Comparison of methods to evaluate total body fat and its distribution

*Comparação de métodos de avaliação da gordura corporal total e sua distribuição**

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Abstract

Objective: To compare two methods for evaluating total body fat and its distribution. **Methods:** Cross-sectional, cohort-nested study. Sixty-two women received a nutritional status evaluation which included total body fat (BF) obtained through the sum of skinfolds (ΣSF) and bioimpedance (BIA). Visceral fat distribution was measured using ultrasonography (USG) (intra-abdominal fat thickness) (IAT) and waist circumference (WC). The concordance correlation coefficient (CCC) and the determination coefficient (r^2) were calculated. **Results:** Mean patient age was 48.19 (8.99) years. Thirty-six women (58.06%) had a very large WC and 42 (67.74%) had high body fat. There was moderate concordance ($r^2 = 0.42$; CCC = 0.59; $p < 0.01$) between the methods for determining body fat (%) and optimal concordance ($r^2 = 0.90$; CCC = 0.91; $p < 0.01$) for body fat (kg) determined by BIA and ΣSF. The comparison between WC and IAT (USG) showed moderate concordance ($r^2 = 0.49$; $p < 0.01$) between the methods. **Conclusions:** Moderate concordance in determining total body fat (%) and optimal concordance in determining body fat (kg) were found between the methods. Moderate concordance was found between the methods for determining body fat distribution.

Keywords: Body composition. Body fat distribution. Skinfold thickness. Electric impedance. Waist circumference. Public health.

Resumo

Objetivo: Comparar dois métodos de avaliação da gordura corporal total e sua distribuição. **Métodos:** Estudo transversal, aninhado a uma coorte. Em amostra de 62 mulheres realizou-se avaliação do estado nutricional, incluindo a gordura corporal (GC) total obtida pelo somatório de dobras cutâneas (ΣDC) e bioimpedância (BIA). Mensurou-se a distribuição da gordura visceral por ultrassonografia (USG) (espessura de gordura intra-abdominal-EIA) e circunferência da cintura (CC). Foram calculados o coeficiente de correlação de concordância (CCC) e o coeficiente de determinação (r^2). **Resultados:** A média de idade das pacientes foi de 48,19 (8,99) anos. Observou-se 36 (58,06%) mulheres com a CC muito aumentada e 42 (67,74%) com GC aumentada. Identificou-se moderada concordância (r^2 = 0,42; CCC = 0,59; p < 0,01), entre os métodos avaliados para determinação da gordura corporal (%) e uma ótima concordância (r^2 = 0,90; CCC = 0,91; p < 0,01) para a gordura corporal (kg), avaliadas por BIA e ΣDC. A comparação entre a CC e EIA (USG) evidenciou uma moderada concordância (r^2 = 0,49; p < 0,01), entre os métodos. **Conclusões:** Evidenciou-se moderada concordância na avaliação da gordura corporal total (%) e ótima concordância na avaliação da gordura corporal (kg), entre os métodos utilizados. Identificou-se uma moderada concordância entre os métodos de distribuição da gordura corporal.

Palavras-chave: Composição corporal. Distribuição da gordura corporal. Dobras cutâneas. Impedância bioelétrica. Circunferência da cintura. Saúde pública.

Introduction

Nutritional status assessment is a key aspect in the identification of problems and/or inadequate nutritional status during any stages of life[1], especially during diseases[2,3] and including neoplasm's, as they directly or indirectly influence an individual's health prognosis[4].

The increase in visceral or total body fat is harmful to health, especially among women and those with non-communicable chronic diseases[3,5], such as breast cancer[6,7]. Throughout time, it was observed that visceral fat more accurately determines the risk factor for metabolic problems than total body fat[8-12].

When the possible consequences of body composition changes in women's nutritional status and health are considered, early assessment and identification of such changes may contribute to the reduction in the effects resulting from the associated health problems[13].

There are several methods that can be used in this assessment, some of which are more accurate and expensive, slower and more complex to be executed, such as Dual-emission X-ray Absorptiometry (DXA), hydrostatic weighing (HW), magnetic resonance imaging (MRI) and X-ray computerized tomography (CT)[14,15]. In contrast, there are other less expensive and easily executed methods to assess total body fat, such as Bioelectrical Impedance or Bioimpedance (BIA) and skinfold measurement[14].

On the other hand, tomography is traditionally considered to be the most efficient and accurate method to determine visceral fat tissue[16], although it becomes impracticable, due to its high cost. Ultrasonography has been used as an alternative, as it shows a high level of agreement with CT, especially in areas with more visceral fat[17].

When more accurate methods like the ones are not available, a more accessible alternative would be skinfold measurement (total body fat assessment) and waist circumference measurement, which indirectly determines visceral fat[14]. These methods are easily executed, applied and accessed, although some studies have questioned their accuracy[1,14].

The majority of studies aimed at comparing total body fat assessment, using easily executed methods such as bioimpedance and the sum of skinfolds, were conducted with sportsmen and women or athletes[18,19]. In contrast, studies conducted with women from several age groups used different methods, including the most expensive ones[15,20-22]. There are few studies that have been performed with women ranging from normal weight to obesity[23], with breast cancer and benign breast changes, coming from public health services. In addition, there are few studies that compare intra-abdominal fat thickness measurement with waist circumference to assess visceral fat[24,25].

The present study aimed at the following: verifying whether the previously mentioned methods can be used in the nutritional follow-up of women cared for in public health services, especially those with breast diseases; comparing two methods used to estimate total body fat (sum of skinfolds and bioelectrical impedance); and assessing the correlation between both estimates of visceral fat (waist circumference measurement and intra-abdominal thickness measurement obtained by ultrasonography).

Methods

A cross-sectional study, nested in a cohort study, was conducted in the city of Goiânia, state of Goiás, Brazil, in 2009. This cohort study is prospective in nature and it is ongoing, aiming to find out the impact of chemotherapy on body fat distribution and lipid profile of women with breast cancer, in two referral centers of Goiânia, GO.

Sample size was calculated for the previously mentioned cohort study. A total of 62 women were included, of which 31 had been recently diagnosed with breast cancer and 31 had benign breast changes. The entire study group participated in the *Universidade Federal de Goiás* Clinical Hospital and the *Hospital Araújo Jorge* Breast Disease Program and the *Associação de Combate ao Câncer de Goiás* (ACCG – State of Goiás Anti-Cancer Association) Gynecology and Breast Service. As a common denominator, both services care for women coming from the *Sistema Único de Saúde* (Unified Health System) and belong to the *Rede Goiana de Pesquisa em Mastologia* (State of Goiás Breast Disease Research Network)

Data collection was conducted by previously trained interviewers and anthropometrists, following the norms of the Measurement Standardization Manual for Interviewers and Anthropometrists and according to the techniques described above[26,27]. Data were collected with a questionnaire applied during a direct interview, with a socio-demographic characterization and nutritional status assessment (anthropometry).

The following socio-demographic variables were analyzed: age (in years), level of education (in years of study) and per capita household income (categorized in minimum wages). The anthropometric variables considered were as follows: current weight, height, biceps skinfold (BSF), triceps skinfold (TSF), suprailiac skinfold (SISF), subscapular skinfold (SESF), and waist circumference (WC). Bioelectrical impedance or bioimpedance (BIA) was used to assess body composition.

Based on the anthropometric measurements, the body mass index (BMI), sum of skinfolds (ΣSF), percentage body fat (% BF) and body fat in kilograms (Kg), using the ΣSF and BIA. Subcutaneous fat thickness and intra-abdominal fat thickness were determined with abdominal ultrasonography (US).

The norms and procedures proposed by Lohman, Roche and Martorell[27] were followed to collect anthropometric data (weight, height, waist circumference and skinfolds). The World Health Organization (WHO) classification[28] was adopted to determine patients' nutritional status according to their BMI, while the classification developed by Kyle et al.[29] was used to determine percentage body fat.

Skinfold measurements were obtained using a Lange Skinfold Caliper, with a 0-60 mm scale, 1 mm accuracy and three repetitions. The sum of the four skinfolds (BSF, TSF, SISF and SESF) enabled the indirect calculation of percentage body fat and body fat (%GC) and body fat in kilograms (Kg). Based on the values found, body density (BD) could be calculated, according to what was proposed by Durnin and Womersley[30] and subsequently applied to the formula suggested by Siri[31], thus obtaining body fat (% and Kg).

Total body fat assessment was performed with a Bodystat Body Composition Monitoring Unit, model 1500, a Bioimpedance (BIA) device with an impedance measurement scale of 20-2000ohms, an accuracy of 6 ohms and frequency of 50 KHz (KiloHertz). The following previous conditions were considered to perform the examination: to not use a pacemaker; to have been fasting for two hours or longer, including coffee or alcoholic beverages; and not to have smoked for at least two hours before this examination; to have an empty bladder; and not to have exercised for at least 12 hours before this examination[32].

Intra-abdominal fat thickness measurement was obtained with the TOSHIBA SSA-250A ultrasonography equipment. The estimate of visceral fat was obtained with a 3-5 MHz convex transducer that measured fat tissue thickness of patients who had been fasting for at least six hours, in a dorsal recumbent position, in the region located right above the navel, on the xipho-umbilical line, applying the minimum pressure required to visualize the image, according to a standard technique[17].

The reading was conducted directly with images frozen on the screen. The measurement between the posterior wall of the rectus abdominis muscle and the posterior wall of the aorta was considered as the intra-abdominal fat thickness[17]. Only the patients cared for in the Clinical Hospital had this exam performed, due to the limited availability of the device, totaling 49 women.

The 2003 Excel software program was use to tabulate data, while the SPSS 8.0 and STATA 8.0 software programs were used for the statistical analysis. Descriptive statistics (frequency, mean, median, minimum and maximum values) were used in the data analysis.

The coefficient of determination (r^2) was used to assess the association between waist circumference measurement and intra-abdominal fat thickness, considering a significance level of $\alpha < 5\%$.

Women were informed about the research objectives during the interview, when an informed consent form was presented to them and they could decide to participate in the study or not.

This research project was approved by the *Universidade Federal de Goiás* Clinical Hospital Human and Animal Research Ethics Committee (HC/UFG), protocol number 073/2008, and by the *Associação de Combate ao Câncer de Goiás* (ACCG – State of Goiás Anti-Cancer Association) Research Ethics Committee of the *Hospital Araújo Jorge*, protocol number 001/09.

Authors declared there were no conflicts of interest.

Results

The mean age of the 62 women studied was 48.19 (8.99) years, mean monthly per capita income was R$ 319.51 or US$ 172.71 (291.64), which represents 0.69 (0.63) minimum wages and a mean of 6.32 (3.71) years of education (Table 1).

With regard to anthropometric variables, the mean BMI of women studied was in the overweight category (BMI ≥ 25 Kg/m²), higher than what is recommended, i.e. there were 42 (67.74%) interviewees with excessive weight, of which 28 (45.16%) patients were overweight (BMI ≥ 25) and 14 (22.58%) were obese (BMI ≥ 30) (Table 1).

With regard to body fat distribution assessment methods, mean values equal to 90.27 cm for waist circumference (14.32) and 53.94 mm (13.13) for intra-abdominal fat thickness were obtained (Table 1). Con-

Tabela 1 - Medidas de tendência central e de dispersão das variáveis sociodemográficas e antropométricas das mulheres do estudo. Goiânia (GO), 2009

Table 1 *– Central tendency and dispersion measurements of sociodemographic and anthropometric variables for women participating in the study. Goiânia (GO), 2009*

Variables	Mean (SD)	Median/ 50º	Inter-quartile interval	
				75º
Age (years)	48.19(8.99)	49.00	43.00	54.00
Per capita income (R$)	319.51(291.64)	240.00	153.75	427.50
Per capita income (MW)	0.69(0.63)	0.52	0.33	0.92
Level of education (years)	6.32(3.71)	6.00	3.75	8.25
Current weight (Kg)	68.39(15.40)	66.90	58.48	73.22
Height (cm)	157.35(6.52)	156.50	153.00	162.25
BMI (Kg/m2)	27.73(6.61)	26.40	23.61	29.82
Waist circumference (cm)	90.27(14.32)	91.00	80.00	98.00
% Body fat (Σ SF)	36.72(5.23)	37.17	34.32	40.74
% Body fat (BIA)	37.93(7.78)	38.20	33.28	42.08
Body fat (Kg) (Σ SF)	25.56(9.14)	24.72	19.97	29.26
Body fat (kg) (BIA)	26.76(12.06)	24.85	19.96	29.85
Triceps skinfold (mm)	25.18(7.50)	25.00	20.00	30.00
Σ of skinfolds (mm)	93.62(30.26)	91.50	75.50	116.00
Brachial circumference (mm)	316.26(51.77)	310.00	280.00	337.75
BMC (mm)	237.18(37.48)	228.77	214.50	259.58
SF-US (mm)	24.24(9.11)	22.30	17.65	32.20
IAT-US (mm)	53.45(13.44)	54.70	43.00	62.30

DP: Standard-deviation; IMC: Body Mass Index; (%): percentage; DC: Skinfold; BIA: Bioimpedance; Σ: sum; CMB: Arm Muscle Circumference; ES-USG: Subcutaneous thickness (Ultrasound); EIA-USG: intra-abdominal thickness (Ultrasound). Minimum Wage for the study period: R$ 465.00. Dollar for the study period: R$ 1.85

DP: Desvio-padrão; IMC: Índice de Massa Corporal; (%): percentual; DC: Dobras Cutâneas; BIA: Bioimpedância; Σ: somatório; CMB: Circunferência Muscular Braquial; ES-USG: Espessura subcutânea (Ultrassonografia); EIA-USG: Espessura intra-abdominal (Ultrassonografia). Valor do Salário Mínimo no perído do estudo: R$ 465,00. Valor do dólar no período do estudo: R$ 1,85

sequently, the mean waist circumference value was within the range of high risk for metabolic complications (> 88 cm) associated with excessive weight.

In terms of percentage of body fat, a mean value of 37.93% (7.78) was found using the BIA, and of 36.72% (5.23), using the sum of skinfolds (ΣSF).

With regard to total body fat values (Kg), a mean value of 26.76 Kg (12.06) was found with the BIA, and of 25.56 Kg (9.14) with the sum of skinfolds (ΣSF). Thus, the mean percentage of body fat (%BF) was also increased in the classification of risk for obesity-related disorders (> 32.0%) (Table 1).

Of all 62 women interviewed, 36 (58.06%) had a much higher risk of metabolic complications, identified by the waist circumference values (≥ 88 cm), indicating increased abdominal fat, which characterizes central obesity. The majority of women evaluated (n=50; 80.64%) had an increased percentage of body fat, i.e. body adiposity assessed with two methods (sum of skinfolds and bioimpedance).

With regard to the correlation between the values of percentage (%) of body fat obtained with the sum of skinfolds and BIA, aiming to compare these two assessment methods, the concordance correlation coefficient (CCC=0.59) and determination coefficient (r^2=0.42; p<0.01) revealed a moderate level of agreement between such methods (Figures 1A and 1B).

In contrast, the correlation between the values of total body fat (Kg) obtained

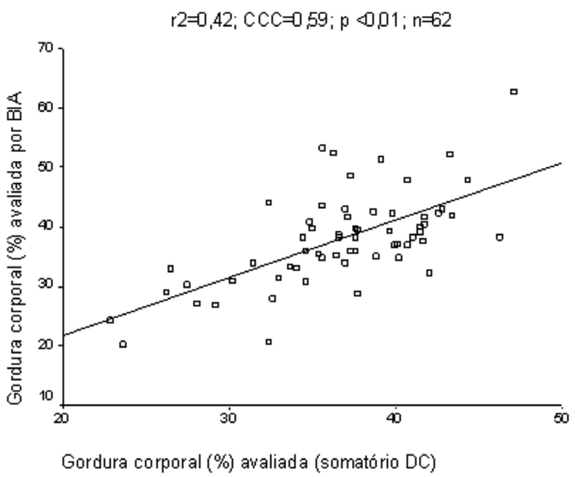

Figure 1A - Dispersion diagram of the concordance between body fat (%) as measured by the sum of skinfolds and bioimpedance (BIA) for women participating in the study. Goiania, GO, 2009

Figura 1A - *Diagrama de dispersão da concordância entre a gordura corporal (%) avaliada pelo somatório das dobras cutâneas (ΣDC) e pela bioimpedância (BIA) das mulheres participantes do estudo. Goiânia (GO), 2009*

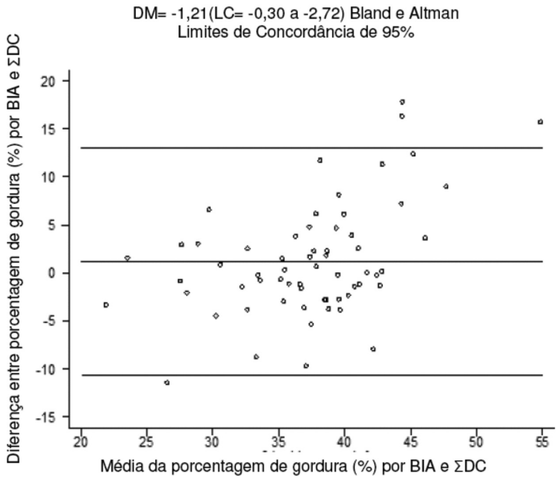

Figure 1B - Graph of the concordance between the mean and mean difference, and the calculation of the body fat percentage (%) concordance limit for women in the study (Bland and Altman). Goiânia,GO. 2009

Figura 1B - *Gráfico de concordância entre a média e a diferença da média e o cálculo do limite de concordância da porcentagem (%) de gordura corporal das mulheres do estudo (Bland e Altman). Goiânia (GO), 2009*

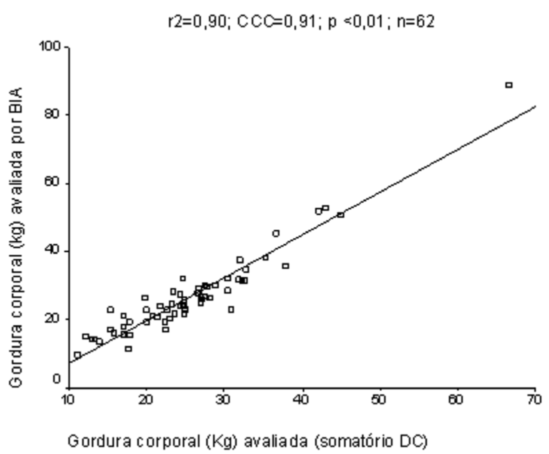

Figure 2A - Dispersion diagram of the concordance between body fat (kg) as measured by the sum of skinfolds and bioimpedance (BIA) for women participating in the study. Goiânia, GO. 2009

Figura 2A - *Diagrama de dispersão da concordância entre a gordura corporal (Kg) avaliada pelo somatório das dobras cutâneas (ΣDC) e pela bioimpedância (BIA) das mulheres participantes do estudo. Goiânia (GO), 2009*

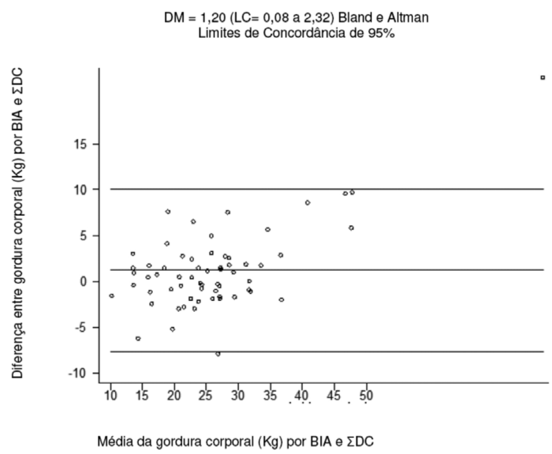

Figure 2B - Graph of the concordance between mean and mean difference, and the calculation of the body fat (kg) concordance limit for women in the study (Bland and Altman). Goiânia, GO. 2009

Figura 2B - *Gráfico de concordância entre a média e a diferença da média e o cálculo do limite de concordância da gordura corporal (Kg) das mulheres do estudo (Bland e Altman). Goiânia (GO), 2009*

with the above mentioned methods identified a concordance correlation coefficient (CCC=0.91) and a determination coefficient (r^2=0.90; p<0.01) that showed an excellent level of agreement between these methods (Figures 2A and 2B).

The correlation between visceral fat (central adiposity) values obtained with

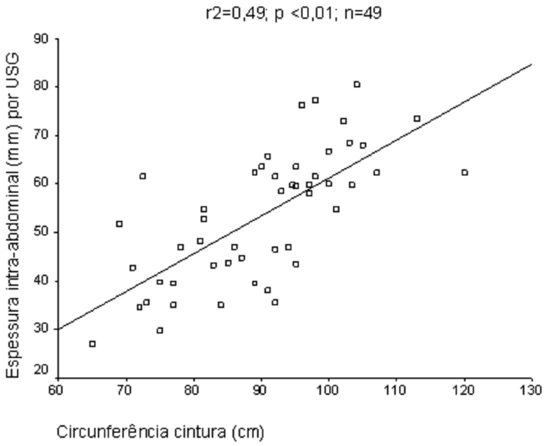

Figure 3 - Correlation between abdominal fat as measured by waist circumference and intra-abdominal fat thickness using abdominal ultrasonography (USG) for women in the study. Goiânia, GO, 2009

Figura 3 - *Correlação entre gordura abdominal avaliada pela medida da circunferência da cintura e espessura intra-abdominal de gordura avaliada pela ultrassonografia abdominal (USG) das mulheres do estudo. Goiânia (GO), 2009*

the US and waist circumference, aiming to compare one with the other, showed a moderate coefficient of determination (r^2=0.49; p<0.01) between waist circumference and intra-abdominal thickness (Figure 3).

Discussion

The present study showed that the women evaluated had a mean weight and BMI higher than the recommendations for ideal weight[28] and an increased percentage body fat[29]. This profile indicates the need for a specific health promotion intervention performed by a multidisciplinary team, aiming to reduce the risk factors of several diseases associated with excessive weight[3,35].

The comparison between the two methods used to assess total body fat, which were proposed by this study (sum of skinfolds and bioelectrical impedance) indicated a significant moderate level of agreement[33,34].

This result was slightly lower than what was expected, when compared to recent studies conducted with a similar population (r^2=0.90) [23], in addition to other populations, such as female soccer players (r^2=0.67)[18] and non-institutionalized elderly women (r^2=0.79)[20].

The present study found a high level of agreement between the two methods (bioimpedance and sum of skinfolds) used to assess body fat in kilograms (Kg). This has also been observed by other authors in studies conducted with women undergoing hemodialysis (r^2=0.96)[36] (r^2=0.87)[37] and with overweight and obese women practicing walking (r^2=0.83)[19].

However, the results shown in this study differ from those found by Rodrigues-Barbosa et al.[22], who analyzed elderly women and did not find agreement (r^2=0.25, p<0.05) between the methods studied (BIA and sum of skinfolds). Such disagreement could suggest that the elderly population must require special attention when the body composition assessment is performed. Nonetheless, Justino et al.[20] found a good level of agreement (r^2=0.79) between the methods when assessing institutionalized elderly women as well, showing that these methods can be used even in such population.

In view of the findings of the present study, researchers believe that the use of bioimpedance and/or sum of skinfolds can benefit the body fat assessment and nutritional follow-up of the women evaluated.

Researchers have shown that bioimpedance is an alternative method to estimate the percentage of body fat, when compared to DXA, a gold standard method, as there is a high level of agreement[21]. However, this assessment must be performed in individuals who are within the normal range of total body fat, because BIA tends to overestimate the percentage of body fat in about 4.40% in lean women and to underestimate it in 2.71% in obese women[21].

As the methods were in disagreement with each other, body fat assessment performed with the sum of skinfolds, due to its wide accessibility and financial viability[14], was found to be a good resource, when a more accurate method could not be used.

This fact becomes very important in services with limited financial resources, as both total body fat assessment methods (sum of skinfolds and bioimpedance) described in this study, due to their disagreement, can be useful in the follow-up of the nutritional state of women cared for in public health services, especially those who go to outpatient clinics aimed at women's comprehensive health care. One limitation to the present study which should be considered are the criticisms about the use of the sum of skinfolds in the assessment of obese patients[13].

With regard to the comparison between ultrasonography and waist circumference measurement in visceral fat assessment, there were few studies that performed the same type of comparison proposed in this study. Some prioritized and performed more specific comparisons between the methods considered to be standard in visceral fat assessment (computerized tomography and ultrasonography) and only few studies dealt with anthropometric measures[38,39].

Ultrasonography was found to be an excellent method to assess abdominal and/or visceral fat, when compared to computerized tomography and when the accuracy of anthropometric measures and that of ultrasonography were compared. Ultrasonography was a more accurate technique[38,39] and it showed greater specificity and accuracy than waist circumference, even when compared to other methods used to estimate visceral fat, such as sagittal abdominal diameter[24].

Sagittal abdominal diameter shows a high correlation with the area of visceral fat assessed with CT, in addition to its good reliability, sensitivity and specificity[40]. Of all the methods with a slightly higher availability and lower cost, ultrasonography could be included in the body composition assessment of the women evaluated[25].

In addition, the present study found that the mean of intra-abdominal fat measurement was out of the ideal limits of estimated cardiovascular risk, as observed in a cross-sectional study conducted with 231 women, where authors identified the value of 7.0 cm of intra-abdominal fat as cut-off point to estimate a moderate risk and 9.0 cm to estimate a high risk[24,41].

It is known that waist circumference is a traditional method used to measure the metabolic risk, when values are higher than 80 cm in the case of women[28], and that, regardless of the increased weight, abdominal/visceral fat is an important risk factor for several chronic diseases, especially cardiovascular diseases[42].

In view of what has been described here, in cases when it is impossible to perform intra-abdominal fat thickness measurement with ultrasonography and when a more accurate method is not available, waist circumference can be used to assess body fat distribution.

Furthermore, as waist circumference measurement is a practical, non-invasive, simple, inexpensive and widely used method with assessment techniques that have been standardized worldwide[27], the inclusion of this technique in the nutritional assessment of patients cared for in the services evaluated is also recommended as an essential part of the nutritional service protocol.

As a possible limitation to the present study, the fact that the number of individuals studied here was in fact calculated for another prospective study should be taken into consideration, so that the present study is a sub-analysis. However, it should be emphasized that other publications aimed at the same theme used a similar sample size[18-20,22,36]. The fact that methods considered to be gold standard were not used, such as the DXA and CT, did not enable the direct comparison between these methods and anthropometry to be made. Nonetheless, previous studies[20-22,25,38,39] showed that both bioimpedance and ultrasonography are accurate methods, allowing researchers to consider them as reference methods for comparison.

The inter- and intra-evaluator difference found when anthropometric measurements were collected could have been a bias of the present study. However, the fact that all anthropometrists were trained according to previously standardized techniques to reduce this possibility should be considered. Few studies with the same design were found, especially those that used the same statistical analysis, thus hindering the comparison of the results obtained.

Consequently, based on the results achieved, the implementation of a minimum nutritional follow-up protocol, more adequate and complete for patients seeking care in outpatient clinics for women's comprehensive health care, is recommended.

Conclusions

There was a moderate level of agreement between the sum of skinfolds and bioimpedance in women with breast cancer and those with benign breast changes, who came from public health services. The level of agreement was also moderate between intra-abdominal thickness identified with ultrasonography and waist circumference.

There was a high level of agreement between bioimpedance and body fat assessment (Kg).

Considering what has been described here and aiming to assess these women's body composition, it is recommended that waist circumference assessment be included to evaluate body fat distribution and that the method of sum of skinfolds be used to evaluate percentage body fat (%) and body fat in kilograms (Kg). These should be performed until it becomes possible to assess such measurements with more precise and accurate methods (USG and BIA), as these are simple, low-cost, practical and reliable methods that can be used to implement the nutritional care protocol in the outpatient clinics analyzed.

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