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Glomerular filtration rate and its relationship with visceral and subcutaneous adiposity: a study with patients from Northeast Brazil

Tasa de filtración glomerular y su relación con la adiposidad visceral y subcutánea: un estudio con pacientes del noreste brasileño

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ABSTRACT

Objective: evaluate the relationship between visceral/subcutaneous adipose tissue (VAT/SAT) and glomerular filtration rate (GFR). Methods: A case series study was conducted with 146 male and female adult outpatients at a hospital in Northeast Brazil. VAT and SAT were quantified using computed tomography and GFR was estimated using the formula proposed by the CKD Epidemiology Collaboration. The conceptual model also considered socio-demographic, clinical, anthropometric and lifestyle variables. Results: Females accounted for 71.9% of the sample and mean age was 52.5±13.2 years. Mean body mass index indicated obesity in both sexes (men:30.4±5.9 kg/m^2; women: 31.6±6.1 kg/m^2). For the same mean age and BMI, men had more VAT and a higher VAT/SAT ratio. Mean GFR was similar between sexes and within the normal range. Simple linear regression analysis revealed that 21.8% of the reduction in GFR in males could be explained by the VAT/SAT ratio (p=0.002). Among females, both VAT alone and the VAT/SAT ratio were predictors of GFR reduction (r2=4.8%, p=0.025 and r2=5.3%, p=0.019, respectively). Conclusion: Mean VAT and VAT/SAT ratio were compatible with abdominal obesity in both sexes and were related to a reduction in GFR.

Key words: Abdominal obesity; Glomerular filtration rate; Kidney disease; Visceral fat.

RESUMEN

Objetivo: Evaluar la relación entre el tejido adiposo visceral (TAV) y subcutáneo (TAS) con la tasa de filtración glomerular. Métodos: Estudio tipo serie de casos, en 146 pacientes adultos de ambos sexos, atendidos en un ambulatorio de un hospital de referencia en el Nordeste brasileño. El TAV y el TAS se cuantificaron por tomografía computadorizada y la tasa de filtración glomerular (TFG) estimada por la fórmula del grupo Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI). El modelo conceptual también consideró variables sociodemográficas, clínicas, antropométricas y de estilo de vida. Resultados: Pacientes con edad promedio de 52,5 ± 13,2 años y el 71,9% de sexo femenino. El promedio del IMC en ambos sexos se encuentra en el rango de obesidad (hombres= 30,4 ± 5,9 kg/m^2 vs mujeres= 31,6 ± 6,1 kg/m^2). Para un mismo promedio de edad e IMC, los hombres presentaron mayor TAV y mayor razón TAV/TAS que las mujeres. El promedio de la TFG fue similar entre los sexos y se encuentra en el rango normal. A través de regresión lineal simple, se evidenció que, en el sexo masculino, la disminución de la TFG puede explicarse en el 21,8% por la razón TAV/TAS (p=0,002). En el sexo femenino, tanto el TAV aislado como la razón TAV/TAS fueron predictores de disminución de la TFG (r2= 4,8%; p=0,025 e r2= 5,3%; p=0,019), respectivamente. Conclusión: Se evidenciaron valores muy elevados de los parámetros antropométricos de obesidad abdominal y promedio de TAV y de la razón TAV/TAS compatible con obesidad visceral en ambos se-

xos, siendo que estos dos últimos parámetros estuvieron relacionados al descenso de la TFG.
Palabras clave: Enfermedad renal; Grasa visceral; Obesidad abdominal; Tasa de filtración glomerular.

INTRODUCTION

Chronic kidney disease (CKD) is a public health problem affecting around 10% of the world's population[1,2], with the highest overall incidence in low- and middle-income countries[3]. At the same time, obesity is growing exponentially, affecting more than 600 million people[4].

Obesity is possibly a strong risk factor with a direct impact on the development of CKD[2]. Studies suggest that, in addition to obesity, localized fat in the abdominal region is an important factor for renal dysfunction[5,6,7]. Total abdominal adipose tissue includes visceral adipose tissue (VAT) and subcutaneous adipose tissue (SAT), which are predictors for different health outcomes. VAT is the component that exerts the greatest deleterious effects on metabolic and hemodynamic parameters[8,9,10]. Madero et al. demonstrated that VAT is significant association with renal function decline and risk of developing CKD[11]. Moreover, beyond the abdominal cavity, adipose tissue stored in ectopic locations outside of subcutaneous tissue such as in muscle, is also associated with kidney function decline[11,12].

Although it is well known that global obesity and abdominal obesity increase the risk of hypertension (HT) and diabetes mellitus (DM), which are the main causes of CKD[13], studies suggest the involvement of other metabolic pathways relating excess body fat and visceral fat to higher risk of CKD[14]. In this regard, the association between abdominal fat and CKD is not fully elucidated, especially in populations in developing countries, such as Brazil, where studies are scarce. Thus, this study aims to evaluate the relationship between abdominal fat components (visceral and subcutaneous fat) and renal function in outpatients in Northeast Brazil.

METHODS

Study population

This was an observational, case-series study conducted with 146 patients at a general nursing outpatient clinic of a public university hospital that is a reference hospital for cardiology in the Brazilian Northeast in 2013.

The sample was designed based on voluntary participation and included individuals of both sexes, aged ≥20 years, without previous diagnosis of CKD. Patients were invited at the first consultation with a nutritionist.

We excluded individuals with hepatomegaly and/or splenomegaly, ascites, recent abdominal surgery, pregnant women, and women who had children ≤6 months prior to the survey because these characteristics could influence the measurement of intra-abdominal fat and/or anthropometric measurements. In addition, we also considered ineligible individuals, those with physical limitations, which could prevent anthropometric measurements. Patients with acute kidney injury were also excluded from this study.

The sample size was calculated assuming a 5% α error, a β error of 20%, an estimated average correlation between the VAT/SAT ratio and GFR of 0.6 (p) and a variability of 0.12 (d2). Using the formula $n = [(Z\alpha / 2 + Z\beta / 2) 2 \times (p \times (1 - p)]/d^2$, the minimum sample size of 131 individuals was obtained. To correct possible losses, that number was increased by 15%, for a total sample of n= 151.

Evaluation of visceral and subcutaneous adipose tissue

VAT was evaluated by computed tomography, without contrast, of the abdomen, performed at the medical care service by a single observer trained in the study protocol. The examination was performed after a four-hour fast with the patient in a supine position. The tomographic cut was obtained with the following radiographic parameters: 140 kV and 45 mA at the level L4 and thickness of 10 mm. Total abdominal fat area and VAT were manually determined by a radiologist using free cursor circumventing each region. VAT area was measured considering as limits the inner edges of the rectus abdominis, internal oblique and quadratus lumborum muscles, excluding the vertebral body and including retroperitoneal, mesenteric and omental fat. SAT was then calculated by subtracting the VFA from total abdominal fat area. All fat areas were expressed in cm^2. To identify the adipose tissue, density values of -50 and -250 Hounsfield units were used[15,16].

A visceral fat volume greater than 130 cm^2 represented visceral obesity diagnosis[16,17]. However, due to a lack of individuals within the normal range, these values were divided into tertiles. The value equal to or greater than the third tertile was considered as the cutoff point: VAT ≥ 284 and 380 cm^2 and SAT ≥ 545 and ≥ 485 cm^2 for women and men, respectively. A VAT/SAT ratio ≥ 0.4 was considered the cutoff point to indicate individual predisposition to accumulate visceral fat[18].

Evaluation of renal function

To assess renal function, the estimated glomerular filtration rate (GFR) was calculated using the formula of the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI)[19]. The cut-off point considered for renal function changes in most studies is GFR < 60 ml/min/1.73 m^2[19,20,21].

Socio-demographic, anthropometric and clinical evaluations

Socio-demographic data (age, gender, years of study) and anthropometric data (weight, height, waist circumference, hip circumference) were collected. Body weight and height of patients were measured using techniques recommended by Lohman, Roche and Martorell[22]. A platform scale with a capacity of 150 kg (100 g precision) and a coupled stadiometer with a precision of 1 mm were used. Weight and height values were used for the calculation of body mass index (BMI), and a value of ≥30.0 kg/m^2 was used for the diagnosis of obesity[23].

Abdominal circumference (AC) and hip circumference (HC) were measured using a non-extendible measuring tape in accordance with the norms recommended by the World Health Organization[23]. Abdominal obesity was defined in this study as AC >102 cm for men and >88 cm for women, which represents very high risk[23].

All measurements were collected in duplicate by a single observer and repeated when the measuring error among them was greater than 0.1 cm (stature, AC and HC) or 0.1 kg (weight). The final measurement was the average between the two closest values. Waist-to-height ratio (WHtR) was calculated by the relation between AC (cm) and height (cm). Waist-hip ratio (WHR) was determined by the division of AC (cm) and HC (cm).

We also considered the presence of clinical co-morbidities such as HT and DM when the patient reported a previous diagnosis made by a physician, used antihypertensive and/or hypoglycemic drugs, respectively, and/or there was a record of it in the medical record.

Statistical analysis

Data were analyzed using the software Statistical Package for Social Sciences (SPSS), version 13.0 (SPSS Inc., Chicago, IL, USA). Continuous variables were tested for distribution normality by the Kolmogorov Smirnov test and, as if they presented a normal distribution, were expressed as mean and standard deviation and compared using the Student t test. For description of proportions, the binomial distribution was approximated to the normal distribution by a 95% confidence interval. Pearson's linear correlation was used to evaluate the correlation between GFR and visceral, subcutaneous and anthropometric fat parameters. Proportions were compared using Pearson's Chi Square test or by Fisher Exact test. A simple linear regression was used to evaluate the explanatory power of VAT, SAT and VAT/SAT ratio in relation to GFR. The statistical significance was defined as $p<0.05$.

The protocol of this study was guided by the ethical standards for research involving humans provided for in the Resolution no. 466/12 of the National Health Council and was submitted to the Research Ethics Committee for Research with Humans of the University of Pernambuco. It was approved under the protocol no. 271.400/2013.

RESULTS

We evaluated 146 patients with a mean age of 52.5 ± 13.2 years, 71.9% of whom were female. Mean BMI was within the obesity range for both sexes. The prevalence of HT and DM was 56.9% and 25.0%, respectively, being similar for both sexes.

Table 1 shows that, for similar average age and BMI, males had higher mean values of VAT and VAT/SAT ratio. In addition, mean GFR was similar for both genders and was within the normal range: 2.8% of patients presented an GFR < 60ml/min/1.73 m^2 (data not shown in table 1).

Correlations between GFR, abdominal fat tissue components and anthropometric variables are presented in table 2. In females, GFR was negatively correlated with VAT (r= -0.22, p= 0.025), VAT/SAT ratio (r= -0.23, p= 0.019) and WHR (r= -0.23; p= 0.023). Among men, GFR was negatively correlated with VAT/SAT ratio (r= -0.47, p= 0.002) (Table 2).

We observed that patients with a VAT ≥ third tertile had a lower mean GFR, a great frequency of DM and HT, were older and had higher mean values of anthropometric parameters

Table 1. Characteristics of the sample (mean plus standard deviation) according to the gender of outpatients in a hospital in the Brazilian Northeast (2013).

Parameters	Males (n= 41) Values	Females (n= 105) Values	p
Age (years)	52.8 (13.9)	52.4 (13.0)	0.859
Years of study	10.4 (4.22)	10.0 (4.24)	0.682
HAS, n (%)	25.0 (30.5)	57.0 (69.5)	0.667
DM, n (%)	9.0 (25.0)	27.0 (75.0)	0.749
BMI (kg/m^2)	30.4 (5.90)	31.6 (6.12)	0.304
WHtR	0.631 (0.111)	0.625 (0.114)	0.405
WHR	1.05 (0.143)	0.924 (0.121)	< 0.001
AC (cm)	106 (15.2)	100 (13.4)	0.024
TAFA (cm^2)	787 (224)	754 (179)	0.355
VAT (cm^2)	331 (115)	251 (78.9)	< 0.001
SAT (cm^2)	457 (165)	502 (155)	0.124
VAT/SAT ratio	0.784 (0.305)	0.544 (0.213)	< 0.001
eGFR (ml/min/1.73 m^2)	104 (21.0)	103 (18.1)	0.913

BMI: Body mass index; WHtR: waist-to-height ratio; WHR: waist-hip ratio; AC: abdominal circumference; TAFA: total adipose tissue; VAT: visceral adipose tissue; SAT: subcutaneous adipose tissue; eGFR: Estimated glomerular filtration rate according to the CKD-EPI (Chronic Kidney Disease Epidemiology Collaboration). p-value: Student t test (for means) and Chi-square (for proportions).

(BMI, AC, WHR, and WHtR). In relation to SAT, patients in the highest tertile were younger, had more education, higher mean BMI, AC and WHrT, and a higher average GFR (Table 3).

Comparative analysis of demographic, anthropometric and clinical variables with the VAT/SAT ratio evidenced that individuals with a higher predisposition for visceral fat accumulation (VAT/SAT ratio ≥ 0.4) were older, had a higher proportion of HT, lower BMI, lower WHtR, lower AC and lower GFR (Table 4).

To explain the relationship between GFR and abdominal fat compartments, we performed a simple linear regression and found that, in males, the decrease in GFR could be explained in 21.8% of cases by the VAT/SAT ratio; for females, both VAT and VAT/SAT ratio were associated with a decrease in GFR (r^2= 4.8% and r^2= 5.3%, respectively) (Table 5).

Table 2. Pearson's correlations between estimated glomerular filtration rate (GFR), abdominal fat components and anthropometric variables, according to sex and age, among outpatients from a hospital in Northeast Brazil, 2013.

FEMALE (n= 105)	**VAT**		**SAT**		**VAT/SAT ratio**		**BMI**		**AC**		**WHtR**		**WHR**	
GFR	-0.22	0.025	0.12	0.214	-0.23	0.019	0.05	0.590	-0.06	0.524	-0.20	0.050	-0.23	0.023
MALE (n= 41)	**VAT**		**SAT**		**VAT/SAT ratio**		**BMI**		**AC**		**WHtR**		**WHR**	
GFR	-0.28	0.078	0.30	0.055	-0.47	0.002	0.23	0.156	0.07	0.686	0.01	0.940	-0.21	0.204

* GFR: Estimated glomerular filtration rate according to the CKD-EPI (Chronic Kidney Disease Epidemiology Collaboration); BMI: Body mass index; AC: abdominal circumference; WHtR: waist-to-height ratio; WHR: waist-hip ratio; VAT: visceral adipose tissue; SAT: subcutaneous adipose tissue.

Table 3. Comparative analyses of demographic, anthropometric and clinical variables according to visceral (VAT) and subcutaneous adipose tissue (SAT) tertile in adults recruited from an outpatient clinic in Northeast Brazil (2013).

Variable	**VAT**			**SAT**		
	1st and 2nd tertile (n= 98)	**3rd tertile** (n= 48)**	**p-value**	**1st and 2nd tertile (n= 97)**	**3rd tertile*** (n= 49)**	**p-value**
Female (n, %)	70.0 (71.4)	35.2 (72.9)	0.851	70.2 (72.2)	35.4 (71.4)	0.926
Age, years (mean/SD)	51.1±14.1	55.4±10.6	0.046	55.1±13.0	47.4±12.0	0.001
Hypertension (n, %)	50.3 (51.4)	32.4 (68.1)	0.060	54.1 (56.3)	28.3 (58.3)	0.812
Diabetes (n, %)	18.5 (18.6)	18.3 (38.3)	0.010	25.1 (26.0)	11.3 (22.9)	0.683
Years of study (mean, SD)	10.3±4.22	9.8±4.13	0.536	9.41±4.53	11.6±2.94	0.001
BMI, kg/m² (mean, SD)	29.7±13.3	34.4±5.72	<0.001	28.3±4.33	37.0±4.6	<0.001
AC, cm (mean, SD)	97.9±13.3	111±11.6	<0.001	96.0±11.8	114±10.0	<0.001
WHR (mean, SD)	0.951±0.101	1.043±0.09	<0.001	0.933±0.121	0.922±0.143	0.801
WHtR (mean, SD)	0.599±0.135	0.697±0.143	<0.001	0.604±0.100	0.700±0.111	<0.001
eGFR, ml/min/1.73 m² (mean, DP)	108±19.9	99.0±15.6	0.048	101±19.9	109±17.6	0.016

*BMI: Body mass index; AC: abdominal circumference; WHR: waist-hip ratio; WHtR: waist-to-height ratio; eGFR: estimated glomerular filtration rate according to the CKD-EPI (Chronic Kidney Disease Epidemiology Collaboration); **3rd VAT Tertile for men: > 380.7 cm²; 3rd VAT tertile for women: > 284.2 cm². ***3rd SAT tertile for men: > 485.2 cm²; 3rd SAT tertile for women: > 545.6 cm²; p-value: *Student's t test to compare means and Chi square test to compare proportions.

Table 4. Comparative analyses of demographic, anthropometric and clinical variables according to ratio between visceral and subcutaneous adipose tissue (VAT/SAT) in adults recruited from an outpatient clinic in Northeast Brazil (2013).

Variable	VAT/SAT ratio		p-value
	< 0.4 n = 32	≥ 0.4 n = 114	
Female (n, %)	26.2 (81.3)	79.2 (69.3)	0.184
Age, years (mean/SD)	46.0 ± 13.8	54.4 ± 12.5	0.001
Hypertension (n, %)	13.0 (40.6)	69.5 (61.6)	0.035
Diabetes (n, %)	7.25 (21.9)	29.5 (25.9)	0.643
Years of study (mean, SD)	11.3 ± 3.63	9.81 ± 4.25	0.086
BMI, kg/m^2 (mean, SD)	34.2 ± 5.73	30.4 ± 5.89	0.002
AC, cm (mean, SD)	106 ± 11.9	101 ± 14.5	0.056
WHR (mean, SD)	0.921 ± 0.143	0.879 ± 0.121	0.057
WHtR (mean, SD)	0.701 ± 0.123	0.630 ± 0.100	0.022
eGFR (mean, SD)	112 ± 19.5	101 ± 18.0	0.003

*BMI: Body mass index; AC: abdominal circumference; WHR: waist-hip ratio; WHtR: waist-to-height ratio; GFR: estimated glomerular filtration rate according to the CKD-EPI (Chronic Kidney Disease Epidemiology Collaboration); p-value: *Student's t test to compare means and Chi square test to compare proportions.

Table 5. Simple linear regression between visceral adipose tissue (VAT), subcutaneous adipose tissue (SAT) and VAT/SAT ratio and glomerular filtration rate estimates in adults attended in an outpatient clinic in a hospital in Northeast Brazil (2013).

	Male (n= 41) eGFR				
Variable	**B**	**Standard error**	**β**	**p-value***	**r²****
VAT	-1.545	0.853	-0.282	0.078	7.9
SAT	2.112	1.068	0.305	0.055	9.3
VAT/SAT ratio	-0.077	0.002	-0.467	0.002	21.8
	Female (n= 105) eGFR				
Variable	**B**	**Standard error**	**β**	**p-value***	**r²****
VAT	-0.945	0.416	-0.220	0.025	4.8
SAT	1.036	0.829	0.123	0.214	1.5
VAT/SAT ratio	-0.003	0.001	-0.230	0.019	5.3

*Wald test. **Coefficient of determination in %. eGFR: Estimated glomerular filtration rate according to the CKD-EPI (Chronic Kidney Disease Epidemiology Collaboration).

DISCUSSION

The data presented here evidence a certain specificity because they were obtained from a sample of individuals who sought nutritional care in a public reference hospital in cardiology, which explains the high proportion of DM and HT in addition to BMI averages within the range of obesity for both sexes. In addition, very high values of anthropometric parameters, VAT and VAT/SAT ratio were evidenced, representing a population with a high level of global, abdominal and visceral adiposity. These last two parameters were related to lower GFR.

Abdominal obesity has been related to lower GFR and to a greater decrease in this rate over the years[6,7]. In this study, the mean value of GFR was within the normal range, and the percentage of individuals with an GFR < 60 ml/min/1.73 m^2 was 2.8%. This low percentage of individuals with a possible diagnosis of CKD may relate to the exclusion criteria that included patients with a previous diagnosis of this disease. That is, the purpose of this study was to assess whether patients with high levels of adiposity already had some indications of early-stage renal damage. It is important to consider that these patients with a reduction in GFR do not necessarily correspond to patients with CKD, since the criteria for diagnosis and other markers of renal damage were not evaluated.

In our study, we also observed that patients with VAT ≥ 3rd tertile were older and had a lower mean GFR. The literature shows that as individuals age, changes in body composition occur, so that fat-free mass decreases and fat mass generally increases. Fat is stored in visceral and intramuscular compartments, rather than subcutaneously, as in young adults[24]. Therefore, age is an important variable predicting the accumulation of VAT[25].

Obesity leads to glomerulomegaly, segmental glomerulosclerosis and obesity-related glomerulopathy[26,27,28]. In a study with 6,475 participants without DM, increased BMI and AC were associated with lower GFR and higher frequency of CKD[29]. Abdominal obesity, defined as AC >102 cm for men and >88 cm for women, was associated with an increased risk of kidney disease (OR 1.4), even after adjustment for other components of the metabolic syndrome, such as dyslipidemia, hyperglycemia and HT[29]. In South Korea, Evangelista et al., in a cohort from 2008 to 2014, found that the prevalence of general obesity and abdominal obesity was highest in stage 2 CKD and stage 3a was significantly associated with abdominal obesity. Furthermore, the association between general obesity/abdominal obesity and CKD disappeared in the more advanced stages of kidney disease[30].

Although it is well known that global obesity and abdominal obesity increase the risk of HT and DM, which are the main causes of CKD[11], studies suggest the involvement of other metabolic pathways, which independently relate to excess body and visceral fat and higher risk of CKD[14].

Few studies have evaluated the influence of abdominal fat components on the risk of declining renal function. It has been shown that the accumulation of VAT may cause renal compression with a consequent increase in intrarenal pressure[31], thus increasing sodium chloride (NaCl) reabsorption by the Henle loop, reducing the amount of NaCl reaching the macula dense[32]. This process can cause, via tubuloglomerular feedback, to a reduction in the afferent arteriolar resistance and increases in renal blood flow, GFR and renin secretion in order to restore the sodium balance. Such compensatory mechanisms may also lead to increased glomerular wall tension and hypertrophy, changes that may cause renal damage, glomerulosclerosis and, ultimately, nephron loss[33].

A recent study evaluating men and women from the U.S. with a mean age of 74 ± 3.0 years showed that SAT, VAT, BMI and WC were all significantly associated with a decline in kidney function and that only VAT remained a significant risk factor for incident CKD after adjustment for possible confounding factors[11].

In our investigation, low GFR was observed for patients with higher VAT/SAT ratio values. Lee et al.[34], evaluated 425 Korean women without a CKD diagnosis, HT, DM or CVD, and compared clinical and metabolic characteristics with VAT/SAT ratio ≥ 0.4 and < 0.4. Authors found that women who had a VAT/SAT ratio ≥ 0.4 were older, had a higher AC, higher blood pressure, higher fasting blood glucose and lower GFR. When evaluating the correlation between VAT and eGFR the same authors found a negative correlation, similar to the findings of our study. Kim et al.[35], evaluating 929 diabetics with a mean age of 55 years, recruited from a hospital in South Korea, also found a negative correlation (r= -0.158; p= 0.001) between VAT and GFR, whereas SAT was not correlated with lower GFR.

VAT/SAT ratio seems to provide information independent from measurements of generalized or abdominal adiposity. The absolute amount of VAT seems to say little about the relative distribution of abdominal tissue36 and does not reflect a predisposition to visceral or subcutaneous fat storage. Therefore, to estimate the predisposition to visceral accumulated fat, Kaess et al.[36], suggests the VAT/SAT ratio as a more relevant metric for abdominal fat composition and thus a better predictor of cardiometabolic changes[36,37,38]. However, there are few studies evaluating this ratio in relation with renal dysfunction. Lee et al.[34], studying apparently healthy Korean women, found that for a VAT/SAT ratio ≥ 0.4, lower GFR was observed.

In our study, the results of simple linear regressions showed that, for males, the VAT/SAT ratio explained 21.8% of the decrease in GFR. For females, VAT explained 4.8% and the VAT/SAT ratio explained 5.3%. Lee et al.[34], conducting a multiple linear regression analysis, found that VAT accounted for 29% of the decrease in GFR in Korean women. Such high results, when compared to ours, may possibly be explained by ethnic differences. Of course, our results should be carefully evaluated, given the limitations of the study described in the paragraphs below.

Race is an important aspect to be considered in the

analysis of body composition, and different results in distinct populations may be partially explained by this aspect. The Brazilian population has specific racial characteristics marked by a complex miscegenation. Therefore, results of studies conducted with other ethnic groups should not be generalized to all populations. This reinforces the need for more studies on the components of the abdominal adipose tissue with the Brazilian population, where they are still very scarce.

The cross-sectional nature of our study also limits the determination of causality between VAT and renal function deterioration. In addition, this study was conducted in a single center; therefore, the generalization of our results to other population groups should be interpreted with caution. In addition, it is important to consider that the changes in glycemia and blood pressure were not evaluated, considering only self-reported diagnosis. The absence of these data may have influenced the findings.

It is difficult to determine VAT in the population and more studies are needed to define simple and population-based methods for the quantification of VAT, as well as predictive equations to estimate the VAT/SAT ratio which can be used for the screening of CKD at early stages.

CONCLUSION

Considering the importance of visceral obesity in the genesis of several co-morbidities, we have demonstrated the importance of accumulating more evidence on the role of VAT as a marker for decreases in renal function to reach more definitive conclusions.

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