

# JOURNAL OF BIOMEDICINE AND TRANSLATIONAL RESEARCH

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Original Research Article

## Diagnostic accuracy of calf circumference for decreased muscle mass in older adults with sarcopenia

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### Article Info

History

Received: 22 Aug 2021

Accepted: 27 Mar 2022

Available: 28 Apr 2022

### Abstract

**Background:** Increasing number of the older adults population results in increasing sarcopenia, a geriatric problem that may lead to poor quality of life, susceptibility to disease, malnutrition, and even death. Muscle mass is an important sarcopenia parameter that can be measured by Bioelectrical Impedance Analysis (BIA). Detection of decreased muscle mass can be done by measuring calf circumference, it is expected to provide an early diagnose of sarcopenia so that early intervention can be given and improve the quality of life of the older adults.

**Objective:** To analyze the diagnostic accuracy of calf circumference for decreased muscle mass in older adults to provide simple way in diagnosing sarcopenia.

**Methods:** This study involved 126 older adults, consisted of 57 men and 69 women aged 60-80 years in the community who met the inclusion criteria. Criteria of sarcopenia were defined based on the Asian Working Group for Sarcopenia (AWGS) Consensus, consisted of three components; muscle mass, handgrip strength, and walking speed. This study analyze the diagnostic accuracy of calf circumference for decreased muscle mass measured by single- frequency BIA and calf circumference was measured using a measuring tape. The analysis was carried out according to the receiver operating characteristic (ROC) curve to determine the cut-off point along with the sensitivity (Se) and specificity (Sp) values, positive and negative predictive values (PPV and NPV) of calf circumference as an indicator for low muscle mass.

**Results:** Optimal cut-off point of calf circumference to indicate low muscle mass is 32.9 cm in women (Se 80.8%, Sp 79.1%, PPV 75.9%, NPV 87.5%) and 33.5 cm in men (Se 78.6%, Sp 74.4%, PPV 50%, NPV 91.4%). PPV in men is lower than women. This is due to a lower prevalence of decreased muscle mass in men than women. There were 49 participants with the calf circumference below cut-off point and 40 (31.7%) of the 126 participants had sarcopenia.

**Conclusion:** Calf circumference has a diagnostic accuracy to find decreased muscle mass in sarcopenia.

**Keywords:** sarcopenia; older adults; calf circumference; muscle mass

**Permalink/ DOI:** <https://doi.org/10.14710/jbtr.v8i1.12115>

### INTRODUCTION

Aging is the process of losing the ability of body tissue to repair or replace itself and maintain its normal structure and function so that it cannot survive injury and repair the damage suffered. The older adults group is prone to health problems and malnutrition because the function of body organs will decrease with increasing age,<sup>1</sup> and associated with physiological, psychological,

social, and economic changes that affect nutritional status and quality of life.<sup>1-4</sup>

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Sarcopenia is a decrease of muscle mass and function, which is characterized by a decrease in muscle strength, physical performance, and associated with increasing age.<sup>2</sup> Older adults with sarcopenia tend to have decreased functional capacity, low quality of life, prone to falls, disease, malnutrition, impaired mobility, and even death.<sup>2,3,5</sup> Research shows the prevalence of sarcopenia in the world ranges between 9.9 to 40.4 %, while research in Indonesia stated the prevalence of sarcopenia was 9.1% to 40.6%.<sup>5</sup>

The algorithm for diagnosing sarcopenia according to the European Working Group on Sarcopenia in Older People (EWGSOP) and the Asian Working Group for Sarcopenia (AWGS) is based on three measurements, namely muscle mass, muscle strength, and physical performance.<sup>2,8</sup> Decreased muscle mass as an important marker of sarcopenia is necessary further scrutinized. Muscle mass can be measured using computed tomography (CT), magnetic resonance imaging (MRI), dual-energy X-ray absorptiometry (DXA), and bioelectrical impedance analysis (BIA).<sup>2,6</sup> CT and MRI are considered the gold standard for determining muscle mass because they can separate images of fat and other soft tissues of the body. Still the high cost and radiation exposure limit the use of these methods in routine clinical examinations. BIA examination procedure estimates the fat volume and lean body mass. The results of the BIA measurement correlate well with the results of the MRI examination so that it can be used as an alternative for determining muscle mass.<sup>6</sup> BIA is an inexpensive and easy-to-use examination, but the availability of BIA has not been evenly distributed to the primary health care center. Lack of availability of tools for assessing muscle mass makes it difficult to diagnose sarcopenia. Anthropometry is a systematic measurement of the human body. The distribution of muscle mass in adults is more in the lower limbs than in the upper limbs. Therefore anthropometric measurements of the lower extremities are good predictors for calculating whole body muscle mass.<sup>7</sup> According to WHO, calf circumference can be used as an anthropometric parameter to determine muscle mass.<sup>8</sup> Early detection of sarcopenia in an easy and simple way will provide benefits because treatment for sarcopenia can be given earlier. These two things are the main keys to improving outcomes so that the older adults can live with better quality of life.<sup>9</sup>

Based on the background described, this study aims to examine the diagnostic accuracy of calf circumference to muscle mass as measured by BIA to diagnose sarcopenia so that cases of sarcopenia can be found easily and earlier in facilities with limited facilities and infrastructure.

## MATERIALS AND METHODS

This study was a cross-sectional study and approved by the Health Research Ethics Committee of Faculty of Medicine Universitas Diponegoro and conducted in the period July-September 2020. All participants received an explanation of the study before measurement and provided their written informed consent. Participants taken from the older adult's community group in the city of Surakarta aged 60-80 years, able to stand, understand orders, willing to participate in research, and

cooperative. Calf circumference measurements were performed by two trained examiners in standardized measurement methods using non-elastics bands, by encircling the calf in a horizontal position and attached to the skin but not pressing the tissue underneath. Then the tape was moved up and down to get the largest circumference. Measurements were made three times to get the mean value. Muscle mass measurements were obtained using OMRON single-frequency hand-to-foot BIA by following protocol guidelines from the manufacturer. Participant age, height (cm), and sex were entered into the device before instructing the participant to step barefoot onto the scale. Participants were then instructed to hold the display unit with both hands and extend their arms parallel to the floor, while standing upright. The data of appendicular skeletal muscle mass (ASM) obtained from adding up total muscle mass in four extremities and then proportioned by dividing the height in meters squared ( $ASM/Ht^2$ ). Validation of BIA measurement based on prior study stated that BIA machines appear to be both reliable and valid for predicting fat free mass of male and female. Therefore, BIA devices is appropriate to use for body composition assessment in a healthy adult population.<sup>10</sup> Handgrip strength examinations were measured using a hydraulic handheld dynamometer and physical performance was assessed by 6 meters usual walking speed. The diagnosis of sarcopenia was based on AWGS consensus criteria, which were low muscle mass ( $ASM/Ht^2$ )  $<7.0$  kg/m<sup>2</sup> for men and  $<5.7$  kg/m<sup>2</sup> for women combined with low muscle function (handgrip strength  $<28$  kg for men and  $<18$  for women and/or 6 meters usual walking speed  $<1.0$  m/s for both sexes).

Participants with chronic disease such as heart failure, end-stage chronic renal failure, or malignancy, participants with edema, prolonged bed rest, or participants with lower extremity abnormalities that resulted in large differences in the right and left legs were excluded.

Data were then analyzed, sample characteristics including age, sex, and body mass index (BMI) will be presented descriptively. The values of Area under the curve (AUC) were determined based on Receiver Operating Characteristics (ROC) curves, and cut-off point of calf circumference calculated by determining the shortest distance between the ROC curve and upper left corner of the graph. The cut-off points were compared with decreased muscle mass based on AWGS criteria using a 2x2 table and then being analyzed to obtain sensitivity (Se), specificity (Sp), positive predictive value (PPV), and negative predictive value (NPV).

## RESULTS

There were 126 participants included in this study. The basic characteristics of the participants are described in Table 1. Most of the participants consisted of female (54.8%). The mean age of all participants being  $68.4 \pm 6.3$  with male participants' mean age was  $67.4 \pm 5.4$  and female participants' mean age was  $69.3 \pm 6.9$ , respectively. The participants' mean BMI was  $24.7 \pm 6.1$  and based on the Asia Pacific BMI criteria, the proportion of research participants is mostly included in the obese I category (37.3%). Table 2 shows based on gender, more female participants experienced a decrease in muscle mass than

**Table 1.** Baseline Characteristics of Study Participants

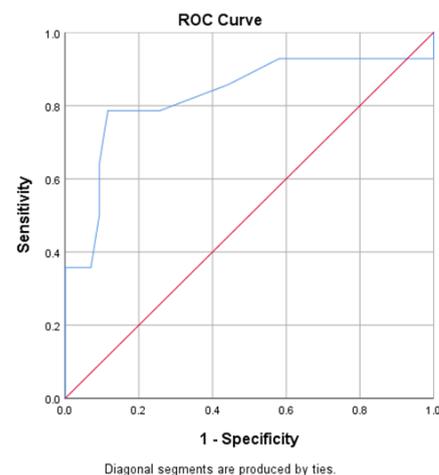
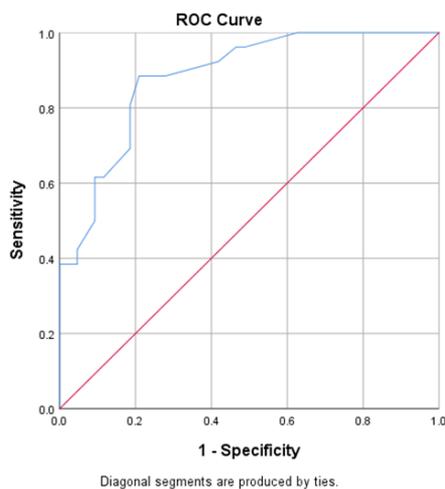
	Male	Female	Total
<b>Sex (%)</b>	57 (45.2%)	69 (54.8%)	126 (100%)
<b>Age (years)<sup>a</sup></b>	67.4 ±5.4	69.3 ± 6.9	68.4 ± 6.3
<b>Body Mass Index<sup>a</sup></b>	24.4 ±7.8	25.5 ± 4.2	24.7 ± 6.1
<b>Asia Pacific BMI criteria, n (%)</b>			
Underweight	6	2	8 (6.3%)
Normal	16	18	34 (26.9%)
Overweight	10	13	23 (18.3%)
Obese I	21	26	47 (37.3%)
Obese II	4	10	14 (11.1%)

<sup>a</sup> : mean (standard deviation)

**Table 2.** Characteristics of the Participants Based on Gender and Sarcopenia Status According to AWGS Criteria

	Male (n=57)	Female (n=69)	Total (n=126)
<b>Calf circumference (cm)<sup>a</sup></b>	33.8 ±3.5	33.5 ±3.9	33.6 ±3.7
<b>Muscle mass</b>	8.0 ±1.7	6.1 ±1.3	6.9 ±1.8
<b>ASM /height<sup>2</sup> (kg/m<sup>2</sup>)<sup>a</sup></b>			
<7, n (%)	12 (21.1%)		
>7, n (%)	45 (78.9%)		
<5.7, n (%)		27 (39.1%)	
>5.7, n (%)		42 (60.1%)	
<b>Hand grip strength/ HGS (kg)<sup>a</sup></b>	24.5±7.8	17.7 ±8.0	20.8 ±8.7
<28, n (%)	40 (70.2%)		
>28, n (%)	17 (19.8%)		
<18, n (%)		37 (53.6%)	
>18, n (%)		32 (46.4%)	
<b>Walking speed (m/s)<sup>a</sup></b>	0.8 ±0.3	0.7 ±0.3	0.7 ±0.3
<b>Sarcopenia AWGS 2019, n (%)</b>	14 (24.6%)	26 (37.7%)	40 (31.7%)
Sarcopenia, n	2	11	13 (10.3%)
Severe sarcopenia n	12	15	27 (21.4%)
Sarcopenic obesity, n (%)	7	21	28 (22.2%)

<sup>a</sup> : mean (standard deviation)

**Figure 1.** Receiver Operating Characteristic curve analysis. Calf circumference in female group (a) and male groups (b)

male, while measurement of hand grip strength shows that more male participants experienced a decrease than female.

Participants were diagnosed as having sarcopenia or severe sarcopenia based on the 2019 AWGS criteria.<sup>11</sup> Mean of ASM, hand grip strength, and walking speed were  $8.0 \pm 1.7$  kg/m<sup>2</sup>,  $24.5 \pm 7.8$  kg, and  $0.8 \pm 0.3$  m/s in men;  $33.5 \pm 3.9$  kg/m<sup>2</sup>,  $17.7 \pm 8.0$  kg and  $0.7 \pm 0.3$  m/s in women. Table 2 shows that 31.7% of the older adults had sarcopenia and 21.4% had severe sarcopenia. We

found older adults who experience obesity sarcopenia and most of them are women.

The average value of calf circumference and muscle mass were greater in men than women. We performed analysis on the ROC curve to obtain calf circumference cut-off points to detect decreased muscle mass as measured by ASM/height as one of the diagnosis criteria of sarcopenia (Figure 1).

From the ROC curve, we can calculate the area under the curve (AUC) which is the parameter of determination

of a diagnostic tool, the closer to 100%, the better the test being studied. The AUC of this study is listed in Table 3. Based on the ROC curve analysis, the AUC value of calf circumference was 88% in female (95% CI 0.80-0.90,  $p=0.000$ ) and 82% in male (95% CI 0.69-0.97,  $p=0.000$ ).

**Table 3.** The Area Under the Curve (AUC) for ROC curve between calf circumference and muscle mass (ASM/height<sup>2</sup>)

Sex	Area	Sd. Error	p	CI 95%	
				Lower	Upper
Female	0.88	0.04	0.000	0.80	0.96
Male	0.82	0.07	0.000	0.67	0.97

**Table 4.** Diagnostic Test of Calf Circumference with Decreased Muscle Mass

	Female	Male
<b>Cut off point of calf circumference (cm)</b>	32.9	33.5
<b>Sensitivity (%)</b>	80.8	78.6
<b>Specificity (%)</b>	79.1	74.4
<b>PPV (%)</b>	70.0	50.0
<b>NPV (%)</b>	87.2	91.4
<b>Prevalence (%)</b>	20.6	11.1
<b>Positive likelihood ratio</b>	3.87	3.07
<b>Negative likelihood ratio</b>	0.24	0.28

The optimal cut-off point for calf circumference were determined using ROC analyses, in female was 32.9 cm with sensitivity and specificity, positive predictive values (PPV), negative predictive values (NPV), positive likelihood ratio (LR+), and likelihood ratio negative (LR-) respectively at 80.0%, 79.1%, 70.0%, 87.2%, 3.87, 0.24, and 33.5 cm for male with sensitivity and specificity, positive predictive values (PPV), negative predictive values (NPV), positive likelihood ratio (LR+), and likelihood ratio negative (LR-) respectively at 78.6%, 78.6%, 50.0%, 91.4%, 3.07, and 0.28 (Table 4).

## DISCUSSION

The majority of the participants consisted of women (54.8%) with age range from 60-80 years. This data is in accordance with the statistics of the older adults population in 2020 which states that the number of women is about 1% greater than men.<sup>12,13</sup> The average age of women is higher than men, consistent with data of higher life expectancy of women than men.<sup>12</sup>

Based on gender, female participants have a more significant decrease in muscle mass, while male participants experienced a more significant decrease in handgrip strength than women (Table 2). These results are consistent with the literature which states that specifically, muscle atrophy due to aging occurs because women experience a greater shift in muscle mass into smaller fibers than men.<sup>14,15</sup> After menopause, estrogen and androgen decrease rapidly. Hormonal changes that promote muscle loss occur more slowly in men than in women.<sup>16</sup> On the other hand, men experience a decrease in handgrip strength earlier than women. Men reach peak hand grip strength at the age of 30 and then decline, while women begin to experience a decrease in handgrip strength at 55.<sup>17</sup>

We found that average calf circumference was greater in male than female. Result of this study as listed in

Table 2 is consistent with previous research which stated that the calf circumference and muscle mass were influenced by gender with the measurement results being greater in men than women so that the assessment of the diagnostic accuracy of calf circumference for decreased muscle mass should consider gender.<sup>18</sup> Other studies observed that calf circumference was not strongly affected by body fat mass so obesity did not affect muscle mass calculations based on calf circumference, and calf circumference was positively correlated with muscle mass as measured in ASM/Ht<sup>2</sup>, weakly positively correlated with HGS, and not correlated with physical performance as measured by a normal 6 meters walking speed.<sup>19</sup>

The diagnosis of sarcopenia was based on the 2019 AWGS criteria.<sup>11</sup> Table 2 shows that 31.7% of the older adults had sarcopenia, and 21.4% of them were severe sarcopenia. In this study, sarcopenia was more common in female than male. This condition is contrary to the AWGS research review, which stated that in general, the prevalence of sarcopenia is higher in men than women.<sup>11,20</sup> The average age of our participants were below 70 years. A study that stated that sarcopenia was more common in women than men in the older adults group less than 70 years.<sup>21</sup> They said that after menopause occurs, estrogen and androgen decrease rapidly. In men, the decline in these hormones is much slower than in women. The decrease in the anabolic action of androgen hormones in women may be an important factor to explain the high prevalence of sarcopenia in women aged 60 to 70 years.<sup>16</sup>

In this study, a ROC curve was created to determine the optimal cut-off point for calf circumference related to muscle mass as measured by ASM/height<sup>2</sup>. AUC is calculated by the area under the curve (Figure 1). The calculation of the AUC area (Table 3) shows results in the range of 80-90%, which means that the calf circumference has good diagnostic ability in determining muscle mass in both women and men.

The optimal cut-off point of calf circumference to determine a decrease in muscle mass in women is 32.9 cm. These results are consistent with previous studies which stated that the optimal threshold value for calf circumference was 29-33 cm.<sup>19,22-25</sup> While the cut-off point of men is 33.5 cm. The results of this study are similar to previous research which states that the optimal threshold value for calf circumference is 34-35 cm for men.<sup>19,22-25</sup>

The results of this study are consistent with previous studies in Asian countries, where the sensitivity of the calf circumference to muscle mass ranged from 65-92% for men and 71-83% for women, while the specificity was 59-88% for men and 50-96% for women.<sup>19,22-25</sup> It appears that calf circumference can be used as a screening tool for low muscle mass. PPV in male was lower than female because of the lower prevalence of decreased muscle mass in male (11.1%) than female (20.6%). Prevalence affects PPV and NPV, with increasing prevalence, PPV will increase and NPV will decrease respectively.<sup>26,27</sup> In this study it can be said that the higher the prevalence, the higher the PPV, which means the higher the probability that someone with a positive result will experience a decreased muscle mass.

Limitations of this study were a relatively small number of study participants and using the criteria of selective subjects in the older adults community, where most of the participants are included in the obesity category so that further research needs to be considered with a larger number with a variety of participants in the population.

## CONCLUSION

Calf circumference has diagnostic accuracy in determining muscle mass as measured by BIA in older adults for sarcopenia. The optimal cut-off point of calf circumference to find decreased muscle mass was less than 32.9 cm in women and less than 33.5 cm in men. Calf circumference is more sensitive and specific to the decrease in muscle mass as measured by BIA in women than men. We suggest that further study be carried out with more extensive and varied participants with the addition of other screening parameters to increase the sensitivity, specificity, and positive and negative predictive values of this study. Based on the study results, the authors suggest that it's important to have early detection of sarcopenia in easily and simple way so that treatment for sarcopenia can be given earlier, and the older adults can live with better quality of life.

## ACKNOWLEDGMENTS

The authors would like to thank all participants that have participated in this study. No specific funding was provided for this study and there were no other conflicts of interest in this study.

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