26 - ESTIMATION OF BODY FAT USING ARM-TO-LEG AND LEG-TO-LEG BIOELETRIC IMPEDANCE ANALYSIS

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Introduction

There is considerable interest in the evaluation of body composition in physical education and sport as it is known that body composition has a significant effect on athletic performance as well as that physical exercise has the potential to alter body composition (Behnke, Wilmore, 1974). Body composition evaluation is generally directed to assess two compartments, fat mass and fat-free mass. It is, nevertheless, not possible to determine exactly the composition of the living human body.

Accordingly, to estimate body composition there is a need of a technique that is safe, noninvasive, rapid and at the same time reliable, accurate, and sensitive to the small differences that may occur over the course of physical exercise programmer. There are several methods by which to estimate the amount of fat mass and fat-free mass (Brozek et al, 1963). Among these methods, the bioelectric impedance method (BIA) has become widely used, since it is a rapid way to estimative of percent body fat (Lukaski, 1987; Brodie, Moscrip, Hutcheon, 1998). The BIA has been validated with reference to underwater weighing (Deurenberg et al, 1990), DEXA (Panatopouolos et al, 2001) and tritium dilution (Wang et al, 1995).

BIA measures the opposition of body tissues to the flow of a small (less than 1 mA) alternating current. Impedance is a function of two components (vectors): the resistance of the tissues themselves, and the additional opposition (reactance) due to the capacitance of membranes, tissue interfaces, and nonionic tissues. The measured resistance is approximately equivalent to that of muscle tissue (Baumgartner, 1996).

Many equations are available to estimate total body water, fat-free mass and fat mass as a function of impedance, weight, height, gender, and age (Segal et al, 1988; Deurenberg et al, 1991; Houtkooper et al, 1992; Sun et al, 2003). In actual use, however, BIA calculations of an individual's body fat may vary by as much as 10% of body weight because of differences in machines and methodologies used. Equations and their variables differ, as does the choice of a reference method (Lukaski et al, 1986; Graves et al, 1989).

From a practical point of view, the conventional arm-to-leg BIA is useful because it is relatively simple, quick, portable, and requires the subject to lie in a relaxed supine position for a few minutes with four electrodes on the hand and foot. However, recent attention has been given to the new leg-to-leg BIA, which has several operational advantages when compared with the conventional arm-to-leg BIA. This leg-to-leg BIA is even easier to use for estimation of body fat, but is functionally different from other BIA system because the four electrodes are stainless steel pressure footpads which are mounted on a scale that is similar to a regular weighing scale (Nunez et al, 1997). Hence, the subject need to do is stand on the platform in their bare feet. Body weight and leg-to-leg BIA are then measured simultaneously. No skill is required as electrodes do not need to be placed at specific sites on the body.

The purpose of this study was to compare estimative of percent body fat using a leg-to-leg BIA system and an arm-to-leg BIA system in healthy young adults.

Methodology

Subjects were 50 Caucasian healthy young adults (27 females and 23 males), with ages between 18 and 25 years. Written informed consent was obtained of each subject before the study. Height was measured with a stadiometer to the nearest 0,1 cm and the body weight was measured with an electronic scale to the nearest 0,1 kg. The subjects were measured without shoes wearing only light clothes. The body mass index [weight in kg/(height in m)^2] was calculated.

Arm-to-leg BIA was measured with the subject lying supine using the Biodynamics 310E (Biodynamics Corporation, USA). The current electrodes were placed on the dorsal surface of the right hand and right foot at the distal metacarpals and metatarsals, respectively. The detector electrodes were placed next to the ulnar head of the right wrist and between the medial and lateral malleolus of the right ankle. Alcohol swabs were used to clean the sites prior to attachment of the electrodes. Height (cm), body weight (kg), age (years) and gender (female/male) were entered and the device output the following values: reactance, resistance, total body water, fat-free mass, fat mass, and percent body fat.

Leg-to-leg BIA was measured by the Tanita Body Fat Analyzer model TBF-305 (Tanita Corporation, Tokyo, Japan). This required the subject to stand on the footpads housing the electrodes, ensuring that the front of each foot was in contact with the toe electrode and the rear of each foot in contact with the heel electrode. The footpads were cleaned with alcohol swabs prior to each measurement. Height (cm), mode (child/adult) and gender (female/male) were entered and the device output the following values: weight, fat-free mass, fat mass, and percent body fat.

Before measuring, subjects were required to adhere to these BIA guidelines: (a) to not eat or drink within 4 h of the measure; (b) to maintain normal body hydration; (c) to not consume caffeine within 12 h of the test; (d) to not consume alcohol within 48 h of the test; (e) to not physical exercise within 24 h of the measure; (f) to not take diuretics within 7 d of the measure; and (g) to urinate within 30 min of the measure (Baumgartner, 1996).

Statistical analyses were performed using the SPSS statistical software, version 12.0. Mean and standard deviation of descriptive data were calculated. Student´s t-test was used to compare the genders. Pearson product moment correlations were used to assess the relationships between the percent body fat predicted by both methods. Differences between the predictions of percent body fat from each method were also investigated using Student´s t-test. To assess the extent to which the percent body fat values estimated from leg-to-leg BIA agreed with the percent body fat values estimated from arm-to-leg, levels of agreement were calculated as described by Bland-Altman (1986). The average bias and 95% confidence interval (95% CI) for the bias was calculated for percent body fat results for both genders separately.

Results

The physical characteristics of the subject's samples, including height, weight, BMI and percent body fat are presented in table 1. As expected, the males were taller and heavier than the females. However, both genders had similar BMI. The percent of body fat analyzed by the arm-to-leg BIA and leg-to-leg BIA was significantly higher in females than in boys, and the values in both genders was greater by leg-to-leg than arm-to-leg BIA.

Table 1 Physical characteristics of the subject's samples (means ± standard deviation)

	Females (n = 27)	Males (n = 23)	*t*-test	*p*-value
Height (cm)	164,56 ± 5,03	177,05 ± 5,46	7,409	0,000
Weight (kg)	57,82 ± 9,27	71,49 ± 9,32	4,554	0,000
BMI (kg/m^2)	21,27 ± 2,52	22,75 ± 2,30	1,843	0,073
Arm-to-leg BIA Fat (%)	22,47 ± 5,63	12,20 ± 3,94	6,398	0,000
Leg-to-leg BIA Fat (%)	26,91 ± 6,54	13,53 ± 4,11	7,370	0,000

There were strong correlations between the estimated percent of body fat by arm-to-leg BIA and leg-to-leg BIA. For the females, the correlation coefficient was 0,82 (p<0,000) and for males 0,61 (p<0,001). Student's t-test showed that in females the Tanita BIA system predicted a higher mean percent body fat than the Biodynamics BIA system (*t*=5,614; p<0,000), but in males there were no differences between mean percent body fat predicted by any of the methods (*t*=1,532; p<0,153) table 2.

Table 2 Pearson product moment correlations and Student's t-test between the percent body fat predicted by arm-to-leg BIA and leg-to-leg BIA.

	Correlation Coefficient (r)	*t*-test
Females (n = 27)	0,82 (p < 0,000)	5,614 (p < 0,000)
Males (n = 23)	0,61 (p < 0,001)	1,532 (p < 0,153)

If the arm-to-leg BIA values were taken as reference, the leg-to-leg BIA overestimated the percent body fat in females and males when analyzed by the Bland-Altman method table 3. Bland-Altman plots did not show any systematic difference between the two methods with respect to different levels of adiposity. However, the intraindividual variation of the percentage of body fat estimated by the two methods was very large, especially in regard to the females (mean difference of 6,0 ± 5,5 and 4,3 ± 5,4 for females and males, respectively).

Table 3 Levels of agreement for percent body fat estimated by arm-to-leg BIA and leg-to-leg BIA.

	Bias (Mean Difference)	Standard Deviation	95% Limits of percent body fat from leg-to-leg BIA relative to arm-to-leg BIA
Females	6,0	± 5,5	0,5 to 11,5
Males	4,3	± 5,4	- 1,1 to 9,7

Discussion

In this study, we compared the conventional arm-to-leg BIA and a different type of impedance analyzer leg-to-leg BIA. The correlations between percent body fat obtained by the two methods were strong, but there was a clear difference between the values of percent body fat. This is partly explained by the fact that the path of the electrical current is different for these two methods.

When the results obtained by the two methods are compared, the leg-to-leg BIA shows higher percent body fat particularly in females. This is probably due to the fact that in the leg-to-leg BIA the electric current travels only through the lower body, where the fat tissue tends to accumulate in females. In the leg-to-leg apparatus, the inbuilt equations to convert the impedance values to percent body fat do not seem to take adequately into account the gender difference in body fat distribution. The correlation between the two methods with respect to percent body fat was higher for females than males. This may be a function of the narrower range of scores in the males' data, which would elicit lower correlations.

Additionally, correlational analysis shows if two measures are related to each other. However, it does not show if the two measures agree with each other. To assess the extent to which the values of the percent body fat measured from leg-to-leg agreed with the values measured from arm-to-leg, levels of agreement were calculated as described by Bland-Altman. The results obtained showed the 95% limits of agreement a bias to overestimation of percent body fat in both genders. For example: a male measuring 12% body fat estimated by arm-to-leg BIA may be estimated as anywhere between 10,9% and 21,7% by the leg-to-leg BIA (95% IC; -1,1 to 9,7). A female measuring 22% body fat estimated by arm-to-leg BIA may be estimated as anywhere between 22,5 and 33,5% by the leg-to-leg BIA (95% IC; 0,5 to 11,5). As females are very susceptible to a fear of fatness this over and under estimation greater has important implications.

In conclusion, values of percent body fat obtained with the simple leg-to-leg BIA method correlate strongly with those obtained by the conventional arm-to-leg BIA, which has been more extensively validated against more sophisticated methods measuring adiposity. However, there were great differences between the absolute percent body fat values obtained by the two BIA methods. More studies are needed to improve the equations of the software of the leg-to-leg method in converting impedance figures to percent body fat. Both methods confirmed that there is a gender difference in the distribution of percent body fat at the age of 18-25 years.

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ESTIMATION OF BODY FAT USING ARM-TO-LEG AND LEG-TO-LEG BIOELETRIC IMPEDANCE ANALYSIS

Abstract

The purpose of the study was to compare estimative of percent fat in adults using arm-to-leg and leg-to-leg bioelectrical impedance analysis (BIA). Subjects were 50 adults (27 females and 23 males), with ages between 18 and 25 years. Arm-to-leg bioelectric impedance was measured using the Biodynamics 320E and leg-to-leg bioelectric impedance was measured using the Tanita TBF-305. The results indicate a strong correlations between body fat estimate by these two devices (r=0,82 for females and r=0,61 for males). However, there was a clear difference in the absolute values due to the fact that the devices measure different segments of the body. Using the Bland-Altman comparison method, a large intraindividual difference was observed in the fat percentages by the two devices, independent of adiposity level.

Key Words: Body composition; Body fat; Bioelectric Impedance

ESTIMATION DE LA GRAISSE CORPORELLE UTILISANT DES PROCÉDÉS DE BIOIMPÉDANCE ÉLECTRIQUE DE CORPS ENTIER ET DE SEGMENT INFÉRIEUR

Resumé

La proposition de cette étude a été de comparer les estimations de la proportion de graisse corporelle en utilisant les procédés de bioimpédance électrique du corps entier et du segment inférieur. Ont été analysés 50 sujets adultes (27 femmes et 23 hommes), agés de 18 à 25 ans. La bioimpédance électrique de corps entier a été mesurée avec l'appareil Biodynamics 320E, alors que la bioimpédance électrique de segment inférieur a été mesuré avec l'appareil Tanita TBF-305. Les résultats indiquent une correlation élevée entre les estimations de graisse corporelle suivant les deux procédés (r=0,82 pour les femmes et r=0,61 pour les hommes). Pourtant, des différences évidentes dans les valeurs absolues de graisse corporelle se constatent dû au fait que les deux procédés ont évalué des différents segments du corps. En comparant les deux procédés d'après la méthode de Bland-Altman, des différences intra-individuelles accentuées se démontrent dans les proportions estimées de graisse corporelle, indépendamment du niveau d'adiposité.

Mots-Clés: Composition Corporelle; Graisse corporelle; Bioimpédance Électrique.

ESTIMATIVA DE LA GRASA CORPORAL MEDIANTE PROCEDIMIENTOS DE BIOIMPEDANCIA ELÉCTRICA DE CUERPO ENTERO Y DE SEGMENTO INFERIOR

Resumen

El objetivo del estudio fue comparar estimativas de la proporción de grasa corporal mediante procedimientos de bioimpedancia eléctrica envolviendo el cuerpo entero y el segmento inferior. Fueron analizados 50 sujetos adultos (27 mujeres y 23 hombres), con edades entre 18 y 25 años. La bioimpedancia eléctrica de cuerpo entero fue medida con el equipo Biodynamics 320E, mientras la bioimpedancia eléctrica de segmento inferior fue medida con el equipo TanitaTBF-305. Los resultados indican una elevada correlación entre las estimativas de grasa corporal presentada por medio de los dos procedimientos (r=0,82 para mujeres y r=0,61 para los hombres). Sin embargo, se notan grandes diferencias en los valores absolutos de grasa corporal con relación al hecho de que ambos procedimientos envuelven diferentes segmentos del cuerpo. Comparando los dos procedimientos, por medio el método de Bland-Altman, se comprueban acentuadas diferencias intra-individuales en las proporciones estimadas de grasa corporal, independiente del nivel de adiposidad.

Palabras-Claves: Composición Corporal; Grasa Corporal; Bioimpedancia Eléctrica

ESTIMATIVA DA GORDURA CORPORAL MEDIANTE PROCEDIMENTOS DE BIOIMPEDÂNCIA ELÉTRICA DE CORPO INTEIRO E DE SEGMENTO INFERIOR

Resumo

O propósito do estudo foi comparar estimativas da proporção de gordura corporal mediante procedimentos de bioimpedância elétrica envolvendo o corpo inteiro e o segmento inferior. Foram analisados 50 sujeitos adultos (27 mulheres e 23 homens), com idades entre 18 e 25 anos de idade. Bioimpedância elétrica de corpo inteiro foi medida com o equipamento Biodynamics 320E, enquanto bioimpedância elétrica de segmento inferior foi medida com o equipamento Tanita TBF-305. Os resultados indicam uma elevada correlação entre as estimativas de gordura corporal apresentada mediante os dois procedimentos (r=0,82 para mulheres e r=0,61 para os homens). No entanto, constatam-se nítidas diferenças nos valores absolutos de gordura corporal devido ao fato de ambos os procedimentos envolverem diferentes segmentos do corpo. Comparando os dois procedimentos, mediante o método de Bland-Altman, comprovam-se acentuadas diferenças intra-individuais nas proporções estimadas de gordura corporal, independente do nível de adiposidade.

Palavras-Chaves: Composição Corporal; Gordura Corporal; Bioimpedância Elétrica.