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BODY COMPOSITION ASSESSMENT IN OLDER PERSONS

BIOELECTRICAL IMPEDANCE WITH DIFFERENT EQUATIONS VERSUS DEUTERIUM OXIDE DILUTION METHOD FOR THE INFERENCE OF BODY COMPOSITION IN HEALTHY OLDER PERSONS

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Abstract: *Background:* There is no consensus regarding the accuracy of bioimpedance for the determination of body composition in older persons. *Objective:* This study aimed to compare the assessment of lean body mass of healthy older volunteers obtained by the deuterium dilution method (reference) with those obtained by two frequently used bioelectrical impedance formulas and one formula specifically developed for a Latin-American population. *Design:* A cross-sectional study. *Participants:* Twenty one volunteers were studied, 12 women, with mean age 72±6.7 years. *Setting:* Urban community, Ribeirão Preto, Brazil. *Measurement:* Fat free mass was determined, simultaneously, by the deuterium dilution method and bioelectrical impedance; results were compared. In bioelectrical impedance, body composition was calculated by the formulas of Deuremberg, Lukaski and Bolonchuck and Valencia et al. *Results:* Lean body mass of the studied volunteers, as determined by bioelectrical impedance was 37.8±9.2 kg by the application of the Lukaski e Bolonchuk formula, 37.4±9.3 kg (Deuremberg) and 43.2±8.9 kg (Valencia et. al.). The results were significantly correlated to those obtained by the deuterium dilution method (41.6±9.3 Kg), with r=0.963, 0.932 and 0.971, respectively. Lean body mass obtained by the Valencia formula was the most accurate. *Conclusion:* In this study, lean body mass of older persons obtained by the bioelectrical impedance method showed good correlation with the values obtained by the deuterium dilution method. The formula of Valencia et al., developed for a Latin-American population, showed the best accuracy.

Key words: Elderly, body composition, lean body mass, bioelectrical impedance, deuterium oxide dilution.

Introduction

Body composition is associated with functional capacity and diseases in older persons (1). Excess of fat and depletion of lean body mass have been associated with a higher risk of chronic diseases and its assessment is a predictor of survival in critical diseases (2).

Various methods have been proposed to estimate body composition in the aged (3). Anthropometry and bioelectrical impedance analysis (BIA) are the most frequently used because of their large availability and easy application. On the other hand, there are many limitations for the use of these methods in older persons, i.e. the presence of edema, disturbances of the fluid metabolism, recent food intake and diaphoresis. Moreover, different formulas to calculate body compartments are available, most of them developed for European or north-American populations.

Bioelectrical impedance (BIA) is a safe, non-invasive and relatively inexpensive method, applicable to all age groups. However, equations need to be validated against more precise (reference) methods. One of them is the deuterium oxide dilution (4), which is safe, gold-standard for the measurement of total body water (TBW) and, as TBW is the main predictor of fat-free mass (FFM) in healthy subjects, highly precise for the measurement of FFM.

The Brazilian population, although being composed largely by European descendants, has a different phenotype due to high miscegenation, different climate, environment and food consumption. It also differs from other populations in anthropometrics and body composition parameters. Consequently, the applicability of the formulas most frequently used for the calculation of body composition by BIA deserves further studies.

This research aimed to compare two equations frequently applied in bioelectric impedance analysis (Lukaski and Bolonchuck (5) and Deuremberg (6)) and the formula of Valencia and colleagues, developed for a Latin-American population, in the assessment of fat free mass of Brazilian older persons, employing as reference the deuterium dilution method.

Methods

Population

Twenty one volunteers aged 60 years or over, followed by Family Health Program of the School of Medicine of Ribeirão Preto, University of São Paulo, were studied. The selection of volunteers was random, including all the census areas of the area followed by the Family Health Program, as determined by the Brazilian Institute of Geography and Statistics, 2000.

Inclusion criteria were: being independent, with intact or mildly impaired cognition. Volunteers with cardiovascular disorders, diabetes, hypertension and other chronic diseases, clinically stable and with no detectable disorders of the hydration status were also included.

Exclusion criteria were: being dependent, home-bound or bed-ridden, with sequelae of cerebrovascular or other chronic

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diseases. Volunteers with non-controlled chronic disorders, losing or gaining weight or under dietetic restrictions were excluded from this research.

Statement of Ethics

This study was approved by the local Human Research Ethics Committee. All volunteers signed an informed consent prior to participation.

Body composition Study

Anthropometric assessment

All volunteers had their weigh measured after overnight fast, with light clothes and empty bladder (Filizola® ID 1500 scale, Brazil). Height was measured by a wall ruler with the volunteers standing without shoes and erect, with neck and head in the same line of the torso.

Bioelectrical impedance analysis

After weight and height evaluation, tetrapolar bioelectrical impedance at 800 microamperes and 50 kilohertz (Quantum BIA 11Q-RJL, RJL Systems, Michigan, USA) was performed with standard electrodes positioned in ipsi-lateral wrist and ankle and in the distal line of metacarpus and carpus in the dominant dimidium (7). Resistance and reactance were employed to calculate FFM by the application of the formulas of Lukaski and Bolonchuck (5), Deurenberg and colleagues (6) and Valencia and colleagues (8), as shown below:

Lukaski and Bolonchuck formula:

Total body water (L) = $0.377 \times H^2 / R + 0.14 \times W - 0.08 \times A + 2.9 \times G + 4.65$

H: height, in cm; R: resistance, in ohms; W: weight, in kg; A: age, in years, and G: gender, with values 0, if female, and 1, if male.

Deurenberg and colleagues formula:

FFM (Kg) = $0.304 \times 104 \times H^2 / R + 15.34 \times H + 0.273 \times W - 0.127 \times A + 4.56 \times G - 12.44$

FFM: fat-free mass; H: height, in m; R: resistance, in ohms; W: weight, in kg; A: age, in years, and G: gender, with values 0, if female, and 1, if male.

Valencia and colleagues formula:

FFM (Kg) = $-7.71 + H^2 / R \times 0.49$ + country or ethnic x 1.12 + $P \times 0.27 + G \times 3.49 + Xc \times 0.13$

FFM: fat-free mass; H: height, in cm; R: resistance, in ohms, and Country or ethnic: Chile: 1; Mexico: 2 and Cuba: 3 (in this study, 1 was adopted as the value for Country), W: weight, in kg; G: gender, with values 0, if female, and 10, if male. Xc = reactance, in ohms.

Deuterium oxide dilution method

After BIA, each volunteer received a dose of 1mL.kg-1 of 7% deuterium oxide (Cambridge Isotope, USA). Saliva samples were collected before and three, four and five hours after dose intake. Samples were stored at –10°C until analysis.

Deuterium enrichment in saliva samples was determined by mass spectrometry (Europa Scientific Hydra System, Cheshire, United Kingdom). 500 µL saliva aliquots were equilibrated with 100% hydrogen with catalysis by platinum on alumina (Thermoquest platinum catalyst rods, Finnigan-Matt, Germany) and analyzed after 6h under constant temperature. Body composition was determined according to Schoeller et al. (1986) (9).

Statistical Analysis

Results are shown as mean and standard deviation (SD). Student's T test, Pearson correlation coefficient and the Friedman test for multiple samples were employed, as appropriate. When differences in the Friedman test were significant, a Wilcoxon Signed Rank test was performed to determine where the differences occurred. The Bland and Altman analysis was used to examine the bias (error) across the distribution of FFM associated with each formula. The level of significance adopted was $p = 0.05$. The SPSS software version 13.0 (SPSS Inc., Chicago, IL, USA) was employed for all statistical analyses.

Results

Twelve of the 21 volunteers (57.1%) were women. Mean age of women and men were, respectively, 70.7±7.3 years (range = 61 to 84 years) and 72.6±5.8 years (range = 65 to 81 years), ($p = 0.552$).

Table 1 shows the anthropometric data of the studied volunteers. According to the BMI classification of the World Health Organization (1997), four women were classified as normal, three as overweight and five as obese. Two men were classified as normal, three as overweight and four as obese. Overall, 28.6% of volunteers had BMI within the normal range, 28.6% in the overweight range and 42.8% in the obese range. None had edema.

Table 1

Anthropometric characteristics of the volunteers, according to gender

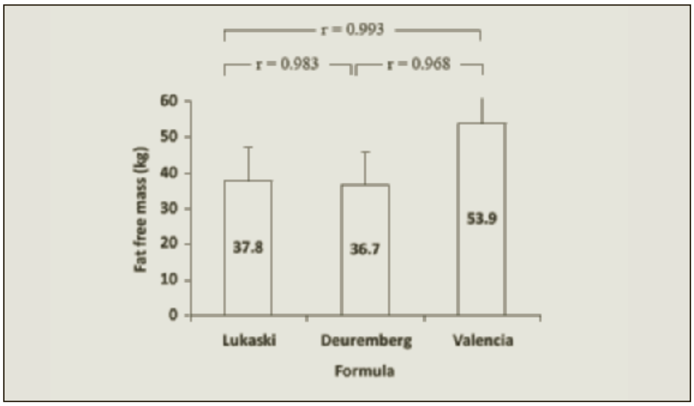
Gender		Minimum	Maximum	Mean	SD	p*
Female	Weight (kg)	48.8	83.3	62.5	7.3	0.002
	Height (m)	1.40	1.60	1.50	0.07	0.000
	BMI (kg/m²)	18.7	36.4	27.6	4.9	0.478
Male	Weight (kg)	65.0	81.0	72.6	5.8	-
	Height (m)	1.60	1.70	1.65	0.04	-
	BMI (kg/m²)	24.1	35.7	29.1	3.7	-

SD: standard deviation; BMI: body mass index; * T-test for independent samples, female versus male.

There was a strong and significant correlation of FFM when the three BIA formulas were compared (Figure 1). FFM was higher when calculated by the formula of Valencia ($p < 0.005$, Friedman test; post-hoc analysis Lukaski versus Deuremberg $p = 0.05$, Lukaski versus Valencia $p < 0.005$, Deuremberg versus

Valencia $p < 0.005$).

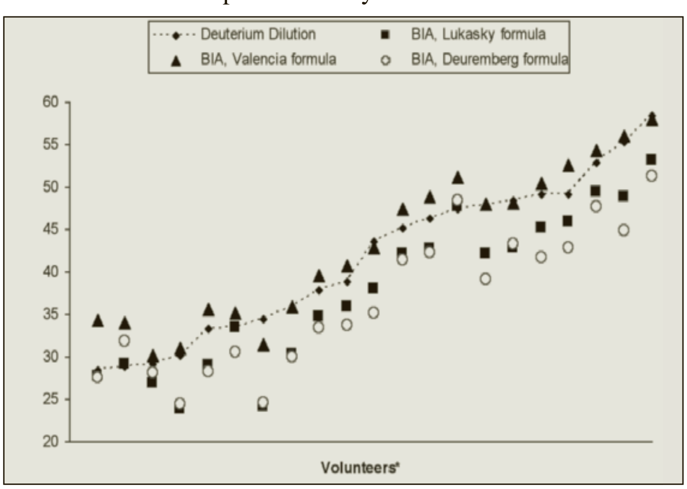
Figure 1
Comparison of fat free mass (kg) obtained by bioelectrical impedance, according to the three different formulas employed (n = 21)



When determined by the deuterium dilution method, mean FFM of the whole group was 41.6±9.3 kg. This value was closer to that obtained by the application of the formula of Valencia et al. The differences were -1.56 kg (95% CI = -2.57,-0.55, p = 0.004), 4.94 kg (95% CI = 3.39, 6.49, $p < 0.005$) and 3.88 kg (95% CI = 2.72, 5.02, $p < 0.005$) against the values calculated by the formulas of Valencia, Deuremberg and Lukaski, respectively.

Figure 2 shows the FFM of each volunteer as determined by the deuterium oxide dilution method and by the three bioelectrical impedance formulas. There was a high correlation between FFM determined by the deuterium dilution method and the values obtained by the application of the three different bioelectrical impedance formulas (R = 0.971 versus Valencia, 0.932 versus Deuremberg and 0.963 versus Lukaski).

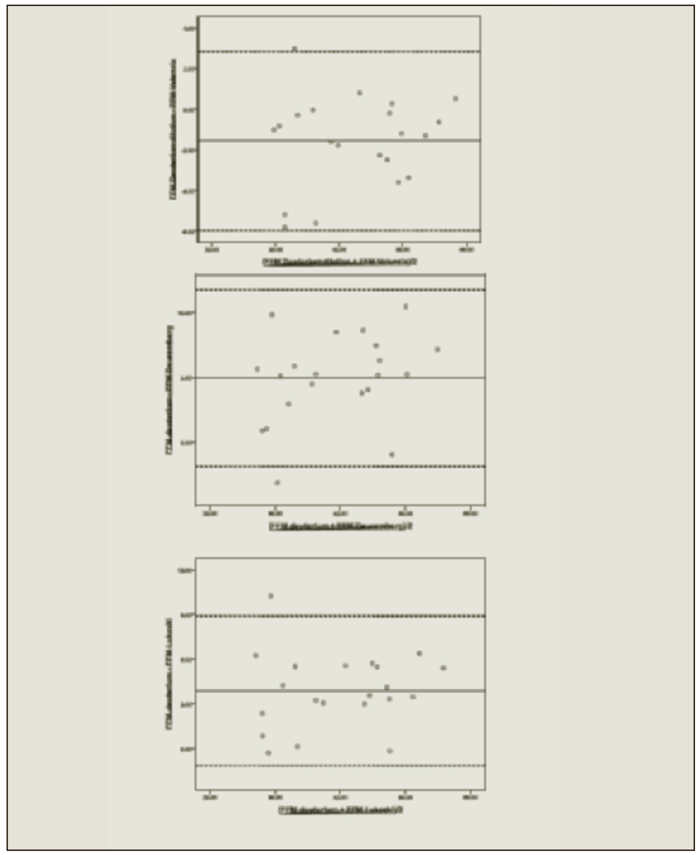
Figure 2
Fat free mass of each studied volunteer as determined by the deuterium dilution method and the three different bioelectrical impedance analysis formulas



* sorted by fat-free mass ascending order.; BIA: Bioelectrical impedance analysis

Figure 3 shows Bland-Altman plots with the limits of agreement (± 2SDs) for the mean difference between FFM as determined by deuterium oxide dilution and by the different BIA formulas. Again, the formula of Valencia et al. showed the best agreement.

Figure 3
Bland-Altman plot showing the limits of agreement between fat free mass of each volunteer as determined by the deuterium dilution method and the three different bioelectrical impedance analysis formulas



Discussion

In this study using the deuterium oxide dilution method as reference, the BIA formulas of Lukaski and Deuremberg underestimated considerably the FFM of healthy older Brazilian volunteers. From the three studied formulas, that of Valencia and colleagues (8) showed the best accuracy.

The determination of FFM by bioelectrical impedance equations has some limitations, especially in old age, when height is changed by senile kyphosis and shortening of vertebrae (10). Broekhoff et al (1992) (11) showed that the underestimation of height in five centimeters can cause underestimation of fat free mass ranging from 0.7 to 1.0 kg in different predictive equations (11).

The best correlation of our deuterium dilution data with those obtained by the application of the formula of Valencia et al. may be explained by its development in a Latin-American population, possibly reflecting geographical and ethnical similarities. Although many of our volunteers were overweight or obese, previous studies showed that BIA is not affected by body fatness and obesity, except when severe obesity is present, which was not the case in this study (12-14).

Some limitations of this study should be highlighted. The relatively small number of volunteers, all belonging to an urban healthy older population may limit the applicability of the results to other older populations (i.e. rural, undernourished, with different diseases). Also, very old volunteers (≥ 85 years) were not included and the results may not apply to this subgroup.

In conclusion, this study demonstrated quite significant differences between the values of FFM of Brazilian healthy older subjects estimated by the application of well known BIA formulas and those obtained by a reference method as the deuterium dilution water. The difference was lower when the formula of Valencia et al., developed for Latin-American populations, was applied. This study supports, therefore, the application of the BIA formula of Valencia for the Brazilian healthy older population and possibly for other populations with the same ethnic and geographic characteristics. Further studies, with a higher number of volunteers, are needed to confirm this finding. Moreover, this study highlights the need for evaluation of different bioelectrical impedance formulas in specific countries, areas and populations.

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