ORIGINAL

Age-related changes in body composition parameters in healthy Japanese

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Abstract Health risks are associated with changes in body composition parameters with age. In the present study, body composition parameters (appendicular skeletal muscle mass [ASMM], fat mass [FM], and water content [water]) using bioelectrical impedance analysis (BIA) and total skeletal MM (TSMM) measured by 24-h creatinine excretion (Cr) were obtained in 30 male and 38 female healthy subjects. BIA-ASMM in both sexes and Cr-TSMM in females were negatively correlated with aging, and BIA-FM was negatively correlated with BIA-water in both sexes. Of note, Cr-TSMM was a more sensitive marker of MM than BIA-ASMM. Thus, decreases in BIA-ASMM and Cr-TSMM were the most consistent markers of aging and sarcopenia. This study may help promote nursing care for healthy aging.

Key words : Aging, Body composition, Skeletal muscle mass, Fat mass, Water content

Introduction

Body composition is influenced by environmental, genetic, and ethnic factors as well as age and sex and is a key component of human health and physical fitness[1]. Significant changes in body composition occur with age[2-4]. The assessment of body composition changes with age is essential for health promotion, nursing care, welfare, and rehabilitation science, as such variations are related to health status and physical function. The standard method for measuring the level of skeletal muscle mass (SMM) is dual-energy X-ray absorptiometry (DXA). However, DXA, similar to other imaging techniques, such as CT and NMR, and biochemical indicators, cannot be easily used in routine investigations ; thus, it is unsuitable for screening and monitoring of the nutritional status of the elderly in nursing homes.

Bioelectrical impedance analysis (BIA) is inexpensive, easy to use, portable, and requires no exposure to radiation. BIA may be useful as a portable alternative

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to DXA[5, 6]. An important limitation is measurement differences between BIA devices from different manufactures[7, 8]. Therefore, we used 24-h creatinine excretion (Cr) as a measure of total SMM (TSMM) in our previous studies[9, 10], as urinary creatinine is proportional to TSMM and a reliable measure of TSMM in advanced renal failure patients, children, adolescents, elderly patients, and in patients with wasting conditions[11 - 13].

The aims of this study were to evaluate age-related changes in body composition and to obtain the reference values for body composition parameters using BIA. In addition, TSMM measured by Cr (Cr-TSMM) was compared with body composition parameters (appendicular skeletal muscle mass [ASMM], fat mass [FM], and water content [water]) analyzed by BIA (BIA-ASMM, BIA-FM, and BIA-water, respectively). This study may help develop higher levels of nursing care by preventing age-related body composition changes.

Materials and Methods

Subjects

We analyzed age-related changes in body composition using a cross-sectional study between April 2017 and March 2018. The subjects consisted of 30 male (23-79 years old [45.6 ± 14.9 years]) and 38 female (24-92 year [53.6 ± 18.3 year]) healthy Japanese (Table 1). Their basic characteristics, such as dietary status, work presence, exercise status, smoking habits, and drinking habits, were obtained using the protocol of a previous study[14]. Among them, six female subjects (aged 82-92 years old) were nursing home residents. The other 62 subjects (aged 23-70 years old) were healthy registered care workers, physical and occupational therapists in nursing homes, and teaching and administration staff at Kenshokai Gakuen College for Health and Welfare. All subjects underwent body weight (BW) and body height (BH) measurements, and BIA to determine body composition under normal body temperature. None of the subjects were engaged in high levels of exercise training or taking any medications just before or during the study.

Assessment of body composition parameters

Body composition parameters, such as ASMM, FM, and water, were measured using direct segmental multi-frequency BIA (TANITA MC-780A, Tokyo, Japan). BIA measures body conductivity or resistance to a small electrical current through the body or across a limb. Resistance is strongly related to total body water content (BIA-water) and is used to assess BIA-ASMM and BIA-FM. BIA requires measurement under standardized conditions including standardized hydration status, recent food and beverage intake, skin temperature, and recent physical activity. Avoiding alcoholic beverages for at least 8 h, fasting, and not drinking water for 4-6 h before BIA assessment were recommended[15]. Furthermore, the participants were required to fast and avoid vigorous exercise for at least 1 h before BIA assessment.

For the measurement of TSMM, each subject collected two 24-h urine samples at inclusion on two con-

Table 1. Characteristics of subjects

	Male (n=30)		Female (n=38)			
	range	mean ± SD	range	mean ± SD	t	p
Age (years)	23-79	45.6 ± 14.9	24-92	53.6 ± 18.3	1.94	0.06
Body weight (kg)	49.8-111.0	69.5 ± 12.0	34.7-92.8	56.9 ± 12.0	4.23	<0.001
Body height (cm)	154.0-178.0	168.6 ± 5.6	136.0-167.0	156.4 ± 7.5	7.68	<0.001
Body mass index (kg/m^2)	18.5-42.3	24.5 ± 4.5	17.0-33.3	23.3 ± 3.8	1.17	0.25

Welch's t test

secutive days. Creatinine excretion was calculated as the mean of the two 24-h urine collections. TSMM was calculated from the 24-h urinary creatinine amount based on the following equation : (Cr-TSMM (kg) = 21.8× Cr (g/day))[11].

Statistics

All data were tested for normality and were continuously distributed. Welch's t-test was used to compare sex differences. The analysis was performed separately in men and women. Pearson's correlation coefficient (r) was used to assess the correlations of BIA-ASMM, BIA-FM, BIA-water, and Cr-TSMM with aging ; those of BIA-ASMM, BIA-FM and Cr-TSMM with BIA-water ; those of BIA-ASMM and Cr-TSMM with BIA-FM ; and that of BIA-ASMM with Cr-TSMM.

Linear regression analyses were performed, and beta coefficients were estimated to assess the effects of Cr-TSMM on male BIA-ASMM and female BIA-ASMM. Significance was set at $p < 0.05$.

Results

1) *Sex differences*

A comparison of sex differences is shown in Table 1. Between male and female subjects, there was no significant different in age and body mass index, but there were significant differences in BW and BH.

2) *Correlation of BIA-ASMM, BIA-FM, BIA-water, and Cr-TSMM with aging, BIA-water, and BIA-FM* (Table 2)

Regarding body composition parameters, BIA-ASMM in males and females exhibited significant weak and strong negative correlations with age, respectively. BIA-FM and BIA water in both sexes did not change with age. BIA-ASMM and BIA-FM in both sexes exhibited strong positive and negative correlations with BIA-water, respectively, and BIA-ASMM exhibited a strong negative correlation with BIA-FM in both sexes. Cr-TSMM was negatively correlated with age and BIA-FM in females, and positively correlated with BIA-water in females, but not in males. Thus, BIA-ASMM in both sexes and Cr-TSMM in female demonstrated significant age-related changes.

When percent of BIA body component parameters were compared between ages and sex, the differences in BIA-ASMM, BIA-FM, and BIA-water between those 20 years old and those 80 years old were 6.7%, 6.2%, and 5.6% in males, and 8.9%, 7.8%, and 2.8% in females (Table 3). Thus, more marked changes were ob-

Table 2. BIA-ASMM, BIA-FM, BIA-water, and Cr-TSMM by sex : Correlation with age, BIA-water, and BIA-FM

	Age		BIA-water		BIA-FM	
	r	p	r	p	r	p
BIA-ASMM						
Male	-0.442	0.015	0.892	<0.001	-0.790	<0.001
Female	-0.645	<0.001	0.805	<0.001	-0.859	<0.001
BIA-FM						
Male	0.219	0.244	-0.929	<0.001	—	—
Female	0.286	0.082	-0.958	<0.001	—	—
BIA-water						
Male	-0.229	0.224	—	—	—	—
Female	-0.169	0.311	—	—	—	—
Cr-TSMM						
Male	-0.082	0.667	0.088	0.646	-0.064	0.736
Female	-0.543	<0.001	0.371	0.022	-0.385	0.017

BIA : bioelectrical impedance analysis, ASMM : appendicular skeletal muscle mass, FM : fat mass, water : water content, Cr : 24-h creatinine excretion, TSMM : total skeletal muscle mass served in BIA-ASMM than in BIA-FM and BIA-water with age.

３）*Comparison of BIA-ASMM and Cr-TSMM*

Cr-TSMM was positively correlated with BIA-ASMM (males : $r = 0.509$, $p < 0.01$; females : $r = 0.627$, $p < 0.001$) in both sexes. Regression equations between BIA-ASMM and Cr-TSMM were as follows :

BIA-ASMM (kg) in males = 0.263 × Cr-TSMM (kg) +16.3.

BIA-ASMM (kg) in females = 0.264 × Cr-TSMM (kg) +11.2.

Therefore, when Cr-TSMM was 10 kg, 20 kg, 30 kg, 40 kg, and 50 kg, BIA-ASMM was 19.0 kg, 21.6 kg, 24.2 kg, 26.8 kg, and 29.5 kg in males, and 13.8 kg, 15.5 kg, 19.1 kg, 21.8 kg, and 24.4 kg in females, respectively (Figure 1). Thus, Cr-TSMM was a more sensitive indicator of changes in MM than BIA-ASMM.

Table 3. Percent of BIA body component parameters in different ages and sexes

	20 years old	40 years old	60 years old	80 years old
Male				
BIA-ASMM (%)	38.1	35.9	33.7	31.4
BIA-FM (%)	19.4	21.5	23.5	25.6
BIA-water (%)	55.8	53.9	52.1	50.2
Female				
BIA-ASMM (%)	33.7	30.7	27.8	24.8
BIA-FM (%)	27.4	30.0	32.6	35.2
BIA-water (%)	51.5	50.6	49.6	48.7

BIA : bioelectrical impedance analysis, ASMM : appendicular skeletal muscle mass, FM : fat mass, water : water content

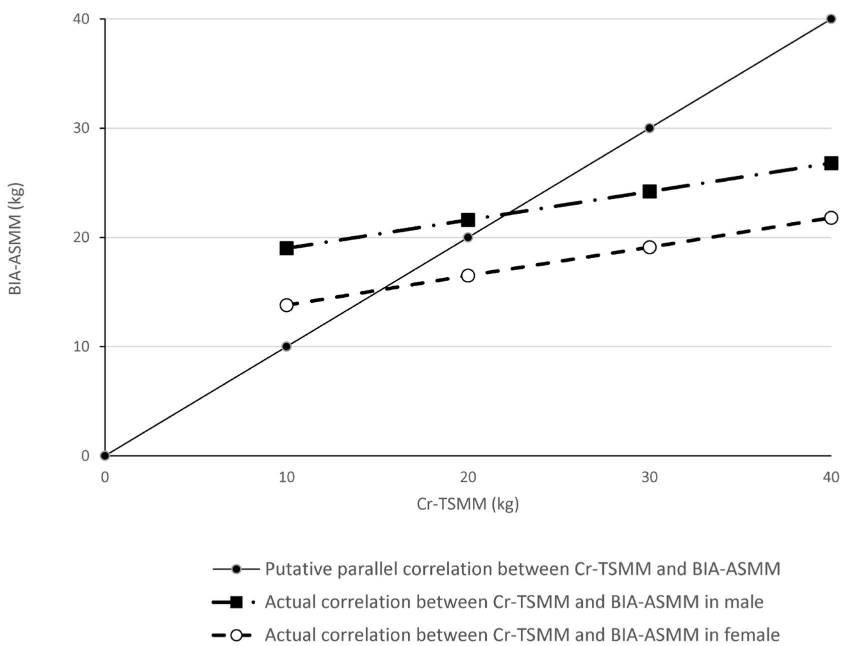

Figure 1. Relationship between Cr-TSMM and BIA-ASMM in males and females
Cr : 24-h creatinine excretion, BIA : bioelectrical impedance analysis,
ASMM : appendicular skeletal muscle mass, TSMM : total skeletal muscle mass

Discussion

In a previous study, there was an increase in total fat tissue with age only in women, whereas a significant increase in percent body fat was noted in both sexes ; thus, fat-free mass and muscle mass in men was generally considered to decrease throughout adulthood[16]. In the present study, BIA-ASMM in both sexes and Cr-TSMM in females significantly decreased with age. The differences in age-related changes in body composition between men and women may affect sex-based differences in age-related changes in physical performance. Age-related decreases in Cr-TSMM and age-related loss of muscle power and functions were observed in Japanese populations, which included nursing home residents, in our previous studies [9, 10, 17].

Loss of SMM is highly prevalent in older adults and represents an impaired state of health with mobility disorders, impaired ability to be well and perform activities of daily living, and loss of independence[18, 19]. Sarcopenia, the progressive and irreversible reduction of SMM and strength, is a widely documented process[20], which results in a reduction of motor neurons and atrophy of muscle fibers, especially the IIa type. A sedentary lifestyle, smoking, and inadequate intake and/or reduced use of protein and vitamin D play a role in the progression of sarcopenia.

Fat mass increases progressively during adulthood because of the reduction of overall energy expenditure. It generally peaks between the fifth and seventh decades of life and then remains constant or decreases slightly[21]. High body fat is associated with poorer physical performance in older adults, and fat accumulation within skeletal muscle is associated with muscle weakness and poor function[22]. In addition, excessive adiposity can downregulate the anabolic actions of insulin[23], testosterone[24], and growth hormone[25], all of which may lead to the progressive loss of MM and associated functions.

Water is the main component of the human body, and accounts for approximately 60% of body weight in adult men and 50-55% in adult women[26]. Water content in lean body mass and adipose tissue are approximately 73% and 10%, respectively. Water is an essential nutrient for life, but as a person ages, total body water decreases because of a decrease in fat-free mass and TSMM. BIA-water was positively and negatively correlated with BIA-ASMM and BIA-FM, respectively, in this study. Water is distributed in the body as intracellular and extracellular water, which mainly includes plasma fluid and interstitial fluid. Previous studies suggested that a relative expansion of extracellular water against intracellular water is observed in skeletal muscles with age[27]. Body water decreases in parallel with the reduction of fat free mass, especially in the intracellular compartment. Therefore, water loss may not only be the result of a parallel decline in SMM, but also a cause of impaired muscle function due to muscle cell dehydration[28].

The percent body weight of BIA-body composition parameters in different ages and sexes is shown in Table 3. BIA-ASMM between 20 and 80 years old exhibited greater percent changes than BIA-FM and BIA-water in both sexes. Thus, BIA-ASMM may be a defining parameter of aging. Previous studies reported that aerobic exercise is associated with a lower fat-free mass when compared with inactivity[29, 30]. Doherty reported that one-repetition maximum strength gains produced by resistance training ranged from 26 to 152% (median 39%) in 13 studies of men and women aged 60 years and older[31]. Thus, aerobic or resistance exercise, nonsmoking, and sufficient intake of energy, protein, and vitamin D are important to prevent sarcopenia and obesity with age.

The limitation of this study was the small number of subjects. Although the quadratic model provided a more accurate fit than a linear model for all body composition variables, the number of subjects in different age groups was insufficient to analyze using a quadratic model in this study. However, BIA-ASMM exhibited a strong positive correlation with Cr-TSMM in both sexes. As shown in Figure 1, a relationship between BIA-ASMM in males and females with Cr-TSMM was observed. In addition, BIA-ASMM was higher than Cr-TSMM by 10 kg, whereas BIA-ASMM was lower than Cr-TSMM by 30-40 kg. Therefore, the present study demonstrated that Cr-TSMM is a more sensitive marker of sarcopenia and aging than BIA-ASMM.

Ethical considerations

The protocol of this project (No 15-01) was approved by the Institutional Review Board of Hinomine Medical Center (Komatsushima, Tokushima, Japan). The procedures were fully explained to subjects and an informed consent form was signed.

Conflict of Interest and Acknowledgement

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