European Geriatric Medicine 4 (2013) 145–149

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Research paper

Comparison of three BIA muscle indices for sarcopenia screening in old adults

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ARTICLE INFO

Article history:
Received 1 October 2012
Accepted 28 November 2012
Available online 8 January 2013

Keywords:
Bioelectric impedance analysis
Body composition
Elderly
Sarcopenia
Skeletal muscle index

ABSTRACT

Purpose: In response to the inconsistent cutoff points for the diagnosis of low muscle mass in elderly, the study endeavored to establish a preferred norm for sarcopenia screening by comparing three muscle indices with physical functional assessment.
Methods: One thousand healthy adults aged 20–40 were recruited for body composition assessment using bioelectric impedance analysis (BIA, Tanita BC-418, Japan) with segmental measures during annual health examination. Additionally, 308 elderly ambulatory outpatients recruited for comprehensive geriatric assessment were assessed for muscle strength, physical performance, and body composition using the same BIA device.
Results: With the definition of low muscle mass set at 2 standard deviations below the mean value of appendicular skeletal muscle index (ASMI, appendicular skeletal muscle mass/height^2) in the young reference groups, the cutoff points for men and women were 6.76 and 5.28 kg/m^2, respectively. The ratios of low muscle mass in the elderly subjects read 8.5% for men and 13.5% for women. The cutoff points of the other two muscle indices – total skeletal muscle index (total skeletal muscle mass/height^2, TSMI), and skeletal muscle index (ASM/total body weight, SMI) – were also calculated and the ratios of low muscle mass appeared to be 25.6% and 69.8%, respectively. Compared to their compartments, the elderly with low muscle mass defined by ASMI were older and demonstrated a higher proportion of physical frailty, lower body mass index, lower muscle strength, and poorer physical performance.
Conclusions: Compared with TSMI and SMI, ASMI might serve as a preferred index for the diagnosis of low muscle mass.

1. Introduction

During the aging process, age-related decline in muscle mass and muscle function is a high risk of adverse health outcomes, such as falls, mobility impairment, frailty, or poor quality of life [1–3]. Previous studies show that muscle mass and strength start to decline progressively around the age of 30 years old with the lost accelerating after the age of 60, while the fat mass increases with age [4–7]. According to the definition by the European Working Group on Sarcopenia in Older People (EWGSOP), the presence of low skeletal muscle mass plus low muscle strength or weak physical function provides a practical and useful tool for sarcopenia diagnosis [8]. Regarding the diagnosis of low skeletal muscle mass, bioelectric impedance analysis (BIA) is relatively more practical and available compared with magnetic resonance imaging, computed tomography, and dual energy X-ray absorptiometry (DXA) [8,9]. Additionally, low skeletal muscle mass shares with osteoporosis the same criterion of skeletal muscle index below 2 standard deviations (SD) of mean value in the healthy young adult population [1,8,10,11]. Various skeletal muscle indices are used to define low muscle mass (sarcopenia) and diverse cutoff points suggested for different races [1,10–14]. Though Chien et al. proposed gender-specific cutoff points of total skeletal muscle index (TSMI) for the Taiwanese population, the equation for estimating skeletal muscle mass was generated from a non-Asian population by a different BIA device [12,15]. Utilizing the advantages of the measurement tool, the study strove to define low muscle mass by three commonly used criteria, appendicular skeletal muscle index (ASMI), TSMI, and skeletal muscle index (SMI), with the Taiwanese young adults as reference and to compare the three muscle indices for low muscle mass using BIA for elderly ambulatory adults in Taiwan.

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1878-7649/$ – see front matter
http://dx.doi.org/10.1016/j.eurger.2012.11.008

2. Materials and methods

2.1. Reference group

One thousand young adults aged 20–40 years old (500 men and 500 women) were recruited from people receiving physical checkup at the Department of Family Medicine, National Taiwan University Hospital (NTUH) in 2011. Signed informed consent was obtained before the implementation of all clinical procedures. Exclusion criteria included:

- morbid obesity (body mass index [BMI] over 35);
- long term use of body composition modified medications like steroid, and medications for endocrine diseases or autoimmune diseases;
- energy consumption diseases, such as cancer and organ failure;
- pregnancy.

With two subjects excluded because of overt obesity, the data of 498 men and 500 women were analyzed.

2.2. Older group

Three hundred and eight elderly participants aged 65–90 were recruited for Comprehensive Geriatric Assessment and Frailty Study of Elder Patients in NTUH ambulatory clinics. The inclusion and exclusion criteria adopted were described previously [16]. Generally speaking, all of these geriatric outpatients with comorbidity were at high risk of frailty; none of them, however, were bed-ridden, long-term residents at nursing homes, and marked with communication impairment and a life expectancy less than six months.

2.3. Bioelectrical Impendence Analysis procedure

All of the recruited young reference and elderly subjects received body composition examination by BIA. This BIA model (Tanita BC-418, Tanita Corp., Tokyo, Japan) with a constant high frequency current (50 kHz, 500 μA) and an 8-contact electrode system was designed to measure the body composition in segmental parts of the whole body, including each arms, legs, and the trunk area. Therefore, fat mass (FM), fat-free mass (FFM), the predicted muscle mass of the appendicular fractions, and appendicular skeletal muscle mass (ASM), could be estimated by the sum of each segment except for the "trunk part," as validated previously [17]. All examinations were conducted in compliance with the standard procedure [18]. For safety concern, subjects with implanted medical devices were excluded.

2.4. Calculation of three skeletal muscle mass indices

Various criteria have been developed to define low muscle mass (sarcopenia) nowadays [8,9]. According to the EWGSOP's recommendation [8], one of the three major indices adopts ASM divided by squared height into ASMI [10]. Another index, termed TSMI, is based on the total skeletal muscle mass (TSM) divided by squared height [11] and calculated using the BIA equation reported by Janssen et al. [15]. Validated for the estimation of TSM in the Taiwanese population [12], the equation can be formulated as follows: TSM (kg) = [0.401 × (height^2/resistance) + 3.825 × gender − 0.071 × age + 5.102], where height is in cm and resistance in ohms, man is coded as 1 and woman 0, and age is in years. The third major index, termed SMI, is based on the proportion of skeletal muscle mass in total body weight (ASM/body mass × 100) [1]. The values of all three major indices could be generated by our BIA equipment.

Table 1
Basic characteristics in body composition of reference young adults and older adults by gender[a].

	20–40 y/o		≥65 y/o	
	Men (n = 498)	Women (n = 500)	Men (n = 155)	Women (n = 157)
Age	23.1 ± 3.0	23.1 ± 2.7	76.3 ± 6.3	74.8 ± 6.1
Body height (cm)	173.7 ± 5.9	160.6 ± 5.2	163.0 ± 6.0	151.0 ± 5.1
Body weight (kg)	66.9 ± 9.8	52.2 ± 7.3	68.4 ± 10.5	58.0 ± 9.1
BMI (kg/m^2)	22.2 ± 3.1	20.2 ± 2.6	25.7 ± 3.7	25.3 ± 3.7
Total FM (kg)	12.9 ± 5.9	15.3 ± 4.8	20.1 ± 6.5	23.6 ± 6.7
Fat%	18.6 ± 5.9	28.7 ± 5.2	29.0 ± 6.0	40.3 ± 5.7
FFM (kg)	54.0 ± 5.2	36.9 ± 3.4	47.9 ± 5.4	34.1 ± 3.4
TBW (kg)	39.5 ± 3.8	27.0 ± 2.5	35.1 ± 4.0	24.9 ± 2.5
Right leg				
FM	2.3 ± 0.9	3.0 ± 0.8	2.6 ± 0.9	3.5 ± 1.0
Fat%	18.4 ± 5.0	30.7 ± 4.4	23.1 ± 5.3	37.7 ± 4.9
FFM (kg)	9.8 ± 0.9	6.6 ± 0.6	8.4 ± 1.1	5.6 ± 0.8
SMM (kg)	9.2 ± 0.8	6.2 ± 0.5	7.9 ± 1.0	5.3 ± 0.7
Left leg				
FM	2.2 ± 0.9	3.0 ± 0.8	2.7 ± 1.0	3.6 ± 1.0
Fat%	18.2 ± 5.1	30.9 ± 4.4	23.9 ± 5.6	38.3 ± 4.7
FFM (kg)	9.7 ± 0.9	6.7 ± 0. 6	8.2 ± 1.0	5.6 ± 0.7
SMM (kg)	9.2 ± 0.8	6.3 ± 0.5	7.8 ± 0.9	5.3 ± 0.7
Right arm				
FM	0.5 ± 0.3	0.5 ± 0.4	0.8 ± 0.3	1.0 ± 0.4
Fat%	13.7 ± 5.5	21.7 ± 5.8	22.6 ± 5.4	35.0 ± 7.2
FFM (kg)	3.1 ± 0.3	1.8 ± 0.2	2.6 ± 0.4	1.7 ± 0.2
SMM (kg)	2.9 ± 0.3	1.7 ± 0.2	2.5 ± 0.4	1.6 ± 0.2
Left arm				
FM	0.5 ± 0.3	0.6 ± 0.2	0.8 ± 0.3	1.1 ± 0.4
Fat%	14.4 ± 5.4	23.1 ± 6.0	23.1 ± 5.4	37.8 ± 7.4
FFM (kg)	2.9 ± 0.5	1.8 ± 0.2	2.5 ± 0.4	1.7 ± 0.2
SMM (kg)	2.7 ± 0.3	1.6 ± 0.2	2.3 ± 0.4	1.5 ± 0.2
Trunk				
FM	7.4 ± 3.6	8.2 ± 2.8	13.3 ± 4.2	14.6 ± 4.0
Fat%	19.8 ± 6.6	28.2 ± 6.0	33.0 ± 6.9	42.1 ± 6.4
FFM (kg)	28.5 ± 3.0	20.1 ± 2.1	26.2 ± 3.0	19.6 ± 1.9
MM (kg)	27.1 ± 2.9	18.9 ± 2.0	24.9 ± 2.8	18.4 ± 1.7
ASM (kg)	24.04 ± 2.14	15.83 ± 1.31	20.55 ± 2.53	13.71 ± 1.73
ASMI (kg/m^2)	7.98 ± 0.65	6.14 ± 0.45	7.75 ± 0.87	6.01 ± 0.66
TSM (kg)	27.32 ± 2.27	17.16 ± 1.57	22.68 ± 2.86	13.87 ± 2.10
TSMI (kg/m^2)	9.06 ± 0.68	6.65 ± 0.52	8.55 ± 0.96	6.07 ± 0.78
SMI (%)	36.30 ± 2.93	30.63 ± 2.41	30.29 ± 2.37	23.80 ± 2.04

FM: fat mass; Fat%: percentage of total fat mass; FFM: fat-free mass; TBW: total body water; SMM: skeletal muscle mass; MM: muscle mass; ASM: appendicular skeletal muscle mass; ASMI: appendicular skeletal muscle mass index; TSM: total skeletal muscle mass; TSMI: total skeletal muscle mass index; SMI: skeletal muscle index. Values represent means ± s.d.

[a] All of the characteristics using BIA device were significantly different by gender and age with two-sample t-test, P-value < 0.05 for all measurements apart from the FM of right arm compared in the young men and women groups, the body weight compared in the young and old men groups, and BMI compared in the old men and women groups.

2.5. Frailty and physical performance evaluation

All of the eligible elderly subjects were invited to accomplish clinical assessment, structuralized questionnaire evaluation, anthropometric measurements, and physical function performance. Frailty evaluation was also conducted, using a modified Fried Frailty Index (FFI) [19,20] with the five indicators of unintentional weight loss, exhaustion, slowness in 5 m walking, weakness in hand grip strength, and low physical activity. A score of 0 was categorized as robust, 1-2 as pre-frail, and greater than or equal to 3 as frail cases. Dominant quadriceps muscle strength representative of lower limbs was further measured with an isometric force dynamometer (Micro FET; Hoggan Health Industries, Draper, Utach) during a 5-second maximal force contraction of knee