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Comparison between Body Fat Measurements Obtained by Portable Ultrasound and Caliper in Young Adults

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Abstract – **The objective of this study was to compare and correlate the Portable Ultra Sound (US) measuring technique to the skinfold measuring technique (SF) to estimate body fat percentage (%F) in young adults. Sixty military were evaluated, all males, divided in two groups: Group 1 (normal) composed by 30 military with Body Mass Index (BMI) until 24.99 *kg/m²* and Group 2 (overweight) composed by 30 military with BMI > 25 *kg/m²*. Weight, height, skinfolds and ultrasound were measured in 9 points (triceps, subscapular, biceps, chest, medium axillary, abdominal, suprailiac, thigh and calf). Body fat average values obtained by skinfold thickness and ultrasound measurements were 13.25 ± 6.32 % and 12.73 ± 5.95 % respectively. Despite significant differences in measurements of each anatomical site, it was possible to verify that the total final body fat percentage calculated by both techniques did not present significant differences and that overweight group presented greater similarity between the values obtained using caliper and ultrasound equipment.**

Keywords - **Body composition, Skinfold thickness, Portable Ultrasound, Anthropometry, Healthcare.**

I. Introduction

Today, the world is suffering from diseases related to the overweight population what has increased the interest in studies of body composition (BC) [1]. There are several techniques for estimating body fat as the Hydrostatic Weighing (HW) [2], Computed Tomography [3], Electrical Bioimpedance (BIA) [4], Dual energy X-ray absorptiometry (DEXA) [5], plethysmography, among other. However, these are difficult to implement and have high cost, being used in laboratory environment. With the evolution of technology, it is observed trend for the development of more sophisticated techniques for estimation of body composition proposed to use outside the laboratory environment [6].

Thus, due to its low cost, the anthropometric technique remains the most used around the world. This technique comprises measurements of diameters, circumferences, mass and skinfolds [7]. This way, the estimated subcutaneous fat percentage (%F) by skinfold caliper has wide acceptance. Besides, it does not significantly differ from Hydrostatic Weighing, recognized as validation criterion to other techniques [8]

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Portable ultrasound (US) recently arrived to the market to estimate the percentage of subcutaneous fat (%F). The main advantage of this method in respect of skinfold would be to minimize variations inter and intra-evaluator, the portability and ease of handling the equipment for beginners.

The goal of this study was to compare the fat percentage (%F) obtained by portable ultrasound to the values calculated from skinfold caliper into two groups with different body compositions because there still has been no interest-free evaluation regarding the effectiveness of this new equipment.

II. Materials and Methods

This is a cross-sectional study, held during the month of July 2010, in a sample comprised of 60 Brazilian Army military selected in a military troop based in the city of Curitiba-PR, Brazil. Two military groups were selected: (1) 30 military with BMI between 18.5 kg/m^2 and 24.99 kg/m^2; (2) 30 military with BMI > 25 kg/m^2.

The following materials were used for data collection: flexible measuring tape, with 0.5 *cm* width and precision of 0.5 *mm*; calibrated Cescorf caliper; a balance equipped with stadiometer, brand Filizola, with a capacity of 150 *kg* and 100 *g* accuracy; Bodymetrix (Model BX2000 – IntelaMetrix, Inc.) ultrasound equipment; a portable computer.

During data collection, there were no denials, losses or operational problems. Skinfold were collected in nine anatomical points [9]: triceps, subscapular, biceps, chest, medium axillary, abdominal, suprailiac, thigh and calf. The skin folds were collected in three consecutive measurements by a single professional with 20 years of experience in this activity. The measure of height and weight were carried out with the military barefoot, wearing shorts.

The equation (1) proposed by Jackson and Pollock [9] has been used for body density (BD) calculation considering nine skinfolds (Sf) (triceps, subscapular, biceps, chest, medium axillary, abdominal, suprailiac, thigh and calf) and Siri equation (2) was used to estimate the percentage of body fat [10].

$$BD = 1.112 - (4.3499 \cdot 10^{-4} \cdot \sum Sf) + [5.5 \cdot 10^{-7} \cdot \sum Sf^2] - (2.882 \cdot 10^{-3} \cdot age) \quad (1)$$

$$\%Fat = \left[\left(\frac{495}{BD}\right) - 450\right] \cdot 100 \quad (2)$$

The software BodyView considers that the interfaces between the layers, body fat-muscle and muscle-bone, have distinct coefficients of reflection (*R*), *R*=0.012 and *R*= 0.22

respectively. It has allowed estimation of these layers [11], as shown in Figure 1. The measure of the fat layer is given by the ultrasonic differences of characteristics of fat, muscles and bones, such as: density (*kg/m³*), impedance (kg/m²s, attenuation coefficient (*dB/cm*).

Descriptive statistics; the Pearson correlation coefficient to verify the correlation of variables; the t-test for independent groups for comparison of the measurements of each anatomical site and the paired t-test to compare the averages of the %F of each technique were used. All statistical tests were conducted at the program SPSS version 13.0 and with significance level of 0.05.

The values obtained by caliper were divided by two in order to estimate the thickness of the skin-fat layer that is evaluated by US for comparison of averages obtained by two equipments in each anatomical site.

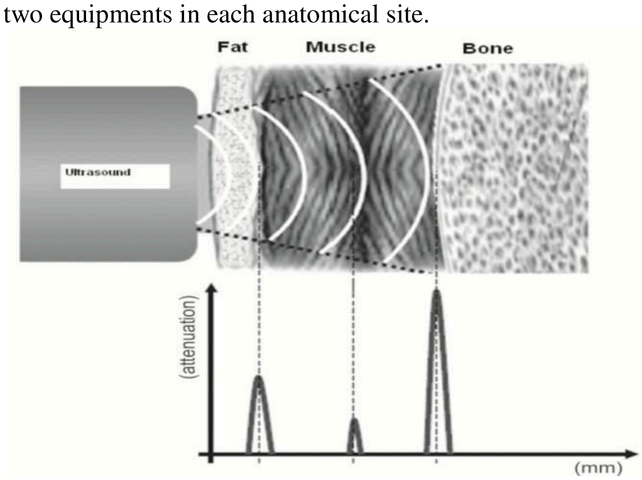

Fig. 1. Illustration of the principle of use of ultrasound to obtain the thickness of body layers [11]

The study followed the ethical aspects recommended by Brazilian laws on researches involving human subjects, as well as the ethical principles contained in the Declaration of Helsinki (1964, revised in 1975, 1983, 1989, 1996 and 2000).

III. RESULTS

Sixty military were evaluated, all male, with average age of 19.43 ± 1.79 *years*, average weight of 71.58±12.25 *kg*, average height of 1.74±0.07 *m* and average BMI of 23.61±3.8 *kg/m²*.

The average values of the body fat percentage, obtained by skinfolds and the US were 13.25 ± 6.32 % and 12.73 ± 5.95 %, respectively. The values of anthropometric variables by group are presented in table 1.

Observing the Tables 2 and 3, it can realize that only for evaluations of biceps skinfold the average values of US were greater than those measured by SF. The paired t-test indicated statistically significant differences ($p = 0$) between measurements obtained through SF to the measurements taken by US.

TABLE 1
Values of anthropometric variables by group of studied BMI

	N	Minimum - Maximum	Mean	Std. Deviation
Normal Group				
Age [*years*]	30	18-23	19	1.31
Weight [*kg*]	30	50.5-70.1	61.12	4.4
Height [*m*]	30	1.64-1.86	1.75	0.06
BMI [kg/m^2]	30	18.68-20.83	19.93	0.62
Overweight Group				
Age [*years*]	30	18-25	19.87	2.1
Weight [*kg*]	30	66.2-101.1	82.04	7.71
Height [*m*]	30	1.60-1.88	1.73	0.07
BMI [kg/m^2]	30	25.62-29.98	27.29	1.05

Tables 2 and 3 show the values in *mm* of the measurements presented by skinfold caliper and by US in the different anatomical sites evaluated for Group 1 and 2 respectively.

TABLE 2
Values obtained for the Group 1[*mm*]

Variables	Normal Group (*N*=30) Skinfold | Ultrasound
Triceps	7.87 ± 1.7 | 3.8 ± 1.26
Subscapular	11.28 ± 2.9 | 4.19 ± 2.89
Biceps	3.92 ± 0.76 | 6.22 ± 5.98
Chest	6.13 ± 1.44 | 3.21 ± 0.89
Medium Axillary	7.6 ± 1.7 | 4.43 ± 2.93
Abdominal	13.48 ± 4.87 | 6.41 ± 3.78
Suprailiac	10.9 ± 4.66| 4.87 ± 2.35
Thigh	11.64 ± 2.63 | 4.71 ± 1.11
Calf	7.45 ± 1.84 | 5.09 ± 6.9

Table 4 shows that for the normal group (18.5 < BMI < 24.99 kg/m^2), only in two anatomical site (chest and thigh) significant correlations were observed. But for the overweight group (BMI>25 kg/m^2) significant correlations were observed in five anatomical sites (triceps, subscapular, abdominal, suprailiac and thigh). Table 5 presents this analysis by anatomical site in both groups.

According to Table 5, although several anatomical sites presented significant differences, the percentage of body fat did not present difference. This fact is due to US uses an equation to estimate the body fat percentage. The overweight group presented greater similarity between the values obtained by caliper and by US, keeping the trend observed in previous analyses.

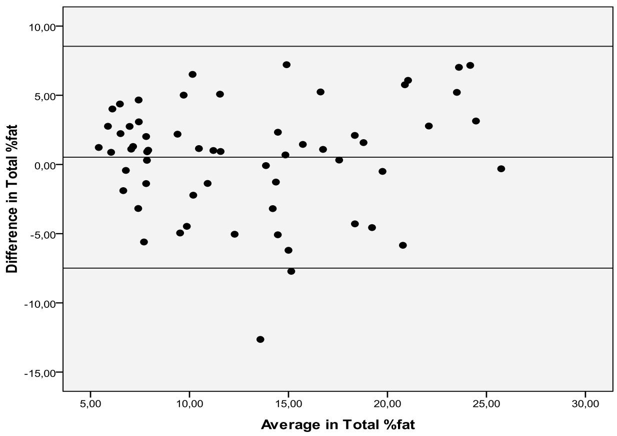

Fig. 2. Bland-Altman plot to Total %fat with reference lines [mean ± 1.96 s.d.], where Difference= (Sf-Us) and Average = [Sf + Us]/2

TABLE 3

Values obtained for the Group 2 [*mm*]

Variables	Overweight Group (*N*=30) Skinfold l Ultrasound
Triceps	13.9 ± 4.36 l 7 ± 2.18
Subscapular	20.96 ± 8.22 l 7.76 ± 2.18
Biceps	6.22 ± 1.81 l 16.26 ± 8.42
Chest	12.83 ± 5.20 l 8.74 ± 6.7
Medium Axillary	17.45 ± 7.55 l 8.53 ± 3.19
Abdominal	28.21 ± 10.63 l 21.71 ± 9.13
Suprailiac	22.61 ± 11.59l 9.30 ± 3.14
Thigh	21.05 ± 6.18 l 8.20 ± 2.22
Calf	12.59 ± 4.41 l 9.13 ± 4.66

TABLE 4

Correlation r between measurements of SF and US per anatomical site.

	Normal Group		Overweight Group	
	R	***P***	***r***	***P***
Triceps	0.095	0.617	0.517*	0.003
Subscapular	0.302	0.105	0.485*	0.007
Biceps	0.12	0.527	0.252	0.18
Chest	0.622*	0	0.334	0.071
Medium Axillary	0.239	0.203	0.033	0.862
Abdominal	-0.006	0.974	0.38*	0.038
Suprailiac	0.047	0.806	0.488*	0.006
Thigh	0.381	0.038	0.746*	0
Calf	-0.032	0.869	-0.164	0.386
Fat Percentage	0.161	0.397	0.5*	0.005

TABLE 5

Differences between the averages of the measurements taken by Skinfold and US

	Normal weight		Overweight	
	T	***P***	***T***	***P***
Triceps	0.504	0.618	-0.121	0.904
Subscapular	5.542	0	4.141	0
Biceps	-3.927	0	-8.746	0
Chest	-1.066	0.295	-2.012	0.054
Medium Axillary	-1.213	0.235	0.215	0.831
Abdominal	0.407	0.687	-4.819	0
Suprailiac	0.985	0.333	2.162	0.039
Thigh	4.470	0	6.174	0
Calf	-1.076	0.291	-2.831	0.008
Fat percentage	1.838	0.076	0.04	0.969

IV - DISCUSSION

Historically, the technique of ultrasound for the evaluation of subcutaneous fat, according to studies of Whittingham, in 1962, has been frequently used in pets. The author, after some modifications in the original methodology, has proposed its use in groups of human beings [12].

In this context, Booth, Goddard and Paton [13] in 1966, raised the possibility of measurements of the subcutaneous fat by ultrasound could be more reliable than by caliper. Fact refuted by Sloan in 1967. He has found similar results between the values of skinfold measurements by ultrasound and calipers [14]. Since then, the SF results are considered trusted and widely used measurements [7, 8, 9].

The study that assessed the estimate of body composition by US and SF [13], has shown that there were differences between the two taken measurements of SF. Iin the first data collection, the results were always higher than those of the second one, especially in overweight individuals. The authors attributed this result to compression of the layer of fat while using the caliper. The correlation between SF and US was found (r = 0.81, *standard error*=±0.60). These authors highlighted the difference between the results obtained by estimation by SF and the US as the main aspect of their study. This study found similar results, since the correlation between the US and the SF presented $r = 0.779$.

Today, new equipments of US whose main advantage is portability are being developed. However, the size reduction of the equipments appears to reduce also the validity of their measurements. Despite of this, some researches point out that the US shows a good correlation with the body fat percentage estimated by SF. When the sample is separated by fat percentage, it is noticed that the correlation found was better for the Overweight Group (r = 0.500) than to the Group 1 (r = 0.397).

The few found studies that compare the accuracy of the measurements obtained by portable with other US equipment were disclosed by the company that sells it in Brazil [15, 16]. The result obtained in this study confronts with the study of Drew *et al.* [15] who has found correlations to the values of body fat percentage above 0.94 between portable US and the SF on young athletes and with low body fat percentage of both genders (24 females e 15 males).

In another study released by the company Hager and Utler [16], they have compared the result of the estimation of body composition by Hydrostatic Weighing, SF and US in a heterogeneous population of 70 high school wrestlers. In this study, it was found a correlation of 0.97 between Hydrostatic Weighing and the US, and 0.96 between Hydrostatic Weighing and SF [16].

These studies [15,16], however, suffered from problems of conflict of interest and have not passed through peer review. It seems to explain the discrepancy with the results of this research.

The only anatomical site that presented a correlation between the SF and the US in our study for both groups was the thigh (point with the lower fat thickness and greater muscular development). The chest anatomical site still presented significant correlation to Group1 and triceps, subscapular, abdominal and suprailiac for the Group 2. It is interesting to note that the US seems to have overestimated only the values of the biceps skinfold in the two groups. This fact can be explained by the distances between the fat-muscle and bone muscle interfaces which are considered as points of reference on the technique used by the equipment.

V - Conclusion

The final body fat percentage calculated by both techniques did not present significant difference. When the skin thickness measured by the two techniques are compared. It can realize that, in several anatomical points, they have significantly different magnitudes. This fact added to the lack of correlation between measurements of US and SF decreases the credibility of portable US equipment used in this study, especially for groups with lower body fat percentages.

However, it is known that these results can be contested by subsequent studies with a greater number of volunteers to verify the feasibility of using portable US equipment for the estimation of body fat, since in studies with conventional US equipment showed validation parameters far better than the tested portable US.

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