Diagnostic Merit of Using the Calf Circumference to Estimate the Muscle Mass as a Component of Sarcopenia in Elderly Outpatients

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Abstract

Objective: Sarcopenia is a geriatric syndrome that can lead to poor clinical outcomes. Therefore, a simple measurement is necessary to estimate the muscle mass as a component of sarcopenia. The aim of this study was to determine the diagnostic merit of using the calf circumference (CC) to estimate the muscle mass in elderly individuals. **Materials and Methods:** This was a cross-sectional study of patients over 60 years conducted at the Geriatric Clinic of the Dr. Cipto Mangunkusumo Hospital in Jakarta, Indonesia, from April to June of 2018. Dual-energy X-ray absorptiometry was used as a reference test for the muscle mass measurements, and the classification of normal or low muscle mass was based on the Asian Working Group for Sarcopenia criteria. The nondominant leg was used to measure the CC. **Results:** Out of 120 patients, 74 were female (61.7%). The optimal CC cutoff points for low muscle mass were 34 cm for the male patients (the values for the sensitivity [Sn], specificity [Sp], positive predictive value [PPV], negative predictive value [NPV], and area under the receiver operating characteristic curve [AUC] were 64.7%, 79.3%, 64.7%, 79.3%, and 73.1%, respectively) and 29 cm for the female patients (the values for the Sn, Sp, PPV, NPV, and AUC were 71.4%, 95.5%, 62.5%, 97.0%, and 96.4%, respectively). **Conclusion:** The sensitivities and specificities of the CCs were 64.7% and 79.3%, respectively, for the males and 71.4% and 95.5%, respectively, for the females. The CC could be used in clinical practice to estimate the muscle mass of elderly outpatients.

Keywords: Calf circumference, elderly, muscle mass, sarcopenia

Introduction

Asia has the largest elderly population in the world, which brings with it various health problems, including geriatric syndromes.[1] Recently, sarcopenia (an age-related decrease in muscle mass and function) has been recognized as a major health problem in the geriatric population, because it has a close association with physical frailty that leads to poor health outcomes, including falls, disabilities, poor quality of life, increased health-related costs, morbidity, and mortality.[2-4]

The diagnostic algorithm of sarcopenia consists of the measurements of handgrip strength, gait speed, and muscle mass. The clinical standard for the muscle mass measurement is a magnetic resonance imaging or computed tomography scan.[5] In the clinical setting, dual-energy X-ray absorptiometry (DXA) or a bioelectrical impedance analysis (BIA) is used more frequently for measuring muscle mass.[5,6] However, in settings with limited resources, a simpler method to measure the muscle mass will be useful.

Previous studies have shown that the calf circumference (CC) can be used as a surrogate biomarker to estimate the muscle mass in the adult population, because the calf area has a relatively lower amount of fat deposition when compared to

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other body areas, such as the abdomen and waist.[7] However, more data are needed to conclude the significance of using the CC for estimating the muscle mass, especially in the elderly population. Moreover, body compositions can differ between the genders, races, and ethnicities as well as different ages.[8] Hence, the aim of this study was to determine the diagnostic performance of the CC, when compared to DXA as a reference test, to estimate the muscle mass in elderly outpatients.

Materials and Methods

This was a cross-sectional study of patients 60 years and older from the Geriatric Outpatient Clinic of the Dr. Cipto Mangunkusumo General Hospital in Jakarta, Indonesia, who were consecutively enrolled from April to June of 2018. This study was approved by the Ethical Committee of the Faculty of Medicine at the Universitas Indonesia–Dr. Cipto Mangunkusumo General Hospital (No. 0137/UN.2F1/ETIK/2018).

The study exclusion criteria were as follows: edema in the lower extremities, leg amputation(s), acute disease episode(s) (e.g., acute heart failure, pneumonia, or acute arthritis), refusal to participate in the study, unable to ambulate, unable to comprehend the study procedure instructions, body weight of more than 100 kg, unable to lie down in the supine position, Parkinson's or another tremor disease, and artificial implants that could interfere with the DXA measurements.

DXA was used as the reference test for the muscle mass measurements, and the DXA scans were performed at the Osteoporosis Center of the Medistra Hospital in Jakarta, Indonesia. The appendicular skeletal muscle mass (ASM) was obtained by calculating the muscle masses of the upper and lower extremities, and the skeletal muscle index (SMI) was obtained by dividing the ASM value by the height squared (kg/m^2).

Based on the European Working Group of Sarcopenia in Older People consensus, the conceptual staging of sarcopenia is classified as presarcopenia, sarcopenia, and severe sarcopenia. The characteristics of "presarcopenia" stage are low muscle mass without low muscle strength or low physical performance. The characteristics of "sarcopenia" stage are low muscle mass, with impact on muscle strength or physical performance. The characteristics of "severe sarcopenia" stage are low muscle mass, plus low muscle strength, and low physical performance.[5]

The CC was measured using the nondominant leg, and a measuring tape was used to encircle the calf at the widest point without putting pressure on the subcutaneous tissue. The body weight and knee height (used to estimate the height) were also recorded. The handgrip strength of the dominant hand was measured three times while the patient was sitting down using a handheld dynamometer (Jamar J00105; Jamar, Indiana, USA), and the highest value was documented. The gait speed was evaluated using a 6 meters walking test. Each patient was asked to walk 6 m on a straight line at their usual walking speed. The time taken to complete this task was measured using a stopwatch. The SMI, handgrip strength, and usual gait speed were classified as low or normal based on the Asian Working Group for Sarcopenia criteria.[6]

The data were analyzed using IBM SPSS Statistics for Windows version 20.0 (IBM Corp., Armonk, NY, USA). The statistical power was set at 80% and the α value was set at 5%. The minimum sample size was 103 patients. For the descriptive data, the Kolmogorov–Smirnov test was used for the normality testing. To present the normally distributed data, the mean (standard deviation) was used, and the median (minimal–maximal) was used for the nonnormally distributed data. The Pearson correlation test was used to determine the correlation between the CC and SMI. The area under the receiver operating characteristic curve (AUC) was used to determine the optimal CC cutoff points (intersections). The cutoff points were then transformed into dichotomous categorical variables and analyzed using a Chi-squared test to determine the sensitivity (Sn), specificity (Sp), positive predictive value (PPV), negative predictive value (NPV), positive likelihood ratio (LR+), and negative likelihood ratio (LR−) values. Finally, the optimal cutoff point, with high Sp and sufficient Sn, was selected for each gender.

Results

Out of 142 possible patients, 120 met the inclusion criteria. There were 46 male (38.3%) and 74 female (61.7%). The male group had a higher SMI, handgrip strength, gait speed, and CC than female group, but they had a lower mean body mass index (BMI) when compared to the females [Table 1].

The underweight, normal weight, overweight, and obese patient proportions for both groups were 20.8%, 37.5%, 10.0%, and 31.7%, respectively. A low handgrip strength was more common in the females than the males (45.9% vs. 39.1%, respectively). However, the proportions of the patients with slow walking speed and low SMI value were higher in the males than the females (60.9% vs. 54.1%, respectively, and 37% vs. 9.5%, respectively). The presarcopenia, sarcopenia, and severe sarcopenia patient proportions in the male group were 6.5%, 13%, and 17.4%, respectively, which were greater than those of the female group (2.7%, 0%, and 6.8%, respectively).

The results of the Pearson correlation coefficient test showed that the CC had a significantly strong positive correlation with the SMI for all of the study patients ($r = 0.73$, $r^2 = 0.53$, $P < 0.05$), the male group ($r = 0.68$, $r^2 = 0.46$, $P < 0.05$), and the female group ($r = 0.8$, $r^2 = 0.66$, $P < 0.05$).

The results of the statistical analysis [Figure 1] showed that the AUC value of the CCs of the males was 73.1% (95% confidence interval [CI] = 57%–89%, $P < 0.05$).

The results of the statistical analysis of the diagnostic accuracy of the CC are shown in Table 2. After the AUC value was

Table 1: The characteristics of the study patients according to the gender

Variable	Males (*n*=46)	Females (*n*=74)
Age (years), *n* (%)		
60-69	16 (34.8)	26 (35.1)
70-79	25 (54.3)	41 (55.4)
≥80	5 (10.9)	7 (9.5)
Mean (SD)	72.41 (6.83)	71.57 (5.64)
BMI (kg/m^2), *n* (%)		
Underweight	10 (21.7)	15 (20.3)
Normoweight	20 (43.5)	25 (33.8)
Overweight	5 (10.9)	7 (9.5)
Obese	11 (23.9)	27 (36.5)
Mean (SD)	21.87 (3.84)	22.88 (4.98)
Handgrip strength (kg), *n* (%)		
Low	18 (39.1)	34 (45.9)
Normal	28 (60.9)	40 (54.1)
Mean (SD)	26.13 (6.24)	18 (10-35)*
Gait speed (m/s), *n* (%)		
Low	28 (60.9)	40 (54.1)
Normal	18 (39.1)	34 (45.9)
Mean (SD)	0.78 (0.22)	0.75 (0.23)
SMI (kg/m^2), *n* (%)		
Low	17 (37.0)	7 (9.5)
Normal	29 (63.0)	67 (90.5)
Mean (SD)	7.45 (0.91)	6.53 (0.82)
Fat mass (%)		
Median (minimal-maximal)	11.97 (1.80-28.13)	15.93 (1.23-43.04)
Sarcopenia status, *n* (%)		
No sarcopenia	29 (63.1)	67 (90.5)
Presarcopenia	3 (6.5)	2 (2.7)
Sarcopenia	6 (13.0)	0
Severe sarcopenia	8 (17.4)	5 (6.8)
CC (cm), *n* (%)		
No sarcopenia	36.07 (3.34)	35.10 (4.36)
Sarcopenia	33.95 (4.22)	27.87 (1.47)
Mean (SD)	35.5 (3.92)	34.42 (4.68)

*Median (minimal-maximal). SD: Standard deviation, BMI: Body mass index, CC: Calf circumference, SMI: Skeletal muscle index

Table 2: Diagnostic accuracy of the calf circumference cutoff points of the male patients

CC cut-off point (cm)	Sensitivity	Specificity	PPV	NPV	LR+	LR−	AUC
<33	52.9	86.2	69.2	75.8	3.83	0.55	0.70
<34	64.7	79.3	64.7	79.3	3.13	0.45	0.72
<35	70.6	72.4	60	80.8	2.56	0.41	0.72

PPV: Positive predictive value, NPV: Negative predictive value, LR+: Positive likelihood ratio, LR−: Negative likelihood ratio, ROC: Receiver operating characteristic, AUC: Area under the ROC curve, CC: Calf circumference

obtained, an analysis was conducted to determine the optimal value of the 45 cutoff points (intersections). The statistical analysis showed that the optimal cutoff point was 35 cm, with Sn, Sp, PPV, NPV, LR+, and LR− values of 70.6%, 72.4%, 60.0%, 80.8%, 2.56, and 0.41, respectively. As this

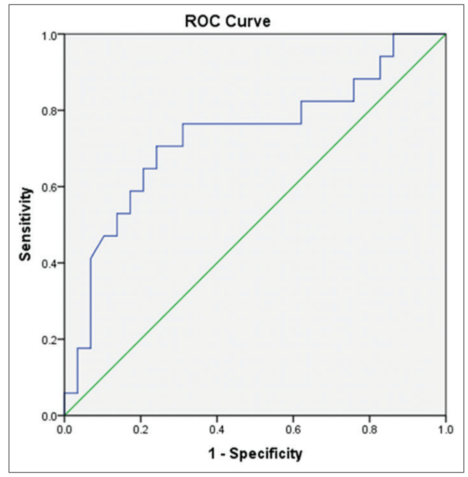

Figure 1: Receiver operating characteristic curve of the calf circumference used to estimate the skeletal muscle index of the male patients

study was designed to determine the optimum cutoff point of the CC in order to diagnose low muscle mass, we looked for a cutoff point that produced higher Sp with sufficient Sn. Therefore, the selected CC cutoff point for the male patients was <34 cm, with Sn, Sp, PPV, NPV, LR+, LR−, and AUC values of 64.7%, 79.3%, 64.7%, 79.3%, 3.13, 0.45, and 0.72, respectively. The AUC value of the female patients was 96.4% (95% CI = 92–100%, $P < 0.05$) [Figure 2]. We determined the optimal value out of 70 cutoff points (intersections), and the results of the statistical analysis revealed that the optimal cutoff point was 30 cm, with Sn, Sp, PPV, NPV, LR+, and LR− values of 85.7%, 88.1%, 42.9%, 98.3%, 7.17, and 0.16, respectively. However, the cutoff point with a higher Sp and sufficient Sn was <29 cm, with Sn, Sp, PPV, NPV, LR+, LR−, and AUC values of 71.4%, 95.5%, 62.5%, 97%, 15.87, 0.30, and 0.84, respectively [Table 3].

Discussion

There were a total of 120 patients included in our study, with a higher proportion of females (61.7%) than males. This data corresponded with the 2017 data from Statistics Indonesia,[9] which stated that the proportion of elderly women in Indonesia was greater than that of the elderly men (9.47% vs. 8.48%, respectively). The mean age of the subjects in our study was 72.41 (6.83) years old for the males and 71.57 (5.64) years old for the females. Incidentally, the life expectancy in Indonesia is 72.51 years for the 2015–2020 time period. Our results were similar to those from a study by Seto *et al*.,[10] which was conducted in the same clinical setting.

The mean SMI value of all of the study patients was 6.88 (0.96) kg/m^2. The median SMI value of the male group was 7.18 (5.28–9.38) kg/m^2 and the mean SMI value of the female group was 6.53 (0.82) kg/m^2. These SMI values were higher than those reported by Maeda *et al*.[11] in a study from Japan, which were 6.1 (1.3) kg/m^2 for the elderly men and 4.7 (1.3) kg/m^2 for the elderly women. These differences may have been due to the differences in the muscle mass

Table 3: Diagnostic accuracy of the calf circumference cutoff points of the female patients

CC cutoff point (cm)	Sensitivity	Specificity	PPV	NPV	LR+	LR−	AUC
<28	57.1	95.6	66.7	95.6	19.03	0.44	0.77
<29	71.4	95.5	62.5	97	15.87	0.30	0.84
<30	85.7	88.1	42.9	98.3	7.20	0.16	0.87

PPV: Positive predictive value, NPV: Negative predictive value, LR+: Positive likelihood ratio, LR−: Negative likelihood ratio, ROC: Receiver operating characteristic, AUC: Area under the ROC curve, CC: Calf circumference

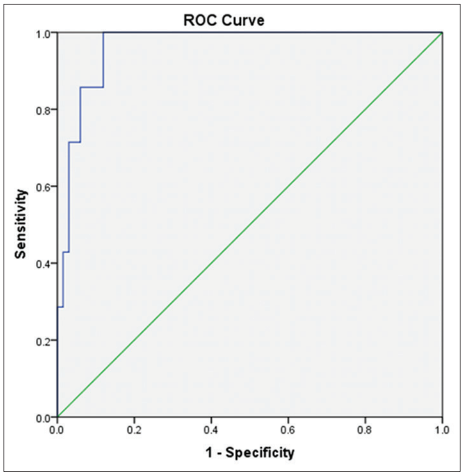

Figure 2: Receiver operating characteristic curve of the calf circumference used to estimate the skeletal muscle index of the female patients

measurement techniques, because a BIA was used to measure the muscle mass in the study by Maeda *et al*.[11] There were also differences in BMI characteristics. The BMI values in this study were greater for both the males and females (21.87 [3.84] kg/m^2 and 22.88 [4.98] kg/m^2, respectively) when compared to the study by Maeda *et al*. (20.7 [3.5] kg/m^2 and 20.6 [3.8] kg/m^2, respectively).[11] However, our study had results similar to those of Rolland *et al*.,[12] who conducted a study in France that also used DXA to measure the muscle mass. They reported that the overall mean of the SMI values was 6.4 (0.8) kg/m^2.

The mean CC of the male patients without sarcopenia (36.07 [3.34] cm) and with sarcopenia (33.95 [4.22] cm) in our study were similar to those from the study by Kawakami *et al*.,[13] which reported values of 37.0 (2.2) cm and 32.7 (1.9) cm, respectively. In contrast, the mean CC of the female patients without sarcopenia (35.10 [4.36] cm) and with sarcopenia (27.87 [1.47] cm) in our study were different from the results from the Kawakami *et al*.[13] study, which reported that the CC means of the female patients without sarcopenia and with sarcopenia were 34.2 (2.3) cm and 31.3 (1.8) cm, respectively. These differences may have been due to the differences in the BMI values, because the mean BMI value of the sarcopenic females (15.98 [2.12] kg/m^2) in our study was smaller when compared to the value reported by Kawakami *et al*. (19.3 [1.9] kg/m^2).[13]

For the male patients, the selected CC cutoff point that indicated low muscle mass was 34 cm. With a cutoff point of 34 cm, the Sp increased from 72.4% to slightly <80%, with an acceptable Sn of 64.7%. This cutoff point was similar to that reported by Kawakami *et al*.[13] in their study from Japan. However, this value was quite different from that reported by Maeda *et al*.,[11] in which the cutoff point was 30 cm. This difference may have been due to the fact that Maeda *et al*.[11] study was conducted in an inpatient setting, with a lower mean muscle mass value. Moreover, instead of using DXA, the muscle mass measurements in Maeda *et al*.[11] study were obtained using BIA.

We found that the AUC of the female group was much better than that of the male group. The AUC of the female group was 96.4% (95% CI = 92%–100%, $P < 0.05$), which is considered to be a good AUC value, whereas the AUC of the male group was only 73.1%. Similar to the results of the male group analysis, the cutoff point for the female group that indicated low muscle mass was set at 29 cm in order to ensure a higher Sp value with sufficient Sn, which supports the CC measurement as a possible diagnostic tool. With a cutoff point of 29 cm, the Sp increased from 88.1% to 95.5%, with a sufficient Sn of 71.4%. Interestingly, this cutoff point (29 cm) was similar to that of the Maeda *et al*.[11] study, but somehow, it was lower than the cutoff point reported by Kawakami *et al*.,[13] which was 33 cm. This discrepancy may have been due to the differences in the patients' characteristics; in the Kawakami *et al*.[13] study, the population included healthy individuals from 40 to 89 years, and they had higher mean muscle mass, BMI, and total body fat values.

This was the first study to investigate the diagnostic performance of the CC used to estimate the muscle mass in both genders of elderly outpatients 60 years old and older. This research was carried out at the geriatric outpatient clinic; therefore, the admission rate bias was avoided, unlike that in an inpatient setting. Selection, recall, and measurement biases were also avoided because the patients were enrolled consecutively. Moreover, our study used primary data, and all of the anthropometric measurements were taken by the same personnel.

However, there were some limitations in this study. For example, there was a discrepancy in the gender proportion among our study patients; the number of male patients was much less than the number of female patients. This may have interfered with the diagnostic performance of the CC for the male study participants. In addition, the sample size calculation did not separate the male and female patients, thus resulting in wide CIs for both the male and female groups. Therefore, external validation should be performed for the cutoff points in daily clinical practice in order to ascertain whether the results obtained in this study can be applied to a wider population. Further studies are necessary to ensure the external validity of the cutoff points reported in this study.

Conclusion

The diagnostic performance and accuracy of the CC used to estimate the muscle mass was good, especially for the elderly female outpatients. However, the age, gender, BMI, and population setting may have affected the CC cutoff point for detecting low muscle mass.

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Conflicts of interest

There are no conflicts of interest.

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