The Need for a New Cut-off Value to Increase Diagnostic Performance of Bioelectrical Impedance Analysis Compared with Dual-Energy X-ray Absorptiometry to Measure Muscle Mass in Indonesian Elderly

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ABSTRAK

Latar belakang: *penggunaan bioelectrical impedance analysis (BIA) dipengaruhi oleh populasi, jenis BIA, dan titik potong yang digunakan. Penelitian ini bertujuan untuk mengetahui performa diagnostik BIA untuk mengukur massa otot pada pasien berusia 60 tahun atau lebih di rawat jalan.* ***Metode:*** *uji diagnostik potong lintang dilakukan di poliklinik geriatri Rumah Sakit Cipto Mangunkusumo selama bulan April–Juni 2018. Pengukuran massa otot menggunakan BIA Tanita MC-780MA (Tokyo, Jepang) dengan dual-energy X-ray absorptiometry (DXA) sebagai uji referensi. Analisis titik potong berdasarkan kriteria Asian Working Group of Sarcopenia (AWGS) dan titik potong baru.* ***Hasil:*** *dari 120 subjek didapatkan 74 perempuan (61,7%). Performa diagnostik BIA dengan menggunakan acuan AWGS mendapatkan sensitivitas dan spesifisitas hanya 79,2% dan 66,7%. Sedangkan performa diagnostik BIA dengan acuan titik potong baru menunjukkan sensitivitas dan spesifisitas sebesar 75% dan 92,7%. Titik potong optimal yang baru dengan menggunakan BIA adalah <6,9 Kg/m^2 pada laki-laki (sensitivitas 70,6%; spesifisitas 82,8%) dan <5 kg/m^2 pada perempuan (sensitivitas 85,7%; spesifisitas 97%).* ***Kesimpulan:*** *BIA Tanita MC-780MA (Tokyo, Jepang) memiliki akurasi diagnostik yang baik untuk mengukur massa otot pada pasien lanjut usia dengan menggunakan titik potong laki-laki kurang dari 6,9 kg/m^2, sedangkan pada perempuan kurang dari 5 kg/m^2.*

Kata kunci: *BIA Tanita MC-780MA, Indonesia, lanjut usia, massa otot, sarkopenia.*

ABSTRACT

Background: *the use of bioelectrical impedance analysis (BIA) is affected by the population setting, the type of BIA, and the cut-off point being used. The aim of this study was to determine the diagnostic performance of BIA to measure muscle mass in Indonesian elderly outpatients aged 60 years or more.* ***Methods:*** *a cross-sectional study was conducted at the Geriatric Clinic of Cipto Mangunkusumo Hospital from April to June 2018. The muscle mass was measured using BIA Tanita MC-780MA (Tokyo, Japan) with dual-energy x-ray absorptiometry (DXA) as the reference test. Analysis on the cut-off point was performed based on the Asian Working Group of Sarcopenia (AWGS) criteria and the new cut-off point.* ***Results:*** *from 120 subjects, 74 were female (61.7%). The diagnostic performance of BIA based on AWGS criteria only showed sensitivity and specificity of 79.2% and 66.7%. The* *diagnostic performance of BIA based on the new cut-off point showed sensitivity and specificity of 75% and 92.7%. The new cut-off point using BIA was found to be <6.9 kg/m^2 in males (sensitivity 70.6%; specificity 82.8%) and <5 kg/m^2 in females (sensitivity 85.7%; specificity 97%).* ***Conclusion:*** *the diagnostic performance of BIA Tanita MC-780MA (Tokyo, Japan) was good to measure muscle mass in Indonesian elderly outpatients using a new cut-off point of <6.9 kg/m^2 for males and <5 kg/m^2 for females.*

Keywords: *BIA Tanita MC-780MA, elderly, Indonesia, muscle mass, sarcopenia.*

INTRODUCTION

The elderly population is rapidly growing, and is predicted to be doubled by 2050, from 11% to 22%.[1] The Indonesian Central Bureau of Statistics (BPS) predicted that there will be a surge of elderly population (aged 60 years or more) in Indonesia, from 9% in 2015 to 19.8% in 2045.[2] Several complex health problems could arise from geriatric patients—more widely known as geriatric syndrome—and one of these is sarcopenia.[3]

The European Working Group on Sarcopenia in Older People (EWGSOP) and the Asian Working Group of Sarcopenia (AWGS) defined sarcopenia as an age-related decline in muscle strength and/or performance in addition to progressive decrease in muscle mass resulting in an increased risk of falling, hospitalization, disability, poor quality of life, and mortality.[3,4] The essential part of the sarcopenia diagnostic algorithm is the measurement of muscle mass. Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) scan are the gold standard methods for muscle mass measurement, nonetheless both methods are high cost and require highly trained human resources.[3,5]

Dual-energy X-ray Absorptiometry (DXA) is a widely used device to measure body composition that also serves as the best alternative to measure muscle mass in research and clinical practice.[6] Another non-invasive device recommended by EWGSOP and AWGS for muscle mass measurement, yet more practical, easier to use with lower cost, and less resources than DXA is the Bioelectrical Impedance Analysis (BIA).[3,4] The BIA is a method that estimates body composition based on the relationship between the volume of a conductor and its electrical resistance.[7] Previous studies indicated that the diagnostic performance of BIA in muscle mass measurement was affected by the population setting, the type of BIA, and the cut-off point being used.[4,8-10] Up to the present time, there is no study that has investigated the diagnostic performance of BIA compared with DXA as the reference test to measure muscle mass in Indonesian elderly. Therefore, this study was aimed to investigate the diagnostic performance of BIA compared with DXA to measure the muscle mass as a component of sarcopenia in Indonesian elderly outpatients aged 60 years or older.

METHODS

This cross-sectional study of the diagnostic test was conducted on patients aged 60 years or more who were consecutively recruited at the Geriatric Clinic of Cipto Mangunkusumo Hospital, Jakarta, Indonesia from April to June 2018. This study was approved by the Ethical Committee of the Faculty of Medicine Universitas Indonesia/Cipto Mangunkusumo Hospital on February 19, 2018 with reference number 0137/UN.2F1/ETIK/2018. The study enrolled patients aged 60 years and older who were able to undergo BIA and DXA examinations. Patients with acute conditions (e.g., pneumonia, acute heart failure, or acute osteoarthritis), inability to walk, and to understand the instructions of the study, conditions which will interfere with DXA measurement including inability to lie down in a supine position, as well as those who have limb amputation and/or edema, Parkinson disease, or other medical conditions with tremor, weighed more than 100 kg, using artificial implants, and refused to participate in this study were excluded.

Muscle mass measurement was performed using BIA Tanita MC-780MA (Tokyo, Jepang) with DXA as the reference test. The BIA measurement was conducted at the Center for Sport and Exercise Studies, Indonesia Medical Education and Research Institute (IMERI) Faculty of Medicine Universitas Indonesia. For BIA measurement, the subjects need to stand on their bare feet and then wait for the results printed from the device. The muscle mass of all four extremities were calculated to obtain the Appendicular Skeletal Mass (ASM). Then, the value of ASM was divided by the square of the height in meters to obtain the Appendicular Skeletal Muscle Index (ASMI) value (kg/m^2). Each subject underwent DXA measurement at the Osteoporosis Center-Medistra Hospital, Jakarta, Indonesia, in which the subject needs to lie down in the supine position on a DXA table with the extremities close to the body. The muscle mass index was then classified as low or normal based on the cut-off point value according to AWGS criteria (for BIA: males <7 kg/m^2 and females <5.7 kg/m^2; for DXA: males <7 kg/m^2 and females <5.4 kg/m^2).

The usual gait speed on a 6-meter straight line was measured using a stopwatch. The measurement of handgrip strength was performed using a hydraulic Jamar J00105 [Jamar, IA, USA] in sitting position on the dominant hand and only the highest handgrip strength out of three trials was documented. The muscle strength and performance were also classified as low or normal based on the cut-off point value according to AWGS criteria.

Statistical Analysis

The IBM SPSS Statistics for Windows version 20.0 (IBM Corp., Armonk, NY, USA) was used to analyze the data. The value of statistical power and α were set at 80% and 5%, respectively. The minimum sample size was 105 subjects. Descriptive data on demographic (age and sex), anthropometric (body weight, height estimation based on knee-height, and body mass index), and clinical characteristics of the subjects were presented as percentage, mean (standard deviation), or median (minimal–maximal) value where appropriate. The values of area under the curve (AUC) and optimal cut-off point for muscle mass index were set according to the receiver operating characteristic (ROC) curve. The cut-off point of muscle mass index was then classified as low or normal and analyzed using a 2 x 2 table to determine the sensitivity, specificity, positive predictive values (PPV), negative predictive values (NPV), positive likelihood ratio (LR+), and negative likelihood ratio (LR–) values.

RESULTS

Out of 142 subjects who met the inclusion criteria, 22 subjects were scheduled. From 120 subjects in the final analysis, 74 were female (61.7%) and 46 were male (38.3%). The subjects' characteristics can be seen in **Table 1**, whereas the profile of sarcopenia's components based on age group is shown in **Table 2**. The mean ASMI in sarcopenic and non-sarcopenic male subjects were 6.57 (0.52) kg/m^2 and 7.83 (0.76) kg/m^2, respectively, while in females they were 5.08 (0.34) kg/m^2 and 6.64 (0.74) kg/m^2, respectively.

The diagnostic performance of BIA Tanita MC-780MA based on AWGS criteria showed sensitivity, specificity, PPV, NPV, LR+, LR–, and AUC values of 79.2%, 66.7%, 37.3%, 92.8%,

Table 1. Subject characteristics

	Male (n = 46)	Female (n = 74)
Age (years), n (%)	71.89 (6.11)[a]	
- 60–69	16 (34.8)	26 (35.1)
- 70–79	25 (54.3)	41 (55.4)
- >80	5 (10.9)	7 (9.5)
BMI (kg/m^2)	22.48 (4.60)[a]	
	21.87 (3.84)[a]	22.86 (5.00)[a]
Handgrip strength (kg)	20 (10–40)[b]	
	26.13 (6.24)[a]	18.00 (10–35)[b]
Usual gait speed (m/sec)	0.76 (0.23)[a]	
	0.78 (0.22)[a]	0.75 (0.23)[a]
ASMI based on BIA (kg/m^2)	7.41 (1.35)[a]	6.00 (0.84)[a]
ASMI based on DXA (kg/m^2)	7.45 (0.91)[a]	6.53 (0.82)[a]
Muscle mass classification based on BIA		
- Low	19 (41.3)	32 (43.2)
- Normal	27 (58.7)	42 (56.8)
Muscle mass classification based on DXA		
- Low	17 (37.0)	7 (9.5)
- Normal	29 (63.0)	67 (90.5)
Sarcopenia status based on BIA		
- Sarcopenia	12 (26.1)	24 (32.4)
- Normal	34 (73.9)	50 (67.6)
Sarcopenia status based on DXA		
- Sarcopenia	14 (30.4)	5 (6.8)
- Normal	32 (69.9)	69 (93.2)

[a] mean (standard deviation)
[b] median (minimal–maximal)

2.38, 0.31, and 0.729 (95% CI 0.619–0.839), respectively. The diagnostic performance of BIA Tanita MC-780MA based on AWGS criteria for each sex group is shown in **Figure 1**.

To improve diagnostic performance of muscle mass measurement using BIA Tanita MC-780MA, we did further statistical analysis to determine the optimal cut-off point with higher specificity. The new optimal cut-off point was found to be <6.9 kg/m2 in males with sensitivity 70.6%, specificity 82.8%, PPV 70.6%, NPV 82.8%, LR+ 4.1, LR– 0.4, and AUC 0.767 (95% CI 0.616–0.918), whereas it was <5 kg/m^2 in females with sensitivity 85.7%, specificity 97%, PPV 75%, NPV 98.5%, LR+ 28.5, LR– 0.15, and AUC 0.914 (95% CI 0.759–1.000). The diagnostic performance of BIA based on the new cut-off point showed sensitivity, specificity, PPV, NPV, LR+, LR–, and AUC of 75%, 92.7%, 72%, 93.7%, 10.3, 0.3, and 0.839 (95% CI 0.731–0.946), respectively.

DISCUSSION

There were 120 subjects involved in this study, more than half were females (61.7%). This proportion was in accordance with the Indonesian Population Projection in 2017 in which the proportion of elderly females was higher than males (52.53% vs 47.47%).[2] The mean age of subjects was 71.87 (6.10) years with the highest proportion (55%) in the age range of 70–79 years old. Although life expectancy in Indonesia for the period between 2015–2020 was 72.51 years, the highest proportion of Indonesian elderly in the community was in the age range of 60–69 years (63.36%).[2]

The proportion of sarcopenia in male and female groups was quite different based on muscle mass measurement between BIA and DXA examination. In the female group, BIA overestimated sarcopenic subjects by 4.76 times compared with DXA. Whereas, in the male group, BIA is underestimated as much as 0.86 times compared with DXA. Hence, it indicates a poor diagnostic performance of BIA to diagnose declined muscle mass when using the cut-off point based on AWGS criteria.

The diagnostic performance of BIA Tanita MC-780MA (Tokyo, Japan) based on AWGS criteria only showed sensitivity, specificity, PPV, NPV, LR+, LR–, and AUC of 79.2%, 66.7%, 37.3%, 92.8%, 2.38, 0.31, and 0.729 (95% CI

Table 2. The profile of sarcopenia components based on age group

Components	Age Group		
	60–69 years old n (%)	70–79 years old n (%)	≥80 years old n (%)
Sarcopenia Status based on BIA			
- Sarcopenia	7 (16.7)	21 (31.8)	8 (66.7)
- Normal	35 (83.3)	45 (68.2)	4 (333)
Sarcopenia Status based on DXA			
- Sarcopenia	1 (2.4)	13 (19.7)	5 (41.7)
- Normal	41 (97.6)	53 (80.3)	7 (58.3)
ASMI based on BIA			
- Low	10 (23.8)	33 (50.0)	8 (66.7)
- Normal	32 (76.2)	33 (50.0)	4 (33.3)
ASMI based on DXA			
- Low	3 (7.1)	16 (24.2)	5 (41.7)
- Normal	39 (92.9)	50 (75.8)	7 (58.3)
Handgrip Strength			
- Low	14 (33.3)	26 (39.4)	12 (100)
- Normal	28 (66.7)	40 (60.6)	0 (0)
Usual Gait Speed			
- Low	23 (54.8)	36 (54.5)	9 (75.0)
- Normal	19 (45.2)	30 (45.5)	3 (25.0)

0.619–0.839), respectively. Therefore, when using the cut-off point value according to the AWGS criteria,[4] the muscle mass measurement using BIA Tanita MC-780MA was not good as either a screening or diagnostic tool. This finding is consistent with a study conducted by Reiss et al.[11] with 60 elderly people which showed that BIA sensitivity and specificity were 77% and 71%, respectively.

From ROC analysis, the AUC value of BIA was obtained. In male subjects, the result was 0.831 (95% CI 0.708–0.953) with a statistically significant value of p ($p < 0.001$). Hence, it can be concluded that BIA is good for muscle mass measurement in male subjects with AUC value >0.8.

After the AUC value was obtained, an analysis was performed to determine the optimal cut-off point out of 44 cut-off points. Based on the Youden index and cut-off point curve, the optimal cut-off point of BIA for male subjects was <6.9 kg/m^2, with sensitivity 70.6%, specificity 82.8%, PPV 70.6%, NPV 82.8%, LR+ 4.1, LR– 0.4, and AUC 0.767 (95% CI 0.616–0.918).

Our optimal cut-off point that indicates low muscle mass in males was higher than Yamada et al,[12,13] slightly less than Yoshida et al,[14] and much less than was reported in studies by Janssen et al[15] and Landi et al[16]. These differences might be contributed by differences in ethnic groups (Asian vs Caucasian), type of BIA being used, the mean age of the subjects, as well as the mean ASMI of sarcopenic and non-sarcopenic subjects.

The Yamada et al[12] study on community-dwelling elderly in Japan revealed that using BIA Inbody 720 (Biospace, Korea) the optimal cut-off point of muscle mass for males was <6.75 kg/m^2. However, the mean age of their subjects was older than our study with lower mean of ASMI. The mean age of their subjects was 74 (4.8) years in non-sarcopenic and 81.1 (4.8) years in sarcopenic subjects with the mean of ASMI being 5.53 (0.73) kg/m^2 in sarcopenic and 7.16 (1.01) kg/m^2 in non-sarcopenic male subjects. A study by Yoshida et al[14] on 250 community-dwelling elderly aged 65 years or more in Japan and using a different type of BIA [Tanita MC-980A (Tokyo, Japan)] reported a slightly higher optimal cut-off point for male subjects than our finding (<7.09 kg/m^2) although the mean age of their subjects was older than ours [73.7 (5.7) years]. Furthermore, the Janssen et al[15] study on non-institutionalized elderly in the US found a much higher optimal cut-off point that indicates low muscle mass in males than our study [≤8.50 kg/m^2 in severe sarcopenia and ≤8.51–10.75 in moderate sarcopenia]. Janssen et al[15] study, which used BIA Valhalla 1990B (Valhalla Medical, California), had younger mean age [70 (7) years] with higher mean ASMI than ours [9.86 (1.18) kg/m^2]. In contrast, though they had much older subjects' mean age [84.1 (6.9) years], using BIA AKERN (Florence, Italy) Landi et al[16] study revealed much higher optimal cut-off point for male subjects in Italy than our study (<8.87 kg/m^2). The mean ASMI in Landi et al[16] study was slightly lower for sarcopenic [6.3 (1.4) kg/

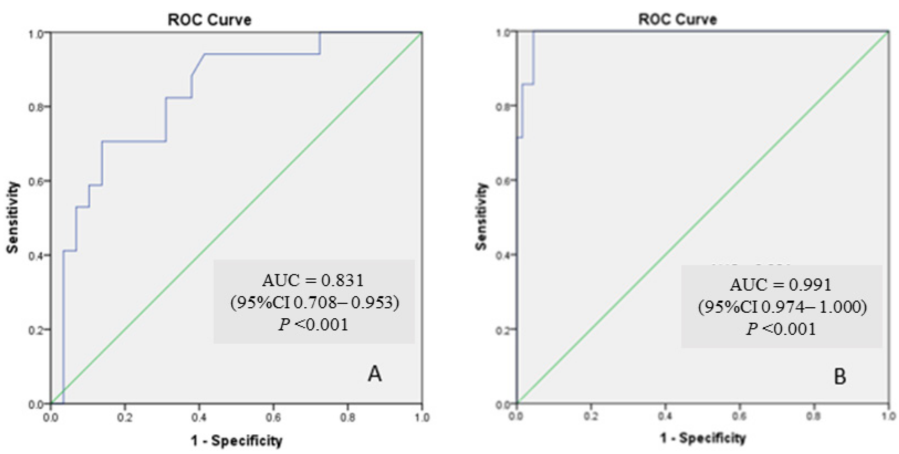

Figure 1. ROC analysis of BIA. Male group (A) and female group (B)

m^2] but much higher for non-sarcopenic subjects [11.7 (3.2) kg/m^2] than our study.

The ROC analysis on female subjects showed a very good AUC value of 0.991 (95% CI 0.974–1.000) with a statistically significant p value ($p< 0.001$). Then, an analysis to determine the optimal cut-off point out of 70 cut-off points was performed. Based on the Youden index and the cut-off point curve, it was determined that the optimal cut-off point of BIA in female subjects was <5 kg/m^2 with sensitivity, specificity, PPV, NPV, LR+, LR–, and AUC of 85.7%, 97%, 75%, 98.5%, 28.5, 0.15, and 0.914, respectively.

Our optimal cut-off point that indicates low muscle mass in females was much less than Yoshida et al,[14] Janssen et al,[15] and Landi et al[16] study, yet quite similar to Yamada et al[12,13] study. Similar to the male subjects, Yoshida et al14 also found that the optimal cut-off point for female subjects was higher than our finding (<5.91 kg/m^2) although the mean age of their subjects was older [73.2 (5.5) years]. Similarly, Janssen et al[15] reported that the optimal cut-off point was much higher than our result due to the higher mean of ASMI [7.04 (1.11)] kg/m^2; ≤5.75 kg/m^2 in severe sarcopenic and 5.76–6.75 kg/m^2 in moderate sarcopenic subjects], though similar mean age [71 (8) years old]. In the same way, Landi et al16 found that the optimal cut-off point was <6.42 kg/m^2. However, a study by Yamada et al[12] on elderly Japanese patients using BIA Inbody 720 (Biospace, Korea) showed a similar result to our study (<5.07 kg/m^2) although the mean age of the subjects was older [73.9 (5.3) years in non-sarcopenic and 77.6 (5.4) years in sarcopenic female subjects] and the mean ASMI was lower than our result (4.23 kg/m2 and 5.65 kg/m^2 in sarcopenic and non-sarcopenic females, respectively). All other studies recruited community-dwelling older adults, except Landi et al[16] who recruited the subjects from nursing home residents.

A cross-tab analysis was then performed between BIA as the diagnostic test and DXA as the reference test using the new cut-off point. The diagnostic performance of BIA compared with DXA was improved. The sensitivity and LR– only slightly decreased from 79.2% to 75% and from 0.31 to 0.3, respectively. However, the specificity, PPV, LR+, and AUC significantly increased from 66.7% to 92.7%, from 37.3% to 72%, from 2.38 to 10.3, and from 0.729 to 0.839, respectively, with slightly increased NPV from 92.8% to 93.7%. The new cut-off point for males was only slightly lower than the AWGS criterion (<6.9 kg/m2 vs <7 kg/m^2), however, the new cut-off point for females was much lower than the AWGS criterion (<5 kg/m2 vs <5.7 kg/m^2).

Our findings show that by using the new cut-off points, BIA has high specificity and LR+ value. Thus, BIA can serve as a diagnostic tool to measure declined muscle mass, which is an essential component of the sarcopenia diagnostic algorithm. Moreover, our findings also support the use of BIA as a valid and practical tool to measure muscle mass when MRI, CT scan, or DXA is unavailable or when there is cost constraint.

Our study was the first study to investigate the diagnostic performance of BIA compared with DXA to measure muscle mass in Indonesian elderly. However, the low proportion of sarcopenic female subjects may interfere with the diagnostic performance of BIA for elderly females. Therefore, further study to investigate the external validation of the new muscle mass index cut-off point should be performed to ascertain whether these new cut-off points for both sex groups can be applied to a wider population.

CONCLUSION

The diagnostic performance of BIA Tanita MC-780MA (Tokyo, Japan) was good to measure muscle mass in Indonesian elderly outpatients, using a new cut-off point of <6.9 kg/m^2 for males and <5 kg/m^2 for females. The differences in the optimal cut-off points which indicate low muscle mass reported by several studies emphasize that different types of BIA devices can affect the results, as well as the age, sex, and ethnicity.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest regarding this study.

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