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original article

Anthropometric indicators associated with hypertriglyceridemia in the prediction of visceral fat

Indicadores antropométricos associados a hipertrigliceridemia na predição de gordura visceral

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Abstract – The accumulation of visceral fat is strongly associated with cardiometabolic changes. Alternative methods, such as the association between anthropometric indicators and hypertriglyceridemia, are used as the best estimate for the accumulation of visceral fat, preventing cardiovascular diseases. The aim of this study was to evaluate the association of anthropometric indicators with hypertriglyceridemia in the prediction of visceral fat in men and women. This was a cross-sectional study conducted with 192 individuals, of both genders, submitted to anthropometric evaluation (sagittal abdominal diameter [SAD], waist circumference [WC], and waist-hip ratio [WHR]), serum dosage of triglycerides (TG), and computed tomography scan, in order to measure the visceral adipose tissue (VAT) area. Descriptive analysis, Pearson's Correlation, and multiple linear regression were performed. Anthropometric indicators had high correlation with the VAT area (p=0.000). Regardless of serum TG levels, individuals with high values of anthropometric indicators had excess VAT area (p<0.05). For every centimeter increased in SAD, there was an average increase of 12.46 cm² in the VAT area. The study showed that both SAD and WC were good indicators to explain the variability in the VAT area, independently of changes in TG levels, making it possible to identify individuals with a risk of developing cardiovascular diseases.

Key words: Anthropometry; Cardiovascular diseases; Computed tomography; Hypertriglyceridemia; Intra-abdominal fat.

Resumo – *O acúmulo de gordura visceral está fortemente associada com alterações cardiometabólicas. Métodos alternativos, como a associação de indicadores antropométricos e hipertrigliceridemia, são usados como uma melhor estimativa para o acúmulo de gordura visceral, prevenindo doenças cardiovasculares. O objetivo foi avaliar a associação entre indicadores antropométricos com a hipertrigliceridemia para predição de gordura visceral em homens e mulheres. Estudo transversal, realizado com 192 indivíduos, de ambos os sexos, que foram submetidos à avaliação antropométrica (Diâmetro Abdominal Sagital -DAS, Circunferência da Cintura -CC e Relação Cintura-quadril -RCQ), dosagem sérica de triglicérides (TG) e tomografia computadorizada, a fim de medir a área do tecido adiposo visceral (ATAV). Análise descritiva, Correlação de Pearson e Regressão Linear Múltipla foram realizados. Indicadores antropométricos apresentaram alta correlação com a ATAV (p=0,000). Independente do nível sérico de TG, os indivíduos com indicadores antropométricos elevados tinham excesso de ATAV (p<0,05). Para cada aumento de um centímetro no DAS, houve um aumento médio de 12,46 cm² de ATAV. O estudo mostrou que ao mesmo tempo, DAS e CC foram os melhores indicadores para explicar a variabilidade na ATAV, independentemente de mudanças no nível de triglicérides, o que possibilitou a identificação de indivíduos com risco de desenvolver doenças cardiovasculares.*

Palavras-chave: *Antropometria; Doenças cardiovasculares; Gordura intra-abdominal; Hipertrigliceridemia; Tomografia computadorizada.*

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INTRODUCTION

The accumulation of adipose tissue in the abdominal region, especially of visceral type, is related to a series of cardiometabolic changes, including dyslipidemia, resistance to insulin, and development of cardiovascular diseases (CVD)[1,2].

Examinations of tomographic images or magnetic resonance for the quantification of visceral adipose tissue (VAT) are considered the gold standard in the evaluation of lipid metabolism disorders[3]. However, their use is limited due to their relatively high cost and difficult execution. As a result, only few clinical studies use this technique. Conversely, anthropometric indicators are the alternative methods most widely used to estimate excess visceral fat[4,5].

Over the last few years, the association between hypertriglyceridemia and waist circumference (WC) has been widely used as an initial, low cost, simple screening method to identify patients likely to be characterized by a cluster of metabolic syndrome features such as fasting hyperinsulinemia, high apolipoprotein B, and an increased proportion of small low density lipoprotein (LDL) particles (the atherogenic metabolic triad). Moreover, the simultaneous analysis of WC and hypertriglyceridemia may be able to distinguish between visceral adiposity and subcutaneous adiposity[1,2,6]. However, few studies have associated serum triglycerides (TG) with sagittal abdominal diameter (SAD) and waist-hip ratio (WHR) in the prediction of visceral fat – traditionally, only WC is assessed[1,2,6].

The present study uses the gold standard method (computed tomography [CT]) for the quantification of VAT. In addition, it collects anthropometric measures, such as SAD, which has been shown to be the best predictor of intra-abdominal fat[4,5,7]. Based on these data, this study evaluated the association between anthropometric indicators and hypertriglyceridemia in the prediction of visceral fat in men and women.

METHODOLOGICAL PROCEDURES

Subjects and Study Design

This was a cross-sectional study performed at the School of Nutrition of the Universidade Federal da Bahia during the first quarter of 2009 with a sample of 192 individuals stratified by gender, age and body mass (estimated by body mass index [BMI]), according to a previous publication[7]. These people were randomly selected from health centers or from the general community based on the following inclusion criteria: age $\geq$ 20 years old and BMI $\leq$ 40 kg/m.

The exclusion criteria were: individuals with severe malnutrition and neurological sequel or dystrophy; amputees or those with any physical problem that could compromise the verification of anthropometric and abdominal fat measures; people who had recently undergone abdominal surgery; pregnant women or those who had their babies in the last six months; patients who had abdominal lesions and tumors, hepatomegaly and/or splenomegaly and ascites.

All individuals were submitted to anthropometric, biochemical and computed tomography (CT) examinations for the assessment of the VAT area. Measurements for each individual were taken in the same week to prevent oscillations in weight, body composition, and distribution of body fat and/or in the individual's lipid profile.

Anthropometric evaluation

Anthropometric evaluation was performed by a properly trained team and comprised the measurement of weight, height, hip circumference, and WC, obtained according to the techniques proposed by Lohman *et al*.[8]. Waist circumference was measured at the midpoint between the lower costal margin and the iliac crest, using a measuring tape made of inelastic synthetic material. The reading was made at the moment of expiration. Hip circumference was obtained at the pubic symphysis level, with the individual wearing light clothes and the tape encircling the hip at the most prominent part between the waist and the thigh. The reading was carried out to the nearest millimeter. WC was classified as high when ≥90 cm for male and ≥80 cm for female, according to the criteria suggested by the International Diabetes Federation[9] for ethnic South American groups. Waist-hip ratio (WHR) was obtained by dividing individuals' WC by their hip circumference and was classified as high when > 1.00 for men and > 0.85 for women[10].

The SAD was measured according to the technique proposed by Kahn[11], i.e., it was verified with the help of a portable abdominal calibrator (Sliding-beam – Holtain, Ltd., Dyfed.Wales, U.K.) and measured with the individual in supine position, with the arms relaxed alongside the body and legs extended. The fixed caliper of the calibrator was placed under the individual's back and the sliding caliper was brought up to the abdominal point between the iliac crests, at the level of the umbilicus. The reading was taken to the nearest millimeter, at the end of expiration. The cut-off point for high SAD was defined as ≥ 20cm, according to what has been demonstrated by previous studies[4,7,12].

All anthropometric measurements were made in duplicate. The coefficient of variation was calculated to assess the inter- and intra-examiner variability of the anthropometric measures (inter-class coefficient >0.90).

Laboratorial Evaluation

Serum TG levels were quantified by a colorimetric assay carried out at a private laboratory with samples collected after a 12-hour overnight, using a kit manufactured by Ortho-Clinical Diagnostics. Serum TG levels ≥150mg/dL were considered to be high[9].

Tomographic Study

The CT was performed at the Radiology Service of the University Hospital of Universidade Federal da Bahia (UFBA) and analyzed by a radiologist.

The examination was performed after 4 hours of fasting, with the individual lying in the dorsal recumbent position and the arms extended overhead. No barite or organo-iodized contrasts were used.

A lateral topogram was taken for precise identification of the location of the L4-L5, followed by a single axial tomography slice in this location, with slice thickness of 10mm and exposition time of three seconds. The external limits of the WC were outlined using an electronic cursor, which then calculated the total waist area. Next, the area of visceral abdominal fat was determined by the delimitation of the abdominal cavity, taking as its limits the rectus abdominis, internal oblique and quadratus lumborum muscles[13]. A tomography software with radiographic parameters of 140kV and 45mA, applying a density of -50 and -150 Hounsfields Unities to identify the adipose tissue. A VAT area ≥130cm² was considered as a risk factor for the development of cardiovascular diseases[14].

Statistical Analysis

Statistical analyzes were performed using the software Statistical Package for Social Sciences (SPSS), version 16.0. Descriptive analysis of the variables was expressed as mean and standard deviation. The distribution of continuous variables was assessed by the Kolmogorov-Smirnov non-parametric test. Average results of the analyzed variables were compared using Pearson correlation and non-rated t-test for independent samples. Multiple linear regression was performed to assess the influence of anthropometric indicators, age, gender, and triglycerides on the estimation of visceral fat. The significance level was set at less than 5%.

Ethical Aspects

This study was approved by the Research Ethics Committee of the School of Nutrition of UFBA (CEPNUT/UFBA), declaration number 01/09. Additionally, all participants provided a written informed consent to participate in this study, after it was approved by the ethics committee.

RESULTS

Of the 192 individuals between 21 and 95 years old, there were 95 men and 97 women. Table 1 shows clinical and biochemical data of study subjects. It can be observed that mean values for the variables weight, WC, WHR, and VAT area were significantly different between genders ($p \leq 0.021$), being higher among men.

Table 2 presents the correlation between anthropometric indicators, triglycerides and VAT area according to gender. A high correlation was found between anthropometric indicators and VAT area, especially in males ($p<0.01$). The correlation between TG and VAT area was very low in both genders, although being slightly higher in the female gender ($p \leq 0.01$).

Table 1. Descriptive analysis of anthropometric variables, TG, and VAT area, according to gender. Salvador, Bahia, Brazil, 2009.

Variables	Men	Women	p
	(n=95)	(n=97)	
	Mean (SD)	Mean (SD)	
Age $_{(years)}$	55.2 (19.9)	56.8 (19.6)	0.589
Weight $_{(Kg)}$	73.1 (12.8)	64.4 (12.0)	0.000
BMI $_{(Kg/m^2)}$	25.7 (3.9)	26.6 (4.4)	0.140
WC $_{(cm)}$	90.9 (11.4)	87.2 (11.0)	0.021
SAD $_{(cm)}$	20.5 (3.5)	19.8 (3.1)	0.158
WHR	0.93 (0.07)	0.87 (0.08)	0.000
TG $_{(mg/dL)}$	126.2 (64.0)	118.4 (62.4)	0.389
VAT area $_{(cm^2)}$	126.2 (80.5)	97.6 (52.7)	0.004

SD: standard deviation; BMI: body mass index; WC: waist circumference; SAD: sagittal abdominal diameter; WHR: waist-hip ratio; TG: triglycerides; VAT: visceral adipose tissue.

Table 2. Correlation coefficient between anthropometric indicators, TG, and VAT area according to gender. Salvador, Bahia, Brazil, 2009.

	WC	SAD	WHR	TG	VAT
Men					
WC	-	0.875†	0.671†	0.351†	0.771†
SAD	0.875†	-	0.552†	0.375†	0.762†
WHR	0.703†	0.552†	-	0.390†	0.730†
TG	0.351†	0.375†	0.390†	-	0.362†
VAT area	0.771†	0.762†	0.730†	0.362†	-
Women					
WC	-	0.834†	0.671†	0.242*	0.677†
SAD	0.834†	-	0.442†	0.250*	0.652†
WHR	0.671†	0.442†	-	0.376†	0.648†
TG	0.242*	0.250*	0.376†	-	0.444†
VAT area	0.677†	0.652†	0.648†	0.444†	-

WC: waist circumference; SAD: sagittal abdominal diameter; WHR: waist-hip ratio; TG: triglycerides; VAT: visceral adipose tissue. †. Correlation is significant at the 0.01 level. *. Correlation is significant at the 0.05 level.

As seen in Table 3, individuals with high values of anthropometric indicators (WC, SAD and WHR) and hypertriglyceridemia showed higher mean values for VAT area in both genders, with higher values among males ($p \leq 0.02$).

Result of the multiple linear regression analysis (Table 4) showed that, in model 2, for every centimeter increased in SAD, there was an average increase of 12.46cm^2 in VAT area in the presence of TG, gender and age variables. Furthermore, this model made it possible to explain up to 65.5% of the variability observed in the VAT area as measured by CT.

Table 3. Descriptive analysis of the VAT area according to anthropometric indicators combined with TG levels for men and women. Salvador, Bahia, Brazil, 2009.

Variables		VAT area		p
		Men	Women	
		Mean (SD)	Mean (SD)	
WC+TG	High WC and TG	187.2 (62.0)	133.71 (40.6)	0.003
	High WC/low TG	169.1 (84.6)	107.17 (46.7)	0.001
	Low WC/high TG	109.8 (32.4)	101.44 (36.6)	0.675
	Low WC and TG	65.3 (38.7)	35.7 (24.8)	0.001
SAD+TG	High SAD and TG	178.9 (64.7)	140.9 (43.7)	0.044
	High DAS/low TG	171.6 (87.2)	125.5 (52.1)	0.021
	Low SAD/high TG	113.2 (36.0)	106.7 (27.8)	0.687
	Low SAD e TG	68.7 (40.5)	64.4 (37.8)	0.615
WHR+TG	High WHR and TG	211.4 (35.4)	131.5(39.4)	<0.001
	High WHR/low TG	193.8 (81.2)	109.9 (48.7)	<0.001
	Low WHR/high TG	140.7 (64.3)	110.3(48.7)	0.340
	Low WHR and TG	81.3 (57.9)	53.8 (38.8)	0.026

VAT: visceral adipose tissue; WC: waist circumference; SAD: sagittal abdominal diameter; WHR: waist-hip ratio; TG: triglycerides.

Table 4. Results of multiple linear regression between VAT area and anthropometric variables, TG, age and gender. Salvador, Bahia, Brazil, 2009.

	VAT area			
	β	R	R^2	p
Model 1				
WC	3.64	0.80	64.4	<0.001
TG	0.15			0.003
Men	15.28			0.014
Age	1.00			<0.001
Model 2				
SAD	12.46	0.81	65.5	<0.001
TG	0.13			0.011
Men	20.89			0.001
Age	1.14			<0.001
Model 3				
WHR	4.65	0.72	51.9	<0.001
TG	0.16			0.010
Men	-3.72			0.644
Age	0.58			0.006

VAT: visceral adipose tissue; WC: waist circumference; SAD: sagittal abdominal diameter; WHR: waist-hip ratio; TG: triglycerides

DISCUSSION

Most studies about visceral fat as measured by CT[15,16] use serum TG levels only to present the metabolic profile of the study population or relate these levels to other biochemical parameters. However, there is scientific evidence[1,6,17] proposing hypertriglyceridemia as a marker of metabolic changes and high atherogenic risk associated with excess intra-abdominal adiposity.

Després *et al.*[1] evidenced the importance of evaluating WC and serum TG levels to identify viscerally obese individuals at risk of developing cardiovascular diseases by creating the concept of "hypertriglyceridemic waist". However, it is important to highlight that differences between genders and age groups must be considered.

Similarly to other studies[4,15,18], this investigation found that males showed significantly higher mean values for VAT area and WC as compared to females. Excess body fat is associated with aspects such as life style, genetic factors and, among men, especially with the secretion of steroid hormones and the local density of their receptors, which decide the specific sexual characteristics of body fat regional distribution leading to higher concentration of abdominal adipose tissue and higher visceral fat accumulation[19].

The analysis of the correlation between anthropometric indicators and VAT area made it possible to observe that WC and SAD had a similar correlation for the male gender. In a study with Italians aged from 27 to 78 years old, Zamboni *et al.*[20] found higher correlations for the male gender, with $r=0.80$ ($p<0.001$) for WC, $r=0.86$ ($p<0.001$) for SAD, and $r=0.82$ ($p<0.01$) for WHR. In contrast to these results, a study conducted by Sampaio *et al.*[4] with Brazilians aged from 20 to 83 years old observed better correlations for WC ($r=0.77$; $p<0.01$) and SAD ($r=0.80$; $p<0.01$) among the female gender.

Despite being low, the correlation between serum TG levels and VAT area was slightly better in females. This result agrees with findings by Després *et al.* [21], who used CT to quantify abdominal and hip fat in a female sample. These authors observed a higher correlation between increased abdominal fat and increased TG levels than between hip fat and TG levels.

The results of our study show that individuals with high values of anthropometric indicators and hypertriglyceridemia had higher mean values for the VAT area in both genders. In a cohort study with men and women with diabetes, Sam *et al.*[6] observed that individuals with higher WC and hypertriglyceridemia had higher mean values for VAT volume.

When analyzing the influence of variables such as anthropometric indicators, serum TG levels, gender, and age on the VAT area, this study observed that, in the presence of other variables, SAD was the best factor to explain the variability in the VAT area, although model 1, which included WC, was able to explain 64.4% of the variability in VAT area, a value very close to that obtained with the SAD (65.5%).

Our study shows that anthropometric measures alone, without taking serum TG levels into account, are able to predict excess visceral fat and also cardiovascular risk. Our results agree with those by Stevens *et al.*[22], who suggested that WC and SAD should be the anthropometric parameters of choice when the aim is to estimate VAT area and evaluate the individuals' cardiovascular risk profile. In addition, Riserus *et al.*[23] stated that SAD was the best cardiovascular predictor when compared to other conventional anthropometric parameters.

With regard to WHR, the results reveal that large hip circumference is associated with an increase in subcutaneous abdominal fat, especially in men. Such results demonstrate different aspects in the body composition and distribution of fat in men and women[24], therefore indicating that the WHR have a better correlation with the subcutaneous adipose tissue than with the visceral adipose tissue. It is important to point out that, unlike WC and SAD, the WHR is an index, so it presented very low values, ranging from 0.68 to 1.09.

In a linear regression model including gender, age, and anthropometric indicators (WC, SAD and BMI), Onat *et al.*[15] found that WC showed the best correlation with the VAT area in the whole study sample, followed by age among women. It is important to mention that these authors did not include serum TG levels in their model of analysis.

Some methodological limitations must be mentioned, e.g., this is a cross-sectional study whose results do not make it possible to establish causal links. Furthermore, sample stratification by gender, age and body mass limited the use of different statistical tests, which could better explain how the relationship between anthropometric measures and hypertriglyceridemia may be used to indicate excess visceral fat.

We concluded that anthropometric indicators showed high correlation with the VAT area, especially WC and SAD among men. Serum TG levels were poorly associated with the VAT area. Additionally, regardless of serum TG levels, individuals who had high measures of anthropometric indicators had excess VAT. SAD and WC were good indicators to explain the variability in VAT area, making it possible to identify individuals at risk of developing cardiovascular diseases. Hence, these indicators may be considered simple screening tools for the identification of individuals at risk for cardiometabolic changes. In view of this, anthropometric indicators can and should be widely used in clinical practice and population studies to identify cardiovascular risk, independently of changes in laboratory parameters (such as TG levels).

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