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Short report

Specific bioelectrical impedance vector reference values for assessing body composition in the Italian elderly

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ABSTRACT

Objective: To obtain *specific* bioelectrical impedance vector reference values for the healthy elderly Italian population, and to study age- and sex-related differences in body composition.
Design: The study group consisted of 560 healthy individuals (265 men and 295 women) aged 65 to 100 y, whose anthropometric (height, weight, and calf, arm and waist circumferences) and bioelectrical measurements (resistance [R] and reactance [Xc], at 50 kHz and 800 μA) were recorded. R (Ω) and Xc (Ω) values were standardized for stature (H, m) to obtain the classic bioelectrical values. *Specific* values (resistivity [R*sp*] and reactivity [Xc*sp*], Ω · cm) were obtained by multiplying R and Xc by a correction factor (A/L) that includes an estimate of the cross-sectional area of the body (A = 0.45 arm area + 0.10 waist area + 0.45 calf area), where L = 1.1 H.
Results: Descriptive statistics were: R*sp* (391.8 ± 57.9), Xc*sp* (42.6 ± 9.9), Z*sp* (394.2 ± 58.2), phase angle (6.2° ± 1.2) in men; R*sp* (462.0 ± 80.1), Xc*sp* (47.9 ± 11.2), Z*sp* (464.6 ± 80.5), phase angle (5.9° ± 1.0) in women. The Xc*sp* and phase angle values showed a significant age-related decrease in both sexes, but especially in men, possibly relating to a gradual loss of muscle mass. Women's R*sp* and Z*sp* values tended to drop, attributable to their declining proportion of fat mass. A declining sexual dimorphism was also apparent.
Conclusions: Specific tolerance ellipses can be used for reference purposes for the Italian population when assessing body composition in gerontological practice and for epidemiological purposes.

1. Introduction

Normal aging is characterized by changes in body mass and composition (Buffa et al., 2011) that can impair an individual's health status and functionality, with the possible onset of geriatric syndromes, such as frailty (Fried et al., 2001), sarcopenia (Morley et al., 2001), and sarcopenic obesity (Baumgartner, 2000). Age-related body mass variations involve an initial tendency for it to increase, followed by a decline (Buffa et al., 2011). This latter reduction is mainly due to a loss of muscle mass (especially in men), total body water (particularly from the intracellular compartment), and skeletal mass (especially in women). The loss of fat mass (FM) is less marked and occurs at a later age. The combined changes in FM and fat-free mass (FFM) give rise to an initial increase in the percentage of body fat, which subsequently levels off (Ding et al., 2007).

Body composition screening and monitoring in the elderly is to be recommended to prevent the risk of malnutrition and related disorders (Cruz-Jentoft et al., 2010).

Bioelectrical impedance vector analysis (BIVA) is a portable, noninvasive and low-cost method for assessing body cell mass and body hydration (Piccoli et al., 1994). The BIVA approach differs from traditional bioelectrical impedance analysis (BIA) in that it analyzes bioelectrical values directly, without referring to predictive equations. Resistance (R, Ω) and reactance (Xc, Ω), at 50 kHz and 800 μA, are normalized for an individual's height and plotted in a tolerance ellipse graph that enables the person's body characteristics to be assessed. BIVA thus avoids the potential error deriving from adopting BIA equations, which can lead to unreliable results in elderly individuals because of the physiological changes associated with aging, such as weight loss and muscle mass atrophy (Baumgartner et al., 1995; Lupoli et al., 2004). BIVA has been amply used in clinical practice (Barbosa-Silva et al., 2005; Norman et al., 2012) and validated for the purpose of assessing nutritional (Norman et al., 2012) and hydration status (Bronhara et al., 2012; Norman et al., 2012). The classic BIVA approach has proven weak, however, in terms of its ability to recognize differences in body composition compared to dual-energy X-ray absorptiometry (DXA) (Buffa et al., 2013; Marini et al., 2013). On the other hand, using the recently-proposed *specific* BIVA approach has resulted in an

Abbreviations: R, resistance; Xc, reactance; Z, impedance; R*sp*, resistivity; Xc*sp*, reactivity; Z*sp*, impedivity; FM, fat mass; FFM, fat-free mass; BIA, bioelectrical impedance analysis; BIVA, bioelectrical impedance vector analysis; DXA, dual-energy X-ray absorptiometry; ECW/ICW, extracellular/intracellular water ratio; FFMI, fat-free mass index; FMI, fat mass index; SMI, skeletal muscle mass index; FM%, fat mass percentage.

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accurate assessment of variations in the proportion of fat mass (FM%) in samples of healthy elderly Italians (Marini et al., 2013) and U.S. American adults (Buffa et al., 2013). *Specific* BIVA differs from the classic approach in that the bioelectrical values are standardized on the basis of an estimated body volume (height and cross-sectional area) rather than just body height. This means that *specific* values (resistivity, reactivity and impedivity) are influenced not by body size and shape, but only by the tissues' properties. *Specific* BIVA has proven to be capable of distinguishing sarcopenic individuals from sarcopenic-obese individuals (Marini et al., 2012). Normal reference values for the elderly have yet to be published, however.

The aim of this study was to establish standard *specific* BIVA values for Italian elderly people, suitable for use in screening programs and in gerontological practice to identify conditions of undernutrition, sarcopenia and sarcopenic obesity. We also aimed to study age-related changes in the *specific* vector (i.e. body composition) in a large sample of elderly individuals.

2. Subjects and methods

2.1. Subjects

The study group consisted of 560 individuals (295 women and 265 men) aged 65 years or more (mean age 76.0 ± 7.1 in women and 77.0 ± 7.2 in men), all born in Italy and recruited on a voluntary basis in the Veneto region and Sardinia. The survey was performed by trained health technicians from the Geriatrics Department of Padova University and from the University of Cagliari. The following exclusion criteria were considered: pulmonary disease, severe cardiovascular or uncontrolled metabolic diseases (diabetes, anemia, or thyroid disease), electrolyte abnormalities, cancer, inflammatory conditions, and the use of any implanted electrical devices. In accordance with the Helsinki Declaration, as revised in 2008, all individuals who agreed to take part in the study were informed about the goals and methods of the research.

2.2. Measurements

Anthropometric measurements (weight, height, and upper arm, waist and calf circumferences) were taken in agreement with international criteria (Lohman et al., 1988), and each individual's body mass index (BMI = weight/height^2, kg/m^2) was calculated. Impedance measurements (resistance, R; reactance, Xc) were obtained using a single-frequency analyzer (BIA 101, Akern, Italy) with an operating frequency of 50 kHz at 800 μA. The whole procedure complied with international criteria (NIH, 1996), and participants avoided eating or drinking (for 4 h), intensive exercise or alcohol intake (for 12 h) before the test.

The "*specific* BIVA standards 2013" database is available at the Cagliari University institutional repository (http://veprints.unica.it/904/).

In a subgroup of 207 individuals, DXA fan-beam technology (QDR 4500 W; Hologic Inc., Bedford, MA) was used to estimate the fat-free mass index (FFMI) (i.e. the sum of lean soft tissue mass and bone mineral content, corrected for height squared [kg/m^2]), and the fat mass index (FMI) (i.e. the fat mass corrected for height squared [kg/m^2]). Individuals of different body mass and composition were classified using the BMI cutoffs proposed for the elderly by Sergi et al. (2005), and the quartiles

Table 1
Descriptive statistics of anthropometric and bioelectrical values, and correlation between bioelectrical impedance variables.

	Men		Women	
	Mean	s.d.[j]	Mean	s.d.[j]
Age (y)[a]	77.0	7.2	76.0	7.1
Anthropometric variables				
Height (cm)	162	8.5	150.2	8.0
Weight (kg)	69.5	11.1	60.1	11.0
BMI[b] (kg/m^2)	26.4	3.3	26.6	4.1
Calf crf.[c] (cm)	34.6	3.4	33.8	3.7
Arm crf.[c] (cm)	28.0	3.3	28.2	3.8
Waist crf.[c] (cm)	95.7	9.2	92.2	10.9
Bioelectrical variables				
R[d] (Ω)	485.3	64.3	554.8	64.9
Xc[e] (Ω)	52.3	9.5	57.1	9.4
R[d]/H[f] (Ω/m)	300.6	44.9	370.4	47.7
Xc[e]/H[f] (Ω/m)	32.4	6.2	38.1	6.3
Phase (degrees)	6.2	1.2	5.9	1.0
Z[g]/H[f] (Ω/m)	302.4	44.9	372.4	47.8
R[d]*sp*[h] (Ω · cm)	391.8	57.9	462.0	80.1
Xc[e]*sp*[h] (Ω · cm)	42.6	9.9	47.9	11.2
Z[g]*sp*[h] (Ω · cm)	394.2	58.2	464.6	80.5
r[i] R[d]/H[f] − Xc[e]/H[f]	0.43**		0.44**	
r[i] R[d]*sp*[h] − Xc[e]*sp*[h]	0.59**		0.75**	

[a] Year.
[b] Body mass index.
[c] Circumference.
[d] Resistance.
[e] Reactance.
[f] Height.
[g] Impedance.
[h] *Specific*.
[i] Correlation.
[j] Standard deviation.
** $p < 0.01$.

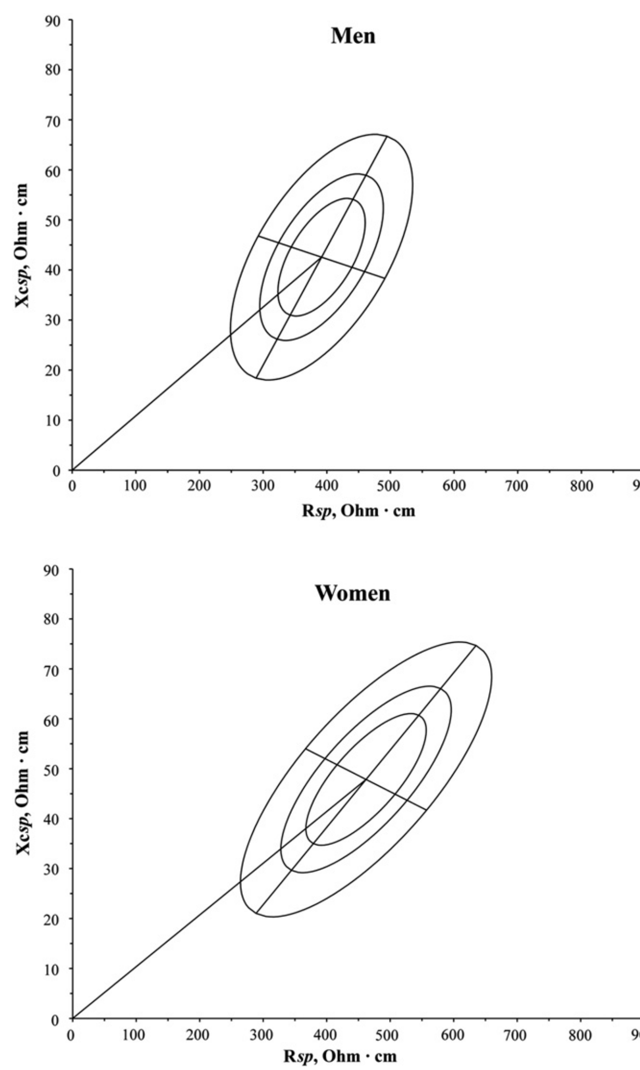

Fig. 1. a. *Specific* tolerance ellipses for the elderly male population. b. *Specific* tolerance ellipses for the elderly female population.