to-Height Ratio as an Index for Cardiometabolic Risk in Adolescents: Results from the 1998-2008 KNHANES. Yonsei Med J 2016;57(3):658. DOI: 10.3349/ymj.2016.57.3.658
4. Caminha TCS, Ferreira HS, Costa NS, Nakano RP, Carvalho RES, Xavier AFS, et al. Waist-to-height ratio is the best anthropometric predictor of hypertension. Medicine (Baltimore) 2017;96(2):e5874. DOI: 10.1097/MD.0000000000005874
5. Bombelli M, Facchetti R, Sega R, Carugo S, Fodri D, Brambilla G, et al. Impact of Body Mass Index and Waist Circumference on the Long-Term Risk of Diabetes Mellitus, Hypertension, and Cardiac Organ Damage. Hypertension 2011;58(6):1029-35. DOI: 10.1161/HYPERTENSIONAHA.111.175125
6. Chen H, Zhang R, Zheng Q, Yan X, Wu S, Chen Y. Impact of body mass index on long-term blood pressure variability: a cross-sectional study in a cohort of Chinese adults. BMC Public Health 2018;18(1):1193. DOI: 10.1186/s12889-018-6083-4
7. Beydoun MA, Wang Y. Gender-ethnic Disparity in BMI and Waist Circumference Distribution Shifts in US Adults. Obesity 2009;17(1):169-76. DOI: 10.1038/oby.2008.492
8. World Health Organization. Obesity and overweight [Internet]. WHO; 2020 [cited 2020 Jul 1]. Available from: http://www.who.int/mediacentre/factsheets/fs311/en/
9. Koch E, Bravo M, Romero C, Diaz A, Castañeda H, Aguilera H, et al. Estatura, factores de riesgo cardiovascular y riesgo de mortalidad en adultos: Proyecto San Francisco, Chile. Rev Chil Cardiol 2011;30(3):198-206. DOI: 10.4067/S0718-85602011000300002
10. Ashwell M, Gunn P, Gibson S. Waist-to-height ratio is a better screening tool than waist circumference and BMI for adult cardiometabolic risk factors: systematic review and meta-analysis. Obes Ver 2012;13(3):275-86. DOI: 10.1111/j.1467-789X.2011.00952.x
11. Dutra MT, Reis DB, Martins KG, Gadelha AB. Comparative Evaluation of Adiposity Indices as Predictors of Hypertension among Brazilian Adults. Int J Hypertens 2018;2018:1-7. DOI: 10.1155/2018/8396570
12. Fan S, Yang B, Zhi X, He J, Ma P, Yu L, et al. Neck circumference associated with arterial blood pressures and hypertension: A cross-sectional community-based study in northern Han Chinese. Sci Rep 2017;7(1):2620. DOI: 10.1038/s41598-017-02879-7
13. Rezende AC, Souza LG, Jardim TV, Perillo NB, Araújo YCL, de Souza SG, et al. Is waist-to-height ratio the best predictive indicator of hypertension incidence? A cohort study. BMC Public Health 2018;18(1):281. DOI: 10.1186/s12889-018-5177-3

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WHEN COMPARED TO OTHER ANTHROPOMETRIC INDEXES?

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14. Nguyen Ngoc H, Kriengsinyos W, Rojroongwasinkul N, Aekplakorn W. Association of Adiposity Indices with Hypertension in Middle-Aged and Elderly Thai Population: National Health Examination Survey 2009 (NHES-IV). J Cardiovasc Dev Dis 2019;6(1):13. DOI: 10.3390/jcdd6010013

15. Lear SA, James PT, Ko GT, Kumanyika S. Appropriateness of waist circumference and waist-to-hip ratio cutoffs for different ethnic groups. Eur J Clin Nutr 2010;64(1):42-61. DOI: 10.1038/ejcn.2009.70

16. Bohr AD, Laurson K, McQueen MB. A novel cutoff for the waist-to-height ratio predicting metabolic syndrome in young American adults. BMC Public Health 2016;16(1):295. DOI: 10.1186/s12889-016-2964-6

17. Woolcott OO, Bergman RN. Relative fat mass (RFM) as a new estimator of whole-body fat percentage - A cross-sectional study in American adult individuals. Sci Rep 2018;8(1):1-11. DOI: 10.1038/s41598-018-29362-1

18. World Health Organization. Obesity: preventing and managing the global epidemic. Report of a WHO consultation. (WHO Technical Report Series 894) 2000;894(i-xii):1-253.

19. Malachias MVB, Gomes MAM, Nobre F, Alessi A, Feitosa AD, Coelho EB. 7th Brazilian Guideline of Arterial Hypertension: Chapter 2 - Diagnosis and Classification. 7ª Diretriz Brasileira de Hipertensão Arterial: Capítulo 2 - Diagnóstico e Classificação. Arq Bras Cardiol 2016;107(Suppl 3):7-13. DOI: 10.5935/abc.20160152

20. Zanuncio VV, Pessoa MC, Pereira PF, Longo GZ. Neck circumference, cardiometabolic risk, and Framingham risk score: Population-based study. Rev Nutr 2017;30(6):771-81. DOI: 10.1590/1678-98652017000600009

21. Bergman RN, Stefanovski D, Buchanan TA, Sumner AE, Reynolds JC, Sebring NG, et al. A Better Index of Body Adiposity. Obesity 201119(5):1083-9. DOI: 10.1038/oby.2011.38

22. Segheto W, Coelho FA, Cristina Guimarães da Silva D, Hallal PC, Marins JCB, Ribeiro AQ, et al. Validity of body adiposity index in predicting body fat in Brazilians adults. Am J Hum Biol 2017;29(1). DOI: 10.1002/ajhb.22901

23. Ashwell M, Gibson S. A proposal for a primary screening tool: `Keep your waist circumference to less than half your height'. BMC Med [Internet] 2014;12(1):207. DOI: 10.1186/s12916-014-0207-1

24. World Health Organization. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. WHO Technical Report Series 854. Geneva: World Health Organization; 1995.

25. Yu P, Huang T, Hu S, Yu X. Predictive value of relative fat mass algorithm for incident hypertension: a 6-year prospective study in Chinese population. BMJ Open 2020;10(10):e038420. DOI: 10.1136/bmjopen-2020-038420

26. Paek JK, Kim J, Kim K, Lee SY. Usefulness of relative fat mass in estimating body adiposity in Korean adult population. Endocr J 2019;66(8):723-9. DOI: DOI: 10.1507/endocrj.EJ19-0064

27. Andreasson A, Carlsson AC, Önnerhag K, Hagström H. Predictive Capacity for Mortality and Severe Liver Disease of the Relative Fat Mass Algorithm. Clin Gastroenterol Hepatol 2019;17(12):2619-20. DOI: 10.1016/j.cgh.2018.11.026

28. Choi JR, Koh SB, Choi E. Waist-to-height ratio index for predicting incidences of hypertension: the ARIRANG study. BMC Public Health 2018;18(1):767. DOI: 10.1186/s12889-018-5662-8

29. Patel SA, Deepa M, Shivashankar R, Ali MK, Kapoor D, Gupta R, et al. Comparison of multiple obesity indices for cardiovascular disease risk classification in South Asian adults: The CARRS Study. PLoS One 2017;12(4):e0174251. DOI: 10.1371/journal.pone.0174251

30. Sánchez A, Muhn M, Lovera M, Ceballos B, Bonneau G, Pedrozo W, et al. Índices antropométricos predicen riesgo cardiometabólico. Estudio de cohorte prospectivo en una población de empleados de hospitales públicos. Rev Argent Endocrinol Metab 2014;51(4):185-91.

31. Knowles KM, Paiva LL, Sanchez SE, Revilla L, Lopez T, Yasuda MB, et al. Waist Circumference, Body Mass Index, and Other Measures of Adiposity in Predicting Cardiovascular Disease Risk Factors among Peruvian Adults. Int J Hypertens 2011;2011:1-10. DOI: 10.4061/2011/931402

32. Wai WS, Dhami RS, Gelaye B, Girma B, Lemma S, Berhane Y, et al. Comparison of Measures of Adiposity in Identifying Cardiovascular Disease Risk Among Ethiopian Adults. Obesity 2012;20(9):1887-95. DOI: 10.1038/oby.2011.103

33. Rodrigues SL, Baldo MP, Mill JG. Associação entre a razão cintura-estatura e hipertensão e síndrome metabólica: estudo de base populacional. Arq Bras Cardiol 2010;95(2):186-91. DOI: 10.1590/S0066-782X2010005000073

34. de Oliveira CM, Ulbrich AZ, Neves FS, Dias FAL, Horimoto ARVR, Krieger JE, et al. Association between anthropometric indicators of adiposity and hypertension in a Brazilian population: Baependi Heart Study. PLoS One 2017;12(10):e0185225. DOI: 10.1371/journal.pone.0185225

35. Amato MC, Giordano C, Galia M, Criscimanna A, Vitabile S, Midiri M, et al. Visceral Adiposity Index: A reliable indicator of visceral fat function associated with cardiometabolic risk. Diabetes Care 2010;33(4):920-2. DOI: 10.2337/dc09-1825

36. Pak K, Lee SH, Lee JG, Seok JW, Kim IJ. Comparison of Visceral Fat Measures with Cardiometabolic Risk Factors in Healthy Adults. Sun Q, editor. PLoS One 2016;11(4):e0153031. DOI: 10.1371/journal.pone.0153031

37. Hingorjo MR, Qureshi MA, Mehdi A. Neck circumference as a useful marker of obesity: A comparison with body mass index and waist circumference. J Pakistan Med Assoc 2012;62(1):36-40.

38. Li H-X, Zhang F, Zhao D, Xin Z, Guo S-Q, Wang S-M, et al. Neck circumference as a measure of neck fat and abdominal visceral fat in Chinese adults. BMC Public Health [Internet] 2014;14(1):311. DOI: 10.1186/1471-2458-14-311

39. Preis SR, Pencina MJ, D'Agostino RB, Meigs JB, Vasan RS, Fox CS. Neck Circumference and the Development of Cardiovascular Disease Risk Factors in the Framingham Heart Study. Diabetes Care 2013;36(1):e3. DOI: 10.2337/dc12-0738

40. Swets J. Measuring the accuracy of diagnostic systems. Science 1988;240(4857):1285-93. DOI: 10.1126/science.3287615