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Bioimpedance vector analysis and conventional bioimpedance to assess body composition in older adults with dementia

María Alicia Camina Martín M.S. [a,*], Beatriz de Mateo Silleras Ph.D. [a], Lexa Nescolarde Selva Ph.D. [b], Sara Barrera Ortega M.S. [c], Luis Domínguez Rodríguez M.S. [c], María Paz Redondo del Río Ph.D., M.D. [a]

[a] Area of Nutrition and Food Science, Faculty of Medicine, Universidad de Valladolid, Valladolid, Spain
[b] Department of Electronic Engineering, Universitat Politècnica de Catalunya, Barcelona, Spain
[c] Residential Care Centre San Juan de Dios, Psychogeriatric Area, Palencia, Spain

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ABSTRACT

Objective: Although dementia and nutritional status have been shown to be strongly associated, differences in body composition (BC) among older people with dementia have not yet been firmly established. The aim of this study was to assess BC through conventional and vector bioimpedance analysis (BIA and BIVA, respectively) in a sample of institutionalized older men with and without dementia, in order to detect dementia-related BC changes.
Methods: Forty-one institutionalized men ages ≥65 y (23 without dementia [CG] and 18 with dementia [DG]) were measured with BIA and interpreted with BIVA and predictive equations.
Results: Age (74.4 and 75.7 y) and body mass index (22.5 and 23.6 kg/m^2) were similar for DG and CG, respectively. Resistance and ratio of resistance to height did not differ significantly between the two groups. Reactance and ratio of reactance to height were 21.2% and 20.4% lower in DG than in CG. Phase angle was significantly lower in DG (mean = 4.0; 95% confidence interval [CI], 3.6°–4.3°) than in CG (mean = 4.7; 95% CI, 4.3°–5.1°). Mean fat mass index (6 and 7 kg/m^2), and mean fat-free mass index (16.4 and 16.6 kg/m^2) were similar in both groups. BIVA showed a significant downward migration of the ellipse in DG with respect to CG ($T^2 = 15.1$; $P < 0.01$).
Conclusion: Conventional BIA showed no significant differences in BC between DG and CG, although reactance and ratio of reactance to height were about 21% lower in DG. Nevertheless, a body cell mass depletion and an increase in the ratio of extracellular to intracellular water were identified in DG using BIVA. BIVA reflects dementia-related changes in BC better than BIA.

Introduction

Dementia and body composition (BC) have been shown to be strongly associated, but there are still conflicting data on the nature of this association. On the one hand, it has been recently evidenced that high body mass index (BMI) values, and hence adiposity, in adulthood are associated with an increased risk for Alzheimer's disease (AD) and vascular dementia (VD) in late life [1,2]; on the other hand, it is well known that malnutrition and particularly unintentional weight loss are common clinical features in patients with dementia, which occur at the preclinical stage of the disease and are maintained at the follow-up, further aggravating the prognosis of these patients [3].

The relationship between BMI and dementia at older ages is less clear [4]. The Cardiovascular Health Study recently reported that the risk for dementia was positively associated with obesity at age 50 y, but negatively associated with BMI after age 65 [5]. Several epidemiologic studies also suggested that overweight and obesity in late life are associated with reduced risk for dementia [6,7], whereas others have found that a higher BMI at older ages predicts dementia [8]. Because it is widely accepted that malnutrition and unintended weight loss not only occur

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* Corresponding author. Tel.: +34 983185249; fax: +34 983183812.
E-mail address: Aliciacamina@gmail.com (M. A. Camina Martín).

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during the final stages of the disease, but also may be a precursor to dementia [9,10], the term *obesity paradox* has been proposed to describe the relationship between BMI in older adults and risk for dementia.

Despite the evidence showing a role of adiposity during adulthood in the subsequent development of dementia, data available on changes in BC in older individuals with dementia have not yet been firmly established. Several factors contribute to this situation. Probably the most notable factor is the method used to measure adiposity. Both BMI and waist circumference (WC) have been employed as indicators of adiposity (overall and central adiposity, respectively) in most studies, but currently there is no consensus on the cutoff points for obesity for the elderly [11,12]. Additionally, age-related changes in BC and loss of height alter the association between BMI and percentage body fat [13].

On the other hand, it has been demonstrated that a few isolated anthropometric measurements, such as calf circumference, are good indicators of BC in this population [14]. Nevertheless, the applicability of the anthropometry to estimate BC in this population also presents a number of challenges and constraints. We recently evidenced that the predictive equations based on anthropometric measurements leads to significant underestimation of fat mass (FM) in older individuals with dementia [14].

Bioelectrical impedance analysis (BIA) is valid for BC analysis in this population when using the specific equations developed and validated in this group [15]. Nevertheless, age-related changes in the amount (hypo- or hyperhydration) and distribution (intra- or extracellular) of body water are relatively common in older institutionalized individuals [16] and may lead to significant errors in estimating body compartments [17] because of assumptions of a constant hydration of the fat-free mass (FFM) [18].

In the vectorial approach of BIA, called bioelectrical impedance vector analysis (BIVA), the individual components of the impedance vector, resistance (R) and reactance (Xc), are normalized by the height of the subject (R/H and Xc/H) and represented in the R-Xc graph (abscissa, R/H; ordinate, Xc/H) [19]. R is inversely related to the intra- and extracellular water (ICW and ECW), whereas Xc is directly related to the amount of soft tissue structures (mass). Therefore, vector length is influenced by tissue hydration (shortening indicates overhydration, and lengthening suggests dehydration), and vector direction (i.e., phase angle [PA]) is influenced by the amount of cell mass contained in soft tissues (a small PA indicates malnutrition-cachexia-anorexia; a large PA may be observed in both obese and athletic individuals). The vector derived for an individual is compared against the normal interval of the healthy, reference population, and is expressed in percentiles of the normal distribution of a bivariate, probabilistic graph. Therefore, BIVA does not yield any absolute estimates of body compartment [20], but it allows assessing changes in both BC and the hydration status. BIVA is simpler and more affordable than dual-energy x-ray absorptiometry (DXA; a commonly used reference method) and, in contrast to anthropometric measurements or conventional BIA, is unaffected by regression adjustments that may introduce clinically relevant bias [20].

Recent studies also emphasize in the role of PA, calculated as arc tan reactance/resistance and expressed in degrees, as a practical indicator of functional and nutritional status in the older population [21]. It also provides information about the clinical outcome and mortality, which is another important advantage of BIVA [22,23].

The objective of this study was to assess BC through BIA and BIVA in a sample of institutionalized older men, including a group of nondemented men and a group of demented men, to detect dementia-related BC changes.

We sought to overcome the limitations of BMI as a general indicator of adiposity by using BIA to estimate BC and BIVA to categorize soft tissue mass and hydration.

Materials and methods

Participants and design

This was a cross-sectional study carried out on a sample of older men institutionalized in the Psychogeriatric Area of the Residential Care Centre San Juan de Dios (Palencia, Spain). Inclusion criteria were being white, male, aged ≥65 y, and at risk for malnutrition or having normal weight on the basis of the BMI cutoffs established for this age group (18.5–21.9 kg/m^2 and 22–26.9 kg/m^2, respectively) [24]. Individuals were excluded if they showed clinical signs of hydration imbalance, had ongoing acute illness, or had pacemakers or metal implants.

The sample consisted of 41 participants ages 65 to 96 y; 18 (43.9%) with dementia according to criteria from the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition [25] (dementia group, DG), and 23 (56.1%) without dementia (control group, CG). All men with dementia were in moderately severe to very severe stages, corresponding to stages 5 to 7 on the Global Deterioration Scale (GDS) [26], and the subtypes of dementia were AD, VD and mixed dementia (MD). The control group consisted of institutionalized men without dementia, matched for age, BMI, and comorbidities.

One trained individual performed anthropometric and recumbent hand-to-food bioelectrical impedance measurements first thing in the morning, following an overnight fast. This study was conducted in accordance with the Declaration of Helsinki and all procedures involving human participants were approved by the Ethics Committee of the Residential Care Centre San Juan de Dios on April 2010. Written informed consent was obtained from the legal guardians of all participants included in the study.

Anthropometry

Anthropometric measurements were performed according to the protocol of the Spanish Society for Parenteral and Enteral Nutrition and the Spanish Society of Geriatric Medicine and Gerontology [24]. Body weight (W; kg) was measured to the nearest 100 g, using a SECA 954 chair scale with the participant wearing underwear; and height (H; m) was estimated from a knee height measurement using a previously described equation [27]. WC and calf circumference (CC) were measured with a flexible, inelastic measuring tape (to the nearest 1 cm).

Body composition analysis

Bioimpedance measurements

Whole-body impedance measurements were made using a standard protocol [28]. A 50 kHz, tetra-polar, phase-sensitive BIA (BIA-101; AKERN-Srl, Florence, Italy) introduced a sinusoidal, alternating current of 400 μA RMS to measure R, Xc, and PA. Measurement errors of the system, determined with a precision resistor and capacitor, were <1% for R and <2% for capacitance.

BIA

The amount of FFM (kg) was estimated with the prediction equation for BIA in adults ages 20 to 94 y [29]. Previous studies evidenced that this equation was accurate in our sample of older individuals [14]. FFM and FM indices (FFMI and FMI, respectively) were calculated as FMI (kg/m^2) = FM/H^2, and FFMI (kg/m^2) = FFM/H^2. These indices were used to compare the BC data obtained in this study with the reference BC data for whites [30].

BIVA

In this study, the reference bivariate tolerance ellipses (50%, 75%, and 95% of the distribution of the values in general population) for the adult and older men [31] were used for the qualitative and semiquantitative assessment of BC and hydration status in each individual. The 95% confidence ellipses for mean vectors of the DG and the CG were drawn to compare these groups.

Statistical analysis

Statistical analysis was carried out using the SPSS® version 18.0 (SPSS, Chicago, IL, USA). All data are presented as mean (95% confidence interval). The normality of the distribution of the variables was checked by the Shapiro-Wilk test and the homogeneity of variances by Levene's test. *t* Tests were used for pairwise comparisons. The level of significance was set at $P < 0.05$.