Experimental Gerontology 85 (2016) 108–111

Contents lists available at ScienceDirect

Experimental Gerontology

journal homepage: www.elsevier.com/locate/expgero

Short report

Vector bioimpedance detects situations of malnutrition not identified by the indicators commonly used in geriatric nutritional assessment: A pilot study

Ma Paz Redondo-del-Río [a], Ma Alicia Camina-Martín [a,*], Laura Moya-Gago [a], Sandra de-la-Cruz-Marcos [a], Vincenzo Malafarina [b], Beatriz de-Mateo-Silleras [a]

[a] Department of Nutrition and Bromatology, Faculty of Medicine, Valladolid University, Spain
[b] Geriatrics Department, Clinica Los Manzanos, Grupo Viamed, Lardero, Spain

ARTICLE INFO

Article history:
Received 30 April 2016
Received in revised form 23 September 2016
Accepted 9 October 2016
Available online 11 October 2016

Section Editor: Holly M. Brown-Borg

Keywords:
Ageing
Nutritional assessment
Body composition
Bioimpedance

ABSTRACT

Objective: To compare body composition as assessed by conventional and vector bioelectrical impedance analysis according to the nutritional cataloging using body mass index (BMI) in a group of institutionalized elderly.
Methods: Cross-sectional study in 38 institutionalized elderly. Body composition was estimated by bioimpedance analysis. Differences in body composition were analyzed using *t*-test and ANOVA, or their corresponding non-parametric tests. Statistical significance was set at $p < 0.05$.
Results: Based on BMI, the sample showed overweight (average BMI: 26.4 kg/m^2), and women had higher BMI values than men (28.9 vs. 25.5 kg/m^2). Based on waist circumference, abdominal obesity was detected in 60.7% of men and 80% of women. Conventional bioimpedance analysis (BIA) yielded high fat mass values and slightly depleted skeletal muscle mass, compatible with sarcopenic obesity. All individual impedance vectors were located on the right of the major axis of the tolerance ellipses, reflecting body-cell-mass depletion in all subjects, regardless of BMI cataloging.
Conclusions: Bioelectrical impedance vector analysis (BIVA) detects body compartment changes in institutionalized elderly that are not identified by the most widely used clinical practice nutritional indicators, such as BMI, waist circumference, and BIA-estimated body composition.

1. Introduction

The elderly constitute a population group with a high risk of malnutrition. In Spain, the prevalence of undernutrition among the institutionalized elderly has increased up to 60%, and overweight and obesity affect 25% of women and 18% of men aged ≥65 years (Abajo-del-Álamo et al., 2008).

Undernutrition in the elderly is associated with the onset of complications for those with acute or chronic conditions and with a worse health-related quality of life; and obesity leads to increased risk of chronic diseases, including type 2 diabetes, hypertension, and cardiovascular disease, and to increased risk of mobility limitation and loss of function (Abajo-del-Álamo et al., 2008).

Nutritional assessment is essential in preventing malnutrition. The body mass index (BMI) is difficult to interpret in the elderly because of age-related changes in body composition (BC) (Camina-Martín et al., 2014). Bioelectrical impedance vector analysis (BIVA) assesses soft tissues, hydration status, and cell integrity using a resistance–reactance graph (R–Xc graph) with the two direct impedance vector components normalized by subject height (i.e., R/H and Xc/H). Both BC and hydration status are then assessed semiquantitatively by directly interpreting the impedance vector (Norman et al., 2007). The vector length indicates tissue hydration (short vector: overhydration; long vector: dehydration), while vector direction (i.e., phase angle) provides information about the amount of soft tissue cell mass (a small phase angle indicates undernutrition) (Piccoli et al., 1994).

The aim of this study was to compare the body composition assessed by conventional and vectorial bioimpedance approaches according to the BMI-established nutritional cataloging in a group of elderly people living in a nursing home.

Abbreviations: BC, body composition; FFM, fat free mass; FFMI, fat free mass index; FM, fat mass; FMI, fat mass index; R, resistance; R/H, resistance normalized by height; SMI, skeletal muscle index; SMM, skeletal muscle mass; WC, waist circumference; Xc, reactance; Xc/H, reactance normalized by height; *Z*-FFMI, fat free mass Z-score; *Z*-FM, fat mass Z-score; *Z*-SMI, skeletal muscle index Z-score.

* Corresponding author: Department of Nutrition and Food Science, Faculty of Medicine, University of Valladolid, C/Ramón y Cajal, 7, 47005 Valladolid, Spain.
E-mail address: aliciacamina@gmail.com (M.A. Camina-Martín).

http://dx.doi.org/10.1016/j.exger.2016.10.002
0531-5565/

Table 1
Descriptive statistics of the anthropometric measurements.

	All (n = 38)	Males (n = 28)	Females (n = 10)
Weight (kg)	65.2 (10.7)	65.8 (10.1)	63.4 (12.5)
Height (m)	1.57 (0.1)	1.61 (0.09)*	1.49 (1.45–1.51)
BMI (kg/m^2)	26.4 (4.05)	25.5 (3.4)*	28.9 (4.7)
AC (cm)	28.6 (3.7)	28.2 (3.4)	29.8 (4.3)
WC (cm)	97.3 (10.8)	96.7 (9.7)	99.0 (14.0)
TC (cm)	45.9 (4.1)	45.4 (4.0)	47.4 (4.2)
CC (cm)	33.2 (2.6)	32.9 (2.6)	33.8 (2.6)

BMI, body mass index; AC, arm circumference; WC, waist circumference; TC, tight circumference; CC, calf circumference.
Results are expressed as mean (SD) or *median* (*interquartile range*).
* $p < 0.05$ with respect to females.

2. Materials and methods

Cross-sectional study carried out between February and March 2015 in the residential care center San Juan de Dios (Palencia, Spain). Inclusion criteria were: Caucasian ethnicity and BMI between 16 and 34 kg/m^2. Individuals were excluded if they showed clinical signs of hydration imbalance, had ongoing acute illness, had a history of body weight change ≥5% within the last month, or had pacemakers or metal implants. In the end, 38 institutionalized older-adults aged 77.4 y (95% CI: 75.3–79.6 y; range: 68–80 y) participated in the study. Written informed consent was obtained from all participants. This study was conducted in accordance with the Declaration of Helsinki and all procedures involving human participants were approved by the East Valladolid Healthcare Area (*CEIC*) Clinical Research Ethics Committee.

Body weight (W; kg) was measured to the nearest 100 g using a SECA scale (Hamburg, Germany); height (H; m) was measured to the nearest 0.1 cm using a SECA stadiometer (Hamburg, Germany); and body circumferences were measured to the nearest 0.1 cm with a flexible, inelastic measuring tape. BMI was calculated as weight (kg) divided by height squared (m^2). All participants were grouped according to BMI cutoffs, as per the WHO classification (WHO, 1995): underweight (<18.5 kg/m^2), normal weight (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2, and obese (≥30.0 kg/m^2).

Whole body impedance measurements were made using a standard protocol (Lukaski, 1991). A 50-kHz tetra-polar phase-sensitive BIA (BIA-101; AKERN-Srl, Florence, Italy) introduced a sinusoidal, alternating current of 400 mARMS to measure R and Xc. These two values were normalized for all subjects by height (R/H and Xc/H, Ω/m) and transformed into *Z*-scores using the reference R/H and Xc/H values for healthy older-adult population (Piccoli et al., 1995).

Fat free mass (FFM) and skeletal muscle mass (SMM) (kg) were estimated using the BIA equations developed by Kyle et al. (2001) and by Janssen et al. (2000). Fat mass (FM; kg) was calculated as W – FFM. The indices for these values (FFMI, FMI and SMI, respectively) were then calculated as FMI (kg/m^2) = FM/H^2; FFMI (kg/m^2) = FFM/H^2; and SMI (kg/m^2) = SMM/H^2. Finally, FMI, FFMI and SMI were converted to age- and sex-specific standard deviation (SD) scores (Z-scores) for all subjects using the reference BC data for whites (Schutz et al., 2002; Janssen et al., 2004).

For BIVA, all participants' R and Xc values were normalized by subject height (R/H and Xc/H, Ω/m) and transformed into Z-scores using reference R/H and Xc/H values for healthy older-adult population (Piccoli et al., 1995). After transforming impedance measurements with respect to their reference population, R/H and Xc/H Z-scores were plotted on the RXc-score graph to assess BC and hydration status in each individual. This procedure allows comparing subjects of different ages and sexes in the same RXc-score graph, eliminating the need to consider the effects of age and sex on bioelectrical variables (R, Xc and phase angle) reported by several researchers (Piccoli et al., 2002; Buffa et al., 2003).

Finally, the 95% confidence ellipses for mean vectors of the BMI-groups were drawn to compare the BMI group-related differences.

2.1. Statistical analysis

The normality of variable distribution was checked using the Kolmogorov Smirnov or Shapiro-Wilk tests. ANOVA and Scheffe post hoc contrasts were used to assess differences in BC and in bioelectrical variables (described as Z-scores) according to the BMI cataloging. Statistically significant differences between the mean vectors were assessed with Hotelling's T^2 test for vector analysis, and distance between groups with Mahalanobis distance. Statistical significance was set at $p < 0.05$. Statistical analysis was performed with SPSS® version 19.0 (SPSS, Chicago, IL, USA).

3. Results

The anthropometric characteristics of the sample are shown in Table 1. Significant differences between males and females were observed in height and BMI. Although there were no significant differences in mean WC values according to sex (Table 1), 60.7% of men had abdominal obesity (WC > 102 cm), while 80% of women did (WC > 88 cm). Overall, 65.8% of the sample had abdominal obesity. With regard to BMI, 42.1% of subjects were of normal weight (BMI between 18.5 and 24.9 kg/m^2), 31.6% were overweight (BMI between 25 and 29.9 kg/m^2), and 26.3%, obese (BMI ≥ 30 kg/m^2) (Table 2).

Table 3 shows the bioelectrical variables and the estimated BC variables. As shown, R/H, FM percentage, and FMI were significantly higher in women, while FFM and SMM percentages were significantly higher in men. However, the FFMI and SMI Z-scores were significantly higher in women. The FMI Z-score was also higher in females, but did not reach statistical significance.

There were statistically significant differences in FMI, FFMI, and SMI *Z*-scores (i.e. Z-FMI, Z-FFMI, and *Z*-SMI, respectively) between normal-weight, overweight, and obese subjects (Table 4). Normal-weight subjects showed a decrease in FFMI and SMI Z-scores (SD −1.09 and −0.78, respectively) together with a FMI Z-score within normal limits (SD −0.40); overweight subjects showed a FMI Z-score of about SD 0.69 together with normal FFMI and SMI Z-score values (0.07 and −0.43 SD, respectively); and obese subjects showed a high level of fatness (FMI Z-score: SD 1.92) together with normal SMI Z-scores (SD 0.13).

As can be observed in Table 4, there were no significant differences in the bioelectrical variables among groups with different nutritional status (BMI classes). The only exception was the R/H Z-score, which was significantly higher in the normal-weight subjects than in the obese individuals.

Table 2
Nutritional status according to the body mass index.

	All (n = 38)	Males (n = 28)	Females (n = 10)
Undernutrition (BMI ≤ 18.5 kg/m^2)	0 (0.0)	0 (0.0)	0 (0.0)
Normal weight (BMI 18.5–24.9 kg/m^2)	16 (42.1)	14 (50.0)	2 (20.0)
Overweight (BMI 25–29.9 kg/m^2)	12 (31.6)	9 (32.1)	3 (30.0)
Obesity (BMI ≥ 30 kg/m^2)	10 (26.3)	5 (17.9)	5 (50.0)

Results are expressed as absolute and relative frequencies: n (%).