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RESEARCH

The potential of the SARC-CalF questionnaire as a screening tool for frailty

SARC-CalF anketinin kırılganlık için bir tarama aracı olarak kullanım potansiyeli

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Abstract

Purpose: Frailty and sarcopenia exhibit overlapping physical characteristics, as described by the Fried Frailty Phenotype (FFP). Although the SARC-CalF questionnaire is widely used for sarcopenia screening, as recommended by the EWGSOP-2 guidelines, its potential to identify frailty has not been thoroughly investigated. This study aims to evaluate the SARC-CalF as a simple, objective tool for assessing frailty in older adults.

Materials and Methods: This cross-sectional study included 337 patients aged 65 years and older. Frailty was assessed through the FFP. Demographic characteristics and the SARC-CalF questionnaire were obtained. To identify appropriate SARC-CalF cut-off points for detecting frailty, we used a receiver operating characteristic (ROC) curve to calculate the area under the curve (AUC) and its 95% confidence interval.

Results: The average age of the participants was 75.27±6.6, with 64.3% (n=217) being women. Frailty was observed in 15.4 % (n=52) of the study population. Frail patients exhibited higher median SARC-CalF scores than non-frail participants (5.5 vs. 1). The AUC of the SARC-CalF score for frailty was 0.800 (95% confidence interval [CI], 0.75-0.84). Using a cut-off value of >2, sensitivity was 84.6%, specificity was 66.3%, PPV was 30.7%, and NPV was 96.1%.

Conclusion: The SARC-CalF questionnaire demonstrated good discriminative performance in identifying frailty among older adults and may serve as a simple tool for frailty screening.

Keywords: Frailty, geriatrics, SARC-CalF, sarcopenia, screening

Öz

Amaç: Kırılganlık ve sarkopeni, Fried Kırılganlık Fenotipi'nde tanımlandığı üzere örtüşen fiziksel özellikler göstermektedir. SARC-CalF anketi, EWGSOP-2 kılavuzlarında önerildiği üzere sarkopeni taraması için yaygın olarak kullanılmasına rağmen, kırılganlığı belirleme potansiyeli yeterince araştırılmamıştır. Bu çalışmanın amacı, SARC-CalF anketinin yaşlı bireylerde kırılganlığın değerlendirilmesi için basit ve objektif bir araç olarak kullanılabilirliğini değerlendirmektir.

Gereç ve Yöntem: Bu kesitsel çalışmaya 65 yaş ve üzeri 337 hasta dahil edildi. Kırılganlık Fried Kırılganlık Fenotipi (FFP) kullanılarak değerlendirildi. Demografik özellikler ve SARC-CalF anketi verileri kaydedildi. Kırılganlığı saptamada uygun SARC-CalF kesim noktalarını belirlemek amacıyla alıcı işletim karakteristiği (ROC) eğrisi analizi kullanılarak eğri altında kalan alan (AUC) ve %95 güven aralığı hesaplandı.

Bulgular: Katılımcıların ortalama yaşı 75,27±6,6 olup %64,3'ü (n=217) kadındı. Çalışma popülasyonunun %15,4'ünde (n=52) kırılganlık saptandı. Kırılgan hastalarda SARC-CalF skoru kırılgan olmayan gruba göre daha yüksekti. Kırılganlığı belirlemede SARC-CalF skorunun AUC değeri 0,800 olarak bulundu (%95 güven aralığı [GA], 0,75-0,84). Negatif prediktif değer %96,1 olarak saptandı ve kırılganlık için SARC-CalF'in optimal kesim değeri tüm bireyler için >2 olarak belirlendi.

Sonuç: SARC-CalF anketi, yaşlı bireylerde kırılganlığı belirlemede iyi ayırt edici performans göstermiştir ve kırılganlık taraması için basit bir araç olarak kullanılabilir.

Anahtar kelimeler: SARC-CalF, kırılganlık, geriatri, tarama, sarkopeni

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INTRODUCTION

Frailty is a multidimensional geriatric syndrome characterized by decreased physiological reserve and impaired resistance to stressors, leading to increased vulnerability to adverse health outcomes[1]. Individuals with frailty experience difficulties in maintaining homeostasis, which results in a higher risk of hospitalization, functional decline, falls, disability, and mortality compared with robust older adults[2]. Early identification of frailty is therefore emphasized in international guidelines, particularly among adults aged 70 years and older or those with unintentional weight loss exceeding 5% in the last year[3]. Despite its clinical importance, frailty remains challenging to diagnose because it involves complex interactions across physical, cognitive, psychological, and social domains. As a result, numerous screening and assessment tools have been proposed, ranging from simple questionnaires to comprehensive geriatric evaluations, each reflecting different conceptual models of frailty.

Among these models, the Fried Frailty Phenotype (FFP) is one of the most widely used operational definitions. It identifies frailty based on five physical criteria: unintentional weight loss, weakness, exhaustion, slow walking speed, and low physical activity[1]. Many of these components overlap biologically and clinically with sarcopenia, a progressive age-related loss of skeletal muscle mass and function. Shared mechanisms, such as chronic inflammation, hormonal alterations, metabolic dysregulation, and neuromuscular impairment, suggest that sarcopenia and frailty are closely interconnected conditions rather than distinct entities[4,5]. Moreover, sarcopenia is linked to adverse outcomes similar to those associated with frailty, such as falls, fractures, physical disabilities, and increased mortality[5]. Consequently, tools designed for sarcopenia case-finding may also hold potential for identifying frailty.

In the clinical screening of sarcopenia, the European Working Group on Sarcopenia in Older People (EWGSOP) recommends the use of simple instruments such as the SARC-F questionnaire or its modified version, SARC-CalF, which incorporates calf circumference[5]. Calf circumference (CC) itself is an easily obtainable anthropometric marker that correlates with appendicular muscle mass and physical performance[6]. The addition of CC substantially improves sensitivity and overall diagnostic performance compared with SARC-F alone[7,8]. Although SARC-CalF has demonstrated enhanced accuracy in detecting individuals at risk for sarcopenia across various populations, its potential role in frailty screening has not yet been systematically examined[8,9].

Given the substantial overlap between frailty and sarcopenia, particularly in domains related to mobility, muscle strength, and physical performance, assessing whether SARC-CalF can also discriminate between frail and non-frail individuals is clinically meaningful. A simple, rapid tool that incorporates both subjective functional limitations and an objective muscle-related measure could offer practical value in busy clinical settings where comprehensive frailty assessments are difficult to perform.

Therefore, this study aims to evaluate the SARC-CalF questionnaire's ability to identify frailty in older adults and assess its discriminative performance using the FFP as the reference standard. We hypothesized that SARC-CalF, originally developed for sarcopenia screening, would demonstrate acceptable discriminative performance in identifying frailty, given the substantial overlap between sarcopenia and frailty domains. To our knowledge, few studies have specifically examined the performance of SARC-CalF for frailty screening, and this study seeks to address this gap in the literature.

MATERIALS AND METHODS

Study design and sample

This cross-sectional study, based on medical records, was conducted at the geriatric outpatient clinic of Gazi University Hospital and included adults aged 65 years and older who presented for routine geriatric assessment. All demographic, clinical, and comprehensive geriatric assessment data were obtained from standardized medical records routinely used in the clinic.

Comprehensive geriatric assessments, including frailty evaluation, handgrip strength measurement, gait speed assessment, and SARC-CalF administration, were performed by geriatricians as part of routine clinical care. Because the study

population consisted of patients evaluated at a specialized geriatric outpatient clinic, the findings may not be fully generalizable to the broader older adult population.

Data were collected from the medical records of patients evaluated between November 2022 and May 2024. A total of 420 patients were screened from medical records. Exclusions were made for individuals aged ≤65 years (n=15), those with moderate-to-severe dementia or communication problems that impeded reliable responses (n=20), those with edema that interfered with accurate CC measurement (n=12), and patients with incomplete data (n=36). After applying the exclusion criteria, 337 patients were included in the study. The participant selection process is presented in Figure 1.

No a priori power analysis was performed because this study was based on available medical record data. All eligible patients aged 65 years and older who met the inclusion criteria during the study period were included.

The study was approved by the Gazi University Institutional Ethics Committee (22.7.2024, 2024-1128) and was conducted in accordance with the ethical principles of the Declaration of Helsinki. Because the study was retrospective and based on existing medical record data obtained during routine clinical care, the requirement for written informed consent was waived by the ethics committee.

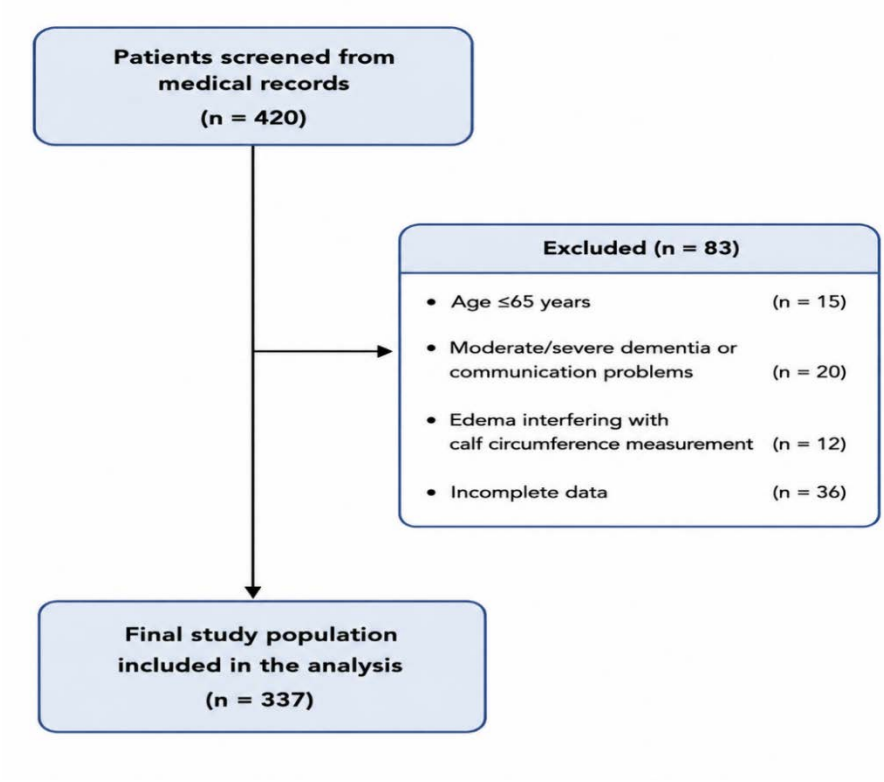


Fig.1: Study population flowchart

Screening with SARC-CalF

The SARC-F questionnaire is a widely used tool for assessing the risk of sarcopenia. It comprises five questions that assess strength, walking assistance, ability to rise from a chair, ability to climb stairs, and history of falls. Each question is scored from 0 to 2, with higher scores indicating a higher likelihood of sarcopenia. The SARC-CalF extends the SARC-F by incorporating CC as a sixth factor. It retains the original five questions from the SARC-F and adds CC measurement. Participants whose CC falls below a

specified cut-off point receive an additional 10 points on their total score, while those above the cut-off receive no additional points[8]. CC was measured using a non-elastic tape with participants in an upright position. The tape was placed at the widest part of the calf without exerting pressure. A population-specific cut-off value was applied, with measurements below 33 cm considered positive for screening[10].

Frailty assessment

We used the FFP tool to assess participants' frailty levels. The phenotype consists of five components: unintentional weight loss, weakness, exhaustion, slow walking speed, and low physical activity. This tool assigns a score between 0 and 5 points. A score of 0 indicates a robust individual (not frail), 1 or 2 points suggest prefrailty, and scores of 3 or higher indicate frailty[1,11]. For the primary analysis, robust and pre-frail individuals were grouped as non-frail to evaluate SARC-CalF's discriminative performance for established frailty.

Covariates

Participant information was gathered by reviewing medical records for demographics and medical history (age, sex, chronic diseases, medications) and conducting a comprehensive geriatric assessment. The comprehensive geriatric assessment included evaluations for depression (Geriatric Depression Scale (GDS))[12], cognition status (Mini-Mental State Examination (MMSE))[13], nutrition (Mini Nutritional Assessment-Short Form (MNA-SF))[14], and daily living abilities (Katz Activities of Daily Living (ADL) & Lawton Instrumental Activities of Daily Living (IADL) scales)[15,16]. For the GDS-15, scores ≥5 were considered indicative of depressive symptoms. MMSE scores <24 were considered suggestive of cognitive impairment. MNA-SF scores of 12–14 indicated normal nutritional status, 8–11 indicated risk of malnutrition, and <8 indicated malnutrition. Lower ADL and IADL scores reflected greater functional dependency. These instruments are widely used in geriatric assessment, and their Turkish versions have been validated and shown to have acceptable reliability and validity in older Turkish adults.

Statistical analysis

The normality of continuous variables was assessed using the Shapiro–Wilk test. Categorical variables were presented as numbers and percentages. Variables with normal distribution (e.g., age, height, weight, body mass index, arm circumference, calf circumference, handgrip strength, and gait speed) were expressed as mean ± standard deviation and compared between groups using the independent samples t-test. Variables with non-normal distribution (e.g., number of medications, ADL, IADL, MMSE, MNA-SF, GDS, SARC-F, and SARC-CalF scores) were reported as median (minimum–maximum) and compared using the Mann–Whitney U test. Categorical variables were analyzed using the chi-square test.

Receiver operating characteristic (ROC) curve analysis was performed to evaluate the discriminative performance of SARC-CalF for frailty. The area under the curve (AUC) and corresponding 95% confidence intervals (CI) were calculated. Sensitivity, specificity, positive predictive values (PPV), and negative predictive values (NPV) were determined for different SARC-CalF cut-off values. The optimal cut-off value for SARC-CalF was identified using the Youden index. Comparisons between ROC curves were performed using DeLong's test. A p-value <0.05 was considered statistically significant. Statistical analyses were conducted using SPSS version 26.0 (IBM Corp., Armonk, NY, USA) and MedCalc Statistical Software version 15.2 (MedCalc Software Ltd., Ostend, Belgium).

RESULTS

The study included 337 participants, with 217 females (64.3%) and 120 males (35.7%). The mean age was 75.3±6.6 years, and frailty was identified in 15.4% of the participants. Although the prevalence of frailty did not differ significantly between sexes, men had significantly higher handgrip strength and gait speed. In contrast, women had higher body mass index, SARC-F scores, and SARC-CalF scores (Table 1).

Participants classified as frail according to the study criteria exhibited significantly higher scores on all SARC-CalF items and the total SARC-CalF score compared to the non-frail group ($p < 0.05$). Frail participants also reported greater difficulty in all individual SARC-CalF domains, including strength, walking assistance, rising from a chair, stair climbing, and falls. In addition, the proportion of participants with a calf circumference <33 cm was significantly higher among frail individuals than among non-frail individuals (38.5% vs. 10.9%, $p<0.001$) (Table 2).

ROC curve analysis demonstrated that SARC-CalF had an AUC of 0.800 (95% CI: 0.75–0.84) for identifying frailty. The optimal cut-off value was >2 according to the Youden index (0.509), yielding a sensitivity of 84.6%, specificity of 66.3%, PPV of 30.7%, and NPV of 96.1%. Although SARC-CalF showed higher AUC and sensitivity values than SARC-F (AUC=0.746), the difference between the ROC curves was not statistically significant according to DeLong's test (p=0.1236) (Table 3). Subgroup analyses revealed an AUC of 0.855 for men ($p < 0.001$) and 0.763 for women ($p < 0.001$). Although the AUC value was higher in men than in women, the difference between the ROC curves was not statistically significant according to DeLong's test ($p = 0.1802$) (Fig. 2).

Table 1. Characteristics of the participants by sex

Variables	Overall n=337	Women n=217	Men n=120	p-value
Age, mean (SD)	75.3±6.6	75±6.7	75.7±6.4	0.28
Height, cm, mean ± SD	156.9±9.5	151.2±6.6	166.2±6.3	<0.001
Weight, kg, mean ± SD	70.1±12.3	68.2±12.3	73.5±12.4	0.001
BMI, kg/m², mean ± SD	28.6±5.1	29.7±5.2	26.5±4	<0.001
Arm circumference, cm, mean ±SD	29±3.4	29.6±3.6	27.9±3.4	<0.001
Calf circumference, cm, mean ±SD	36.3±3.8	36.4±3.9	36.1±3.4	0.54
Waist circumference, cm, mean ±SD	99.7±11.4	99.6±11.9	99.8±10.4	0.92
Handgrip strength, kg, mean ±SD	20.8±7.5	17±4.5	27.7±6.8	<0.001
Gait speed, m/s, mean ±SD	0.97±0.3	0.91±0.3	1.07±0.32	<0.001
Diabetes Mellitus, n(%)	117 (34.8)	83 (38.4)	34 (28.3)	0.06
Hypertension, n(%)	238 (70.8)	161 (74.5)	77 (64.2)	0.24
Atherosclerotic heart disease, n(%)	82 (24.4)	42 (19.4)	40 (33.3)	0.005
Number of medicines used (min-max)	3 (0-11)	3 (0-11)	4 (0-11)	0.002
ADL, median (min-max)	6 (3-6)	6 (3-6)	6 (3-6)	0.10
IADL, median (min-max)	8 (1-8)	8 (1-8)	8 (1-8)	0.09
MNA-SF, median (min-max)	12 (5-14)	12 (5-14)	13 (5-14)	0.26
MMSE, median (min-max)	28 (18-30)	27 (18-30)	28 (18-30)	0.024
GDS, median (min-max)	2 (0-14)	2 (0-14)	2 (0-10)	<0.001
SARC-F score	1 (0-9)	2 (0-9)	1 (0-8)	<0.001
SARC-CalF score	2 (0-18)	2 (0-17)	1 (0-18)	<0.001
FFP, n (%)				0.24
Robust	81 (24)	46 (21.2)	35 (29.2)	
Prefrail	204 (60.5)	135 (62.2)	69 (57.5)	
Frail	52 (15.4)	36 (16.6)	16 (13.3)	

ADL: Activity of Daily Living, BMI: Body Mass Index, FFP: Fried Frailty Phenotype, GDS: Geriatric Depression Scale, IADL: Instrumental Activity of Daily Living, MNA-SF: Mini Nutritional Assessment Short Form, MMSE: Mini-Mental State Examination, SARC-F: Strength, Assistance with walking, Rise from a chair, Climb stairs, and Falls, SARC-CalF: SARC-F plus calf circumference

Table 2. Association between SARC-F, SARC-CalF, and frailty

Variable	Nonfrail n=285 (84.6%)	Frail n=52 (15.4%)	p
SARC-F score, median(min-max)	1 (0-7)	4 (0-9)	**<0.001**
SARC-CalF score, median(min-max)	1 (0-17)	5.5 (0-18)	**<0.001**
SARC-CalF items			
Strength (difficulty in lifting and carrying 10 pounds) n(%)			**<0.001**
None	188 (66%)	20(38.5%)	
Some	73(25.6%)	16(30.8%)	
A lot or unable	24(8.4%)	16(30.8%)	
Assistance (difficulty in walking across a room) n(%)			**<0.001**
None	245(86%)	26(50%)	
Some	38(13.3%)	19(36.5%)	
A lot or unable	2(0.7%)	7(13.5%)	
Rise from a chair (difficulty in transferring from a chair or a bed) n(%)			**<0.001**
None	206(72.3%)	20(38.4%)	
Some	73(25.6%)	24(46.2%)	
A lot or unable	6(2.1%)	8(15.4%)	
Climb stairs (difficulty in climbing a flight of 10 stairs) n(%)			**<0.001**
None	177(62.1%)	19(36.5%)	
Some	90(31.6%)	19(36.5%)	
A lot or unable	18(6.3%)	14(26.9%)	
Falls in the past year n(%)			**0.039**
None	201(70.5%)	30(57.7%)	
Some	78(27.4%)	18(34.6%)	
A lot or unable	6(2.1%)	4(7.7%)	
Calf Circumference n(%)			**<0.001**
≥33 cm	254(89.1%)	32(61.5%)	
<33 cm	31(10.9%)	20(38.5%)	

SARC-F: Strength, Assistance with walking, Rise from a chair, Climb stairs, and Falls; SARC-CalF: SARC-F plus calf circumference
The analyses presented for individual SARC-CalF items were exploratory and descriptive; therefore, no formal correction for multiple comparisons was applied.

Table 3: ROC Curve Analysis of SARC-F and SARC-CalF for Frailty

	Cut-off	AUC	P	95% CI	Youden Index	Sensitivity	Specificity	PPV	NPV
SARC-F	>2	0.746	**<0.001**	0.70-0.79	0.403	67.3	73	30.5	92.7
SARC-CalF	>2	**0.800**	**<0.001**	0.75-0.84	**0.509**	**84.6**	66.3	30.7	**96.1**

AUC: Area under the curve, CI: Confidence interval, NPV: Negative predictive value, PPV: Positive predictive value
The optimal cut-off values were determined using the highest Youden index. P values represent the significance test of AUC against the null hypothesis value of 0.5.

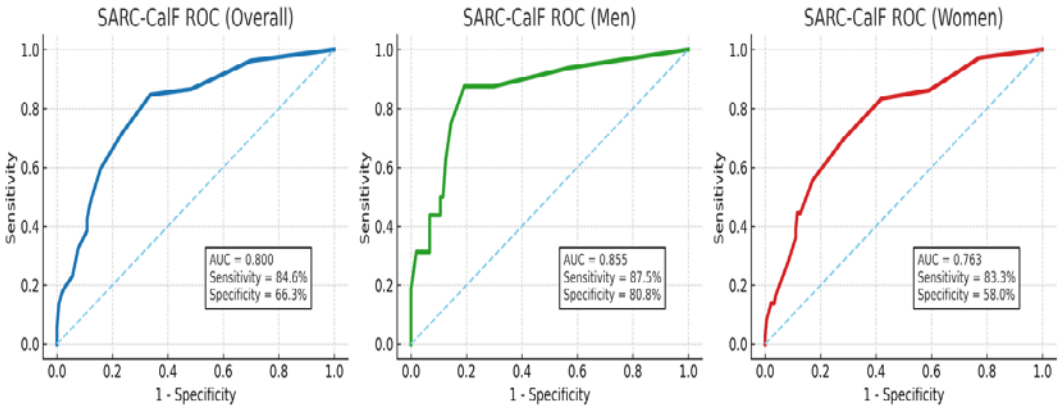


Fig.2. ROC curves for the predictive accuracy of the SARC-CalF score in the overall, men and women.

DISCUSSION

In this study, the SARC-CalF questionnaire, originally developed for sarcopenia screening, demonstrated meaningful discriminative performance for identifying frailty among older adults. Frailty was observed in 15.4% of the participants, with frail individuals exhibiting significantly higher SARC-CalF scores than their non-frail counterparts. The score demonstrated strong discrimination, with an AUC of 0.800 and a high negative predictive value of 96.1%. These findings suggest that the SARC-CalF score can effectively differentiate frail from non-frail individuals and may serve as a valuable screening tool in clinical practice. Most previous studies have evaluated SARC-F and its modified forms, including SARC-CalF, in the context of sarcopenia case finding rather than frailty. Several diagnostic accuracy analyses in community-dwelling older adults, nursing home residents, and hospitalized patients have consistently shown that SARC-F alone has limited sensitivity, whereas adding CC (SARC-CalF) improves overall screening performance and AUC values for sarcopenia[7,17]. In some cohorts, SARC-CalF or related calf-based indices demonstrated clearly superior accuracy compared with SARC-F. In others, CC alone or BMI-adjusted CC achieved the best AUC, with SARC-CalF still outperforming SARC-F[9,18]. More recent studies have further supported these findings. Sousa et al. demonstrated that SARC-CalF showed better diagnostic performance than SARC-F for identifying sarcopenia and low muscle strength among hospitalized older adults, whereas Vanitcharoenkul et al. reported that CC achieved the highest diagnostic accuracy and demonstrated superior screening performance compared with both SARC-F and SARC-CalF[19,20]. These findings underscore two key observations: first, that CC is a robust anthropometric marker of muscle mass and structure; secondly, that combining functional self-report items (SARC-F) with a structural measure (CC) may yield improved screening performance compared to functional items alone. Our findings extend these observations into the domain of frailty rather than sarcopenia alone. However, some previous studies have suggested that CC alone may perform comparably to or even better than SARC-CalF for sarcopenia screening[9]. Therefore, the relative contributions of the questionnaire-based SARC-F components and CC measurement to frailty discrimination remain unclear and warrant further investigation.

Sarcopenia, characterized by loss of muscle mass and function, shares several biological pathways with frailty, including chronic inflammation, hormonal dysregulation, and neuromuscular impairment[21]. This overlap helps explain why a questionnaire and measurement set originally designed to screen sarcopenia risk also discriminates frailty. By demonstrating that SARC-CalF can accurately distinguish frail from non-frail older adults, our study suggests that muscle-related screening instruments may serve a dual purpose: case-finding for sarcopenia and broader frailty risk stratification.

From a measurement standpoint, SARC-F and CC capture different but complementary dimensions of muscle health. SARC-F relies on self-reported

functional limitations related to strength, mobility, and falls. Because it is subjective, its sensitivity may be limited, as repeatedly shown in sarcopenia screening studies[8]. In contrast, CC provides an objective anthropometric marker that correlates with appendicular muscle mass and skeletal muscle index[6]. However, it may be influenced by factors such as obesity or peripheral edema. The strength of SARC-CalF lies in integrating both functional (SARC-F) and structural (CC) components thus capturing individuals who either perceive functional decline or already have measurable structural muscle deficiency.

Previous sarcopenia screening studies have suggested that screening performance may vary by sex[18]. Although the mechanisms underlying sex-based differences in screening performance remain unclear, variations in baseline muscle mass, fat distribution, and anthropometric characteristics may contribute. In the present study, subgroup analysis showed numerically higher AUC values for SARC-CalF in men than in women; however, the difference between the ROC curves was not statistically significant. Similar findings have been reported in a recent study evaluating SARC-F and SARC-CalF against ultrasound-derived muscle thickness, in which sex-specific differences in screening performance were observed[22]. However, the overall diagnostic performance remained broadly comparable between sexes. This finding may be related to the use of a single CC cut-off value for both sexes despite known anthropometric differences between men and women. Further research should explore whether sex-specific cut-offs or tailored interpretation may enhance screening accuracy.

A key strength of this study is that it specifically evaluated the discriminative performance of SARC-CalF for frailty assessment using the FFP, allowing for robust classification of frailty. Our study has limitations. Because it is cross-sectional, we cannot determine whether higher SARC-CalF scores predict future adverse events such as disability, hospitalization, or mortality. Our sample is drawn from a single geriatric outpatient clinic, which may limit generalisability to community-dwelling older adults or institutionalized populations. The exclusion of individuals with moderate-to-severe dementia or communication problems may have introduced spectrum bias and contributed to an underestimation of frailty prevalence in the study population. No a priori sample size or power analysis was performed because the study was based on available medical record data, which may limit the statistical generalizability of the findings. The use of a single CC cut-off value for both sexes and the absence of multivariable analyses adjusting for potential confounding factors may also have influenced the observed discriminative performance of SARC-CalF. In addition, the relatively small number of frail participants may have influenced subgroup analyses, particularly sex-stratified analyses. Furthermore, because SARC-CalF and the FFP share overlapping physical domains related to muscle function and mobility, this conceptual overlap should be considered when interpreting the findings. Sarcopenia was also not directly assessed using objective muscle mass measurements or standardized diagnostic criteria.

In conclusion, SARC-CalF appears to be a practical, low-burden instrument that combines functional self-report and anthropometric measurement and may have potential utility in frailty screening. Future prospective and multicenter studies are needed to validate these findings in more diverse populations and to determine whether SARC-CalF predicts clinically important outcomes, including disability, hospitalization, institutionalization, and mortality. Further research should also investigate the independent contribution of calf circumference and questionnaire-based components to frailty detection, evaluate sex-specific calf circumference cut-off values, and compare SARC-CalF with other established frailty screening tools. Such studies may help clarify the optimal role of SARC-CalF within comprehensive frailty assessment strategies.

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Ethical Approval: The study was initiated with the approval of the Gazi University Clinical Research Ethics Committee (Date: 22.07.2024, Decision No: 1128)
Peer-review: Externally peer-reviewed.
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