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Risk of sarcopenia in older adults with type 2 diabetes mellitus: evaluation of the SARC-F and SARC-CalF as screening tools

Risco de sarcopenia em idosos com diabetes mellitus tipo 2: avaliação do SARC-F e SARC-CalF como ferramentas para rastreamento

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Abstract

Objective: To evaluate the diagnostic power of SARC-F and SARC-CalF as screening tools for sarcopenia risk in older adults with type 2 diabetes mellitus.

Methods: This cross-sectional study of 128 patients was conducted at the endocrinology outpatient clinic of a hospital in Recife, Brazil between July 2022 and February 2023. Sarcopenia was diagnosed according to original and updated European Consensus criteria for older adults. Muscle mass was assessed with electrical bioimpedance, muscle strength was assessed with a handgrip test, and physical performance was assessed with gait speed. Sarcopenia risk was assessed using the SARC-F and SARC-CalF instruments. The sensitivity, specificity, positive and negative predictive values, receiver operating characteristic curve, and area under the curve were analyzed to determine the best diagnostic performance.

Results: According to the original and updated versions of the European Consensus criteria, the prevalence of sarcopenia was 25.00% and 10.90%, respectively. Sarcopenia risk was 17.20% according to the SARC-F and 23.40% according to the SARC-CalF. The sensitivity and specificity of the SARC-F ranged from 12.55% to 36.11% and 71.87% to 92.39%, respectively, while those of the SARC-CalF ranged from 47.22% to 85.71% and 82.46% to 88.89%, respectively. The area under the curve for the SARC-F and SARC-CalF varied between 0.51 and 0.71 and 0.67 and 0.86, respectively.

Conclusions: The SARC-CalF had better diagnostic performance for all analyzed diagnostic criteria. Adding calf circumference to the SARC-F was an effective screening method for sarcopenia risk in the study population.

Keywords: sensitivity and specificity; ROC curve; muscle strength; sarcopenia; Diabetes Mellitus.

Resumo

Objetivo: Avaliar o poder diagnóstico do SARC-F e SARC-CalF como ferramentas de rastreamento para o risco de sarcopenia em idosos com diabetes mellitus tipo 2.

Metodologia: Estudo transversal com 128 pacientes desenvolvido no ambulatório de endocrinologia de um hospital do Recife entre julho de 2022 e fevereiro de 2023. A sarcopenia foi diagnosticada de acordo com os critérios do Consenso Europeu para sarcopenia em pessoas idosas e sua versão atualizada. Foi realizada bioimpedância elétrica para avaliar a massa muscular, teste de preensão palmar para a força muscular e teste de velocidade de marcha para a performance física. O risco para sarcopenia foi avaliado por meio do SARC-F e SARC-CalF. Realizou-se análise de sensibilidade, especificidade, valores preditivos positivos e negativos, curva Característica de Operação do Receptor (ROC) e área sob a curva (AUC) para determinar a melhor performance diagnóstica.

Resultados: A prevalência de sarcopenia foi de 25,00% de acordo com a primeira versão do Consenso Europeu e 10,90% considerando a versão atualizada. O risco para sarcopenia foi de 17,20% (SARC-F) e 23,40% (SARC-CalF). A sensibilidade do SARC-F variou entre 12,55 e 36,11%, e a especificidade entre 71,87 e 92,39%, enquanto o SARC-CalF apresentou sensibilidade entre 47,22 e 85,71% e especificidade entre 82,46 e 88,89%. A AUC do SARC-F variou entre 0,51 e 0,71, enquanto o SARC-CalF ficou entre 0,67 e 0,86.

Conclusões: O SARC-CalF apresentou melhor performance diagnóstica quando comparado a todos os critérios diagnósticos analisados. A adição da circunferência da panturrilha é um método eficaz para o rastreamento do risco de sarcopenia na população do estudo.

Palavras-chave: sensibilidade e especificidade; curva ROC; muscle strength; sarcopenia; Diabetes Mellitus.

INTRODUCTION

Diabetes mellitus (DM) is a chronic syndrome that is considered a public health problem in a number of countries, irrespective of their level of development, due to its impact on people's lives.¹ In 2021, the International Diabetes Federation² estimated that around 10.50% of the world's population aged 20 to 79 years (approximately 537 million people) live with diabetes. Currently, around 15.7 million Brazilians have DM, and this number is projected to reach 23.2 million by 2045.²

Chronic hyperglycemia, a result of uncontrolled type 2 DM (DM2), causes microcirculatory damage, impairing the function of various organs and tissues and predisposing patients to chronic complications from micro- and macrovascular injuries. These complications mainly manifest as retinopathy, nephropathy, neuropathy, peripheral arterial disease, and coronary disease.³ However, damage to skeletal muscles, such as accelerated decline in muscle quality and quantity, has also been described as a complication of diabetes.⁴

In 2010, the European Working Group on Sarcopenia in Older People (EWGSOP)⁵ defined sarcopenia as a progressive and generalized loss of muscle mass associated with a decline in performance and muscle strength. In 2018, the consensus was updated by the EWGSOP 2,⁶ in which sarcopenia was characterized as a muscle disease, with reduced muscle strength as the main determinant; sarcopenia can be suspected by the presence of this condition alone.

Several studies have evaluated the prevalence of sarcopenia in people with diabetes according to current diagnostic criteria. In Singapore, in association with the Asian Working Group for Sarcopenia, Fung et al.⁷ found a 27.4% prevalence among older diabetics aged 60 to 89 years. Using Foundation for the National Institutes of Health criteria in a sample of Brazilians aged > 50 years, Pechmann et al.⁸ found sarcopenia prevalences of 12.9% and 5.4% among DM2 patients and controls, respectively. In 2020, Freitas et al.⁹ assessed sarcopenia among older adults with DM according to EWGSOP and EWGSOP 2 criteria, finding prevalences of 16.9 and 7%, respectively.

Sarcopenia has been independently associated with many negative health outcomes, such as falls, increased risk of functional disability, lower quality of life, admission to long-term care facilities, hospitalization, and even death.¹⁰

The SARC F questionnaire (S – strength, A – assistance in walking, R – rising from a chair, C – climbing stairs, and F – falls) was developed in 2013 as the first simple and easy-to-use screening tool to identify sarcopenia risk in clinical practice. It consists of 5 questions on: strength, assistance in walking, difficulty getting out of bed or a chair, difficulty climbing stairs, and history of falls.¹¹ However, the SARC F

has high specificity and low sensitivity, which is an important limitation, since sensitivity determines a test's ability to correctly identify people with the disease.¹² In 2016, Barbosa-Silva et al.¹³ proposed the SARC CalF, which added calf circumference to the SARC F questionnaire to increase the instrument's sensitivity and enable sarcopenia risk monitoring in clinical practice.

Given the health problems that diabetes and sarcopenia can cause, especially among older adults, screening, diagnosis, and intervention should occur early to minimize negative effects, especially in the initial stage of sarcopenia. Thus, the SARC F and SARC CalF can help health professionals care for these patients. However, these instruments must be validated in different populations.

The objective of this study was to evaluate the diagnostic power of the SARC F and the SARC CalF as screening tools for sarcopenia risk in older adults with DM2.

METHODS

This cross-sectional study was conducted at the endocrinology outpatient clinic of the Hospital das Clínicas de Pernambuco; data were collected between July 2022 and February 2023.

A total of 138 older men and women diagnosed with DM2 were recruited. The exclusion criteria for this convenience sample were: decompensated chronic renal failure (serum creatinine ≥ 2.0 mg/dL), neuromuscular diseases, a previous history of stroke and motor sequelae, cognitive impairment that could prevent comprehension of the questions and/or communication with the researchers, active malignant neoplasm, body mass index ≥ 40 kg/m², or physical limitations that could prevent anthropometry and bioelectrical impedance testing. The final sample consisted of 128 participants who met the inclusion criteria: age 60 to 80 years and diagnosed with DM2 for > 12 months.

Anthropometric assessment included weight (kg), height (m), and calf circumference (cm). Calf circumference was determined with a measuring tape (1 mm accuracy) while the participant was seated with both feet on the floor. For all measurements (taken in duplicate), the participants were barefoot and wearing light clothing. If a measurement difference > 0.1 kg or 0.1 m occurred, a third measurement was taken and the average of the two closest measurements was used in the analysis. We used the cut-off points of Barbosa-Silva et al.^{13,14} to determine adequate calf circumference: > 33 cm for women and > 34 cm for men.

Body mass index was determined as weight/height² and was classified according to Pan American Health Organization cut-off points.¹⁵

A Biodynamics BIA 310E bioimpedance body composition analyzer (Biodynamics, Seattle, WA, USA), was used for bioelectrical impedance testing. This device analyzes muscle mass using an equation with resistance and reactance values. Skeletal muscle mass was calculated using an equation by Janssen et al.¹⁶, and the skeletal muscle mass index was determined using the following formula: skeletal muscle mass/height². Appendicular skeletal muscle mass was calculated according to a formula by Sergi et al.¹⁷, and the appendicular skeletal muscle mass index was determined using the formula: appendicular skeletal muscle mass/height².

Muscle strength was assessed as handgrip strength using a Saehan model SH5001 manual dynamometer (Saehan, Seoul, Korea). The dynamometer was calibrated prior to data collection. Handgrip strength was measured 3 times, and the average of the highest 2 measurements was used in the analysis.

Physical performance was determined through a gait speed test. The participants were instructed to walk in a straight line for 4 meters at their usual pace. The average of 2 round trips was used to calculate gait speed (distance covered/time taken to complete the course). Time was measured in thousandths of a second using a stopwatch. All cut-off points used in this study are described in Box 1.

The SARC F and SARC CalF instruments were used to assess the risk of sarcopenia. The SARC F includes 5 domains:

1. muscle strength
2. the need for assistance in walking
3. the ability to get up from a chair
4. the ability to climb stairs
5. the frequency of falls.

Each item was scored from 0 to 2 points, with a maximum score of 10 points. Participants scoring ≥ 4 points were considered at risk of sarcopenia.

The SARC CalF includes all 5 items on the SARC F (with the same score) plus CC, which is scored 0 if > 34 cm for men and > 33 cm for women, and 10 if ≤ 34 cm for men

and ≤ 33 cm for women. Total SARC CalF scores ≥ 11 indicate a possible risk of sarcopenia.

Two sets of criteria were used to diagnose sarcopenia: EWGSOP, published in 2010, and the EWGSOP 2, published in 2018. According to the EWGSOP, sarcopenia is defined as low muscle mass associated with low muscle strength and/or low physical performance. According to the EWGSOP 2, sarcopenia is defined as low muscle strength associated with low muscle mass; when combined with low physical performance, it is considered severe sarcopenia.

Data on demographic (age, sex, race, and education) and clinical (comorbidities and disease duration) variables were collected through interviews conducted by the researchers.

The assessments were carried out in a single session, before or after pre-scheduled outpatient medical care, and were conducted by two interviewers, both of whom were nutritionists who had undergone prior training to administer the questionnaires and the electrical bioimpedance, handgrip strength, and gait speed tests.

The study was approved by the research ethics committees of the Federal University of Pernambuco (No. 5,517,887/CAAE: 53329721.2.0000.5208) and the Hospital das Clínicas da Pernambuco (No. 5,551,658/CAAE: 53329721.2.3002.8807). After the study's objectives and methods had been explained to them, the participants provided written informed consent to participate.

IBM SPSS Statistics 25.0 (IBM, Armonk, NY, USA) was used for the statistical analysis. The normality of continuous variables was determined with the Kolmogorov-Smirnov test, and those with normal distribution were presented as mean and SD. Continuous variables with non-normal distribution are presented as median and IQR (P25 and P75). Student's *t*-test and the Mann Whitney U test were used to compare continuous variables with normal and non-normal distribution, respectively.

Categorical variables were presented as frequencies and percentages, and the χ^2 and Fisher's exact test (when

BOX 1. Cutoff point for sarcopenia according to the European Working Group on Sarcopenia in Older People and the European Working Group on Sarcopenia in Older People 2.

	(1) Low muscle strength	(2) Low Muscle Mass	(3) Low Physical Performance	Sarcopenia
EWGSOP (2010) ⁵	Handgrip strength: < 30 kg (men) < 20 kg (women)	SMMI: < 10.76 kg/m ² (men) < 6.76 kg/m ² (women)	Gait speed: ≤ 0.8 m/s (4-m)	(2) + (1) or (2) + (3)
EWGSOP 2 (2019) ⁶	Handgrip strength: < 27 kg (men) < 16 kg (women)	ASMMI: < 7.0 kg/m ² (men) < 5.5 kg/m ² (women)	Gait speed: ≤ 0.8 m/s (4-m)	(1) + (2) or (1) + (2) + (3)

ASMMI: appendicular skeletal muscle mass index; EWGSOP: European Working Group on Sarcopenia in Older People; EWGSOP 2: European Working Group on Sarcopenia in Older People 2; SMMI: skeletal muscle mass index.

applicable) were used to determine the associations between variables. The prevalence ratio was used to evaluate potential protective and risk variables.

The diagnostic power of the SARC F and SARC CalF was evaluated through sensitivity, specificity, and positive and negative predictive values. Sensitivity indicates the probability of correctly identifying individuals with sarcopenia, whereas specificity is the probability of correctly identifying individuals without sarcopenia. Positive predictive value measures the probability of having sarcopenia, while negative predictive value measures the probability of not having sarcopenia. A higher positive predictive value (fewer false positives) indicates a more specific test, while a higher negative predictive value (fewer false negatives) indicates a more sensitive test.

The diagnostic accuracy of the investigation methods was determined through ROC curve and AUC analysis. The AUC of the instruments was compared using the DeLong method.¹⁸ $P < 0.05$ was considered significant.

RESULTS

A total of 128 older adults were included, of whom 90 (70.30%) were women and 38 (29.70%) were men. Their mean age was 67.37 (SD, 5.3) years. Overall, the mean age of the men was higher than the women (68.74 vs 66.80 years), although not significantly so ($p = 0.09$). There were no significant differences between men and women regarding sociodemographic data, as shown in Table 1A. As expected, the men had a higher appendicular

TABLE 1A. Participant characteristics according to sex, Recife, Brazil, 2022–2023.

	Total		Men		Women		p-value
	n	%	n	%	n	%	
Participants	128	100.00	38	29.70	90	70.30	-
Age (years)							
60 to 70	90	70.30	22	17.20	68	53.10	0.04†
71 to 80	38	29.70	16	12.50	22	17.20	
Race							
White	55	43.00	18	14.10	37	28.90	0.51†
Non-White	73	57.00	20	15.60	53	41.40	
Education							
< 8 years	94	73.40	27	21.10	67	52.30	0.69†
> 8 years	34	26.60	11	8.60	23	18.00	
Chronic diseases							
SAH	108	84.40	31	24.20	77	60.20	0.57†
Dyslipidemia	95	74.20	25	19.50	70	54.70	
Illness duration							
≤ 10 years	48	37.50	15	11.70	33	25.80	0.76†
> 10 years	80	62.50	23	18.00	57	44.50	
SARC-F							
Non-sarcopenic	106	82.80	34	26.60	72	56.30	0.19†
Risk of sarcopenia	22	17.20	4	3.10	18	14.10	
SARC-CalF							
Non-sarcopenic	98	85.20	35	27.30	74	57.80	0.61†
Risk of sarcopenia	30	23.40	10	7.80	20	23.40	
EWGSOP							
Non-sarcopenic	96	75.00	21	16.40	75	58.60	0.001†
Sarcopenic	32	25.00	17	13.30	15	11.70	
EWGSOP 2							
Non-sarcopenic	114	89.10	34	26.60	80	62.50	1.00\$
Sarcopenic	14	10.90	4	3.10	10	7.80	
LMM (EWGSOP)							
Yes	90	70.30	15	11.70	75	58.60	< 0.001†
No	38	29.70	23	18.00	15	11.70	
LMS (EWGSOP 2)							
Yes	92	71.90	26	20.30	66	51.60	0.57†
No	36	28.20	12	9.40	24	18.80	

(Cont. Table 1B)

TABLE 1B. Participant characteristics according to sex, described as means (SD) and medians (IQR), Recife, Brazil, 2022 - 2023.

Variable	Total	Men	Women	p-value
	Mean $\pm$ SD	Mean $\pm$ SD	Mean $\pm$ SD	
Age (years)	67.37 $\pm$ 5.34	68.74 $\pm$ 6.38	66.80 $\pm$ 4.76	0.09‡
Weight (kg)	71.67 $\pm$ 11.51	75.92 $\pm$ 12.51	69.87 $\pm$ 10.63	0.006‡
Height (m)	1.56 $\pm$ 0.07	1.64 $\pm$ 0.06	1.53 $\pm$ 0.05	< 0.001‡
BMI (kg/m ²)	29.13 $\pm$ 4.33	28.07 $\pm$ 4.36	29.57 $\pm$ 4.26	0.07‡
CC (cm)	36.14 $\pm$ 3.2	36.80 $\pm$ 2.90	35.80 $\pm$ 3.30	0.10‡
ASMMI (kg/m ²)	7.00 $\pm$ 1.10	7.81 $\pm$ 1.08	6.65 $\pm$ 0.92	< 0.005‡
SMMI (kg/m ²)	8.59 $\pm$ 1.72	10.50 $\pm$ 1.41	7.78 $\pm$ 1.09	< 0.001‡
Variable	Total	Men	Women	p-value
	Median (IQR)	Median (IQR)	Median (IQR)	
Duration of DM (years)	15.00 (10.00 – 21.00)	15.00 (10.00 – 20.00)	15.00 (10.00 – 22.00)	0.38*
HGS (kg)	21.30 (17.30 – 39.00)	30.20 (26.70 – 34.30)	19.50 (15.70 – 23.30)	< 0.001*
GS (m/s)	1.03 (0.89 – 1.60)	0.99 (0.80 – 1.19)	1.05 (0.94 – 1.28)	< 0.05*
SARC-F (score)	1.00 (0.00 – 5.00)	1.00 (0.00 – 2.00)	2.00 (1.00 – 3.00)	< 0.001*
SARC-CalF (score)	2.00 (1.00 – 12.00)	2.00 (0.00 – 11.00)	3.00 (1.00 – 10.00)	0.003*

ASMMI: appendicular skeletal muscle mass index; BMI: body mass index; CC: calf circumference; DM: diabetes mellitus; GS: gait speed; HGS: handgrip strength; LMM: low muscle mass according to EWGSOP; LMS: low muscle strength according to EWGSOP 2; SARC-CalF: the SARC-F questionnaire + CC; SARC-F: the SARC-F questionnaire; SMMI: skeletal muscle mass index.

† χ^2 test; ‡ Student's *t*-test; § Fisher's exact test; * Mann-Whitney U test.

skeletal muscle mass index ($p = 0.005$), skeletal muscle mass index ($p < 0.001$), and handgrip strength ($p < 0.001$), and the women had lower gait speed ($p = 0.004$) (Table 1B).

According to EWGSOP and EWGSOP 2 criteria, the prevalence of sarcopenia was 25.00% and 10.90%, respectively. In both sets of criteria, the prevalence differed according to sex, being higher among men for the EWGSOP ($p = 0.001$) and higher among women for the EWGSOP 2 (although not significantly so).

The risk of sarcopenia according to the SARC F and SARC CalF was 17.20% and 23.40%, respectively. In both sets of criteria, the prevalence was higher in women, but not significantly so. In the EWGSOP, sarcopenia risk is based on low muscle mass, which is reflected in the skeletal muscle mass index. Low muscle mass was found in 29.70% of the participants and was more prevalent in men ($p = 0.001$). However, in the EWGSOP 2, sarcopenia risk is based on low muscle strength, which is measured through handgrip strength. Low muscle strength was found in 28.20% of participants. Table 2 describes

TABLE 2. Components related to the risk of sarcopenia and sarcopenia in patients with type 2 diabetes mellitus, Recife, Brazil, 2022-2023.

Variable	EWGSOP				p-value	PR (95% CI)	EWGSOP 2				p-value	PR (95% CI)
	Non-sarcopenic n	Sarcopenic %	n	%			Non-sarcopenic n	Sarcopenic %	n	%		
SARC-F ≥ 4 points	17	13.30	5	3.90	0.78†	0.89 (0.38 – 2.05)	17	13.30	5	3.90	0.06§	2.67 (0.99 – 7.21)
SARC-CalF ≥ 11 points	11	8.60	19	14.80	< 0.001†	4.77 (2.68 – 8.48)	18	14.10	12	9.40	< 0.001§	19.60 (4.64 – 82.72)
LMM	6	4.70	32	25.00	< 0.001†	N/A	10	7.80	14	10.90	< 0.001§	N/A
LMS	41	32.00	22	17.20	0.01†	2.26 (1.17 – 4.40)	22	17.20	14	10.90	< 0.001§	N/A
Low GS	77	60.20	28	21.90	0.35†	1.53 (0.59 – 3.94)	92	71.90	13	10.20	0.26§	2.84 (0.39 – 20.69)
Low CC	15	11.70	19	14.80	< 0.001†	4.04 (2.24 – 7.26)	24	18.80	10	7.80	< 0.001§	6.91 (2.32 – 20.58)

95% CI: 95% confidence interval; CC: calf circumference; GS: gait speed; LMM: low muscle mass according to the EWGSOP; LMS: low muscle strength according to the EWGSOP 2; PR: prevalence ratio.

† χ^2 test; § Fisher's exact test; N/A: not applicable (variable = a prerequisite of sarcopenia).

and comparatively analyzes individuals considered at risk of sarcopenia according to the SARC F and SARC CalF, as well as those diagnosed with sarcopenia according to EWGSOP and EWGSOP 2 criteria.

Table 3 shows the results of the sensitivity/specificity analysis, positive predictive value, negative predictive value, and AUC for the SARC F and SARC CalF in comparison with the diagnostic criteria for sarcopenia and probable sarcopenia (low muscle mass [EWGSOP] and low muscle strength [EWGSOP 2]). For the SARC F, sensitivity varied between 12.55% (95% CI 3.55–29.12) and 36.11% (95% CI 20.81–53.79) and specificity varied between 71.87% (95% CI 61.85–80.63) and 92.39% (95% CI 84.91–96.90). For the SARC CalF, sensitivity varied between 47.22% (95% CI 30.40–64.55) and 85.71% (95% CI 57.22–98.23) and specificity varied between 82.46% (95% CI 74.24–88.90) and 88.89% (95% CI 80.50–94.55).

Both instruments presented relatively high negative predictive values. For example, when compared according to EWGSOP 2 criteria, the negative predictive value of the SARC CalF was 97.94% (95% CI 92.89–99.41) and that of the SARC F was 91.72% (95% CI 88.10–94.20). This means that if the test result was negative for

sarcopenia, the chance that the person actually did not have sarcopenia was 97.94 and 91.72% for the SARC CalF and SARC F, respectively.

The SARC CalF had higher ROC curve values than the SARC F. According to EWGSOP 2 criteria, the AUC of the SARC CalF and SARC F was 0.86 (95% CI 0.78–0.91) and 0.62 (95% CI 0.53–0.70), respectively; there was a significant difference between the curves ($p < 0.001$). Similar results were found for the EWGSOP criteria ($p = 0.009$). The AUC of the SARC CalF was higher for both low muscle mass ($p = 0.32$) and low muscle strength ($p = 0.54$) than the SARC F, but not significantly so. All ROC curves for the SARC-F and SARC-CalF are compared with reference diagnostic methods in Figure 1.

DISCUSSION

Among older adults with DM2, this study found a sarcopenia prevalence of 25% and 10.9% according to EWGSOP and EWGSOP 2 criteria, respectively. This variation can be explained by the fact that low muscle mass is the main diagnostic criterion for sarcopenia in the EWGSOP, whereas low muscle strength is used in the EWGSOP 2.

TABLE 3. Sensitivity, Specificity, PPV, NPV and AUC of the SARC-F, SARC-CalF questionnaires compared to the sarcopenia diagnostic criteria of EWGSOP, EWGSOP 2 and to the probable sarcopenia criteria, LMM (according to EWGSOP) and LMS (according to EWGSOP 2), Recife, Brazil, 2022–2023.

	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	AUC	p-value*
EWGSOP						
SARC-F	12.55 (3.55 – 29.12)	71.87 (61.85 – 80.63)	12.90 (5.31 – 28.12)	71.11 (67.30 – 74.72)	0.51 (0.42 – 0.60)	0.009
SARC-CalF	65.62 (46.84 – 81.42)	88.54 (80.39 – 94.09)	65.61 (50.90 – 77.82)	88.50 (82.61 – 92.60)	0.75 (0.67 – 0.82)	
EWGSOP 2						
SARC-F	35.71 (12.83 – 64.90)	86.84 (79.20 – 92.41)	25.00 (12.50 – 43.70)	91.72 (88.10 – 94.20)	0.62 (0.53 – 0.70)	< 0.001
SARC-CalF	85.71 (57.22 – 98.23)	82.46 (74.24 – 88.90)	37.50 (27.60 – 48.52)	97.94 (92.89 – 99.41)	0.86 (0.78 – 0.91)	
LMM (EWGSOP)						
SARC-F	21.05 (9.61 – 37.32)	74.44 (64.22 – 83.10)	25.80 (14.62 – 41.40)	69.10 (64.60 – 73.33)	0.57 (0.48 – 0.66)	0.32
SARC-CalF	57.89 (40.80 – 73.72)	88.89 (80.50 – 94.55)	68.72 (53.64 – 80.68)	83.33 (77.40 – 88.00)	0.67 (0.58 – 0.75)	
LMS (EWGSOP 2)						
SARC-F	36.11 (20.81 – 53.79)	92.39 (84.91 – 96.90)	65.00 (44.60 – 81.00)	78.71 (74.23 – 82.60)	0.71 (0.62 – 0.79)	0.54
SARC-CalF	47.22 (30.40 – 64.55)	83.70 (74.55 – 90.60)	53.12 (38.91 – 66.92)	80.20 (74.60 – 84.80)	0.74 (0.65 – 0.81)	

AUC: area under the curve; LMM: low muscle mass; LMS: low muscle strength; NPV: negative predictive value; PPV: positive predictive value; SARC-F: the SARC-F questionnaire; SARC-CalF: the SARC-F questionnaire + calf circumference. Values in parentheses are 95% CI.

*The p-value represents the difference between the AUC of SARC-F and SARC-CalF scores among the groups.

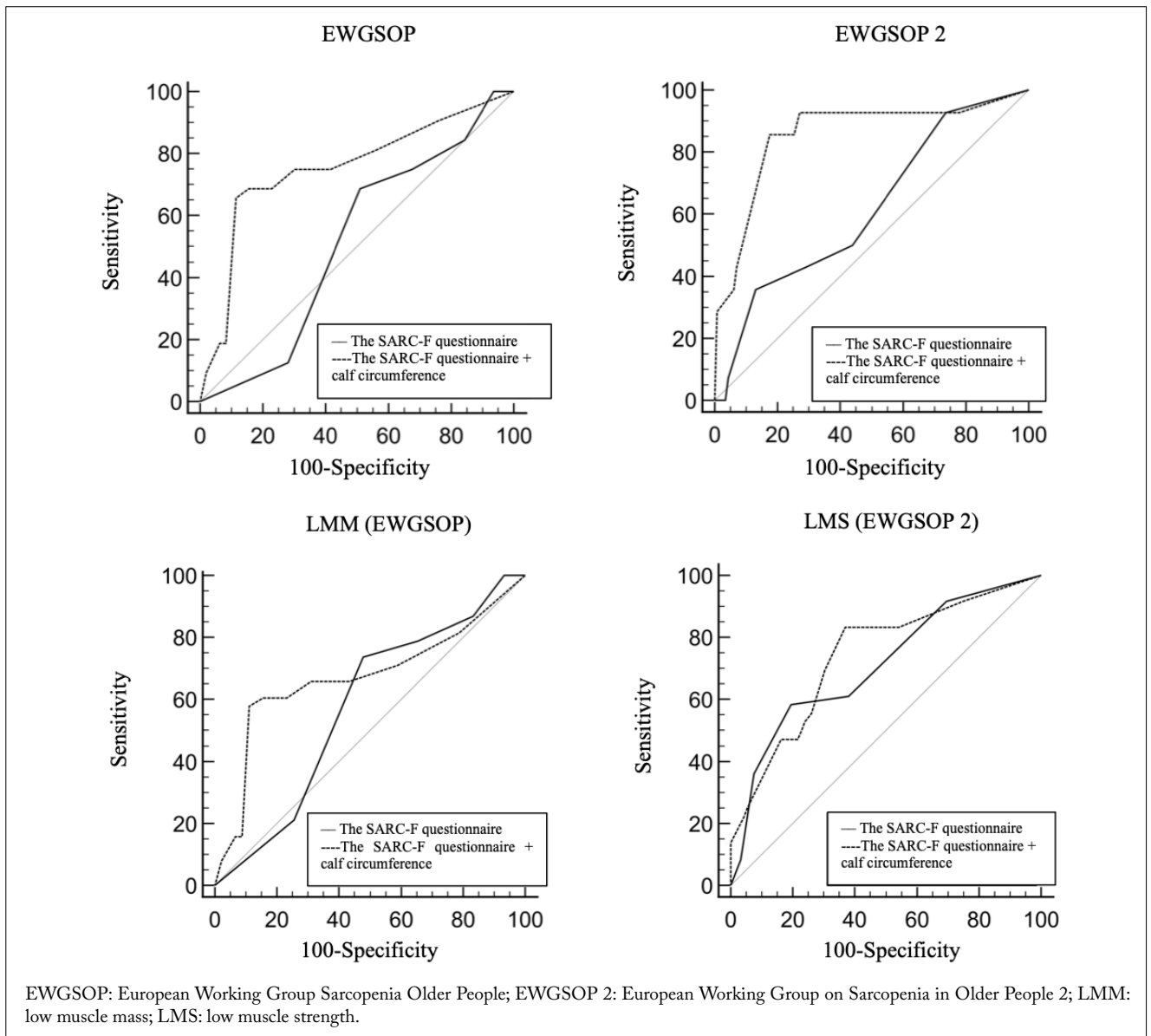


FIGURE 1. ROC curve of the SARC F and SARC CalF compared with the European Working Group Sarcopenia in Older People, the European Working Group on Sarcopenia in Older People 2, low muscle mass (according to the European Working Group on Sarcopenia in Older People) and low muscle strength (according to the European Working Group on Sarcopenia in Older People 2).

Another important to consider is the change in cut-off points used to assess muscle mass and strength, since both were lowered in EWGSOP 2. These results corroborate the findings of Freitas et al.⁹ in a population of older Brazilians diagnosed with DM2: the prevalence of sarcopenia according to EWGSOP (16.9%) criteria was more than double that of EWGSOP 2 (7%).

In older adults, sarcopenia is associated with frailty syndrome and unfavorable health outcomes, including physical disability, low quality of life, risk of institutionalization, and

even death. Therefore, this population should be routinely screened for sarcopenia and, in positive cases, additional diagnostic tests should be performed.¹⁹ However, to diagnose sarcopenia skeletal muscle mass must be determined through computed tomography, magnetic resonance imaging, dual energy X-ray absorptiometry, or bioelectrical impedance testing. Muscle strength (using a dynamometer) and physical performance must also be determined, which makes diagnosis expensive, time-consuming, and less accessible, especially in public health units.

Although the SARC F questionnaire is a quick and easy method of screening for sarcopenia risk, studies have reported that the instrument has high specificity and low sensitivity. For example, when validating the SARC F as a screening tool for sarcopenia in a Hong Kong community, using different reference criteria to diagnose sarcopenia, Woo et al.¹² found a specificity of 94.4% and a sensitivity of 9.9%. The instrument's low sensitivity limits its applicability due to the high possibility of not detecting individuals with sarcopenia. On the other hand, its high specificity indicates that it correctly identifies people who do not have the condition, ie, if a patient is not at risk according to the SARC F, a diagnosis of sarcopenia can be discarded without further testing.²⁰

Calf circumference has consistently been associated with favorable or unfavorable health outcomes, especially in older adults. Grigol et al.²¹ evaluated survival among nonagenarians and centenarians, finding that calf circumference was the only anthropometric variable significantly associated with mortality. With each additional centimeter of calf circumference, there was a 9% reduction in mortality risk for each month of follow-up. In our study, calf circumference was the most closely associated variable with sarcopenia, regardless of the reference standard. Thus, it can be considered a risk factor for sarcopenia. Kawakami et al.²² found a positive correlation between calf circumference and muscle mass, indicating that it could be an alternative means of assessing muscle mass for sarcopenia diagnosis; the suggested cut-off values for predicting low muscle mass were < 34 cm for men and < 33 cm for women.

Barbosa-Silva et al.¹⁰ suggested adding calf circumference to the SARC F questionnaire, which then became known as SARC-CalF. Barbosa-Silva et al.¹³ evaluated 179 older Brazilians, reporting that when using EWGSOP criteria to diagnose sarcopenia, the sensitivity of the SARC CalF and SARC F was 66.7% and 33.3%, respectively. Likewise, in our study, for all reference criteria the SARC CalF was more sensitive than the SARC F for predicting sarcopenia risk in older adults with diabetes.

Other studies have compared the diagnostic power of the SARC CalF and SARC F regarding sarcopenia risk. Tsuji et al.²³ assessed 172 older adults with chronic muscle pain in Japan and found that the SARC-CalF had better sensitivity than the SARC F, although the specificity of both instruments was similar. Luz et al.²⁴ found similar results in older Brazilians with Parkinson's disease, ie, the SARC-CalF was more sensitive than the SARC-F, except at diagnosing low muscle mass.

An important result of this study was that sarcopenia was significantly more frequent among women than men according to EWGSOP criteria, indicating that sex can affect the prevalence of sarcopenia and low muscle mass, the main diagnostic criterion for sarcopenia according to the consensus. Some studies^{25,26} have reported that sex and age can also affect the screening capacity of the SARC F and SARC CalF. This could be due to the fact that, when answering questions about physical performance, men tend to overestimate their physical ability, unlike women, who may underestimate it. Xu et al.²⁶ applied the SARC F and SARC CalF to older adults with DM2 in China, finding higher scores among women than men. However, in determining the risk of sarcopenia with these instruments, we found higher, but not significantly higher, scores among women. This divergence may be attributable to demographic and clinical variables between populations, given that Xu et al.²⁶ evaluated hospitalized patients in China and we evaluated outpatients in Brazil.

Generally, an AUC of 0.5-0.7 indicates low accuracy, 0.7-0.9 indicates moderate accuracy, and > 0.9 indicates high accuracy.²⁷ In all 4 analyzed criteria, the AUC was higher for the SARC CalF than the SARC F. However, although the AUC of the SARC CalF was greater than that of the SARC F, its accuracy is in the low-to-moderate range. These findings demonstrate that, although the SARC CalF has better diagnostic power than the SARC F, it is still imperfect. However, calf circumference can also be influenced by the amount of adipose tissue, as well as the presence of edema, which can mask sarcopenia in some individuals.²⁸

In 2019, Kurita et al.²⁹ added 2 variables to the SARC F that are associated with an increased risk of sarcopenia: age ≥ 75 years and BMI ≤ 21 kg/m². This new version was called the SARC F + EBM (E for elderly, and BM for body mass index). The validation study investigated 959 Japanese patients hospitalized with musculoskeletal disease, finding greater sensitivity than the SARC-F (77.8 vs 41.7%, respectively), as well as a higher AUC (0.82 vs 0.56, respectively). However, further research should compare and determine the validity of new instruments with better diagnostic sensitivity for sarcopenia in older adults with DM2.

This study involves certain limitations. Due to its cross-sectional design, causality could not be determined. Regarding bioelectrical impedance, which was used to assess body composition, most of the equations were developed and validated for healthy, non-obese individuals and have not been validated in clinical situations, so the assessment was an estimate.

CONCLUSIONS

Regardless of the reference criteria, the SARC-CalF had better sensitivity and diagnostic performance than the SARC-F. Therefore, the SARC-CalF seems to be the most appropriate tool for sarcopenia risk screening, and it can be a practical and simple alternative for health professionals to investigate signs and symptoms in clinical practice and help prevent sarcopenia among older outpatients with diabetes.

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Conflict of interests

The authors declare no conflicts of interest.

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Author contributions

AAA: project administration, conceptualization, data curation, writing – original draft, writing – review & editing, methodology, software. IKGA: formal analysis, writing – review & editing, supervision. MCCL: formal analysis, conceptualization, writing – review & editing, supervision. NKAS: project administration, writing – original draft, methodology.

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