Reproducibility of ultrasonography as a method to measure abdominal and visceral fat*

Avaliação da reprodutibilidade ultrassonográfica como método para medida da gordura abdominal e visceral

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Abstract **OBJECTIVE: The purpose of this study was to evaluate the interobserver variability of ultrasound in the measurement of subcutaneous, visceral and perirenal fat through standard technique. MATERIALS AND METHODS: From November 2006 to January 2007, 50 patients were evaluated. The subcutaneous fat thickness was measured with a 7.5 MHz linear transducer transversely positioned 1 cm above the umbilical scar. For the visceral fat, a 3.5 MHz transducer was also positioned 1 cm above the umbilical scar, considering the distance between the internal surface of the abdominal rectus muscle and the posterior aortic wall in the abdominal midline. The perirenal fat was measured in the middle third of the right kidney, with the transducer positioned at the axillary midline. RESULTS: The *t*-Student test was utilized to analyze the interobserver reproducibility with significance level of 95%. No statistically significant difference was observed among mean values for subcutaneous, visceral and perirenal fat (p = 0.7141, 0.7286 and 0.6368, respectively). Mean and standard deviation corresponded to 2.64 ± 1.37 for subcutaneous thickness, 6.84 ± 2.38 for visceral fat, and 4.89 ± 2.6 for perirenal fat. CONCLUSION: Ultrasound presented a good interobserver reproducibility in the evaluation of abdominal fat based on measurement of subcutaneous, visceral and perirenal fat as parameters.**
Keywords: Abdominal fat; Ultrasound; Metabolic syndrome.

Resumo **OBJETIVO: O objetivo deste estudo é avaliar a variabilidade interobservador do método ultrassonográfico para medida da gordura subcutânea, visceral e perirrenal por meio de técnica padronizada. MATERIAIS E MÉTODOS: Foram avaliados 50 pacientes entre novembro de 2006 e janeiro de 2007. A medida da espessura subcutânea foi realizada com transdutor linear de 7,5 MHz posicionado transversalmente a 1 cm acima da cicatriz umbilical. Para a gordura visceral foi utilizado transdutor de 3,5 MHz posicionado 1 cm acima da cicatriz umbilical, considerando-se a medida entre a face interna do músculo reto abdominal e a parede posterior da aorta na linha média do abdome. A gordura perirrenal foi medida no terço médio do rim direito, com transdutor posicionado na linha axilar média. RESULTADOS: A reprodutibilidade interobservador foi analisada por meio do teste *t* de Student, com significância de 95%. Não houve diferença significativa entre as médias das medidas das gorduras subcutânea, visceral e perirrenal, com p = 0,7141, 0,7286 e 0,6368, respectivamente. As médias encontradas, com seus respectivos desvios-padrão, foram: 2,64 ± 1,37 para a espessura subcutânea, 6,84 ± 2,38 para a espessura visceral e 4,89 ± 2,6 para a espessura perirrenal. CONCLUSÃO: A ultrassonografia apresentou boa reprodutibilidade interobservador para avaliação da gordura abdominal por meio das medidas das espessuras subcutânea, visceral e perirrenal.**
Unitermos: Gordura abdominal; Ultrassom; Síndrome metabólica.

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INTRODUCTION

Metabolic syndrome is currently considered as a worldwide epidemic achieving increasing and alarming numbers, associated with high cardiovascular morbimortality rates besides increased socioeconomic costs[1–3].

Several studies demonstrate the closed relation between abdominal adiposity and glucose intolerance, hyperinsulinemia, hypertriglyceridemia and arterial hypertension. Recently, it has been believed that, more than a simple association, abdominal fat, particularly the visceral one, plays a significant role in the metabolic syndrome physiopathology[1–4].

Therefore, the quantification of visceral fat is important to identify those individuals with higher risk for developing metabolic syndrome and thus eligible for being

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submitted to earlier interventions in an attempt to reduce the impact of metabolic alterations on the cardiovascular morbimortality in such individuals[3,4].

Computed tomography is the method of choice for quantifying visceral fat, but it has not been solely utilized in the diagnostic routine of patients with metabolic syndrome[5,6]. Waist size and waist-hip ratio, although indirectly, constitute other methods for visceral fat evaluation[7]. Magnetic resonance imaging has been proposed as an alternative method free from ionizing radiation, but the literature reports restrictions for patients with morbid obesity, claustrophobia, or metal prosthesis and pacemaker[8–10].

Ultrasonography is a low cost and useful method besides not requiring radiation for evaluating visceral fat tissue[5,6,8,10]. Additionally, recent publications have demonstrated similar effectiveness of both ultrasonography and computed tomography in the quantification of visceral fat[5–7]. However, ultrasonography is operator-dependent, besides requiring the definition of specific anatomic landmarks and a standardized scanning technique.

The present study is aimed at evaluating the interobserver variability of the sonographic method in the measurement of subcutaneous, visceral and perirenal fat by means of a standardized technique.

MATERIALS AND METHODS

Observational study analysing abdominal and visceral fat in 50 patients by means of ultrasonography performed by two observers with a same scanning technique. The abdominal fat was quantified through the following sonographic measurements: abdominal subcutaneous, visceral and perirenal fat.

The present study was developed in the Division of Ultrasonography at Hospital de Clínicas of Universidade Federal de Uberlândia, Minas Gerais, Brazil, with previous approval by the Committee for Ethics in Research of the institution. All the patients signed a term of free and informed consent.

The study group included both male and female patients consecutively and randomly selected, independently from their body mass índex. The mean age of such patients was 42 years ± 12 years.

The ultrasonography scans were performed by two radiologists who utilized a same, previously standardized scanning technique. Each of the patients was evaluated on the same day by two investigators who were not aware of the results of each other, in order to avoid samples contamination.

A Versa Pro (Siemens; Erlangen, Germany) equipment was utilized with electronic, linear 7.5 MHz and convex, 3.5 MHz transducers. All the scans were performed with the patient under 12-hour fasting, lying in dorsal decubitus and maximum abduction of the right arm.

The measurement of subcutaneous fat was performed with a linear 7.5 MHz transducer transversely positioned 1 cm above the umbilical scar, without exerting any pressure over the abdomen in order to avoid underestimation of the measurement. The subcutaneous thickness corresponded to the distance in centimeters between the skin and the outer surface of the fascia of the abdominal muscles.

For the visceral fat, a 3.5 MHz transducer was also transversely positioned 1 cm above the umbilical scar on the abdominal midline, without exerting any pressure over the abdomen. The visceral fat thickness corresponded to the measurement in centimeters between the internal surface of the abdominal rectus muscle and the posterior aortic wall in the abdominal midline, during expiration. The perirenal fat was measured with a convex 3.5 MHz transducer longitudinally positioned on the axillary midline, with identification of the right kidney image. The perirenal fat thickness corresponded to the distance in millimeters between the lateral border of the kidney and the iliopsoas muscle surface adjacent to the middle third of the right kidney (Figure 1).

Statistical analyses

Descriptive statistical analysis was utilized for sociodemographic characterization and for calculating mean and standard deviation of the values found for the three measurements performed by the two investigators.

The data normality was evaluated by the Lilliefors test. The Student *t*-test was utilized to compare the measurements performed by the two investigators for the subcutaneous and visceral fat variables, and the Mann-Whitney test, for perirenal fat.

The intraclass correlation coefficient and respective confidence interval[11] were utilized for determining the reproducibility of the measurements obtained by the two investigators. Additionally, the Bland-Altman plot[12] was utilized for evaluating the interobserver agreement.

The level of statistical significance was defined as $p < 0.05$.

RESULTS

Mean values and respective standard deviations were 2.64 cm ± 1.37 for subcutaneous fat thickness, 6.84 cm ± 2.38 for visceral fat thickness, and 4.89 mm ± 2.6 for the perirenal fat thickness.

No statistically significant difference was observed among the measurements of subcutaneous, visceral and perirenal fat performed by the investigators 1 and 2 (p = 0.7141, 0.7286 and 0.6368, respectively), indicating a good level of interobserver agreement (Figure 2). Such good interobserver agreement can be confirmed on Figures 3, 4 and 5 regarding subcutaneous, visceral and perirenal fat, respectively.

Figure 3 (subcutaneous fat) demonstrates that most of times, the values remained between mean ± one standard deviation, and in only seven patients the values were > one standard deviation. The mean difference was very low, i.e., –0.10 cm and standard deviation, 0.31 cm, showing excellent interobserver agreement. Additionally, the maximum and minimum values for the differences were, respectively, 0.9 and –0.9.

As regards the interobserver agreement for the visceral fat variable (Figure 4), an excellent level was observed, with the majority of values remaining between the mean and one standard deviation. The differences were a little higher as compared with the subcutaneous fat, i.e., the mean difference was 0.16 cm and standard deviation, 0.93 cm. Measurements for eleven patients remained above this threshold.

The measurements performed by the two investigators for perirenal fat also pre-

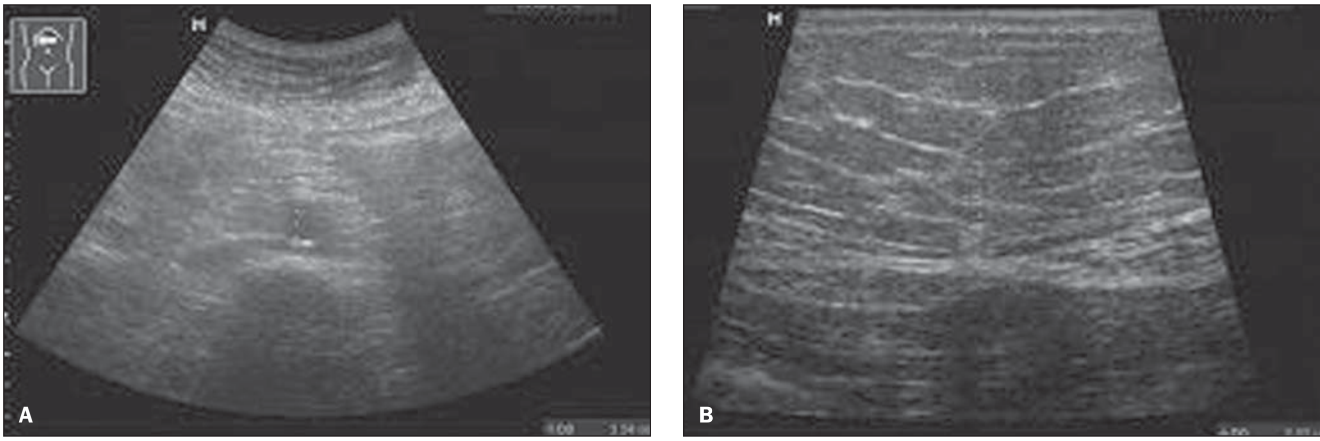

Figure 1. A: Measurement of muscular aortic thickness. B: Measurement of subcutaneous fat. C: Measurement of perirenal fat.

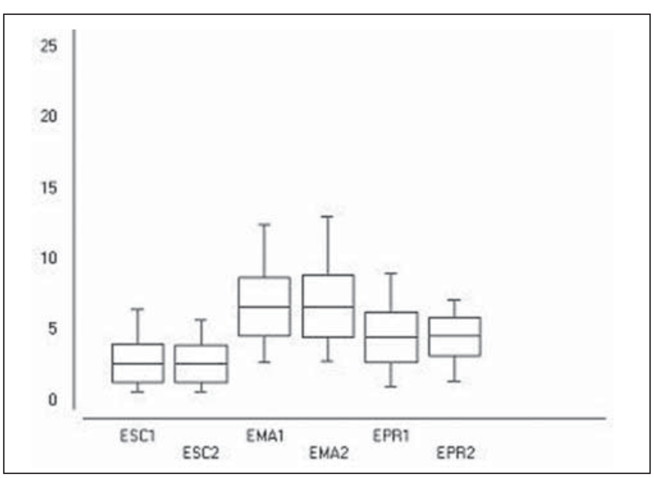

Figure 2. Means and standard deviations of measurements obtained by the investigators 1 and 2, ESC corresponding to subcutaneous thickness, EMA to muscular aortic thickness, and EPR to perirenal thickness. No significant difference was observed among the means for the three measurements obtained by the two investigators.

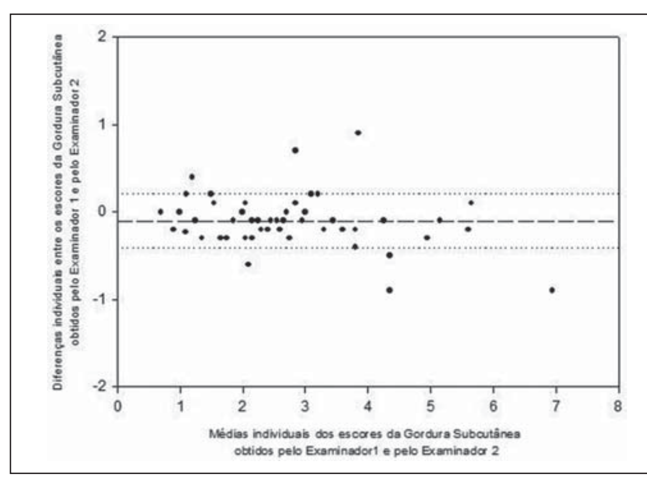

Figure 3. Means for measurements of subcutaneous fat obtained by the two investigators, demonstrating excellent interobserver agreement.

sented a good interobserver agreement, with the majority of values remaining between the mean and one standard deviation (Figure 5). The mean difference was –0.14 mm and standard deviation, 1.39 mm. Measurements for twelve patients remained above this threshold.

As regards the interobserver reproducibility, intraclass correlation coefficient of 0.97 was observed (confidence interval [CI] 95%: 0.96–0.99, $p < 0.01$) for subcutaneous fat, 0.91 (CI 95%: 0.86–0.95, $p < 0.01$) for visceral fat, and 0.63 (CI 95%: 0.44–0.78, $p < 0.01$) for perirenal fat. An excellent interobserver reproducibility is

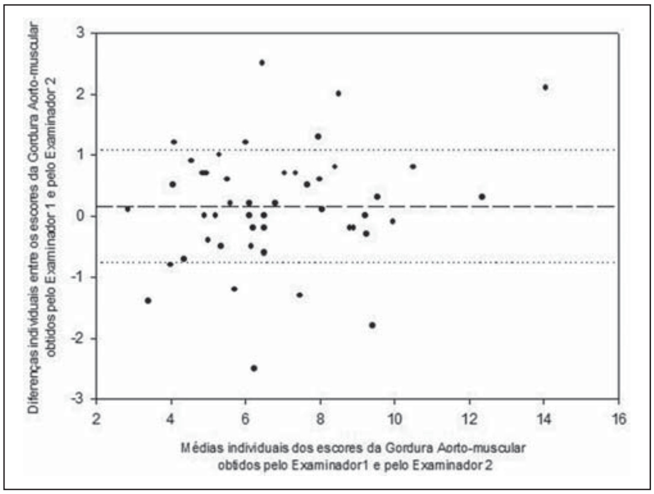

Figure 4. Means for measurements of muscular aortic fat obtained by the two investigators, demonstrating excellent interobserver agreement.

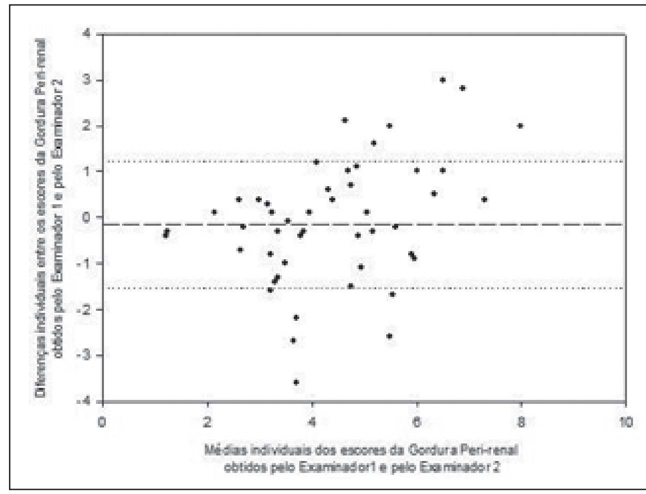

Figure 5. Means for measurements of perirenal fat obtained by the two investigators, demonstrating excellent interobserver agreement.

observed for subcutaneous and visceral fat, and satisfactory correlation for perirenal fat.

DISCUSSION

Considering the current worldwide epidemics of metabolic syndrome, and the knowledge on the obesity's impact on the morbidity and mortality resulting from cardiovascular events, it is increasingly necessary to develop diagnostic methods capable of evaluating and quantifying the distribution of the body fat, particularly the visceral fat[2–4,13,14]. It is known that fat may accumulate in several abdominal compartments, including the epiploon, viscera such as the liver, as well as in the retroperitoneal region, including the perirenal region.

Ultrasonography has shown to be a practical, effective and low-cost method besides not requiring ionizing radiation[5,7,9,10,14,15]. Such factors, in association with its relevant role in the identification of individuals with increased central adiposity, may represent an important step towards the future possibility of selecting patients at high risk for developing metabolic syndrome, aiming at allowing an early intervention, thus minimizing the impact resulting from the complications of this condition[3,8,13,16].

In the present study, ultrasonography has demonstrated to be highly reproducible and capable of measuring the thickness of subcutaneous, visceral and perirenal fat.

Among the several advantages of ultrasonography, it is important to observe that high availability, low cost and reproducibility are factors that meet the needs of developing countries which may utilize this method in public health measures to reduce social costs[7,9,14,15,17,18].

The study of abdominal fat by means of ultrasonography was first undertaken early in the nineties by Armellini et al. by comparison of sonographic and computed tomography findings in a group of 50 obese women. The sonographic findings presented a good correlation with the computed tomography findings ($r = 0.66$, $p < 0.001$), corroborating the hypothesis that ultrasonography could be useful in the assessment of abdominal fat[15]. Later studies have demonstrated a poor correlation between sonographic and tomographic findings for measurement of visceral fat[7,14,17,18]. However, study developed by Stolk et al. concluded that the low reliability of the measurements of visceral fat by ultrasonography would be a result from failures in a strict standardization of visceral measurements such as inappropriate transducer positioning, pressure on the abdomen and measurements at different phases of the respiratory cycle[17]. Such factors may impair the quantification of abdominal fat, leading to poorly reproducible results. This fact has not been observed in the present study that has been developed in compliance with strict standardization for measurement of abdominal fat.

Abdominal computed tomography is considered as the gold standard in the determination of visceral fat, since this method can differentiate subcutaneous from visceral fat, besides being highly reproducible[5–7,14]. The advantage of computed tomography and magnetic resonance imaging in the evaluation of abdominal fat is the fact that these methods do not depend on the operator ability to identify the structures during the examination, besides not being influenced by the pressure exerted by the transducer over the patient's abdomen during the measurements. However, the ionizing radiation present in computed tomography and the high cost and long acquisition time of magnetic resonance imaging represent unfavorable aspects in the utilization of such methods in the routine for quantifying abdominal fat, considering that ultrasonography presents an optimum reproducibility[6,7,10].

The present study has demonstrated a high interobserver agreement and thus the ultrasonography reproducibility in the quantification of abdominal fat by means of measurements of subcutaneous, visceral and perirenal fat, with excellent CI for the first two types of fat, and a reasonable CI for perirenal fat – an already expected result because of the higher technical difficulty in the evaluation of the perirenal fat. Additionally, the perirenal fat is measured in millimeters, becoming more susceptible to biometric errors. The development of the present study only was possible because the description and utilization of a strict protocol for measurement of abdominal fat.

It is important to mention some technical limitations, since they may pose some difficulty to the performance of the US scan, limiting its reliability. Among these limitation, one may observe non-cooperation of the patient in respiratory maneuvers, utilization of inappropriate transducers and, particularly, inappropriate operator training and technique[5,17,18].

Therefore, ultrasonography presented a good interobserver reproducibility in the evaluation of abdominal and visceral fat by means of measurements of the thickness of subcutaneous, visceral and perirenal fat.

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