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Original Article

Validity of Standing Posture Eight-electrode Bioelectrical Impedance to Estimate Body Composition in Taiwanese Elderly☆

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SUMMARY

Background: Standing eight-electrode bioelectrical impedance analysis, which can be used to estimate percentage body fat (BF%) and lean soft tissue (LST) in the whole body and different body segments of elderly adults, is potentially an ideal method for clinical assessment of body composition.
Methods: In this study, dual-energy X-ray absorptiometry (DXA) was used as a criterion method to validate a standing eight-electrode bioelectrical impedance analysis device BC-418 (hereafter abbreviated as BIA_8; Tanita Corp., Tokyo, Japan). LST and BF% were measured in the whole body and various body segments (upper limbs, lower limbs, and trunk) of each participant using BIA_8 and DXA; correlation and differences between the LST and BF% results measured in the whole body and various body segments were compared. A total of 77 individuals, 42 males and 35 females, aged 55.2–76.8 years, were included in the analysis.
Results: The impedance indexes (h^2/Z) of hand to foot, and upper and lower limbs of the left side of the body measured by BIA_8 were highly correlated with the LST values in the corresponding body segment measured by DXA ($r = 0.96$, $r = 0.92$, and $r = 0.88$, respectively; all $p < 0.001$). LST values of the whole body and various body segments of participants measured using BIA_8 were highly and significantly correlated with the corresponding DXA data (all $r > 0.88$, $p < 0.005$); the whole body and segmental BF% measured by BIA_8 and DXA also showed a significant correlation ($r > 0.84$, $p < 0.005$). In addition, the agreement between the results of BIA_8 and DXA was assessed by Bland–Altman analysis; the bias and SD were, respectively, 1.89 kg and −4.25% in limb LST, and 2.18 kg and 4.06% in whole body BF%.
Conclusion: The results of this study showed that the impedance index and LST in the whole body, upper limbs, and lower limbs derived from DXA findings were highly correlated. The LST and BF% estimated by BIA_8 in whole body and various body segments were highly correlated with the corresponding DXA results; however, BC-418 overestimates the participants' appendicular LST and underestimates whole body BF%. Therefore, caution is needed when interpreting the results of appendicular LST and whole body BF% estimated for elderly adults.

1. Introduction

Body composition is a relatively important information source for diagnosing the nutritional status of the human body. Particularly, the body composition of elderly adults, whose physical state is frail and changes with aging. Fat-free mass (FFM), muscle mass, and muscle strength decline with age[1–4], whereas fat mass increases with age[2,5,6]. Several reference methods can be used to estimate human body composition, such as dual-energy X-ray absorptiometry (DXA), computed tomography, magnetic resonance imaging,

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air-displacement plethysmography, underwater weighing, neutron activation analysis, and dilution methods[7]. However, these methods have limitations when applied to elderly adults, whereas bioelectrical impedance analysis (BIA) can widely be used for estimating body composition of immobile elderly adults, because it is simple, easy to use, safe, noninvasive, mobile, and efficient[8,9].

A standing-posture BIA device, usually with built-in weight measurement and body composition features, is widely used in home health care, clinical applications, and epidemiological studies, but the established built-in predictive equations and the specific population for it to apply are only known by the manufacturer; the applicability is subject to certain restrictions[10]. Therefore, attention needs to be paid to its accuracy and precision of measurement results.

In the past, BIA mostly used a single hand-to-foot impedance measurement to represent the whole body impedance value of individuals, and also to estimate the elements of body composition such as whole body FFM, percentage body fat (BF%), total body water, and intracellular water. With increasing clinical applications and demand, the segmental BIA technique[11,12] was modified to a convenient standing segmental impedance measurement technique, which can also be applied to evaluate the functions of the upper limbs, lower limbs, and trunk[13–16]. The technique (or device) is able not only to estimate whole body BF%, but also to quantify the lean soft tissue (LST) in limbs, which can be applied to assess accurately the whole body skeletal muscle mass[17]. The results obtained using the existing standing segmental BIA in case of European elderly adults have been evaluated[18]. Although there are studies that examined the measurement results using similar devices in Asian adults[19,20], the number of related studies on Asian elderly adults are still very limited.

This study addresses the above issue by using DXA[21,22] and a standing eight-electrode bioelectrical impedance analysis device (BIA_8) to measure the impedance and body composition in whole body and different body segments of elderly adults who are healthy and mobile. Results of the studies conducted by Kohrt[23] and Salamone et al[24] indicated that DXA is an accurate criterion method for assessing body composition of elderly adults. Therefore, the correlation and agreement between the measurement results of the two methods were assessed.

2. Methods

2.1. Experimental design

Body composition of each participant was estimated using a standing segmental BIA_8 and DXA. This study was conducted at the Radiology Department of Jen-Ai Hospital in Dali, Taichung, Taiwan. The experimental protocol was approved by the Human Subject Research Ethics Committee of Jen-Ai Hospital.

2.2. Participants

A total of 42 male and 35 female elderly adults in Taiwan were recruited as participants. No alcohol was consumed 48 hours and no diuretics were taken 7 days prior to assessment. All participants had no medical history of endocrine, nutrition, or growth disorders, and not more than 3 kg of weight loss 6 months prior to the experiment.

2.3. Anthropometry

Participants were weighed by a Weight-Tronix (Scale Electronics Development, New York, NY, USA) electronic scale nearest to 0.1 kg. Their heights, without shoes, were measured by a Stadiometer (Holtain, Crosswell, Wales, UK) nearest to 0.5 cm. The formula used to calculate the body mass index (BMI) is as follows: weight (kg) divided by height (m) squared (kg/m^2).

2.4. BIA analysis

The standing eight-electrode BIA device BC-418 (Tanita Corp., Tokyo, Japan), with stainless-steel plates replacing traditional electrode patches, is used for measuring whole body and segmental impedance. Eight stainless-steel plates are located on a handgrip and on the built-in weight sensor base. Participants stand on the base and hold the handgrips with embedded electrodes; soles of both feet are in contact with the electrode plates through which a low voltage current passes during measurement. They were weighed, and impedance was measured using BIA_8 with sine-wave currents with single frequency 50 kHz and 550 mA.

BIA_8 can measure the impedance of five different body segments within a very short period of time. In this study, the whole body impedance was measured through the left hand to the left foot electrical pathway, and the impedance of each limb was measured by the electrode framework developed by Bracco et al.[12] Next, the derived impedance of five different body segments can be incorporated with other anthropometrics (height, weight, age, and sex) to estimate the LST and BF% in the total body, and left and right limbs. The appendicular LST (ALST) can be estimated by adding the LST of left and right limbs.

In order to ensure repeatability of the impedance measurements, within- and between-day coefficient of variations [CV%; (standard deviation (SD)/mean)%] of the impedances measured through the left hand to the left foot pathway were calculated. The impedance was measured 10 times in each of three male and three female participants within an hour the same day, so as to estimate the within-day CV%. Impedance measurements of those six individuals were performed on 5 consecutive days, so as to estimate the between-day CV%.

All BIA measurements were carried out in a room with good ventilation, fixed temperature, and controlled humidity. For each participant, BIA measurement was completed within 10 minutes.

2.5. Dual-energy X-ray absorptiometry

Each participant was scanned using DXA (Lunar Prodigy, GE, Madison, WI, USA) for measuring fat mass, bone mineral mass, BF%, and LST. During scanning, the participants were wearing a light cotton robe, lying down on a bed with the upper limbs stretched out, and lying flat on the side of the body; the two legs were lightly closed and toes pointed upward. Scans were performed using a whole body scan mode in the following order: head, upper limbs, lower limbs, and trunk. Each participant underwent approximately a 20-minute whole body scan; results were analyzed by the enCore 2003 software, version 7.0 (Lunar Prodigy, GE, Madison, WI, USA).

2.6. Statistical analysis

In this study, data were analyzed using SPSS version 12 (SPSS Inc., Chicago, IL, USA) statistical analysis software. Group data were expressed as mean ± SD. ALST and LST were measured in kilograms. The unit of body fat was measured in percentage (BF%). The level of significant differences was set at 0.05, unless explained otherwise.

The results of body composition parameters (ALST and BF%) measured by DXA and BIA_8 were compared using paired t test. Linear regression analysis was used for describing the relationship between the measurement results of DXA and BIA_8 (i.e., the ALST and BF% measured by BIA_8 and DXA). In addition, the agreement