Original Article

Imaging Assessment of Visceral Adipose Tissue Area and Its Correlations with Metabolic Alterations

Anna Karla Carneiro Roriz, Adriana Lima Mello, Juliana Fontes Guimarães, Fabiana Cajuhy dos Santos, Jairza Maria Barreto Medeiros, Lílian Ramos Sampaio

Escola de Nutrição da Universidade Federal da Bahia (UFBA), Salvador, BA - Brazil

Abstract

Background: **Androgenic obesity is associated with a higher risk of metabolic disorders, thus favoring the occurrence of cardiovascular diseases and other morbidities.**

Objective: **To verify the influence of the visceral adipose tissue (VAT) area, measured by computed tomography (CT), on the metabolic alterations in adult and elderly individuals.**

Methods: **CT results and lipoprotein levels, total cholesterol and fractions, triglycerides, glycemia and uric acid levels, were obtained from 194 individuals stratified by sex, age group and body mass and analyzed using the tests of correlation and means.**

Results: **The elderly individuals presented higher VAT area, glycemia, uric acid and total cholesterol levels. The most important correlations were observed between VAT area, triglycerides (TG) and VLDL-c ($r > 0.5$; $p < 0.01$), in both age groups. The mean VAT area was always higher when TG and glycemia levels were altered, in both age groups.**

Conclusion: **Most tests showed a strong correlation with VAT area, which was considered as risk for metabolic alterations. In elderly individuals, the risk VAT area seems to be higher than that of adult individuals. (Arq Bras Cardiol 2010;95(6):698-704)**

Keywords: **Abdominal fat; lipoproteins; blood glucose; uric acid; computed tomography.**

Introduction

Androgenic obesity, represented by the excess deposition of visceral abdominal adipose tissue, is associated with a higher risk of metabolic and hemodynamic disorders and favors the occurrence of events, such as arterial hypertension, atherogenic cardiovascular disease, diabetes mellitus, gout and coronary disease[1-3], increasing the need for medication use and interfering with the quality of life.

The literature has pointed out several physiopathological mechanisms to explain such association, although they are yet to be elucidated[2,4-6]. A large number of endocrine alterations is more frequent in the presence of visceral obesity, when compared to the peripheral obesity, due to the differentiation in the metabolic and endocrine activity, more active in the visceral adipose tissue (VAT)[5,7,8].

Among the physiological characteristics of visceral adipocytes is such differentiation, as the VAT presents: more cells per mass unit; higher blood flow; more glucocorticoid receptors (cortisol); more androgen receptors (testosterone); higher catecholamine-induced lipolysis. Moreover, the VAT presents lower insulin sensitivity and contribution to lipolysis, by showing a faster insulin-receptor dissociation[7,8].

According to several authors[2,9,10], the metabolic alterations, which include dyslipidemia, insulin resistance and morbidities such as hypertension and cardiovascular disease, are independent from the degree of obesity and are of equal magnitude for both sexes, with the visceral tissue being the probable mediator of this association.

The most accurate methods used in the characterization of this visceral fat are high-cost and difficult to perform. To directly quantify this compartment, the imaging technique, such as computed tomography (CT), is used, which is considered the "gold-standard", with high reproducibility[11], albeit with little applicability in clinical and epidemiological practice. The cutoff of the visceral adipose tissue (VAT) area ≥ 130 cm^2 is the one considered in most studies as excess of visceral adipose tissue and establishing the risk for the development of metabolic alterations, cardiovascular diseases and other morbidities[12-14].

Therefore, considering the importance of biochemical assessment and its possible associations with the visceral fat considered to be of risk for human health, the present study aimed at verifying the existence of a correlation between this assessment and the VAT area identified through CT in adult and elderly individuals.

Mailing address: Anna Karla Carneiro Roriz •
Avenida Araújo Pinho, 32 - Canela - 40110-150 - Salvador, BA - Brazil
E-mail: karlaroriz@hotmail.com, annakarlaroriz@yahoo.com.br
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Materials and methods

Patients

The present was a cross-sectional study carried out at the *Escola de Nutrição da Universidade Federal da Bahia* (UFBA), during the first trimester of 2009. A total of 194 individuals, aged > 20 years volunteered for the study, from the outpatient clinic and the community. They were stratified by sex, age and body mass determined by the BMI (body mass index = kg/m²).

Individuals with BMI > 40 kg/m², those presenting severe malnutrition and severe disorders (neural sequelae, dystrophy), as well as pregnant and nursing women, individuals who had recently undergone abdominal surgery or presented tumors, hepatomegaly, splenomegaly or ascites or any problem that could compromise the recommended technique to measure the visceral fat by CT were excluded from the study.

All volunteers were submitted to a blood sample collection in a private laboratory and CT. They had fasted for 12 hours. The blood samples were used to measure serum lipoprotein levels: total cholesterol (TC), high-density lipoprotein cholesterol (HDL-c), low-density lipoprotein cholesterol (LDL-c), very-low density lipoprotein cholesterol (VLDL-c), triglycerides (TG), as well as glycemia and uric acid levels. All results were returned to the participants for follow-up and/or treatment and they were also referred to nutritional consultation given by professionals from one of the Ambulatories of Nutrition at Professor Francisco Magalhães Netto Ward of *Hospital Universitário Professor Edgar Santos* (HUPES).

Biochemical analyses

Glycemia, TC and fractions, TG and uric acid were quantified in sera, using a colorimetric system, dry chemistry method, with kits manufactured by Ortho-Clinical Diagnostics™, Rochester, NY and the values considered normal were the ones described in Table 1.

Table 1 - Reference values for the performed laboratory tests

Biochemical data	Reference value
Glycemia(I)	< 100 mg/dl
Triglycerides(II)	< 150 mg/dl
Total Cholesterol (II)	< 200 mg/dl
LDL-c(II)	< 160 mg/dl
HDL-c(II)	
Male sex	> 40 mg/dl
Female sex	> 50 mg/dl
VLDL-c(II)	< 50 mg/dl
Uric acid (III)	
Male sex	3.5 - 8.5 mg/dl
Female sex	2.5 - 6.2 mg/dl

Sources: I - Guideline of the Brazilian Society of Diabetes, 2008[15]; II – IV Brazilian Guidelines on Dyslipidemias and Atherosclerosis Prevention, 2007[16]; III - Tietz , 1995[17].

The LDL and VLDL values were calculated using the following formulas: LDL = CT – (HDL – VLDL); VLDL = Triglycerides/5, with CT = total cholesterol, HDL = high-density lipoprotein cholesterol, VLDL = very-low density lipoprotein cholesterol. All TG values > 400 mg/dl were excluded from the sample, as they prevented the calculation of the LDL-c and VLDL-c levels and also could interfere with the other assessments.

Computed tomography to evaluate the VAT area

The computed tomographies were obtained using a Spirit Siemens CT scanner from the Service of Radiology of *Hospital Universitário* and they were analyzed by a same observer. The examination was initiated under complete 4-hour fasting, with the patient on dorsal decubitus and the arms extended above the head. For the precise identification of the L4-L5, a lateral topogram was performed and then a single axial tomographic slice was performed on this site, with a thickness of 10 mm and exposure time of 3 seconds.

After the slice was obtained, using a free electronic cursor that contemplated the external borders that limit the abdominal circumference, the outer limits of the abdomen were delimitated and then, the total abdominal area was calculated. After the measurement of the total abdominal area, the visceral abdominal area was also delimitated, with a free cursor, which corresponded to the area of visceral fat. That was determined by the detection of the abdominal cavity, considering as limits the inner borders of the rectus abdominis, internal oblique and quadratus lumborum muscles, excluding the vertebral body and including the retroperitoneal, mesenteric and omental fat. The areas of fat were described in square centimeters. The subcutaneous abdominal area was calculated by subtracting the total abdominal area from the visceral abdominal area[18].

No barium or organic iodinated contrast media were administered. The tomographer program was used to examine the abdomen with radiographic parameters of 140 kV and 45 mA. To identify the adipose tissue, a density of -50 and -150 *Hounsfields* units were used. An area of visceral tissue ≥ 130 cm² was considered as excess of visceral adipose tissue and a risk for the development of cardiovascular diseases[12].

In this study, the selected individuals were associated or not to the Basic Health Units, in order to achieve a higher degree of group representativeness equivalently in terms of visceral fat, as the presence/absence of morbidities influences this amount of fat.

Statistical analysis

The statistical analysis was carried out using the software *SPSS,* release 11.5. The normality of the variables' distribution was determined based on the Kolmogorov-Smirnov test. The variables with a normal distribution were expressed as means and standard deviations. The variables without a normal distribution are presented as medians and maximum and minimum values.

When comparing the two study groups, the normal numerical variables were analyzed using the Student's *t* test and the non-normal ones, by Mann-Whitney U-test. Pearson's correlations were carried out for a normal distribution and Spearman's correlations for a non-normal distribution between the area of visceral fat and the biochemical tests. The mean test was carried out to verify differences between the measurement of the visceral area at the CT, according to the cutoffs of the lipid profile, glycemia and uric acid. Differences between the variables were considered significant when $p \leq 0.05$.

The study was approved by the Research Ethics Committee of *Escola de Nutrição da UFBA* (protocol # 01/09) and all subjects signed the Free and Informed Consent Form before enrollment.

Results

Of the 194 participants, 97 were adults with a mean age of 39.53 years and 97 were elderly individuals with a mean age of 72.97 years. Table 2 presents the descriptive values of the studied variables.

In the male sex, there was a statistically significant difference in the means of VAT area, glycemia, LDL-c and uric acid between adult and elderly individuals. In this study, only 08 individuals were identified with glycemia levels > 126 mg/dl, with the elderly presenting a higher median value when compared to the adult individuals. Only 19 individuals presented TG levels > 200 mg/dl. It was verified that the highest mean values of VAT area were observed in the elderly individuals of both sexes. There was no difference between the mean values of HDL in both men and women. Except for the HDL levels, elderly women presented higher levels of all biochemical parameters when compared to the adult women.

The analyses of the correlations between the biochemical assessments and VAT area considered to be excessive identified by the CT, according to the age groups, are shown in Figure 1. Most of the biochemical variables presented a strong correlation with the VAT area and, among them, the serum levels of TG and VLDL-c (both with $r > 0.51$; $p < 0.01$) and uric acid ($r > 0.42$; $p< 0.01$) presented the highest correlations with this area in both age groups, followed by a good correlation between the glycemia, TC, LDL-c and VAT area in adult individuals. Total cholesterol and LDL-c were the variables that presented the lowest correlations, especially among the elderly individuals, and were not statistically significant. An inverse correlation was observed between the serum levels of HDL-c and VAT area, mainly in elderly individuals.

Table 3 presents the mean area of visceral adipose tissue in adult and elderly individuals according to the cutoffs recommended as normal and abnormal values (Table 1) for glycemia, triglycerides, total cholesterol, LDL-c, HDL-c, VLDL-c and uric acid. The mean VAT area showed to be always higher when the TG and glycemia levels were altered in both age groups, as well as for uric acid, only in elderly women, being statistically significant. The mean VAT area did not present difference between the normal and elevated values of LDL-c and VLDL-c in the two studied groups. The inverse association between the VAT area mean and the HDL-c levels was observed only in elderly individuals of both sexes ($p < 0.05$).

Discussion

The present is a pioneer study in Brazil, mainly because it assesses the association between biochemical assessments and the area of visceral adipose tissue, identified by CT in different age groups. In other studies on visceral fat measured by CT[1,19-23], the same biochemical tests were used only to characterize the population, categorize risk factors for a certain morbidity or correlate with other indicators, limiting the comparison of such results with those presented in this study.

Moreover, the absence of analysis according to age range in other studies, as well as categorizations by body mass and sex, which was not performed in most of the studies and the variations in the methodology used can be responsible for the different results obtained.

Currently, the computed tomography (CT) is considered the method that best identifies the area of visceral fat. Among the several cutoffs for the identification of the excess of this fat by CT, most studies indicate an area $\geq 130\ cm^2$ as the cutoff associated with the development of cardiovascular diseases and other morbidities[12-14]. According to Rankinen et al[24], values from 150 to 200 cm^2 have been considered as representing very high levels of visceral adipose tissue. Bouza et al[25], when assessing 108 patients aged 18 to 78 years,

Table 2 - **Descriptive values of the analyses of biochemical tests and visceral fat tissue area in adult and elderly individuals, according to the sex - Salvador, 2009**

Variables (n = 194)	Male		p-value	Female		p-valor
	Adult (n = 49)	Elderly (n = 47)		Adult (n = 48)	Elderly (n = 50)	
VAT area	94.18 (± 58.74)	157.14 (± 88.65)	0.000	72.20 (± 43.88)	120.26 (± 51.02)	0,000
Glycemia	87.00 (71 - 253)	92.00 (69 - 198)	0.020	82.00 (69 - 116)	88.50 (76 - 117)	0,000
TG	123.00 (43 - 349)	116.00 (49 - 300)	0.575	83.50 (35 - 261)	113.0 (40 - 363)	0,011
TC	187.22 (± 39.90)	202.30 (± 35.02)	0.052	192.85 (± 40.19)	228.54 (± 52.09)	0,000
LDL-c	114.65 (± 31.50)	128.46 (± 32.92)	0.038	114.45 (± 36.92)	143.40 (± 52.06)	0,002
HDL-c	47.80 (± 10.31)	48.38 (± 12.62)	0.803	57.54 (± 12.77)	58.42 (± 15.79)	0,763
VLDL-c	24.00 (8 - 69)	23.0 (1.6 - 66)	0.679	16.00 (7 - 52)	22.0 (8 - 72)	0,016
Uric acid	5.29 (± 1.09)	5.94 (± 1.36)	0.010	4.15 (± 0.98)	4.84 (± 1.30)	0,004

VAT - visceral adipose tissue; TG - triglycerides; TC - total cholesterol; LDL-c - low-density lipoprotein; HDL-c - high-density lipoprotein; VLDL-c - very-low density lipoprotein.

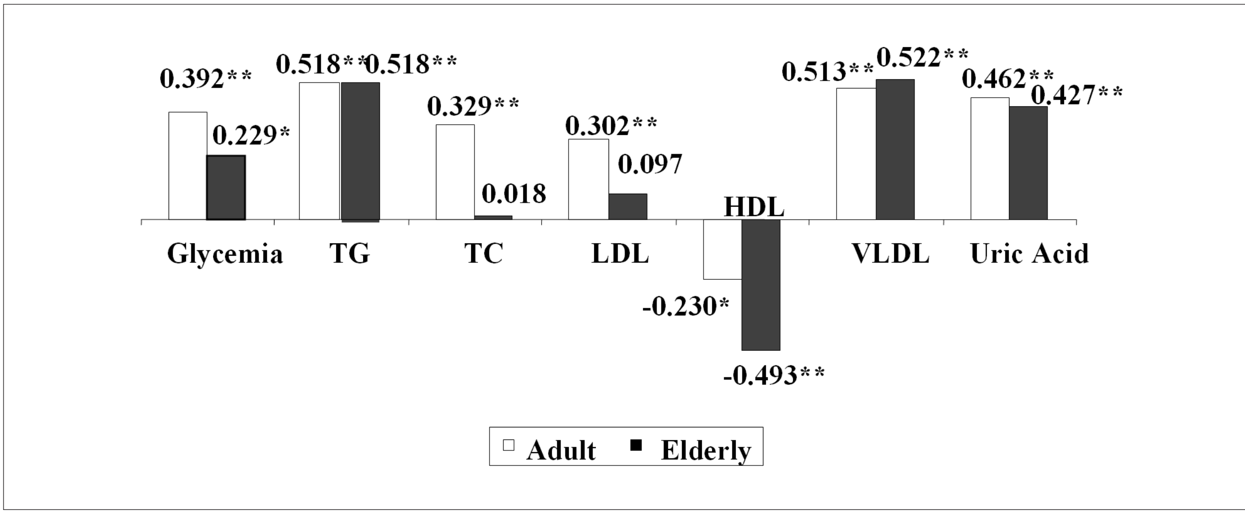

*Figure 1 - Coefficient of correlation between the biochemical tests and the VAT area according to the age range - Salvador, 2009. TG - triglycerides; TC - total cholesterol; LDL-c - low-density lipoprotein ; HDL-c - high-density lipoprotein; VLDL-c - very-low density lipoprotein. * p < 0.05; ** p < 0.01.*

observed a mean that was markedly higher (197.5 cm^2) than this cutoff; however, they did not stratify the participants by sex. Sampaio et al[26], evaluating adult and elderly Brazilians, identified a mean VAT area of 102.5 cm^2 for the male sex and 84.1 cm^2 for the female sex.

In the present study, the mean VAT area values were higher in the elderly group and a mean > 130 cm^2 was observed only in male elderly individuals. There is scientific evidence that, in both sexes, an increase in the amount of visceral adipose tissue occurs with age and that regardless of the body mass, the accumulation of visceral fat is more predominant in men than in women[27], although abdominal obesity is common in post-menopausal women[28].

The visceral adiposity associates with hypertriglyceridemia, decrease in HDL-c, adequate levels of LDL-c and increase in small and dense LDL-c[2], which increases the atherogenic risk in these individuals[3,29], characterizing a dyslipidemia with considerable risk of cardiovascular morbimortality[30, 31].

It is known that the visceral fat is highly lipolytic[8,27] and that one of the best known mechanisms is the direct draining to the liver through the portal system, leading to an excess flow of non-esterified fatty acids. Such phenomenon triggers a series of alterations, such as for instance, the overproduction of VLDL-c and, indirectly, of LDL-c, which can result in hypertriglyceridemia and hypercholesterolemia[28].

According to Wajchenberg[27], the visceral adipose tissue would have a limited capacity to prevent the fatty acids from reaching the hepatocytes, which can contribute to the metabolic abnormalities observed in the presence of visceral obesity.

The results of the present study showed that elderly women presented higher mean values of all biochemical tests, except HDL-c, when compared to the adult women. This result is expected, as this age group is more affected by factors that promote these metabolic alterations. The natural aging process associated to life habits, such as poor nutritional habits and sedentary lifestyle collaborates to the development of alterations in body composition and the metabolism of lipids and carbohydrates[32]. In addition to the aforementioned mechanisms, it is evident that the presence of diseases and stress can influence the levels of these tests, which are frequent conditions in elderly individuals[33].

Therefore, the interpretation of the biochemical assessments, especially the lipid profile, must be associated with complementary information on the aforementioned conditions. Among these, we highlight the use of medications, where, in this study, 56.8% of the individuals reported the use of some type of medication (data not shown), which might have influenced the observed results. However, although important, this variable was not considered due to the great difficulty to control it, especially among the elderly.

The strong correlation between the VAT area and the TG, VLDL-c and uric acid levels in adult and elderly individuals indicates a direct association between them; however, the specific mechanisms involved in this association are yet to be clarified. However, it is noteworthy the fact that TG represent 99.0% of the circulating fat and are substrates for the formation of VLDL. Thus, the increase in their levels is almost always accompanied by hypercholesterolemia[16].

On the other hand, an inverse correlation was observed between VAT area and HDL-c, which characterizes the most important cardioprotective factor, especially in elderly individuals, demonstrating its reverse effect for a VAT area considered as being of risk. Several studies have demonstrated the association between the serum levels of high-density lipoproteins (HDL-c) and cardiovascular disease. Decreased HDL-c levels are present in approximately 10.0% of the population and these individuals could be incapable of effectively eliminating the cholesterol excess from the vascular walls, contributing to the inflammatory process and characterizing the pathogenesis of atherosclerosis in its initial phases, in addition to having anti-atherogenic effects, such as anti-oxidant effects and others[34].

In spite of evidence that uric acid is considered a cardiovascular risk factor[23], there is no reference in the

Table 3 - **Means and standard deviation of VAT area, in relation to biochemical tests, according to the age range - Salvador, 2009**

	Adult	p-value	Elderly	p-value
Glycemia (mg/dl)				
< 100	79.42 (49.62)	0.032	128.07 (66.69)	0.008
≥ 100	114.91 (69.45)		176.87 (87.70)	
Triglycerides (mg/dl)				
< 150	72.40 (50.12)	0.000	124.30 (76.64)	0.003
≥ 150	116.45 (47.51)		172.23 (53.33)	
Total cholesterol (mg/dl)				
< 200	76.08 (55.62)	0.055	134.65 (83.91)	0.717
≥ 200	97.96 (43.83)		140.28 (67.37)	
LDL-c (mg/dl)				
< 160	83.14 (54.58)	0.921	132.45 (77.48)	0.175
≥ 160	85.08 (28.47)		156.41 (57.88)	
HDL-c (mg/dl)				
Male				
< 40	91.50 (37.32)	0.850	217.19 (68.84)	0.002
≥ 40	95.14 (65.19)		131.67 (84.41)	
Female				
< 50	75.89 (53.37)	0.713	158.24 (42.77)	0.004
≥ 50	70.68 (40.16)		109.55 (48.37)	
VLDL (mg/dl)				
< 50	81.65 (51.66)	0.138	135.91 (74.16)	0.205
≥ 50	121.76 (73.39)		178.94 (56.48)	
Uric Acid (mg/dl)				
Male				
Adequate	97.13 (58.15)	0.088	154.73 (85.51)	0.546
Inadequate	24.69 (0.55)		183.11 (130.98)	
Female				
Adequate	70.85 (43.34)	-	111.46 (47.60)	0.002
Inadequate	135.60 (-) *		174.35 (37.76)	

*VAT - visceral adipose tissue; LDL-c - low-density lipoprotein; HDL-c - high-density lipoprotein; VLDL-c - very-low density lipoprotein. (p < 0.05). *Only one case found.*

literature about the correlation between this biochemical variable and the visceral fat measured by CT, in addition to the fact that its mechanism is yet to be fully elucidated[23,35]. A hypothesis has been formulated, being that uric acid is related to hypertension, dyslipidemia and glucose metabolism impairment, being capable of having a causal function in the pathogenesis of cardiovascular disease and therefore, representing a risk marker for these diseases[36,37].

The present study showed that TC and LDL-c presented a low correlation with VAT areain elderly individuals; however, the analysis was statistically significant. Nevertheless, there are no data in the literature that can explain such observation. On the other hand, there are studies that suggest assessing the cholesterol as an index and not separately, such as the TC/HDL-c ratio, considered a potent predictive indicator for coronary disease[38,39] due to the probability of high atherogenic effect[29].

Further studies are necessary to evaluate the correlation between the cholesterol levels and VAT area.

The mean VAT area levels were markedly higher than the value of 130 cm^2**,** when the cutoffs of TG and glycemia, in both adult and elderly individuals, and of uric acid, only in elderly women, were above those recommended as normal values[12-14].

In elderly individuals, when the cutoff values of HDL-c were < 40 mg/dl for men and < 50 mg/dl for women, the mean VAT area was also much higher than 130 cm^2. Nilsson et al[40] concluded that there is a significant association between decreased serum levels of HDL-c and cardiovascular morbimortality in men, but not in women and that elderly men with levels of HDL-c < 40 mg/dl deserve particular attention regarding the prevention of cardiovascular diseases.

When verifying that the VAT area mean was higher in elderly individuals of both sexes, the results suggest that the VAT area considered of risk for the onset of metabolic alterations in elderly individuals perhaps should be considered from a cutoff higher than that recommended for adult individuals, i.e., > 130 cm^2.

In conclusion, the present study confirms the importance of investigating the visceral adipose tissue, demonstrating that most of the biochemical parameters analyzed presented a strong correlation with the VAT area identified by CT in adult and elderly individuals and, among them, especially TG, VLDL-c and uric acid, which presented better correlations.

Considering that the VAT area and the values of this area related to metabolic alterations were higher in elderly individuals, it correct to affirm that a VAT area that establishes risk in these individuals seems to be higher than that in adults.

Thus, new investigations are necessary on this subject, including other age groups and different cutoffs for VAT area, to allow a better strategy for risk assessment and health-complication prevention.

However, it is necessary to acknowledge that the biochemical tests performed in the present study are indicators of risk for cardiovascular diseases and not of diagnosis. Hence, other variables must be considered in these assessments, such as the use of medications, pathologies, lifestyle, socioeconomic status and diet, as they are strongly associated with metabolic alterations.

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Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Study Association

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