Diagnostic Performance of Calf Circumference, Thigh Circumference, and SARC-F Questionnaire to Identify Sarcopenia in Elderly Compared to Asian Working Group for Sarcopenia's Diagnostic Standard

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ABSTRAK

Latar belakang: *sarcopenia merupakan salah satu masalah geriatri yang menimbulkan dampak luaran klinis yang besar. Lingkar betis dan paha berkorelasi kuat dengan massa otot, sedangkan kuesioner SARC-F merupakan prediktor fungsi otot. Belum ada studi yang mengevaluasi performa diagnostik kombinasi lingkar betis dan paha dengan kuesioner SARC-F untuk mendeteksi sarcopenia. Penelitian ini bertujuan untuk mengevaluasi performa diagnostik kombinasi lingkar betis dan paha dengan kuesioner SARC-F dibandingkan dengan metode diagnostik sarcopenia menurut the Asian Working Group for Sarcopenia (AWGS) untuk memprediksi sarcopenia pada pasien berusia 60 tahun atau lebih.* ***Metode:*** *studi potong lintang dilaksanakan di klinik geriatri Rumah Sakit Cipto Mangunkusumo, Jakarta, Indonesia selama periode April hingga Juni 2018. Analisis dilakukan sesuai kurva receiver operating characteristic (ROC) untuk menentukan titik potong beserta nilai sensitivitas dan spesifisitas, nilai duga positif dan negatif, rasio kemungkinan positif dan negatif lingkar betis dan paha sebagai acuan massa otot yang rendah, serta skor kuesioner SARC-F untuk mendeteksi penurunan fungsi otot.* ***Hasil:*** *sebanyak 74 dari 120 (61,7%) subjek penelitian adalah perempuan. Kombinasi lingkar betis dengan titik potong <34 cm pada lelaki dan <29 cm pada perempuan serta lingkar paha <49 cm pada lelaki dan <44 cm pada perempuan dengan skor kuesioner SARC-F ≥4 memiliki nilai sensitivitas dan spesifisitas, nilai duga positif dan negatif serta rasio kemungkinan positif dan negatif berturut-turut sebesar 15,79%; 99,01%; 75,00%; 86,21%; 15,95; and 0,85.* ***Kesimpulan:*** *kombinasi lingkar betis dan paha dengan kuesioner SARC-F memiliki akurasi diagnostik yang baik dalam memprediksi sarcopenia pada pasien lanjut usia.*

Kata kunci: *kuesioner SARC-F, lanjut usia, lingkar betis, lingkar paha, sarcopenia*

ABSTRACT

Background: *sarcopenia is one of many geriatric problems that may lead to major clinical outcomes. Calf and thigh circumference have good correlation with muscle mass, whereas SARC-F questionnaire is very predictive of muscle function. There has not been a study that evaluates the diagnostic performance of calf and thigh circumference in combination with SARC-F questionnaire in detecting sarcopenia. The aim of this study was to investigate the diagnostic performance of calf and thigh circumference in combination with SARC-F questionnaire compared* *to standard diagnostic methods of sarcopenia according to the Asian Working Group for Sarcopenia (AWGS) to predict sarcopenia in patient aged 60 years or older.* ***Methods:*** *this cross-sectional study was conducted in Geriatric Clinic Cipto Mangunkusumo Hospital, Jakarta, Indonesia during April–June 2018. Analysis was performed using receiver operating characteristic (ROC) curve to determine the cut-off point as well as sensitivity (Sn), specificity (Sp), positive and negative predictive value (PPV and NPV), positive and negative likelihood ratio (LR+ and LR-) of calf and thigh circumference as an indicator of low muscle mass, and SARC-F questionnaire score to detect decreased muscle function.* ***Results:*** *from 120 participants, there were 46 men (38.3%) and 74 women (61.7%). The combination of calf circumference with cut-off point below 34 cm in men and below 29 cm in women, thigh circumference below 49 cm in men and below 44 cm in women with SARC-F questionnaire score of ≥4 have Sn, Sp, PPV, NPV, LR+, and LR- of 15.79%; 99.01%; 75.00%; 86.21%; 15.95; and 0.85 respectively.* ***Conclusion:*** *combination of calf and thigh circumference with SARC-F questionnaire showed good diagnostic accuracy in predicting sarcopenia in elderly outpatients.*

Keywords: *calf circumference, elderly, thigh circumference, SARC-F questionnaire, sarcopenia.*

INTRODUCTION

The number of older people in Asia, including Indonesia as well as globally, are increasing every year.[1] This increase may impose a health burden when the proportion of frail individuals within the older people population is also increasing. Beside frailty, sarcopenia is another important health problem that is commonly found in elderly. Sarcopenia is defined as age-related decrease in muscle mass as well as decline in muscle function, characterized by decrease in muscle strength and/or physical performance.[2-4] Sarcopenia is associated with dependency,[5,6] decreased cognitive and cardiopulmonary function,[7-10] falls,[11] lower quality of life, mortality,[12-16] and high health costs.[17] Sarcopenia is a treatable condition and early intervention can improve the clinical outcomes, thus rapid identification is important in the management of sarcopenia. Based on the definition, diagnosis of sarcopenia requires measurement of muscle mass, muscle strength, and physical performance. However, such diagnostic approach is time consuming, expensive, and requires trained personnel. Therefore, a simple method to rapidly diagnose sarcopenia will be a very valuable tool, especially for health personnel with limited access to facilities.

SARC-F questionnaire is a tool to diagnose sarcopenia quickly. It consists of questions regarding strength, assistance with walking, ability to rise from chair and climb stairs, as well as falls. SARC-F score ≥ 4 is indicative of sarcopenia and poor clinical outcome. A number of studies have shown that the SARC-F questionnaire showed comparable performance with the European Working Group on Sarcopenia in Older People (EWGSOP) and the Asian Working Group for Sarcopenia (AWGS) methods in identifying sarcopenia.[18] In addition, SARC-F questionnaire is highly predictive of muscle function and its use has been validated in general population in community setting,[18-20] populations with diabetes mellitus,[21] and populations with cardiovascular disease.16 However, the sensitivity of the SARC-F questionnaire is unsatisfactory.[22] In effort to increase the sensitivity, Barbosa-Silva et al[23] added measurement of calf circumference as the representation of muscle mass besides SARC-F questionnaire. This addition of calf circumference measurement besides SARC-F increased the sensitivity without compromising ability to detect sarcopenia both in community and nursing homes. However, the sensitivity was still unsatisfactory even after addition of calf circumference.[23,24]

In addition to calf circumference, thigh circumference also has a strong correlation with muscle mass.[25] Moreover, decreased thigh muscle mass is associated with a decrease in lower limb performance as seen in walking speed and repeated chair stand test.[26] Therefore, thigh circumference may also be used as a surrogate marker of muscle mass to diagnose sarcopenia in addition to calf circumference. The addition of the thigh circumference, beside the calf circumference is expected to improve diagnostic performance of SARC-F questionnaire. There has been a study that assessed the performance of of SARC-F questionnaire and calf circumference combination compared to diagnostic criteria of sarcopenia based on EWGSOP. However, there has not been a study that investigate the diagnostic performance of the combination of calf and thigh circumference with SARC-F questionnaire to detect sarcopenia. Therefore, this study was aimed to investigate the diagnostic performance of combination of calf and thigh circumference with SARC-F questionnaire compared to diagnostic methods of sarcopenia from AWGS to predict sarcopenia in patient aged 60 years or older.

METHODS

This cross-sectional study was approved by the Ethical Committee of Faculty of Medicine Universitas Indonesia/ Cipto Mangunkusumo Hospital (No. 0137/UN.2F1/ETIK/2018) and was conducted in April–June 2018 at the Geriatric Clinic of Cipto Mangunkusumo Hospital, Jakarta, Indonesia. We recruited patients aged 60 years and older consecutively. Those who had acute cardiovascular or respiratory diseases, cognitive impairment (Abbreviated Mental Test <8), body weight >100 kg, Parkinson's disease or other conditions with symptoms of tremor, limb edema and/ or amputation, artificial implants, as well as inability to walk or to lie down in flat position, unwilling to take part in this study, and uncooperative were excluded.

Anthropometric measurements were performed using non-elastic bands by examiners who were trained in standardized measurement methods. The subjects stand with their feet about 25 cm in distance in a relaxed position so that the body weight was evenly distributed on both legs. Measurements were made on the non-dominant side with the legs uncovered by clothes or with thin clothing. The thigh circumference was measured on the gluteal fold around the thigh in a horizontal position and was attached to the skin but did not suppress the tissue underneath. The calf circumference was measured 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 3 times and then rounded to the nearest 0.1 cm to get the mean value.

Handgrip strength examination was carried out with a calibrated JAMAR® J00105 hydraulic handheld dynamometer. The examination was performed on the dominant hand 3 times with a break time of 30 seconds between examinations. The highest value was taken as the hand-held muscle strength. Physical performance was assessed by usual walking speed at a distance of 6 meters. Subjects were asked to walk straight as usual, then the time used to walk at a distance of 6 meters were recorded by using a stopwatch and the usual walking speed was calculated.

Muscle mass measurements were examined using dual energy X-ray absorptiometry (DXA) at Osteoporosis Center-Medistra Hospital, Jakarta. Appendicular Skeletal Muscle Mass (ASM) was obtained by summing the soft tissue mass in the arms and legs, while the Skeletal Muscle Index (SMI) is obtained from ASM divided by the square of height in meters (kg/m^2).

The original SARC-F questionnaire was translated into Indonesian and then translated back into English by registered English translators and then verified again to maintain the same concept of the term used. The SARC-F questionnaire that has been adapted was then applied to the research subject (attachments 1). Subjects with SARC-F score ≥4 were considered sarcopenia. The diagnosis of sarcopenia was established based on the criteria set by AWGS, which were low muscle mass (SMI <7.0 kg/m^2 for men and <5.4 kg/m^2 for women) plus low function muscle (hand held strength <26 kg in men and <18 kg in women and/ or walking speed <0.8 m/second for both sexes).

Statistical Analysis

Data analysis was performed using Statistical Package for the Social Sciences (SPSS) program version 20.0. The statistical power was set at 80%, whereas 5% for the α value. The minimum sample size was 86 subjects. Categorical data was presented in numbers and percentages. Numerical data was presented in the mean (standard deviation) if the data distribution was normal and median (minimum–maximum) values if the data distribution was not normal. Value of Area Under the Curve (AUC) as well as cut-off point of calf and thigh circumference, and SARC-F score were determined based on Receiver Operating Characteristics (ROC) curves. The cut-off points were then processed into dichotomous categorical variables, combined, and compared with the diagnosis of sarcopenia based on AWGS criteria using a 2x2 table. Based on the analysis of the 2x2 table, sensitivity (Sn), specificity (Sp), positive predictive value (PPV), negative predictive value (NPV), positive likelihood ratio (LR+), and negative likelihood ratio (LR-) were obtained.

Table 1. Baseline characteristics of study participants

Variables	Male (n=46)	Female (n=74)	Total (N=120)
Age (years)[a]	72.41 (6.83)	71.57 (5.64)	71.89 (6.11)
Levels of education, n (%)			
- Low	4 (8.7)	15 (20.3)	19 (15.8)
- Middle	13 (28.3)	27 (36.5)	40 (33.3)
- High	29 (63.0)	32 (43.2)	61 (50.9)
Body Mass Index (kg/m^2)[a]	21.87 (3.84)	22.88 (4.98)	
Body Mass Index group, n (%)			
- Underweight	10 (21.7)	15 (20.3)	25 (20.8)
- Normal	20 (43.5)	25 (33.8)	45 (37.5)
- Overweight	5 (10.9)	7 (9.5)	12 (10)
- Obese I	10 (21.7)	22 (29.7)	32 (26.7)
- Obese II	1 (2.2)	5 (5)	6 (5)
Comorbidity, n (%)			
- Diabetes mellitus	20 (43.5)	22 (29.7)	42 (35)
- Hypertension	36 (78.3)	61 (82.4)	97 (80.8)
- Chronic Heart Failure	16 (34.8)	15 (20.3)	31 (25.8)
- Cerebrovascular Disease	13 (28.3)	7 (9.5)	20 (16.7)
- Chronic Kidney Disease	11 (23.9)	6 (8.1)	17 (14.2)
- Chronic Liver Disease	3 (6.5)	8 (10.8)	11 (9.2)
- Asthma/ COPD	3 (6.5)	7 (9.5)	10 (8.3)
- Malignancy	0 (0)	3 (4.1)	3 (2.5)
- Skeletal Muscle Index (kg/m^2)[a]	7.45 (0.91)	6.53 (0.82)	
Muscle mass status,* n (%)			
- Low	17 (37)	7 (9.5)	24 (20)
- Normal	29 (63)	67 (90.5)	96 (80)
- Hand grip strength (kg)[a]	26.13 (6.24)	18 (10–35)b	
Hand grip strength status,* n (%)			
- Low	18 (39.1)	34 (45.9)	52 (43.3)
- Normal	28 (60.9)	40 (54.1)	68 (56.7)
- Walking speed (meter/second)[a]	0.78 (0.22)	0.75 (0.23)	
Walking speed status,* n (%)			
- Low	28 (60.9)	40 (54.1)	68 (56.7)
- Normal	18 (39.1)	34 (45.9)	52 (43.3)
- Calf circumference (cm)a	35.29 (3.78)	34.42 (4.68)	
- Thigh circumference (cm)a	51.75 (6.10)	52.92 (8.87)	
- SARC-F score[b]	1 (0–7)	2 (0–8)	
Sarcopenia status,* n (%)			
- Sarcopenia	14 (30.4)	5 (6.8)	19 (15.8)
- No sarcopenia	32 (69.6)	69 (93.2)	101 (84.2)

* : based on the diagnosis criteria of sarcopenia from Asian Working Group for Sarcopenia;
[a] : mean (standard deviation); [b] : median (minimal-maximal); COPD: Chronic Obstructive Pulmonary Disease

RESULTS

There were 142 subjects who met the inclusion criteria and 22 subjects who did not, so that a total of 120 subjects were analyzed. The basic characteristics of the subject in this study can be seen in **Table 1**. Of the 120 subjects who participated in this study, there were 46 men (38.3%) and 74 women (61.7%). The mean age of all subjects was 71.89 (6.11) years with a mean age of 72.41 (6.83) years in the male subjects and 71.57 (5.64) years in the female subjects. The proportion of subjects with body mass index (BMI) categories of underweight, normal, overweight, obese I, and obese II were 20.8%, 37.5%, 10%, 26.7%, and 5% respectively. The most comorbidities obtained were hypertension (80.8%), diabetes mellitus (35%), chronic heart failure (25.8%), cerebrovascular disease (16.7%), chronic kidney disease (14.2%), chronic liver disease (9.2%), asthma/ COPD (8.3%), and malignancy (2.5%). The proportion of subjects with decreased muscle mass was 20%, with the proportion of male subjects was higher than female subjects (37% vs. 9.5%). The proportion of subjects with low handgrip strength was 43.3%, with the proportion of female subjects was higher than male subjects (45.9% vs. 39.1%). The proportion of subjects

Table 2. Characteristics of the subjects based on gender and sarcopenia status according to AWGS criteria

Variables	Male (n = 46)		Female (n = 74)		Total (N = 120)	
	Sarcopenia (n =14)	No sarcopenia (n = 32)	Sarcopenia (n = 5)	No sarcopenia (n = 69)	Sarcopenia (n = 19)	No sarcopenia (n = 101)
Age (years)[a]	78.36 (5.44)	69.81 (5.68)	76.4 (4.04)	71.22 (5.60)	77.84 (5.08)	70.77 (5.64)
Body Mass Index, n (%)						
- Underweight	7 (15.2)	3 (6.5)	4 (5.4)	11 (14.9)	11 (9.2)	14 (11.7)
- Normal	6 (13.0)	14 (30.4)	1 (1.4)	24 (32.4)	7 (5.8)	38 (31.7)
- Overweight	1 (2.2)	4 (8.7)	0 (0)	7 (9.5)	1 (0.8)	11 (9.2)
- Obese I	0 (0)	10 (21.7)	0 (0)	22 (29.7)	0 (0)	32 (26.7)
- Obese II	0 (0)	1 (2.2)	0 (0)	5 (6.8)	0 (0)	6 (5)
Body Mass Index (kg/ m^2)[a]	18.81 (2.85)	23.22 (3.44)	16.71 (1.91)	23.32 (4.84)	18.26 (2.75)	23.29 (4.43)
Comorbidity, n (%)						
- Hypertension	11 (23.9)	25 (54.3)	3 (4.1)	58 (78.4)	14 (11.7)	83 (69.2)
- Diabetes Mellitus	7 (15.2)	13 (28.3)	2 (2.7)	20 (27)	9 (7.5)	33 (27.5)
- Chronic Heart Failure	5 (10.9)	11 (23.9)	0 (0)	15 (20.3)	5 (4.2)	26 (21.7)
- Chronic Kidney Disease	6 (13.0)	5 (10.9)	0 (0)	6 (8.1)	6 (5.0)	11 (9.2)
- Cerebrovascular Disease	4 (8.7)	9 (19.6)	0 (0)	7 (9.5)	4 (3.3)	16 (13.3)
- Chronic Liver Disease	0 (0)	3 (6.5)	0 (0)	8 (10.8)	0 (0)	11 (9.2)
Asthma/ COPD	1 (2.2)	2 (4.3)	1 (1.4)	6 (8.1)	2 (1.7)	8 (6.7)
- Malignancy	0 (0)	0 (0)	0 (0)	3 (100)	0 (0)	3 (2.5)
Calf circumference (cm)[a]	33.35 (4.25)	36.14 (3.28)	27.71 (1.23)	34.90 (4.46)		
Thigh circumference (cm)[a]	47.86 (6.62)	53.52 (4.99)	40.10 (2.70)	53.91 (8.43)		
Skeletal Muscle Index (kg/m^2)[a]	6.57 (0.52)	7.83 (0.76)	5.08 (0.34)	6.64 (0.74)		
Handgrip strength (kg)[a]	22.71 (6.51)	27.63 (5.59)	16 (12–16)b	18 (10–35)b		
Walking speed (meter/ second)[a]	0.67 (0.15)	0.83 (0.22)	0.44 (0.18)	0.77 (0.22)	0.61 (0.19)	0.79 (0.22)
SARC-F score[b]	1 (0–4)	1 (0–7)	5 (2–6)	2 (0–8)	2 (0–6)	1 (0–8)

[a] : mean (standard deviation); [b] : median (minimal–maximal); COPD : Chronic Obstructive Pulmonary Disease.

with low usual walking speed was found to be 56.7%, with the proportion of male subjects was higher than female subjects (60.9% vs 54.1%). In this study, the proportion of sarcopenia was 15.8%, with higher proportion was found in male subjects compared to female subjects (30.4% vs 6.8%). The differences in the characteristics of the subjects in the sarcopenia and non-sarcopenia groups by gender can be seen in **Table 2**.

We performed analysis on ROC curve to obtain the calf circumference and thigh circumference cut-off points to detect low muscle mass as a component of the diagnosis of sarcopenia (**Figure 1**). Based on the ROC curve analysis, the AUC value of calf circumference was 73.1% in the male subjects (95% CI 57.0–89.2, p = 0.009) and 96.4% in the female subject (95% CI 0.92–1.00, p<0.001). Statistically optimal calf circumference cut-off points were 35 cm for male subjects with sensitivity, specificity, PPV, NPV, LR+, LR-, and AUC respectively at 70.6%, 72.4%, 60%, 80%, 8%, 2.56, 0.41, and 0.72; and 30 cm for female subjects with sensitivity, specificity, PPV, NPV, LR+, LR-, and AUC respectively at 85.7%, 88.1%, 42.9%, 98.3%, 7.17, 0.16 and 0.87. In order to obtain a higher specificity value, we set the lower calf circumference cut-off points at <34 cm in male subjects with sensitivity, specificity, PPV, NPV, LR+, LR-, and AUC respectively were 64.7%, 79.3%, 64.7%, 79.3%, 3.13, 0.45 and 0.72; and <29 in female subjects cm with sensitivity, specificity, PPV, NPV, LR+, LR-, and AUC respectively were 71.4%, 95.5%, 62.5%, 97%, 15.87, 0 , 30, and 0.84.

Based on the ROC curve analysis, the AUC

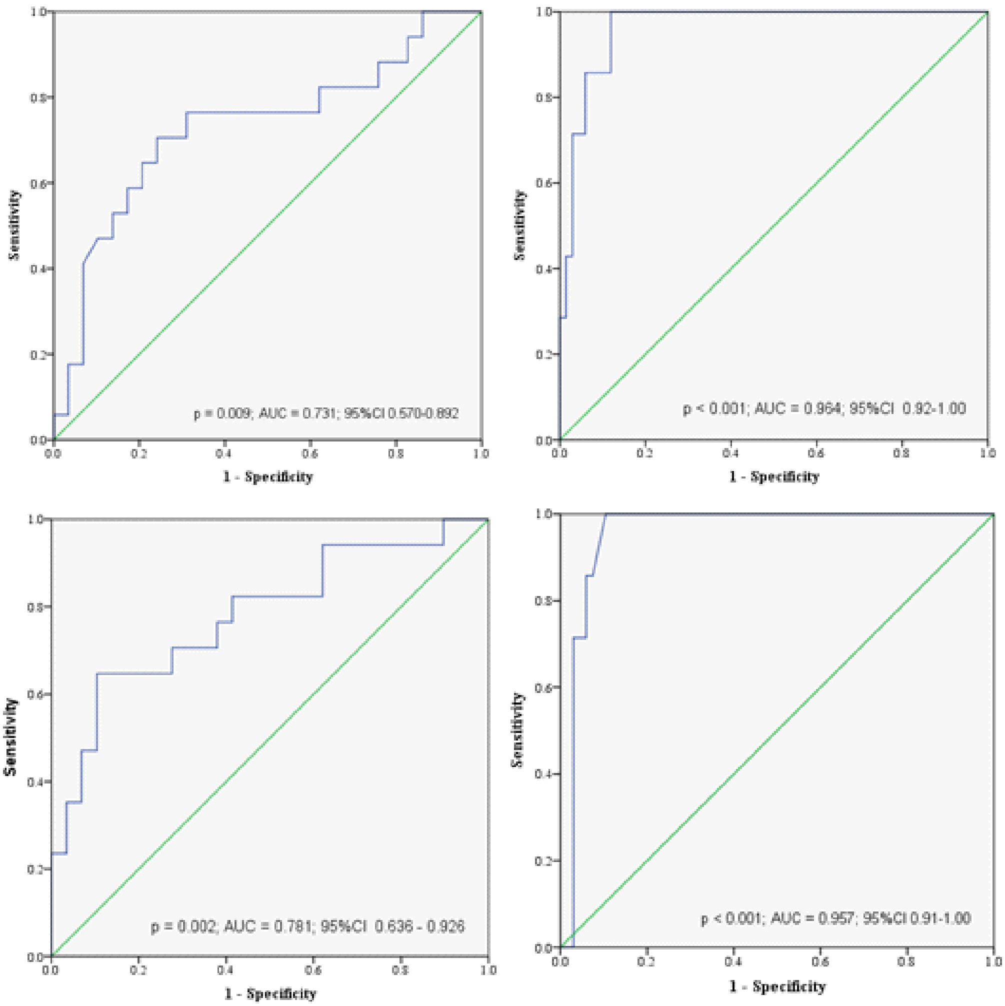

Figure 1. ROC Curve Analysis. Calf Circumference in Male Group (A) and Female Group (B); and Thigh Circumference in Male Group (C) and Female Group (D).

value of the thigh circumference was 78.1% in the male subjects (95%CI 63.6–92.6, p=0.002) and 95.7% in the female subjects (95%CI 0.91–1.00, p<0.001). The statistically optimal thigh circumference cut-off point were 52 cm for male subjects with sensitivity, specificity, PPV, NPV, LR+, LR-, and AUC respectively at 70.6%, 72.4%, 60%, 80 , 8%, 2.56, 0.41, 0.72; and 44 cm for female subjects with sensitivity, specificity, PPV, NPV, LR+, LR-, and AUC respectively at 85.7%, 94%, 60%, 98.4, 14.28, 0.15, and 0.90. The diagnostic values for female subjects were quite good. However, in order to obtain a higher specificity value for male subjects, we set the

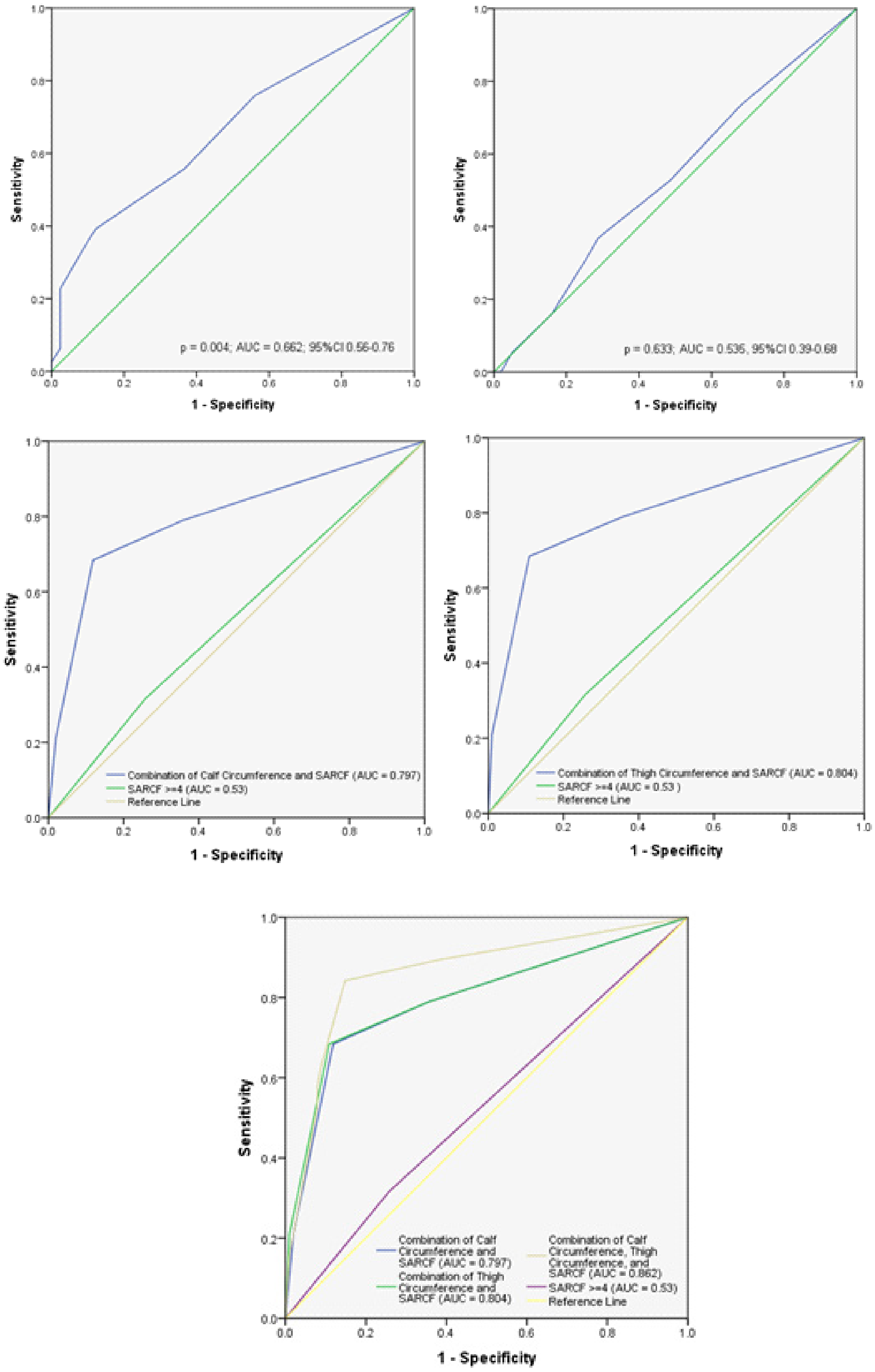

Figure 2. Comparison of ROC Curve Analysis. A. SARC-F to Muscle Function. B. SARC-F to Diagnose Sarcopenia According to AWGS. C. Combination of Calf Circumference and SARC-F. D. Combination of Thigh Circumference and SARC-F. E. Combination of Calf Circumference, Thigh Circumference and SARC-F.

lower thigh circumference cut-off at <49 cm with sensitivity, specificity, PPV, NPV, LR+, LR-, and AUC were 64.7%, 89,7%, 78.6%, 81.3%, 6.25, 0.39 and 0.77 respectively. We used the same cut–off that was considered optimal for thigh circumference in female subjects which were below 44 cm. The value of diagnostic accuracy of various cutting points can be seen in the table in **Appendix 2** (http://actamedindones.org/index.php/ijim/editor/proofGalley/976/356).

Analysis of ROC curve of SARC-F questionnaire was performed both on muscle function and the diagnosis of sarcopenia based on AWGS criteria (**Figure 2**). From this figure, it appears that SARC-F questionnaire is better at describing muscle function than the diagnosis of sarcopenia (AUC 0.662 vs 0.535). At the cut-off point of SARC-F score ≥4, the sensitivity, specificity, PPV, NPV, LR+, LR-, and AUC were 35.4%, 90.2%, 87.5%, 42.1%, 3.63, 0.72 and 0.63, respectively.

A combination of calf circumference and SARC-F questionnaire to detect sarcopenia was performed using cut-off points of calf circumference <34 cm in male subjects and <29 cm in female subjects to determine low muscle mass, and SARC-F score ≥4 to determine a decrease in muscle function. A combination of thigh circumference and SARC-F questionnaire to detect sarcopenia was performed using cut-off points of thigh circumference <49 cm in male subjects and <44 cm in female subjects to determine low muscle mass, and SARC-F score ≥4 to determine a decrease in muscle function. In addition, a combination of calf circumference, thigh circumference and SARC-F questionnaire to detect sarcopenia was carried out using cut-off points of calf circumference <34 cm in male subjects and <29 cm in a female subject; and thigh circumference <49 cm in a male subject and <44 cm in female subjects to determine low muscle mass, as well as a SARC-F score ≥4 to determine a decrease in muscle function. Logistic regression analysis was then carried out and continued with ROC curve analysis. Based on the ROC curve analysis, the AUC value of the combination of calf circumference and SARC-F was 79.7% (95% CI 0.67–0.92, p <0.001), the AUC value of the combination of thigh circumference and SARC-F was 80.4% (95% CI 0.68–0.93, p <0.001), and the AUC value of the combination of calf circumference, thigh circumference and SARC-F was 86.2% (95% CI 0.76–0.96, p <0.001). The curve can be seen in **Figure 2**. The comparison of diagnostic performance analysis of SARC-F questionnaire, combination of SARC-F with calf circumference, thigh circumference, and both can be seen in **Table 3**.

DISCUSSION

From the results above, it can be seen that by combining either calf circumference, thigh circumference, or both which represent muscle mass to SARC-F questionnaire that represents muscle function, then the ability to detect sarcopenia was increasing compared to SARC-F questionnaire alone. This appears from its very high specificity value of (98.02% vs. 99.01% vs 99.01% vs. 74.26% respectively). However, considering the low sensitivity value, then combination of calf circumference,

Table 3. Diagnostic Performance Analysis of Combination of Calf Circumference, Thigh Circumference, and SARC-F Questionnaire

	SARC-F	CC + SARC-F	TC + SARC-F	CC+ TC + SARC-F
Sensitivity[a]	31.58 (0.13–0.57)	21.05 (6.05–45.57)	21.05 (0.06–0.46)	15.79 (0.03–0.40)
Specificity[a]	74.26 (0.65–0.82)	98.02 (93.03–99.76)	99.01 (0.95–1.00)	99.01 (0.95–1.00)
PPV[a]	18.75 (0.10–0.33)	66.67 (0.28–0.91)	80 (0.32–0.97)	75 (0.25–0.96)
NPV[a]	85.23 (0.81–0.89)	86.84 (0.84–0.89)	86.96 (0.84–0.89)	86.21 (0.84–0.88)
LR+	1.23 (0.59–2.57)[b]	10.63 (2.09–54.00)[b]	21.26 (2.51–179.97)[b]	15.95 (1.75–145.30)[b]
LR-	0.92 (0.66–1.28)[b]	0.81 (0.64–1.02)[b]	0.80 (0.63–1.01)[b]	0.85 (0.70–1.03)[b]
AUC	0.535 (0.39–0.68)[b]	0.797 (0.67–0.92)[b]	0.804 (0.68–0.93)[b]	0.862 (0.76–0.96)[b]

[a] : % (95% CI); [b] : 95% CI; CC : calf circumference; TC : thigh circumference; PPV : positive predictive value; NPV : negative predictive value; LR+ : positive likelihood ratio; LK- : negative likelihood ratio

thigh circumference or both with SARC-F questionnaire cannot be used as sarcopenia screening tool. Even the combination of calf circumference and SARC-F questionnaire had a lower sensitivity value compared to the SARC-F questionnaire alone. This very high specificity value allows these combinations to be used as a sarcopenia diagnostic tool especially in health care facilities with limited resources. In addition to its high specificity, positive predictive value and positive likelihood ratio also increased significantly so that if we get the measurements that meet those criteria then we will be more convinced that the subject is indeed experiencing sarcopenia.

The results of our study differed from those obtained by Barbosa-Silva et al[23] and Urzi et al.[24] In Barbosa-Silva et al[23] study, adding calf circumference made the sarcopenia screening ability of the SARC-F questionnaire became better as can be seen from the increase in sensitivity value from 33.3% (11.8-61.6) to 66.7% (38.4-88.2) without much affecting the specificity from 84.2% (77.6-89.4) to 82.9% (76.3-88.4). Urzi et al[24] who validated the result from Barbosa-Silva et al study in nursing home also got similar result with sensitivity 77.4% (58.9-90.4) and specificity 89.8% (77.7-96.6). While in our study, combining calf circumference, thigh circumference, or both with the SARC-F questionnaire increased its specificity but the opposite happened with the sensitivity. The disparity might be caused by difference in diagnostic test goals setting. In the study of Barbosa-Silva et al the objective is to evaluate combination of calf circumference and SARC-F questionnaire as sarcopenia screening tool hence they set cut-off points that have higher sensitivity value which are <34 cm for calf circumference in men, <33 cm for calf circumference in women, and SARC-F score ≥1.23. Urzi et al[24] validated the result from Barbosa-Silva et al so they used the same cut-off points value with Barbosa-Silva.[23] While in our study, we want to evaluate combination of calf circumference, thigh circumference, and SARC-F questionnaire as sarcopenia diagnostic tool, so we set cut-off points that have higher specificity, which are <34 for calf circumference in men, <29 cm for calf circumference in women, and SARC-F score ≥4. Other than that, in Urzi et al[24] study they used bioelectrical impedance analysis (BIA) to measure muscle mass while in our study we used DXA. Moreover, there are also differences in study participants. In the study of Barbosa-Silva et al[23] the subjects were the elderly population in the community and in the Urzi et al[24] study, the research subjects were elderly population in nursing home, with both study used diagnosis criteria of sarcopenia from EWGSOP. In our study, the subjects were elderly patients in outpatient care and we used diagnosis criteria of sarcopenia from AWGS.

Our study was the first study that evaluate the diagnostic performance of combination of calf circumference, thigh circumference, and SARC-F questionnaire to detect sarcopenia. This study followed diagnostic criteria from AWGS and used DXA in measuring muscle mass. Several other studies with similar setting have been carried out but those studies used diagnostic criteria from EWGSOP which had different cut-off points measurement from AWGS. The limitation of our study was that the number of participants between male and female were uneven, where there were fewer male subjects than female subjects and this may contribute for the wide range of 95%CI in male group compared to female group.

CONCLUSION

The optimal cut-off points of calf circumference to detect low muscle mass are less than 34 cm in men and less than 29 cm in women, while the optimal cut-off points of thigh circumference to detect low muscle mass are less than 49 cm in men and less than 44 cm in women. The optimal cut-off point for the SARC-F questionnaire score to detect a decrease in muscle function is 4 or more. Combination of calf circumference, thigh circumference and SARC-F questionnaire have good diagnostic accuracy to detect sarcopenia in patients aged 60 years or older and can be used as a tool for diagnosing sarcopenia in health services with limited resources. We still need external validation of the combination of calf circumference, thigh circumference and SARC-F questionnaire in the elderly population in other secondary and tertiary health care to detect sarcopenia. We also suggest to do further study with appropriate numbers of participants between male and female subjects.

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