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# Anthropometric clinical indicators in the assessment of visceral obesity: an update

## Indicadores clínicos antropométricos na avaliação da gordura visceral: uma atualização

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### ABSTRACT

**Introduction**: Visceral obesity is associated with an increased risk of metabolic disorders and occurrence of chronic diseases. The quantification of the visceral fat becomes necessary and advantageous in clinical practice, especially through accurate and precise methods in replacement of imaging methods as computed tomography (CT).

**Objective**:To present the use of anthropometric indicators that have been linked to visceral fat.

**Methods**: The selection of items was taken in from Scopus, Scielo, Lilacs, CAPES journals, PubMed/MEDLINE and Google Scholar, in the period between 2007 and 2014. Anthropometric and clinical indicators as waist circumference (WC), waist- to- height ratio (WHtR), waist-to- thigh ratio (WTR), waist- to- hip ratio (WRH), sagittal abdominal diameter (SAD), abdominal diameter height index (SAD/ Height), abdominal diameter index (ADI), conicity index (CI), visceral adiposity index (VAI) and the lipid accumulation production (LAP) were investigated for their relationship with visceral fat measured by CT.

**Results**: Most indicators have strong correlation ($r>0.70$) with visceral fat. It was observed that there are few recent studies evaluating this relationship, especially with the indices derived of the WC and the SAD, besides the LAP and the VAI. Most studies investigated the relationship between these indicators with the diseases that are consequent of the visceral obesity.

**Conclusion**: The clinical anthropometric indicators are accurate in estimating visceral obesity, easy to use and has low cost enabling clinical nutritional assessment able to intervene earlier and more effectively in the prevention and/or treatment of this obesity.

### KEYS WORDS

Anthropometry, waist circumference, sagittal abdominal diameter, computed tomography, abdominal obesity.

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## RESUMO

**Introdução**: A obesidade visceral está associada a um risco maior de distúrbios metabólicos e ocorrência de doenças crônicas. A quantificação da gordura visceral torna-se necessária e vantajosa na prática clínica, sobretudo por métodos acurados e precisos em substituição aos métodos por imagem, como a tomografia computadorizada (TC).

**Objetivo:** Descrever a utilização de indicadores clínicos antropométricos que têm sido relacionados à gordura visceral.

**Métodos:** A seleção dos artigos foi feita no Scopus, Scielo, Lilacs, periódicos Capes, Pubmed/Medline e Google Acadêmico, no período entre 2007 e 2014. Indicadores clínicos antropométricos como circunferência da cintura (CC), Razão cintura altura (RCA), Razão cintura coxa (RCCx), Razão Cintura Quadril (RCQ), Diâmetro abdominal sagital (DAS), Diâmetro abdominal altura (DAS/ALT), Índice Diâmetro abdominal (IDA), Índice conicidade (IC), Índice de adiposidade visceral (IAV) e o Produto de acumulação lipídica (PAL) foram investigados quanto sua relação com o tecido adiposo visceral medido pela TC.

**Resultados:** A maioria dos indicadores tem forte correlação (r>0.70) com a gordura visceral. Observou-se que há poucos estudos recentes que avaliaram essa relação, sobretudo com os índices derivados da CC e do DAS, além do PAL e o IAV. A maioria dos estudos investigou a relação entre esses indicadores com as doenças que são consequentes da obesidade visceral.

**Conclusão**: Os indicadores clínicos antropométricos são acurados na estimativa da gordura visceral, fáceis de utilizar e apresentam baixo custo possibilitando uma tomada de decisão na avaliação clínica nutricional capaz de intervir mais precoce e efetivamente na prevenção de risco de doenças.



## PALAVRAS CHAVES

Antropometria, circunferência da cintura, diâmetro abdominal sagital, tomografia computadorizada, obesidade abdominal.


## ABBREVIATIONS

ADI: Abdominal Diameter Index.

AUC- ROC: Area under curve- Receiver Operating Characteristic.

BMI: Body Mass Index.

CI: Conicity Index.

CT: Computerized Tomography.

CVD: Cardiovascular Disease.

HDL: High Density Lipoproteins.

LAP: Lipid Accumulation Production.

SAD: Sagittal Abdominal Diameter.

SAD/Height: Sagittal Abdominal Diameter Height Index.

TG: Triglyceride.

VAI: Visceral Adiposity Index.

VAT: Visceral Adipose Tissue.

WC: Waist Circumference.

WHR: Waist –to-hip Ratio.

WHtR: Waist-to- Height Ratio.

WTR: Waist-to-Thigh Ratio.

## INTRODUCTION

Visceral obesity is closely associated with insulin resistance, hypertension, dyslipidemia, type 2 diabetes and with the high risk of cardiovascular diseases and mortality[1,2]. Studies have been reporting that the distribution of the body fat is more important than the amount of fat itself, since abdominal adiposity, especially the visceral one, is having a more expressive association with the increase of those morbidities[3].

It is important to consider that, independently of overweight, individuals may have visceral obesity represented by the deposition of visceral adipose tissue. The more accurate methods for quantifying visceral fat are the ones using image, such as magnetic resonance and computed tomography (CT). CT, the comparison method of this work, is considered to be the "golden-standard", able to precisely distinguish visceral fat from subcutaneous fat in any body region. One of the reasons for that is due to its high reproductability[4,5]. However, its high cost, the need of sophisticated equipment, specialized people and the exposition of the individual to radiation are the main limitations for its use in the practice routine and in epidemiological studies[5].

This way, anthropometry is considered like an alternative method for estimating visceral fat, by indicators such as Waist Circumference (WC) and the Sagittal Abdominal Diameter (SAD), their respective indexes, Waist-to-Height Ratio (WHtR), Waist-to-Thigh Ratio (WTR), Conicity Index (CI), Sagittal Abdominal Diameter Height Index (SAD/Height), and the Abdominal Diameter Index (ADI), which are considered to be low cost, non-invasive and easy to measure[4,6]. The Lipid Accumulation Product (LAP) and the Visceral Adiposity Index (VAI) have been proposed as alternative parameters for evaluating the excess of lipids accumulation. Both include anthropometric and metabolic parameters[7-9].

There is no consensus about the anthropometric clinical indicator that better correlates or discriminates visceral fat, especially when measured by CT, in both sexes. Then, it becomes fundamental to have a better comprehension about the detection of visceral fat, because it is an advantageous and needed replacement in the evaluation and follow-up in the individual and collective clinical practice. The objective of this revision is to describe the use of anthropometric clinical indicators that have been related to visceral fat.

## METHODS

For the unsystematic revision, a search was performed in the databases: Scopus, Scielo, Lilacs, Periódicos from CAPES, PubMed/MEDLINE and Google Scholar. The following expressions were searched: abdominal fat, visceral fat, visceral obesity, abdominal obesity, visceral adipose tissue, waist circumference, sagittal abdominal diameter, Waist-to-Height Ratio, Waist-to-Thigh Ratio, Waist-Hip Ratio, Conicity Index, Sagittal Abdominal Diameter Height Index, Abdominal Diameter Index, Lipid Accumulation Product, Visceral Adiposity Index, Anthropometry and Computed Tomography. The search expressions were constructed combining those terms or using them in an isolated way.

The search criteria for selecting studies were: descriptors present in the title, abstract or subject, documents in paper format and full available version. Identified studies have been assessed according to the following inclusion criteria: (1)- population (adults and elderly), (2)- theme (visceral fat measured by CT and anthropometrics indicators) and (3)- quantitative approach**.**

Searches were limited to studies involving humans, of both sexes, over 18 years old, from any ethnical group, published in Portuguese, English and Spanish**,** and the publishing date was established between 2007 and 2014, besides the incorporation of previously published classic works about the theme. The references of the papers were also analyzed in order to find out studies that were not identified using the databases.

After selection, articles were read in full and those that were not within the established criteria were excluded from the study. For analysis of the studies, data was summarized in the tables as follows: work identification (author and year), location of the study and sample, and information about the anthropometrics clinical indicators and the computed tomography and results. According to the predetermined inclusion criteria, twelve papers were selected for comparison of studies evaluating the relationship between anthropometric clinical indicators and visceral fat measured by CT.

## RESULTS AND DISCUSSION

### *Visceral obesity*

Currently the interest about the original observation made by the French doctor Jean Vague [10] about the relation between abdominal obesity and development of chronic diseases is being renovated. Posteriorly, several studies pointed to an association between abdominal adiposity increase with several metabolic disorders and morbidities, especially cardiovascular diseases, showing the importance of the localization of fat in detriment of the total body obesity[3].

Therefore, the proof that there is a relation between the excess of abdominal fat tissue and co-morbidities such as hypertension, type 2 diabetes, arthritis, coronary artery disease, sleep apnea and some type of cancer is not recent. This phenomenon is normally verified at any level of total body adiposity[2,3,11].

It is increasingly notorious the notion that visceral obesity may be a dysfunctional marker of subcutaneous adipose tissue leading to the deposition of ectopic fat (undesirable lipid accumulation in the heart, liver, skeletal muscle and pancreas)[2].

Abdominal adipose tissue is a complex organ that may be divided into compartments such as subcutaneous and intra abdominal (or visceral) and this last one into intraperitoneal (or portal) and retroperitoneal, followed by mesenteric and omental sub-compartments[12]. However, between those compartments, the visceral adipose tissue is considered to be the highly metabolically active risk marker with greater expressivity for development of the mentioned events.

From the mechanisms through which visceral obesity may influence the increase of metabolic and cardiovascular risk the highlights are the intense lipolytic activity, its large adipocytes responsive to lipolytic enzymes and partially resistant to insulin, determining an inappropriate and excessive release of free fatty acids in the portal circulation, finally, triggering a cascade of alterations that lead to diabetes, hypertension, production of inflammatory cytokines and disorders in the serum lipid profile[13].

Age, sex, genetics and ethnicity are huge etiological factors contributing for the variation in the accumulation of visceral adipose tissue. It has been evidenced that the commonly used methods to measure body fat are not able to predict the visceral fat in the same way. The quantification or estimative of visceral fat is necessary for nutritional clinical evaluation and several methods and techniques have been developed to evaluate it.

## *Methods related with the evaluation of visceral FAT*

The more clinically convenient for evaluating visceral fat are the methods that may be performed quickly, simply, noninvasive and of low cost, such as the anthropometry. Table 1 presents the main characteristics of anthropometric clinical indicators which were studied in this paper.

Table 2 has the resume of studies which observed the relation between the nutritional clinical indicators and visceral fat when measured by CT.

## *Waist circumnference*

The measurement of waist circumference is widely used and has been recommended for estimating the proportion of abdominal adipose tissue. WC also has the advantage of being simple and having strong correlation with body mass index and with visceral fat. Its main limitation consists of the different measuring techniques, which require proper training, especially in very obese individuals. With regards to the different tech-

**Table 1.** Resume of the main characteristics of the anthropometric clinical indicators.

| Anthropometric clinical indicators | Main characteristics |
|---|---|
| **Waist Circumference (WC)** | - Evaluates cardiovascular risk and visceral obesity and is one of the criteria for Metabolic Syndrome. |
| **Waist-to-Height Ratio (WHtR)** | - When WC is over half the value of the individual height, it expresses a health risk.<br>- Has discriminatory power for visceral obesity, cardiovascular risk, high coronary and mortality risk. |
| **Waist-to-Thigh Ratio (WTR)** | - Suggested as a replacement for the waist-height ratio<br>- Able to estimate visceral fat and its risks. |
| **Waist-to-Hip Ratio (WHR)** | - Indicator of fat distribution.<br>- Care must be taken when interpreting individuals with weight and corporal adiposity variations. |
| **Conicity Index (CI)** | - Able to identify fat distribution and the risk of diseases. |
| **Sagittal Abdominal Diameter (SAD)** | - Has discriminatory power for visceral obesity.<br>- Indicator of fat distribution. |
| **Sagittal Abdominal Diameter Height Index (SAD/Height)** | - Correlates with cardiovascular risk and may predict mortality.<br>- Has discriminatory power for visceral obesity. |
| **Abdominal Diameter Index (ADI)** | - Has discriminatory power for visceral obesity.<br>- Predictor of cardiovascular diseases. |
| **Lipid Accumulation Product (LAP)** | - Estimates over-accumulation of lipids.<br>- Expresses a continuous risk and is a predictor of cardiovascular diseases and mortality. |
| **Visceral Adiposity Index (VAI)** | -Expresses the function of visceral fat.<br>-Has correlation with cardiometabolic risk associated with visceral obesity. |

**WC:** Waist Circumference**; SAD:** Sagittal Abdominal Diameter; **WHR**: Waist Hip Ratio; **WHtR**: Waist-to- Height Ratio; **WTR**: Waist-to-Thigh Ratio; **SAD/Height**: Sagittal Abdominal Diameter Height Index; **ADI**: Abdominal Diameter Index; CI: Conicity Index; **LAP**: Lipid accumulation product; **VAI**: Visceral adipose index.

**Table 2.** Comparison of studies evaluating the relationship between anthropometric clinical indicators and visceral fat measured by computed Tomography.

| Studies | Anthropometric clinical indicators and visceral fat |
|---|---|
| **Sampaio et al (2007):** 92 Brazilians,> 20 years, both sexes. Excess VAT= 100cm². VAT measured at L4- L5 and WC at the midpoint | **WC**: M: r = 0,73 / F: r = 0,77 |
| | **WHR**: M: r = 0,58 / F: r = 0,72 |
| | **SAD**: M: r=0,64; AUC= 0,89 / F: r=0,80; AUC= 0,84 |
| **Kanda et al (2007):** 419 Japanese diabetic. VAT measured at L4- L5. Not reported technique for WC. | **WC**: M: r = 0,78 / F: r = 0,82 |
| **Demura & Sato (2007):** 112 Japonese, both sexes. VAT measured at L4-L5. WC: umbilical level. | **WC**: r=0,66 |
| | **WHR**: r=0,55 |
| **Bouza et al, (2008):** 108 obese, both sexes. VAT measured at L4- L5 and WC at the midpoint. | **WC**: r= 0,62 |
| | **WHR**: r= 0,61 |
| **Wu et al (2009):** 111 Chinese men (40 - 60 years). VAT measured at L4-L5. WC: umbilical level. | **WC**: r=0,823 |
| | **WHtR**: r= 0,868 |
| | **WHR**: r= 0,654 |
| **Berker et al (2010):** 104 both sexes. VAT measured at L4- L5 and WC at the midpoint. | **WC**: M: r = 0,84 / F: r = 0,867 |
| | **WHR**: M: r = 0,739 / F: r = 0,612 |
| **Gradmark et al (2010):**16 men and 13 Swedish women. VAT: L4 (single cut). WC: at the midpoint. | **WC**: r=0,85 |
| | **WHtR**: r= 0,81 |
| | **WHR**: r=0,81 |
| **Yim et al (2010):** 5257 Koreans, both sexes. TAV: measured at the umbilicus. WC: at the midpoint. | **WC**: M: r = 0,705 / F: r = 0,636 |
| | **SAD**: M: r = 0,804 / F: r = 0,724 |
| **Roriz et al (2011):** 197 Brazilians ≥ 20 years, both sexes. Excess VAT≥ 130cm². VAT measured at L4- L5. WC at the midpoint. | **WC:** M: r=0,75 in adults and r=0,77 in elderly/ F: r=0,75 in adults and r= 0,64 in elderly/ AUC > 0,80 |
| | **WHR**: M: r=0,69 in adults and r= 0,72 in elderly/ F: r=0,69 in adults and r= 0,49 in elderly |
| | **SAD**: M: r = 0,70 in adults and r=0,78 in elderly; AUC> 0,79/ F: r = 0,74 in adults and r=0,65 in elderly AUC> 0,84 |
| **Barreira et al (2012):** 2.037 individuals of a biracial sample (18-69 years). VAT at L4-L5. WC at the midpoint. | **WC:** r>0,61 |
| | **WHtR:** r>0,59 |
| | **WHR:** r> 0,50 |

**WC:** Waist Circumference; **SAD:** Sagittal Abdominal Diameter; **WHR**: Waist to Hip Ratio; **WHtR**: Waist-to- Height Ratio; **WTR**: Waist-to-Thigh Ratio; **SAD/Height**: Sagittal Abdominal Diameter Height Index; **ADI**: Abdominal Diameter Index; **CI**: Conicity Index; **VAI**: Visceral adipose index; **LAP**: Lipid accumulation product; **VAT**: Visceral adipose tissue area (cm²) measured by computed tomography. **M**: men and **F**: female. **AUC**: Area under curve ( ROC curve). All correlactions: p< 0,05.

**Table 2. continuación.** Comparison of studies evaluating the relationship between anthropometric clinical indicators and visceral fat measured by computed Tomography.

| Studies | Anthropometric clinical indicators and visceral fat |
|---|---|
| **Roriz et al (2014):** 194 Brazilians ≥ 20 years, both sexes. Excess VAT≥ 130cm². VAT measured at L4- L5. WC at the midpoint**.** | **WC**: M: r =0,76 in adults and r= 0,74 in elderly/ F: r=0,75 in adults and r= 0,60 in elderly |
| | **WHtR**: M: r =0,79 in adults and r= 0,79 in elderly/ F: r=0,73 in adults and r= 0,64 in elderly/ AUC > 0,81 |
| | **WTR**: M: r =0,64 in adults and r= 0,62 in elderly/ M: r=0,53 in adults and r= 0,35 in elderly |
| | **SAD:** M: r =0,70 in adults and r= 0,76 in elderly/F: r=0,75 in adults and r= 0,62 in elderly |
| | **SAD/Height**: M: r =0,78 in adults and r= 0,79 in elderly/ F: r=0,73 in adults and r= 0,64 in elderly/ AUC > 0,84 |
| | **ADI**: M: r =0,60 in adults and r= 0,66 in elderly/ F: r=0,67 in adults and r= 0,48 in elderly/ AUC > 0,73 |
| **Roriz et al (2014):** 191 Brazilians ≥ 20 years, both sexes. Excess VAT≥ 130cm². VAT measured at L4- L5. WC at the midpoint. | **WHtR**: M: r =0,79 in adults and r= 0,80 in elderly/F: r=0,73 in adults and r= 0,64 in elderly/AUC > 0,81 |
| | **CI**:M: r =0,68 in adults and r= 0,82 in elderly/ F: r=0,72 in adults and r= 0,47 in elderly |
| | **LAP**:M: r =0,70 in adults and r= 0,73 in elderly/ F: r=0,61 in adults and r= 0,60 in elderly/ AUC > 0,78 |
| | **VAI**: M: r =0,50 in adults and r= 0,56 in elderly/ F: r=0,38 in adults and r= 0,47 in elderly/ AUC > 0,65 |

**WC:** Waist Circumference; **SAD:** Sagittal Abdominal Diameter; **WHR**: Waist to Hip Ratio; **WHtR**: Waist-to- Height Ratio; **WTR**: Waist-to-Thigh Ratio; **SAD/Height**: Sagittal Abdominal Diameter Height Index; **ADI**: Abdominal Diameter Index; **CI**: Conicity Index; **VAI**: Visceral adipose index; **LAP**: Lipid accumulation product; **VAT**: Visceral adipose tissue area (cm²) measured by computed tomography. **M**: men and **F**: female. **AUC**: Area under curve ( ROC curve). All correlactions: p< 0,05.

niques for measuring it, a systematic review of 120 studies revealed that the place of measurement has no substantial influence over the association between WC, cardiovascular diseases, diabetes and mortality risk[14]. However, it is a consensus that the most used technique is the one recommended by the WHO, measured through the mean point between the last rib and the iliac crest[15,16].

Currently, this indicator has been receiving important attention in evaluating cardiovascular risk because it is a strong predictor of visceral fat with a correlation over 0.70 with VAT, being also one of the criteria to define the metabolic syndrome[17-19].

It may be observed, in Table 2, that Kanda et al.[20] and Sampaio et al.[18] studies show significant correlation between WC and VAT both for men (r > 0.73) as well as for women (r > 0.77). Studies with obese patients[21] and in Japanese people[22] observed correlation equal to 0.62 and 0.66 with visceral fat, respectively. Berker et al.[23] observed correlation over 0.84 for men and women, however when the sample by total body mass was stratified over or below 30kg/m² the correlations with visceral fat decreased.

In Roriz et al.[19] study there was positive correlation in adults and elderly, being more strong in elderly men (r=0.77). The cutoff points that identified a VAT area of risk (≥130cm²) were below the ones recommended by WHO[15] in men (adults = 90.2 cm and elderly = 82.2 cm) and over them among women (adult = 92.3 cm and elderly = 88.2 cm), concluding that the cutoff points of WC as a predictor of visceral obesity in elderly are lower than the ones in adults.

However using only the waist circumference may have an important limitation. For a given measurement of waist circumference, some individuals will have an increased amount of visceral fat, while in others the larger content may be subcutaneous, thus, not distinguishing visceral fat from the subcutaneous one[24]. Among women in advanced age, for the same WC, there is a larger amount of visceral fat than among younger women[6].

### *Waist– to- height ratio*

The value of WC will depend on the individual height in order to express a health risk. Thus, its interpretation must be judicious, especially when individually and isolatedly evaluated. Thus, by taking height into consideration, the Waist-to-Height Ratio seems to be better than WC for discriminating cardiometabolic risk, especially in individuals of short stature[25].

WHtR is determined by the ratio between WC (cm) and Height (cm), and is considered a simple, fast, low cost trial tool superior than BMI for evaluating health risks and mortality by cardiovascular disease (CVD) and for all the causes[26-28].

Despite the limitation represented by the absence of a specific cutoff point, the average value of 0.50 was suggested, allowing its use in both sexes, different age groups and ethnicities for predicting cardiometabolic risk[29-31]. This value has been used to support the simple message of public health "keep your waist circumference between the half of your height". However, a meta-analysis found that in non-Asian populations the ideal cutoff was higher than in Asian ones[25]. The different measurement techniques of WC and the height averages between the population would justify this variation.

Several studies showed discriminatory power of WHtR for different morbidities, mainly high cardiovascular and coronary risk as well as for mortality[6,30,32-34]. However, few studies evaluated the relation between WHtR and the VAT area measured by CT. Barreira et al.[17] in an study with 2037 individuals between 18 and 29 years old from a biracial sample verified correlations over 0.59 and Gradmark et al.[35] observed high correlations (r> 0.81) of WHtR and WC with the area of visceral fat measured by CT in Swedish adults. Wu et al.[36] showed that WHR was a stronger predictor of visceral fat than WC, BMI or WHtR in Chinese men. Studies in Brazil[37,38] observed strong correlation of WHtR with visceral fat, in adults and elderly of both sexes and showed that when WC was divided by height it had a better discriminatory power for detecting visceral obesity with cutoffs of 0.54 and 0.55 in men and of 0.59 and 0.58 in adult women and in elderly, respectively.

Among the mechanisms which explain the health risk previewed by WHtR it is suggested that the risk may be explained due to its strong association with elevations of abdominal obesity which trigger the mentioned morbidities.

### *Waist-to-thigh ratio*

The Waist-to-Thigh Ratio is found by dividing the waist circumference by the thigh circumference. It was suggested as a substitute of the Waist-to-Hip Ratio and able to estimate visceral fat and its respective risks[39]. WTR does not considers the proportionality regarding the stature, it may remain unchanged if there is a proportional increase or decrease in the measurement of its circumferences.

There are few studies comparing this index with WC alone. Most of the studies with WTR investigated its relationship with diseases in consequence of obesity and not with visceral fat as this work pretended. Roriz et al.[37] observed strong correlation of WTR with the visceral fat area, except in elderly women and good accuracy in discriminating the excess of this adiposity. Most of the studies related this indicator with other outcomings[40-42]. In a sample representing 11.437 american adults it was observed that WTR had the stronger association with mortality and that the increase in mortality risk of men was not specially related with increased WC, but with a relative decrease of the thigh circumference[43]. Reis et al.[44] showed that WTR and WHR increase the prediction of mortality in individuals with normal weight and in obese ones.

### *Waist-to-hip ratio*

The Waist-to Hip Ratio is determined by the division between waist circumference and hip circumference. It is an indicator used to identify the type of body fat distribution. Values above 1.00 for men and 0.85 for women indicate a distribution of the android type, central or abdominal, considered as risky for development of cardiovascular diseases due to the great concentration of fat in this region. Values above those cutoffs indicate a distribution of the gynaecoid type, peripheral or gluteal-femoral of smaller cardiovascular risk[45].

One of the main limitations for its practical use is its incapacity of detecting changes during the follow-up of individuals in treatment for weight loss, since the WC measurement varies simultaneously with the hip measurement, keeping WHR constant. Also, hip measurement does not considers variations in the pelvic structure between individuals, nor the reduction of tissues in this area with the aging process. There is, still, incapacity of WHR in differentiating accumulation of subcutaneous visceral fat[46]. Independently of body adiposity the individuals may have equal values of WHR, even with substantial inter-individual variation in the total body fat and in the areas of visceral and subcutaneous and visceral abdominal adipose tissue[47].

Several studies evaluated the correlation between WHR and visceral fat observing that in comparison with other anthropometric indicators, WHR had smaller correlation with this tissue[17-19,21-23,35,36]. The use of this indicator as a predictor of visceral fat must be cautious, mainly in individuals with variations of weight and body adiposity.

### *Conicity index*

Conicity index has the objective of identifying the distribution of fat and the risk of diseases. This index is based on the idea that the human body changes from a cylindrical shape to a "double cone" with the accumulation of fat around the waist and its theoretical range varies from 1.00 to 1.73. The CI is calculated by the following equation[48]: $WC/0.109\sqrt{(BW/H)}$ where: WC = waist circumference (m); BW = body weight (kg); H = height (m).

One limitation for using CI in epidemiological studies is the lack of consensus about cutoffs for identifying cardiovascular risk, besides the difficulty of calculation proposed by its formula. Pitanga & Lessa[49] proposed a table with values for the denominator of the CI equation for the ease of use.

This index increases according to the accumulation of abdominal fat increasing the risk of diseases[47]. Studies show that CI has been a good predictor of High Coronary Risk with the Area Under the ROC Curve of 0.80 (95% CI: 0.74-0.85) in men, of cardiovascular risk and hypertension in adults[49-51]. A study with 191 Brazilians[38] observed strong correlation and accuracy of CI with the area of visceral adipose tissue measured by CT, especially in adults (r= 0.68) and elderly (r=0.82) men and in adults women ( r= 0.72).

Despite existing a relationship between CI and the mentioned morbidities there is a lack of studies using the index as a predictor of visceral obesity.

### *Sagittal abdominal diameter*

Sagittal Abdominal Diameter may be measured anthropometrically or by image methods, such as CT. SAD has been appointed as an important anthropometric indicator for estimating visceral adipose tissue[18,19,52,53].

The measurement in supine position better estimates the fat tissues more associated with CVD risk, being this the more widely used technique by researchers. This technique is based in the principle that with individuals in this position the increase of visceral fat accumulation keeps the abdomen height in the sagittal position while subcutaneous abdominal fat reduces abdominal height due to the force of gravity[54].

From SAD other anthropometric indexes are derived, the ratio between SAD and height (SAD/Height) and the ratio between SAD and WTR or the Abdominal Diameter Index (ADI). SAD/Height has similar or superior correlation with cardiovascular risk when compared with WHR and may predict mortality as well as SAD[47,55]. ADI is considered as an effective indicator for estimating visceral adipose tissue, a better predictor of coronary disease than WTR and of risk for cumulative incidence of ischemic CVD[56,57].

However SAD has been studied more as an isolated measure of fat distribution than its indexes and, when related with the other anthropometric indicators or clinical parameters, shows to be superior as a measurement of visceral obesity and coronary disease index. Stevens et al.[58] suggested WC and SAD instead of BMI for evaluating the cardiovascular risk profile among individuals in different populations and ethnicities. Other studies show SAD as a marker of risk factors for CVD[53,59-61].

Sampaio et al.[18] carried the first study of SAD validation in Brazil and observed high reliability (inter-class coefficient = 0.99) and high correlation of this measure and abdominal visceral fat area measured by CT (r=0.80 for women and r=0.64 for men). Cutoffs of 19.3 cm and 20.5 were identified for men and women, respectively, with better sensibility and specificity corresponding to the area of visceral fat excess (> 100cm²). Another Brazilian study[19] with a larger sample observed correlations over 0.7 between SAD and visceral fat area and posteriorly SAD indexes were evaluated, with high correlation being observed between SAD/Height and

ADI and this fat, especially in men, with greater accuracy for SAD/Height (AUC-ROC > 0.84) showing better influence of height in SAD measurement for discriminating visceral obesity ( VAT area ≥ 130m²)[37].

Yim et al.[62] observed greater correlation of SAD with visceral fat than WC in 5,257 adult Koreans, in both sexes. Kullberg et al.[63] showed correlations over 0.78, however, visceral fat was measured by magnetic resonance and not CT, the focus of this study.

Although SAD and its indexes are simple and low cost methods, it is unlikely that they will replace the indicators that contemplate circumferences, measured by inelastic tape, of large applicability in clinical practice. Vasques et al.[64] in their revision study with some of those indicators verified that, generally, WC and SAD correlated more with visceral fat than BMI and WHR.

### *Lipidic accumulation product*

Lipidic Accumulation Product is a simple indicator developed to express a continuous risk and predictor of cardiovascular diseases and mortality and is obtained by formulas proposed by Kahn[9]. For the masculine sex, LAP = (CC[cm] – 65) × (triglycerides [mmol/L]) and feminine, LAP= (CC[cm] –58) × (triglycerides [mmol/L]). It estimates the over-accumulation of lipids and suggests that the values of WC and serum triglyceride (TG) are prone to accumulate along time, in other words, they express a function of constant risk associated with the cardiovascular risk among adults[9].

Kahn[9] stated that LAP rises faster according to the age for men than for women, which may contribute for the increase of cardiovascular events in younger men. Studies presented more discriminatory capacity of LAP for the incidence of diabetes similarly to BMI, WHR and WHtR and for identifying Metabolic Syndrome in men and women[65,66].

Recently, Roriz et al.[38], was the first one evaluating the performance of LAP for discriminating visceral fat and observed correlations over 0.7 in men and over 0.60 in women, with area under the ROC curve over 0.78 and cutoffs ranging from 26.4 to 37.4 in men and from 40.6 to 44.0 in women, showing the good accuracy of this indicator.

### *Visceral adiposity index*

The Visceral Adiposity Index also expresses the function of visceral fat and its peculiarity consists in reflecting the altered production of adipocytokines, increase of lipolysis, plasma and free fatty acids – factors that are not identified by BMI, WC, TG and high density lipoproteins (HDL) separately[8]. In consequence, it is an index proposed as a substitute marker of dysfunction and distribution of adipose tissue and independently correlated with cardiometabolic risk associated with visceral obesity. The visceral adiposity index (VAI) is obtained by formulas proposed by Amato et al.[8]: for females VAI = (WC/36.58+(1.89 x BMI)) x (TG/0.81) x (1.52/HDL) and for males, VAI= (WC/39.68+(1.88 x BMI)) x (TG/1.03) x (1.31/HDL).

Knowles et al.[67] showed that VAI, WC and WHtR are correlated with cardiovascular risk as predictors of Metabolic Syndrome. Bozorgmanesh et al.[68] and Elisha et al.[69] showed that VAI was not superior than anthropometric indicators, being a weak indicator for forecasting cardiovascular diseases and for visceral adipose tissue function. Roriz et al.[38] observed positive correlation, especially in adult and elderly men, as showed in Table 2. A study[70] observed high correlation of serum levels of triglycerides and HDL, mainly in elderly, which compound VAI formulas and concluded that the average of the visceral adipose tissue area was always more elevated when triglycerides values were altered, both in adults and elderly.

The VAI is proposed as being able to evaluate the dysfunction of the adipose tissue and its association with cardiometabolic risk, mainly in the absence of a manifested metabolic syndrome[7].

Both LAP and VAI are still few explored about their capacity of discriminating visceral fat excess, especially measured by CT. However, those indicators have large possibilities for future investigations.

## METHODOLOGICAL LIMITATIONS

Most of the studies used different methodologies regarding anthropometric techniques and the image method for quantifying visceral fat, besides different cutoffs of the TAV area. The lack of standardization between the adopted protocols indicates a limiting factor when comparing data from the different studies.

## CONCLUSION

Considering the importance of visceral fat as a determinant of metabolic changes associated with obesity, the replacement of CT by simpler methods of low cost and free of radiation means an advancement in the diagnosis of visceral obesity and in the prevention of events associated with this adiposity.

Most of the studies evaluated the relationship between anthropometric clinical indicators with diseases resulting from visceral obesity, however, this work concluded that there are few recent studies evaluating the relationship between those indicators and visceral fat measured by CT, especially with the ones derived from WC and SAD, LAP and VAI.

In face of the presented studies, the most consistent results were from WC, WHtR, CI and SAD because they have better correlation and accuracy for estimating visceral fat when compared with the other indicators. The remaining indicators have been demonstrating positive results, however, WC and WHtR have the advantage of being more practical, fast, simple and not demanding formulas.

Generally, the anthropometric clinical indicators are accurate for estimating visceral fat. However, caution must be taken when interpreting those indicators, especially when evaluated individually and isolatedly. The investigation about alternative methods which estimate visceral obesity is essential for the decision taking during the nutritional clinical evaluation able to intervene earlier and more effectively in the prevention of diseases risk.

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## REFERÊNCIAS


1. Després JP, Lemieux I, Bergeron J, Pibarot P, Mathieu P, Larose E, et al. Abdominal obesity and the metabolic syndrome: contribution to global cardiometabolic risk. Arterioscler Thromb Vasc Biol, 2008;28:1039-49.
2. Tchernof A, Despres JP. Pathophysiology of human visceral obesity: an update. Physiological Reviews, 2013; 3(1): 359-404.
3. Fox CS, Massaro JM, Hoffmann U, Pou KM, Maurovich-Horvat P, Liu CY, et al. Abdominal visceral and subcutaneous adipose tissue compartments: association with metabolic risk factors in the Framingham Heart Study. Circulation, 2007; 116:39-48.
4. Shuster A, Patlas M., Pinthus JH, Mourtzakis M. The clinical importance of visceral adiposity: a critical review of methods for visceral adipose tissue analysis. The British Journal of Radiology, 2012; 85, 1–10.
5. Van Der Kooy K, Seidell JC. Techniques for the measurement of visceral fat: a practical guide. Int J Obes Relat Metab Disord, 1993; 17 (4): 187-96.
6. Pitanga FJG. Anthropometry for the assessment of abdominal obesity and coronary risk. Rev Bras Cineantropom Desempenho Hum, 2011;13(3):238–241.
7. Amato MC & Giordano C. Visceral Adiposity Index: An Indicator of Adipose Tissue Dysfunction. International Journal of Endocrinology, 2014: 1-7.
8. Amato MC, Giordano C, Galia M, Criscimanna A, Vitabile S, et al. Visceral Adiposity Index: a reliable indicator of visceral fat function associated with cardiometabolic risk. Diabetes Care, 2010; 33: 920–922.
9. Kahn H. The "lipid accumulation product" performs better than the body mass index for recognizing cardiovascular risk: a population-based comparison. BMC Cardiovascular Disorders, 2005; 5:26.
10. Vague J. The degree of masculine differentiation of obesities: a factor determining predisposition to diabetes, atherosclerosis, gout and uric calculous disease. Am J Clin Nutr., 1956;4:20-34.
11. Pinheiro MAS; Wellington OLJ; Alves de CSH. Abdominal Obesity in Elderly with Prostate Cancer of Ceara, Brazil. Nutr Clín Diet Hosp, 2013; 33(2):23-29.
12. Klein S. Is Visceral Fat Responsible for the Metabolic Abnormalities Associated With Obesity? Diabetes Care, 2010; 33 (7): 1693-1994.
13. Björntorp P. The associations between obesity, adipose tissue distribution and disease. Acta Med Scand, 1998; 723:121-34.
14. Ross R, Berentzen T, Bradshaw AJ, Janssen I, Kahn HS, Katzmarzyk PT, et al. Does the relationship between waist circumference, morbidity and mortality depend on measurement protocol for waist circumference? Obesity Reviews, 2008; 9, 312–325.
15. World Health Organization - Obesity Preventing and managing the Global Epidemic. Report of a WHO Consultation on Obesity. Geneva, WHO/NUT/NCD, 1998.
16. Ashwell M, Browning LM. The Increasing Importance of Waist-to-Height Ratio to Assess Cardiometabolic Risk: A Plea for Consistent Terminology. The Open Obesity Journal, 2011, 3, 70-77.
17. Barreira TV, Staiano AE, Harrington DM, Heymsfield SB, Smith SR, Bouchard C et al. Anthropometric correlates of total body fat, abdominal adiposity, and cardiovascular disease risk factors in a biracial sample of men and women. Mayo Clin Proc, 2012; 87: 452–460.
18. Sampaio LR, Simões EJ, Assis AMO, Ramos LR. Validity and Reliability of the Sagittal Abdominal Diameter as a Predictor of Visceral Abdominal Fat. Arq Bras Endocrinol Metab, 2007; 51: 980–986.
19. Roriz AKC, Oliveira CC, Moreira AP, Eickemberg M, Medeiros JMB, Sampaio LR. Methods of predicting visceral fat in adults and older adults: a comparison between anthropometry and computerized tomography. Arch Latinoamericanos Nutrición, 2011; 61(1): 5-12.
20. Kanda Y, Matsuda M, Hamamoto S, Fumiko K, Ko K, Michihiro M, et al. Analysis of waist circumference in Japanese subjects with

type 2 diabetes mellitus: Lack of propriety to define the current criteria of metabolic syndrome. Diabetes Res Clin Pract., 2007; 77 (3): 220–223.

21. Bouza A, Bellido D, Rodríguez, B, Pita S, Carreira J. Estimacíon de la grasa abdominal visceral y subcutánea en pacientes obesos a través de ecuaciones de regressíon antropométricas. Revista Española de Obesidade, 2008; 6 (3): 153-162.

22. Demura S, Sato S. Prediction of visceral fat area in Japanese adults: proposal of prediction method applicable in a field setting. Eur J Clin Nutr., 2007; 61(6):727-35.

23. Berker D, Koparal S, Işık S, Paşaoğlu L, Aydın Y, et al. Compatibility of different methods for the measurement of visceral fat in different body mass index strata. Diagn Interv Radiol, 2010; 16:99–105.

24. Chiang JK, Koo M. Lipid accumulation product: a simple and accurate index for predicting metabolic syndrome in Taiwanese people aged 50 and over. BMC Cardiovascular Disorders, 2012;12:78.

25. Scheneider HJ, Klotsche J, Silber S, Stalla GK, Wittchen HU. Measuring Abdominal Obesity: Effects of Height on Distribution of Cardiometabolic Risk Factors Risk Using Waist Circumference and Waist-to-Height Ratio. Diabetes Care, 2011; v 34: 1, e7.

26. Savva SC, Lamnisos D, Kafatos AG. Predicting cardiometabolic risk: waist-to-height ratio or BMI. A meta-analysis. Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy, 2013; 6:403–419.

27. Schneider HJ, Friedrich N, Klotsche J, Pieper L, Nauck M, John U, et. al. The predictive value of different measures of obesity for incident cardiovascular events and mortality. J Clin Endocrinol Metab, 2010; 95:1777–1785.

28. Ashwell M, Hsieh SD. Six reasons why the waist-to-height ratio is a rapid and effective global indicator for health risks of obesity and how its use could simplify the international public health message on obesity. Int J Food Sci Nutr., 2005;56:303-7.

29. Browning LM, Hsieh SD, Ashwell M. A systematic review of waist-to-height ratio as a screening tool for the prediction of cardiovascular disease and diabetes: 0.5 could be a suitable global boundary value. Nutr Res Rev, 2010; 23: 247–269.

30. 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. Obesity Reviews, 2012; 13: 275–286.

31. Ashwell M. Charts Based on Body Mass Index and Waist-to-Height Ratio to Assess the Health Risks of Obesity: A Review. The Open Obesity Journal, 2011, 3, 78-84.

32. Haun DR, Pitanga FJG, Lessa I. Razão Cintura/Estatura comparado a outros indicadores antropométricos de obesidade como preditor de risco coronariano elevado. Rev Assoc Med Bras, 2009; 55(6): 705-1.1.

33. Almeida RT, Almeida MMG, Araújo TM. Obesidade Abdominal e Risco Cardiovascular: Desempenho de Indicadores Antropométricos em Mulheres. Arq Bras Cardiol, 2009;92(5):375-380.

34. Lee CMY, Huxley RR, Wildman RP, Woodward M. Indices of abdominal obesity are better discriminators of cardiovascular risk factors than BMI: a meta-analysis. J Clin Epidemiol., 2008; 61 (7): 646-53.

35. Gradmark AMI, Rydh A, Renström F, De Lucia-Rolfe E, Sleigh A, Nordström P, et al.Computed tomography-based validation of abdominal adiposity measurements from ultrasonography, dual-energy X-ray absorptiometry and anthropometry. British Journal of Nutrition, 2010; 104, 582–588.

36. Wu H, Xu S, Chen L, Zhang H. Waist to Height Ratio as a Predictor of Abdominal Fat Distribution in Men. Chinese Journal of Physiology, 2009; 52(6): 441-445.

37. Roriz AKC, Passos LCS, de Oliveira CC, Eickemberg M, Moreira PA, Sampaio LR. Discriminatory power of indicators predictors of visceral adiposity evaluated by computed tomography in adults and elderly individuals. Nutrición Hospitalaria, 2014;29:1401-1407.

38. Roriz AKC, Passos LCS, de Oliveira CC, Eickemberg M, Moreira PA, Sampaio LR. Evaluation of the Accuracy of Anthropometric Clinical Indicators of Visceral Fat in Adults and Elderly. Plos One, 2014; 9(7): e103499.

39. Kahn HS, Austin H, Williamson DF, Arensberg D. Simple anthropometric indices associated with ischemic heart disease. J. Clin. Epidemiol., 1996; 49:1017-24.

40. Li C, Ford ES, Zhao G, Kahn HS, Mokdad AH. Waist-to thigh ratio and diabetes among US adults: the Third National Health and Nutrition Examination Survey. Diabetes Res Clin Pract, 2010; 89: 79–87.

41. Jung KJ, Kimm H, Yun JE, Jee SH.Thigh circumference and diabetes: obesity as a potential effect modifier. J Epidemiol., 2013; 23(5):329-36.

42. Lu B, Zhou J, Waring ME, Parker DR, Eaton CB. Abdominal obesity and peripheral vascular disease in men and women: a comparison of waist-to-thigh ratio and waist circumference as measures of abdominal obesity.Atherosclerosis, 2010;208(1):253-7.

43. Kahn HS, Bullard KM, Barker LE, Imperatore G. Differences between Adiposity Indicators for Predicting All-Cause Mortality in a Representative Sample of United States Non-Elderly Adults. Plos One, 2012;7(11): e50428.

44. Reis JP, Araneta MR, Wingard DL, Macera CA, Lindsay SP, et al. Overall obesity and abdominal adiposity as predictors of mortality in U.S. white and black adults. Ann Epidemiol, 2009;19: 134–142.

45. Bray, G. A. Classification and evaluation of the obesities. The Medical Clinics of North America, 1989, 73:161-184.

46. Perissinotto E, Pisent C, Sergi G, Grigoletto F, Enzi G. Anthropometric measurements in the elderly: age and gender differences. Brit J Nutr., 2002; 87: 177–186.

47. Pouliot MC, Despres JP, Lemieux S, Moorjani S, Bouchard C, et al. Waist circumference and abdominal sagittal diameter: best simple anthropometric indexes of abdominal visceral adipose tissue accumulation and related cardiovascular risk in men and women. Am J Cardiol., 1994; 73 (7): 460-8.

48. Valdez R, Seidell JC, Ahn YI, Weiss KM. A new index of abdominal adiposity as an indicator of risk for cardiovascular disease. A

cross-population study. Int J Obes Relat Metab Disord, 1993;17: 77–82.

49. Pitanga FJG, Lessa I. Sensibilidade e Especificidade do Indice de Conicidade como Discriminador do Risco Coronariano de Adultos em Salvador, Brasil. Rev Bras Epidemiol, 2004;7(3):259-69.

50. Vidigal FC, Rosado LEFPL, Rosado GP, Ribeiro RCL, Franceschini SCC, et al. Predictive ability of the anthropometric and body composition indicators for detecting changes in inflammatory biomarkers. Nutr Hosp., 2013; 28(5):1639–1645.

51. Silva DAS, Petroski EL, Peres MA. Accuracy and measures of association of anthropometric indexes of obesity to identify the presence of hypertension in adults: a population-based study in Southern Brazil. Eur J Nutr, 2013; 52:237–246.

52. Duarte Pimentel G; Portero-McLellan KC; Maestá N; Corrente JE; Burini RC. Accuracy of sagittal abdominal diameter as predictor of abdominal fat among Brazilian adults: a comparation with waist circumference. Nutr Hosp., 2010; 25(4): 656-661.

53. Petersson H, Daryani A, Risérus U. Sagittal abdominal diameter as a marker of inflammation and insulin resistance among immigrant women from the Middle East and native Swedish women: a cross-sectional study. Cardiovasc. Diabetol., 2007;6:10.

54. Kvist H, Chowdhury B, Grangard U, Tylen U, Sjöström L. Total and visceral adiposetissue volumes derived from measurements with computed tomography in adult men and women: predictive equations. Am J Clin Nutr, 1988;48: 1351–1361.

55. Seidell JC, Andres R, Sorkin JD, Muller DC. The sagittal waist diameter and mortality in men: the Baltimore Longitudinal Study on Aging. Int J Obes Relat Metab Disord 1994; 18: 61–67.

56. Ehrlich AC, Smith DA. Abdominal diameter index and 12-year cardiovascular disease incidence in male bridge and tunnel workers. Int J Obes (Lond), 2011;35(3):409-15.

57. Kahn H. Choosing an index for abdominal obesity: an opportunity for epidemiologic clarification. J Clin Epidemiol, 1993; 46: 491–494.

58. Stevens J, Mcclain JE, Truesdale KP. Selection of measures in epidemiologic studies of the consequences of obesity. Int J Obes, 2008; 32(3): 60-6.

59. De Souza NC, de Oliveira ER. Sagittal abdominal diameter shows better correlation with cardiovascular risk factors than waist circumference and BMI. Journal of Diabetes & Metabolic Disorders, 2013; 12:41.

60. Pimentel GD, Moreto F, Takahashi MM, Portero-Mclellan KC, Burini RC. Sagittal abdominal diameter, but not waist circumference is strongly associated with glycemia, triacilglycerols and HDL-c levels in overweitht adults. Nutr Hosp, 2011, 26(5):1125–1129.

61. Risérus U, Faire U, Berglund L, et al. Sagittal Abdominal Diameter as a Screening Tool in Clinical Research: Cutoffs for Cardiometabolic Risk. Journal of Obesity, 2010,1-7.

62. Yim JY, Kim D, Lim SH, Park MJ, Choi SH et al. Sagittal Abdominal Diameter Is a Strong Anthropometric Measure of Visceral Adipose Tissue in the Asian General Population. Diabetes Care, 2010, 33:2665–2670.

63. Kullberg J, Von Below C, Lönn L, Lind L, Ahlström H, Johansson L. Practical approach for estimation of subcutaneous and visceral adipose tissue. Clin Physiol Funct Imaging, 2007;27:148–53.

64. Vasques ACJ, Priore SE, Rosado LEFPL, Franceschini SCC. Utilização de medidas antropométricas para a avaliação do acúmulo de gordura visceral. Rev. Nutr., Campinas, 2010; 23(1):107-118.

65. Bozorgmanesh M, Hadaegh F, Azizi F. Diabetes prediction, lipid accumulation product, and adiposity measures; 6-year follow-up: Tehran lipid and glucose study. Lipids in Health and Disease, 2010; 9:45.

66. Taverna MJ, Martınez-Larrad MT, Frechtel GD, Serrano-Rıos M. Lipid accumulation product: a powerful marker of metabolic syndrome in healthy population. Eur J Endocrinol., 2011; 164, 559–567.

67. Knowles M, Paiva LL, Sanchez SE, Revilla L, Lopez T, 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; 1–10.

68. Bozorgmanesh M, Farzad H, Davoud K, Fereidoun A. Prognostic significance of the Complex "Visceral Adiposity Index" vs. simple anthropometric measures: Tehran lipid and glucose study. Cardiovascular Diabetology, 2012; 11:20.

69. Elisha B, Messier V, Karelis A, Coderre L, Bernard S, et al. The Visceral Adiposity Index: Relationship with cardiometabolic risk factors in obese and overweight postmenopausal women - A MONET group study. Applied Physiology, Nutrition, and Metabolism, 2013; 38(8): 892–899.

70. Roriz AKC, Mello AL, Guimarães JF, dos Santos FC, Medeiros JMB, Sampaio LR. Imaging Assessment of Visceral Adipose Tissue Area and Its Correlations with Metabolic Alterations. Arq Bras Cardiol, 2010; 95(6): 698-704.