COMPARISON OF THE FAT PERCENTAGE OBTAINED BY BIOIMPEDANCE, ULTRASOUND AND SKINFOLDS IN YOUNG ADULTS

ORIGINAL ARTICLE

Eduardo Borba Neves (Physiotherapist)[1]
Wagner Luis Ripka (Physical educator)[2]
Leandra Ulbricht (Veterinarian)[1]
Adriana Maria Wan Stadnik
(Physical educator)[1]

1. Federal Technological University of Paraná, Curitiba – Brazil.

Mailing address:
Academic Department of
Physical Education.
Av. Sete de Setembro, 3.165, Rebouças.
80230-901 – Curitiba, PR, Brasil.
borbaneves@hotmail.com

ABSTRACT

Introductions e objective: To compare portable ultrasound (US) and bioimpedance analysis (BIA) with skinfolds (SF) to estimate body fat percentage in adults. Methods: 195 military men were assessed and they had their weight, height, body fat by bioimpedance, skinfold in 9 points and ultrasound (US) collected. Linear Regression was used for the development of a new equation for body fat percentage estimation in young adults (males). Results: The group had mean age of 23.07 ± 7.55 years and height and weight with mean and standard deviation of 72.65 ± 10.40 kg, 1.74 ± 0.06 meters, respectively. Comparing the results between the US and SF, there was significant correlation for all points evaluated, with the thigh skinfold presenting the highest correlation, followed by the chest one. When the three methods are compared, the US presented better correlation with the BIA than with SF. A new equation for estimation of fat percentage by US can hence be proposed. Conclusions: It was noticed that in the studied population, US and BIA can estimate the body fat percentage with good correlations with the SF method.

Keywords: ultrasound, bioimpedance, skinfolds, body composition.

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INTRODUCTION

One of the characteristics developed during the human evolution was the ability to stock energy as fat, a characteristic which has occurred since our ancestors faced extreme survival conditions. With the species evolution, this characteristic became a negative point, since in the last decades humans have developed technologies which help them conserve energy and make less effort, making them obese and hypokinetic[1]. It is commonly shown in the literature that there are countless problems related to weight excess and fat accumulation or excessive loss[2]. The World Health Organization (WHO) classifies obesity as epidemic in the XXI century, highlighting that there are 300 million people in this situation[3]. These problems may be diagnosed, for example, by evaluation of body composition (BC), which along the time has been a potential source of studies for being an instrument which tries to quantify the components of the human body[4], allowing hence the follow-up in many variables of physical fitness related to health, disease and quality of life of individuals[5].

Due to the relevance of information on body composition, new instruments come up to fill in existing gaps in practicality, reliability and reproducibility[6]. Buscariolo *et al.*[4] highlight the evaluation of the body composition components through the skinfolds (SF) and the use of indices relating body weight and height as the body mass index (BMI), as the mostly used for estimation of subcutaneous fat (%F), each one with its advantages and limitations; for example, the WHO due to practical reasons, places the BMI as a valid indicator for epidemiological studies and in situations when the equipment is not available. However, this technique does not present a strong correlation with the real body fat. The use of an adipometer, may be fairly accurate once the test is performed by a trained professional and using suitable equipment[7]. Other methods less used may be mentioned, such as hydrostatic weighing (HW), computerized tomography, bioimpedance assessment (BIA), *Dual Energy X-Ray Absorptiometry (*DEXA) and ultrasound (US)[8,9]. Nevertheless, these last ones are many times of difficult performance and/or are costly, being usually used in a laboratory environment[2].

Rodrigues *et al.*[2] compared the bioimpedance, skinfolds and hydrostatic weighing (reference method) techniques and concluded that the skinfolds better related with the reference method than with the bioimpedance. Similar result was found by Lintsi *et al.*[10], when they compared the SF and BIA with the results obtained by DEXA. Thus, the SF remain being the choice method for assessment of large groups at low cost. The application of US for estimation of fat percentage has been used in zootechny with relative success, as shown in the study by Suguisawa *et al.*[11] in bovines; however, the literature still lacks information on the application of US in the human population.

The main advantage of the electrical impedance and the portable US compared with the skinfolds would be the minimization of the inter and intra-evaluator variations, portability of the equipment and easy handling by beginners. Thus, the present study has the aim to compare the portable US and the BIA with the SF to estimate the body fat percentage in young adults.

METHODOLOGY

It is a transversal study which evaluated the body composition of 195 military men from the Brazilian Army hosted in the city of Curitiba. The data collection took place in July, 2010.

The following equipment was used for the anthropometric assessment: 0.5cm wide flexible measure tape, graded in centimeters and centimeter decimals; calibrated scientific adipometer (Cescorf); digital scale (Wiso W801), with capacity of 0-180 kg and grading of 100 g; stadiometer (WCS *Woody Compact*). For the bioimpedance, the instrument BF-900 (Maltron, United Kingdom), with gel electrodes for ECG was used. Ultrasound used the instrument BX2000 (BodyMetrix – IntelaMetrix, Inc.) attached to a computer Pentium 4, 3.4 Ghz, with 2 Gb of RAM memory.

BMI was calculated with the equation that calculates weight (kg) over height to the square (in meters). Values below 25 kg/m^2 were adopted as normal and values above or equal to this reference were considered overweight. Neves[12] points out that the relative risk of mortality aassociated with the BMI ir represented by a U or J chart, in which the values below 25 kg/m^2 comprehend less risk to health.

The collected measures were: chest (C), triceps (TR), subscapular (SB), medial axillary (MA), suprailiac (SI), abdomen (AB), thigh (T), medial calf (MC) and biceps (B); where skinfold thickness was determined three times for each point and the arithmetic mean later calculated.

Body density (BD) calculation used the equation of seven skinfolds developed by Jackson and Pollock[13], and for estimation of the body fat percentage the Siri's equation was used[14].

The individuals received guidance concerning the following procedures for bioimpedance[15]: do not drink large amounts of water; do not eat in the two last hours before the examination; do not ingest alcoholic drinks or perform vigorous exercises in the 24 hours prior the examination; and to have urinated at least 30 minutes before the test. The measurements were taken only once with the individual at dorsal decubitus, wearing only a swimsuit and being free of any metallic object and four electrodes were attached to the right side on their hands and feet.

Ultrasound assessment, which operates in the 2.5 MHz frequency, also occurred in a single time and the instrument operated with a USB interface to the computer. The *Body View software,* based on the refraction indices of the muscle, fat and bone, measured the layers and measured the amount of fat of the analyzed point, being the reflection fraction (R) fat-muscle R = 0.012 and muscle-bone R = 0.22 (figure 1). The refraction coefficient is calculated based on the change of velocity and direction which the sound wave suffers when passing from one elastic mean to another. The same points of the adipometer were evaluated and the fat percentage was automatically calculated by the equipment *software*.

The study performed the descriptive statistics with position and dispersion measurements for sample characterization and inferential statistics for variables correlation and significance verification. The Spearman correlation coefficient was used for analysis of the correlation between values in millimeters obtained by the adipometer and the ultrasound equipment. Linear regression was used to reach to a new prediction equation of fat percentage from the thickness values of the skin-fat layer estimated by US. The *Wilcoxon Signed Ranks Test* was used to verify the difference between means of the SF, BIA and US measurements. The premise for the use of the non-parametric statistics was the Kolmogorov-Smirnov test.

The test followed the ethical aspects recommended by the Resolution nº 196/96 about research involving humans, as well as ethics principles from the Declaration of Helsinki.

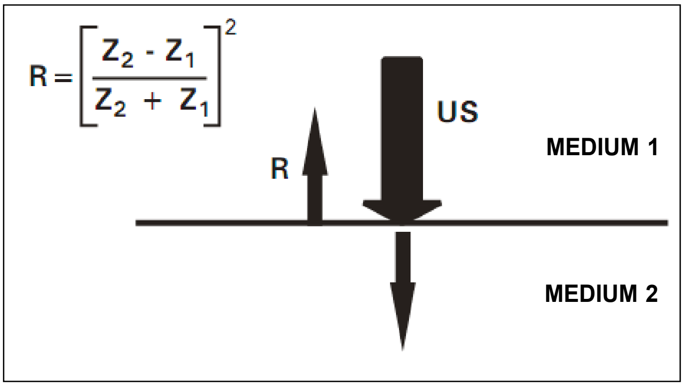

Figure 1. Refraction of the ultrasound waves in biological tissue.

RESULTS

195 male military individuals, mean age of 23.07 ± 7.55 yeras; for weight, height and BMI were evaluated. The mean and standard deviation values were: 72.65 ± 10.40 kg; 1.74 ± 0.06 meters and 23.96 ± 3.02 kg/m^2, respectively; for the fat percentage, obtained by the skinfolds, mean values of the group was of 14.59 ± 6.42%, according to table 1.

The studied variables were verified with the Kolmogorov-Smirnov test and did not present distribution close to the normal curve. The results of table 2 present the values in millimeters from the reading of the adipometer with value presented by the US.

Table 2 evidences that only in three points (subscapular, suprailiac and thigh) the mean US values were lower than the ones measured by SF. The highest discrepancy found was in the biceps skinfold. The *Wilcoxon Signed Ranks Test* indicated statistically significant difference between means of the following anatomic points: triceps, biceps, chest, abdominal, suprailiac, thigh and calf. The results presented in table 3 express the correlation between the three used methods, being these calculated for the general sample and sectioned by BMI lower than 25 kg/m^2 and higher or equal to 25 kg/m^2. The *Wilcoxon Signed Ranks Test* indicated statistically significant difference between means of the fat percentage evaluated by bioimpedance and by SF and among the individuals by bioimpedance and by US. In both cases bioimpedance overestimated the values ($p < 0.001$). Table 4 presents the correlations point by point for the values obtained in millimeters with the adipometer and the ultrasound machine. When the group was generally evaluated, significant

Table 1. Sample characterization.

	BMI < 25		BMI ≥ 25		General	
Variables	**N**	**Mean / SD**	**N**	**Mean / SD**	**N**	**Mean / SD**
Age	129	21.28 ± 5.80	66	26.56 ± 9.22	195	23.07 ± 7.55
Weight	129	67.45 ± 6.75	66	82.82 ± 8.63	195	72.65 ± 10.40
Height	129	1.74 ± 0.05	66	1.73 ± 0.06	195	1.74 ± 0.06
BMI	129	22.20 ± 1.79	66	27.38 ± 1.73	195	23.96 ± 3.02
% Fat	129	12.00 ± 4.98	66	19.66 ± 5.89	195	14.59 ± 6.42

Table 2. Mean values ± standard deviations in millimeters of the skin thickness by ultrasound and adipometer (skinfold/2).

Variables	Adipometer | Ultrasound BMI < 25 (N = 129)	Adipometer | Ultrasound BMI > 25 (N = 66)	Adipometer | Ultrasound All (N = 195)
Triceps	4.82 ± 1.56 | 5.04 ± 2.13	6.57 ± 2.50 | 6.80 ± 2.33	5.41 ± 2.10 | 5.63 ± 2.35
Subscapular	7.5 ± 2.60 | 5.70 ± 2.57	11.59 ± 4.69 | 8.31 ± 2.35	8.59 ± 4.06| 6.58 ± 2.78
Biceps	2.27 ± 0.64 | 9.36 ± 7.39	3.45 ± 1.29 | 15.74 ± 7.61	2.57 ± 1.70 | 11.52 ± 8.03
Chest	4.14 ± 1.80 | 5.51 ± 6.64	7.17 ± 2.91 | 8.83 ± 5.35	5.16 ± 2.70 | 6.63 ± 6.42
Medial axillary	5.28 ± 2.34 | 6.07 ± 3.26	9.83 ± 3.93 | 8.77 ± 3.59	6.82 ± 3.67 | 6.98 ± 3.60
Abdominal	9.38 ± 4.54 | 12.59 ± 7.12	15.73 ± 5.40 | 21.73 ± 8.66	11.53 ± 5.69 | 15.68 ± 8.80
Suprailíiac	7.48 ± 4.17 | 6.57 ± 3.03	11.62 ± 5.12 | 9.93 ± 3.07	8.88 ± 4.91| 7.71 ± 3.43
Thigh	7.22 ± 2.48 | 5.99 ± 2.63	8.89 ± 3.25 | 8.15 ± 2.66	8.13 ± 3.04 | 6.72 ± 2.82
Calf	4.43 ± 1.96 | 7.05 ± 5.78	5.68 ± 2.35 | 10.07 ± 5.74	4.85 ± 2.18 | 8.07 ± 5.93

Table 3. Corelation between SF, BIA and US.

	BMI < 25		BMI ≥ 25		General	
Variables	**N**	**rho**	**N**	**rho**	**N**	**rho**
US *vs.* SF	129	0.558*	66	0.629*	195	0.709*
US *vs.* BIA	129	0.646*	66	0.603*	195	0.767*
SF *vs.* BIA	129	0.570*	66	0.677*	195	0.742*

*p < 0,05.

Table 4. Correlation between measurements of SF and US by location.

	BMI < 25			BW ≥ 25			General	
Location	**N**	**Rho**	**p**	**N**	**rho**	**P**	**N**	**p**
Triceps	129	0.547*	0.001	66	0.593*	0.001	195	0.001
Subscapular	129	0.419*	0.001	66	0.483*	0.001	195	0.001
Biceps	129	0.238*	0.007	66	0.271*	0.027	195	0.001
Chest	129	0.666*	0.001	66	0.538*	0.011	195	0.001
Medial xillary	129	0.318*	0.001	66	0.096	0.445	195	0.001
Abdominal	129	0.287*	0.001	66	0.272*	0.027	195	0.001
Suprailiac	129	0.317*	0.001	66	0.386*	0.001	195	0.001
Thigh	129	0.661*	0.001	66	0.597*	0.001	195	0.001
Calf	129	0.204*	0.021	66	0.177	0.155	195	0.001

*p < 0,05.

correlations were observed between all the assessed points, and the measurements which presented the highest and the lowest correlation were the thigh skinfold (rho = 0.715) and the calf skinfold (rho = 0.249), respectively.

A possible explanation for the low correlation for the calf may be the proximity of the fat-muscle and muscle-bone layers, and concerning the thigh fold, the good correlation may be connected with the thickness of the layers, which in that place are relatively smaller.

The identification of the anatomic points with better correlation allowed the elaboration of a new equation (equation 1), considering the places with correlation above 0.600 and the variables age and weight. It was developed through a linear regression in which the following equation was determined:

Gord_US_new = -13,658 + 0,597 x USTriceps + 0,272 x USThigh + 0,203 x Weight + 0,322 x Age + 0,121 x USSubscapular

where: Gord_US_new – fat percentage calculated from the estimation of the thickness of the skin-fat layers by the portable US *Bodymetrix,* weight and height of the subjects;
USTriceps – thickness estimated by the US for the triceps anatomic site;
USThigh – thickness estimated by the US for the thigh anatomic site;
USSubscapular – thickness estimated by the US for the subscapular anatomic site.

The chest measurement was ignored in the equation, since it presented coefficient lower than 0.10, since despite the chest measurement of the US presenting good correlation with the SF measurement of the same anatomic point, when the fat percentage is the independent variable, there are other dependent variables, such as weight and age, which modified the capacity of prediction of the fat percentage by the chest measurement of the US. The fat percentage values obtained through the equation presented a correlation rho = 0.783 by Spearman.

DISCUSSION

Body fat excess is in fact a chronic-degenerative disease which is associated with the increase in morbidity and mortality of adults, since it is a triggering factor to many disorders for men, such as cardiovascular diseases, diabetes, decrease in respiratory capacity and even cancer[16,17]. Thus, instruments with accurate, reliable and widely applicable evaluation become a crucial factor[18]. The adipometer can be a useful method to obtain fat percentage when used by a trained and reliable technician, and it can be used to monitor the body composition of the population. Unfortunately, the number of equations used by this method indicates the use for specific populations, which increases the error expected for this method[19]. Historically, the ultrasound technique for assessment of subcutaneous fat, according to studies by Whittingham[20], had been frequently used in pets, and the author, after some alterations in the original methodology, left a favorable impression about its use in human groups. Still within this context, Booth *et al.*[21] even raised the possibility that measurements of the subcutaneous fat by ultrasound would be more reliable than with the calipers, a fact refused by Sloan[22], who found similar results between the skinfold values and the ultrasound measurements.

The study by Booth *et al.*[21] evaluated the CC estimation by US, BIA and SF. Concerning the SF measurements, the study demonstrated that there were differences between the two measurements performed, and in the first collection the results were always higher than in the second one, especially in more obese individuals. The authors attributed this result to the compression of the fat layer during the use of the calipers. The best correlation found was between the US and BIA (r = 0.98, *standard error* = ±0.24) better than between SF and BIA (r = 0.81, *standard error* = ±0.57) or SF and US (r = 0.81, *standard error* = ±0.60). The authors highlighted the difference between the results obtained through SF estimation and the two other techniques as the main aspect in their study.

This research found similar results, since the correlation between the US and BIA was higher (0.767) than by BIA and SF (0.742) and US and the SF (0.709), as presented in table 3. Concerning the more obese subjects, BMI higher or equal to 25, alteration in the obtained correlations was also observed, since the correlation found decreased in comparison with all the other methods. However, in this population, the correlation between the US and the SF is higher (0.629) than between the US and the BIA (0.623) These results seem to reinforce the limitation of the CC estimation in more obese subjects.

However, some limitations of the study by Booth *et al.*[21], can be highlighted, the main are: the low number of subjects (both sexes) involved and the collection of few anatomic points, since the results comparing the US and BIA and the SF and BIA were only obtained from the assessment of the abdominal skinfold and using 20 and 14 subjects, respectively. A better comparison, but still limited, was obtained between SF and the US, which used the abdominal and subscapular skinfolds in 35 subjects[22].

In 1984, research by Fanelli and Kuczmarski[23] involving 124 men aged between 18 and 30 years, comparing the CC obtained by three techniques, SF, US (7.0 MHz) and hydrostatic weighing (HW) was conducted. The subcutaneous fat measurements with the US and SF were performed in seven anatomic points: triceps, subscapular, biceps, abdominal, suprailiac, thigh and calf and demonstrated good correlation for all points, being higher for triceps (r = 0.807), abdominal (r = 0.855) and thigh (r = 0.871). In order to estimate which method was the most accurate for estimation of body fat, both were compared with hydrostatic weighing and both presented high correlations, despite the SF present a higher correlation for five (triceps, biceps, subscapular, suprailiac and calf) out of the seven evaluated points. The US obtained better correlations only for abdomen and thigh.

This study also presented the thigh skinfold as the highest correlation; however, the lowest was the calf, while in the study by Fanelli and Kuczmarski[23] it was the subscapular (0.677).

The study by Black *et al.*[24] with US with high frequency pulses (10 MHz) compared the subcutaneous fat estimations among the US, SF and computer scan (CAT). In this study 39 volunteers were investigated (30 men and nine women) for the comparison between the US and SF, in four anatomic points (abdominal, subscapular, triceps and thigh) and 10 patients (four men and six women) for the comparison between the CAT and the US (in four points located on the abdomen, situated 5 and 10 cm away from each side of the umbilical region). In the comparison between the US and the CAT, the US underestimated the CC and, in the comparison between the US and SF, the results were opposite, once the US obtained higher measurements than the SF (despite the difference having been statistically significant for the two measurements: subscapular and thigh). The study concluded that it is clear that the measurement by ultrasound may produce satisfactory estimations of the subcutaneous fat thickness when compared with the CAT (r = 0.758) or SF (r = 0.804).

The authors also describe that SF presented reduction of 20% in the abdominal skinfold value in comparison with the US, due to the compression by the instrument, and that the best application of the SF technique was on the abdomen (r = 0.865) due to the easiness to pinch this skinfold. The other points presented poorer correlations due to the difficulty in pinching, especially on the thigh region, which presents thinner fat layer (r = 0.343).

A problem found during the study by Black *et al.*[24], with obese subjects, was the onset of a division membrane (*septum*) in the fat layer, which resulted in the formation of two echoes in the measurement check of the US. In our study, as the sample used was of thin men (general BMI of 23.96), this situation may have not interfered in the results. Body fat assessment was performed by Pineau *et al.*[25], with 93 young athletes aged between 18 and 33 years, mean of 23.5 years, of both sexes (24 women and 69 men), compared the results obtained through the portable US (5.0 MHz) and the DEXA. As results, the authors verified that the total body fat estimation performed by the US and the DEXA was highly accurate for both sexes (general
r = 0.99, *standard error* = 1.13 ± women (n = 11) r = 0.98, *standard error* = 1.61 ± men (n = 35) r = 0.98, *standard error* = ± 0.96).

A recent study by Reyes *et al.*[26], performed with obese children, indicated that the correlations obtained for the intra-abdominal adipose segment measured by US were better than the ones obtained by anthropometry. Moreover, significant associations were found between the intra-abdominal adipose storage estimated by the US and the presence of factors of cardiovascular risk, which allowed discriminating the onset of alterations in the metabolic parameters of obese children.

In another study released by the company *IntelaMetrix*, the authors Utler and Hager[27] compared the result of the body composition estimation through hydrostatic weighing, SF and US in an heterogeneous population of 70 high school fighters. In this study correlation of 0.97 was found between the hydrostatic weighing and US, and of 0.96 between hydrostatic weighing and the SF.

The skinfolds which presented the highest correlation in this study were: thigh, chest, subscapular and tricipital (table 3). However, it is impressive the fact that the US had overestimated the tricipital and chest skinfolds values and underestimated the subscapular and thigh skinfolds values when compared with the SF. This fact may be connected with the distances between the fat-muscle and muscle-bone interfaces, which are considered reference points in the technique used by the equipment.

The functioning principle of the *Bodymetrix* (2.5 MHz) follows the simplest operation way of an ultrasound system; that is, short-duration pulses are sent by a single transducer which also works as a receptor of echoes reflected on the interfaces among the many body layers. The greatest reflections occur in the great interfaces, for example: on the subcutaneous fat layer and in the muscle. However. There is replication of the ultrasound waves in the small interfaces (particles smaller than the length of the ultrasound wave), for example: intramuscular fat. Thus, random distribution of interfaces originates interference causing artifacts in the signal. Haymes *et al.*[28], in the study with 20 women and 17 men, verified that the correlation between the measurements obtained through the SF and the US were usually higher among women on each of the four skinfolds assessed (abdominal, suprailiac, subscapular and forearm). Such fact reinforces the idea that the variability of the distances between the interfaces in each anatomic point is still an unsolved issue in this methodology.

Since the studied population consisted of young individuals considered thin and military, who usually perform exercises on the bar, and consequently, develop the latissimus dorsi muscle, the subscapular and thigh skinfolds represent areas with muscular development; the underestimation in this case agrees with the findings by Suguisawa *et al.*[11], who studied the body composition of bovines and verified that there was decrease of the estimation of the subcutaneous fat via the US in the measurement which increased the muscles of the carcass.

The identification of the anatomic points with best correlation enabled the development of a new equation (equation 1) for the percentage of body fat through a linear regression. This new equation presented correlation significantly lower with the SF (rho = 0.783) than the values of fat percentage calculated by the *software* of the *Bodymetrix* device (rho = 0.709).

Bioimpedance is the magnitude of the opposition of the biological substrate to the passage of a given electrical current (alternated). Its measurement is influenced by variables as: frequency of the electrical signal, electrochemical processes, temperature, the hydrogen power (pH), hydration status and viscosity of the fluid or biological tissue under question[8]. Thus, the lean tissues are highly conducing of electrical current due to its large amount of water and electrolytes; that is, they present low resistance to the passage of electrical current. On the other hand, fat, bones and skin constitute a mean of low conductibility, presenting hence high resistance.

Among the bioimpedance instruments tested by Rodrigues *et al.*[2], the one which demonstrated the highest indices of concordance and association with hydrostatic weighing was the Maltron BF-900, the same used in this study. However, in the present study, the correlation found with the reference method was higher (rho = 0.742) than the one found by Rodrigues *et al.*[2], which was r = 0.55 with a $p < 0.01$.

From the electrical point of view, the biological tissues may be interpreted as a complex circuit made of resistors and capacitors both arranged in series and paralelly which act as conduces or dielectricals in which the current flow will follow the path of shorter opposition[8]. Thus, the fact higher correlation between biopimedance and SF in subjects with BMI > 25 is observed may related with the estimation of the capacitors reactance value which simulate the lectrode-sikin interface, since in the subjects with more subcutaneous adipose tissue the variability of the reactance of this interface tends to have lower influence on the impedance final value.

For this same reason, the good correlation (rho = 0.767) found between the measurements found by the US and the bioimpedance would be explained, since, as previously discussed, too thin skin-fat layers seem to increase the variability of the US measurements.

CONCLUSION

New instruments have been devised to fill in gaps in practical, reliable and reproducible use; however, all the assessment methods of body composition present positive and negative aspects. When the fat percentage values estimated by the portable ultrasound (US) and the skinfolds (SF) are compared, significant correlations among all the assessed points were observed. The points with higher correlation were thigh (rho = 0.715) and chest (rho = 0.700), which are points with lower fat thickness and higher muscle development. The worst correlations found were calf (rho = 0.249) and medial axillary (rho = 0.377).

Generally speaking, the US overestimated the fat percentage values when compared with the ones obtained by SF, except for the subscapular, suprailiac and thigh skinfolds Similar results have been described in other studies, evidencing that the SF presented reduction of 20% in the abdominal skinfold value in comparison with the US, due to the compression way by the instrument, and that the better application of the SF technique occurred in points where it was easy to pinch the skinfold. When the three methodologies are compared, the US presented better correlation with the BIA (rho = 0.767) than with the SF (rho = 0.709), both in general and within the thinner subjects. The situation is opposite between the overweight and obese subjects (BMI higher or equal to 25) and the correlation between the US and the SF is higher (rho = 0.629) than between the US and the BIA (rho = 0.603). Finally, based on the anatomic points with best correlation (higher than 0.600), a new equation by linear regression is suggested, for estimation of the CC by US which increased the correlation obtained through the traditional equation from rho = 0.709 to rho = 0.783. Although the best correlation does not surpass 0.080 points, it is important to observe that the new equation uses only three anatomic points, which reduces the time of collection with improvement in the fat percentage when compared with the values estimated by SF.

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