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Comparison of SARC-F, SARC-CalF, and Age-Augmented SARC-F for Detecting Probable Sarcopenia in Older Turkish Adults

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Abstract

Background

The EWGSOP2 algorithm begins with SARC-F case-finding and proceeds to grip strength measurement, which defines probable sarcopenia. SARC-F has low sensitivity, and SARC-CalF adds calf circumference to improve it. Whether this helps where obesity is common, and calf circumference reflects fat as well as muscle, is unclear. We compared SARC-F, SARC-CalF and an age-augmented SARC-F in older Turkish outpatients.

Methods

In this cross-sectional diagnostic accuracy study, 317 community-dwelling outpatients aged 65 years and older underwent SARC-F, calf circumference measurement and handgrip dynamometry at the same visit, so all received the reference standard regardless of screening result. Probable sarcopenia was defined by EWGSOP2 grip cut-offs (men < 27 kg, women < 16 kg). SARC-F was positive at 4 or more. SARC-CalF added 10 points for low calf circumference (men < 34 cm, women < 33 cm), and age-augmented SARC-F applied the same construction for age 70 years or older, both positive at 11 or more. Tools were compared with McNemar tests.

Results

Mean age was 70.9 (4.8) years, 60.3% were women and 52.4% had obesity. Probable sarcopenia affected 82 participants (25.9%). Sensitivity was 23.2% for SARC-F, 15.9% for SARC-CalF and 47.6% for age-augmented SARC-F (specificities 90.6%, 94.9% and 75.3%). Age-augmented SARC-F detected more cases than SARC-F (39 versus 19; P = 0.001) and SARC-CalF (39 versus 13; P < 0.001), with a larger area under the curve than SARC-F (difference 0.071; P = 0.022). SARC-CalF did not outperform SARC-F. Calf circumference correlated with body mass index (r = 0.648), and low calf circumference was much less common with obesity (4.2% versus 31.1%); SARC-CalF sensitivity fell to 5.7% with obesity, whereas age-augmented SARC-F retained 54.3%. A rule of SARC-F 4 or more or age 70 years or older reached 79.3% sensitivity.

Conclusions

Where obesity is common, SARC-CalF did not improve on SARC-F and performed poorly with obesity, because adiposity inflates calf circumference. Augmenting SARC-F with age was more effective and needed no extra measurement. Since grip dynamometry takes under a minute, direct strength testing, or at minimum testing all patients aged 70 years and older, is preferable to questionnaire-based case-finding.

Trial registration

Not applicable. This study is a cross-sectional diagnostic accuracy study and does not meet the ICMJE definition of a clinical trial; no prospective registration was required.

Background

Sarcopenia is a progressive skeletal muscle disorder associated with falls, functional decline and mortality. The revised European Working Group on Sarcopenia in Older People consensus (EWGSOP2) restructured its diagnosis into a stepwise pathway of case-finding, assessment of muscle strength, confirmation by muscle quantity and grading of severity by physical performance [1]. Low muscle strength alone defines probable sarcopenia, a stage at which EWGSOP2 recommends that management can begin without waiting for imaging-based confirmation [1]. Earlier work described age-related weakness disproportionate to muscle mass as dynapenia [16]; probable sarcopenia is the currently accepted operational term and is used throughout this report.

For the case-finding step, EWGSOP2 recommends the SARC-F questionnaire, a five-item self-reported instrument covering strength, walking assistance, rising from a chair, climbing stairs and falls [1–3]. SARC-F requires no equipment, but it was designed to capture the functional consequences of established sarcopenia rather than early weakness. Validation studies consistently report high specificity and low sensitivity: a score of 4 or more identified only 15% of participants with probable sarcopenia in the 1946 British birth cohort [5], 35% in a national validation against EWGSOP2 criteria [7], and a systematic review of SARC-F and its modified versions reached similar conclusions [6].

To improve sensitivity, Barbosa-Silva and colleagues proposed SARC-CalF, which adds calf circumference to the questionnaire as a surrogate marker of muscle mass, awarding 10 points when calf circumference falls below a sex-specific cut-off and defining a positive screen as a total of 11 or more [4]. SARC-CalF has since outperformed SARC-F in several populations [9, 10]. However, calf circumference reflects both muscle and subcutaneous fat. In populations where obesity is common, calf circumference may remain above the cut-off despite low muscle strength, which would blunt the advantage of SARC-CalF precisely where additional case-finding is most needed. Turkish older adults have a high prevalence of obesity and larger anthropometric measurements than the Brazilian and East Asian cohorts in which SARC-CalF was developed and validated [11], yet the tool has not been directly compared with SARC-F against a strength-based reference standard in this setting.

An alternative way to augment SARC-F is to use a variable that is universally available, requires no measurement and is strongly related to muscle strength, namely chronological age. Whether such an age-augmented instrument would outperform the anthropometric augmentation used by SARC-CalF has not been examined.

In our geriatric outpatient clinic, SARC-F, calf circumference and handgrip strength are recorded at the same visit in every patient, so the reference standard is available irrespective of the screening result. We

therefore compared the diagnostic accuracy of SARC-F, SARC-CalF and an age-augmented SARC-F for probable sarcopenia, and examined whether obesity modifies the performance of these tools.

Methods

Study design, setting and participants

This single-centre, cross-sectional diagnostic accuracy study was conducted in the geriatric outpatient clinic of the Division of Geriatrics, Department of Internal Medicine, Ankara University Faculty of Medicine, Ankara, Türkiye, between January 2025 and January 2026. Consecutive community-dwelling patients aged 65 years and older attending for comprehensive geriatric assessment were eligible. Participants were included when SARC-F, calf circumference and a valid handgrip measurement were all available at the same visit. Of 409 patients aged 65 years and older assessed during the study period, 89 lacked SARC-F or grip data and 2 lacked calf circumference; one further record with an out-of-range SARC-F value was excluded, leaving 317 participants for analysis. Reporting follows the STARD 2015 statement for diagnostic accuracy studies [17].

Index tests

SARC-F was administered by trained clinical staff before any strength or anthropometric measurement, and its result did not determine whether grip strength was measured. Each of the five items was scored 0 to 2, giving a total of 0 to 10, with 4 or more defining a positive screen as recommended by EWGSOP2 [1–3].

Calf circumference was measured with a non-stretch tape at the widest part of the right calf with the participant seated and the knee flexed at 90 degrees. SARC-CalF was calculated by adding 10 points to the SARC-F score when calf circumference was below the sex-specific cut-off of 34 cm for men and 33 cm for women, giving a range of 0 to 20, with a total of 11 or more defining a positive screen [4].

Age-augmented SARC-F was constructed identically to SARC-CalF so that the two augmentations were directly comparable: 10 points were added to the SARC-F score when the participant was aged 70 years or older, and a total of 11 or more defined a positive screen. A threshold of 75 years was also evaluated. Because this scoring requires a SARC-F score of at least 1, we additionally evaluated a simpler clinical rule in which a screen was positive if SARC-F was 4 or more or the participant was aged 70 years or older.

Reference standard

Maximal handgrip strength was measured with a hand dynamometer (Grip-D; Takei Scientific Instruments Co. Ltd., Niigata, Japan) with the participant seated, shoulder adducted, elbow flexed at 90 degrees and forearm in neutral position; the best of repeated attempts was recorded. Probable

sarcopenia was defined as low grip strength using EWGSOP2 cut-offs of less than 27 kg for men and less than 16 kg for women [1]. Because grip strength norms are population-dependent and higher cut-offs of less than 32 kg for men and less than 22 kg for women have been proposed for Turkish older adults, all analyses were repeated with these thresholds as a pre-specified sensitivity analysis [11]. Grip measurements were performed by staff who were not informed of the SARC-F result.

Other measurements

Height, weight, body mass index and mid-upper arm circumference were recorded, and obesity was defined as a body mass index of 30 kg/m2 or more. Usual 4-m gait speed was measured, with slow gait defined as less than 0.8 m/s. Comprehensive geriatric assessment included the Mini-Mental State Examination, the Geriatric Depression Scale, the Mini Nutritional Assessment Short Form, the FRAIL scale, the Lawton instrumental activities of daily living scale, the Katz activities of daily living index and fall risk assessment. Comorbidity was summarised with the Charlson Comorbidity Index and the number of regularly used medications was recorded.

Statistical analysis

Continuous variables are presented as mean (standard deviation) or median (interquartile range) according to distribution and compared with the independent samples t test or the Mann-Whitney U test; categorical variables are presented as n (%) and compared with the chi-square or Fisher exact test. For each index test we calculated sensitivity, specificity, positive and negative predictive values and overall accuracy, with 95% confidence intervals derived by the Wilson method, together with the number of cases missed. Discrimination of the underlying continuous scores was summarised by the area under the receiver operating characteristic curve with 95% confidence intervals from 2000 bootstrap resamples, and differences between areas were tested by bootstrap. Because all index tests were applied to the same participants, sensitivities were compared pairwise with the exact McNemar test restricted to participants with probable sarcopenia. Because the recommended SARC-CalF threshold of 11 or more can only be reached when a low calf circumference is accompanied by a SARC-F score of at least 1, we additionally examined, post hoc, a threshold of 10 or more, which corresponds to low calf circumference alone. Because the recommended SARC-CalF threshold of 11 or more can only be reached when a low calf circumference is accompanied by a SARC-F score of at least 1, we additionally examined, post hoc, a threshold of 10 or more, which corresponds to low calf circumference alone. Effect modification by obesity was examined by calculating sensitivity separately in participants with and without obesity. A two-sided P value below 0.05 was considered statistically significant. Analyses were performed in Python 3.12 with pandas, SciPy, statsmodels and scikit-learn. No large language model was used to generate or interpret the data.

Results

Participant characteristics

Of the 317 participants, 60.3% were women, mean age was 70.9 (4.8) years and mean body mass index was 30.9 (5.6) kg/m2; 52.4% met criteria for obesity. Mean calf circumference was 36.6 (3.5) cm and 17.0% had a calf circumference below the SARC-CalF cut-off. Probable sarcopenia was present in 82 participants (25.9%) by EWGSOP2 cut-offs. Participants with probable sarcopenia were older, had smaller calf and mid-upper arm circumferences, slower gait and greater instrumental activity limitation than those without (Table 1).

Diagnostic accuracy of the three tools

SARC-F identified 41 participants as screen positive, SARC-CalF 25 and age-augmented SARC-F 97. Against probable sarcopenia, sensitivity was 23.2% (15.4–33.4) for SARC-F, 15.9 (9.5–25.3)% for SARC-CalF and 47.6 (37.1–58.2)% for age-augmented SARC-F at a threshold of 70 years, with corresponding specificities of 90.6 (86.2–93.7)%, 94.9 (91.3–97.1)% and 75.3 (69.4–80.4)% (Table 2, Fig. 1). SARC-CalF missed 69 of the 82 cases, more than the 63 missed by SARC-F, whereas age-augmented SARC-F missed 43. Areas under the curve were 0.587 (0.515–0.655) for SARC-F, 0.635 (0.561–0.703) for SARC-CalF and 0.658 (0.592–0.724) for age-augmented SARC-F. The simple rule of SARC-F 4 or more or age 70 years or older achieved the highest sensitivity, 79.3 (69.3–86.6)%, at a specificity of 47.2 (40.9–53.6)%, and missed only 17 cases.

Pairwise comparisons

Among the 82 participants with probable sarcopenia, age-augmented SARC-F detected significantly more cases than SARC-F (39 versus 19; P = 0.001) and than SARC-CalF (39 versus 13; P < 0.001), and the simple age rule detected more than SARC-F (65 versus 19; P < 0.001). SARC-CalF detected fewer cases than SARC-F, but this difference was not statistically significant (13 versus 19; P = 0.286). Age-augmented SARC-F had a significantly larger area under the curve than SARC-F (difference 0.071; P = 0.022), whereas the differences between SARC-CalF and SARC-F and between SARC-CalF and age-augmented SARC-F were not significant (Table 3). Although SARC-CalF detected fewer cases than SARC-F at the recommended threshold, the area under the curve for the SARC-CalF score was numerically higher (0.635 versus 0.587; difference −0.048; P = 0.122), indicating that calf circumference carries discriminatory information that a threshold of 11 or more does not capture. In a post hoc analysis, lowering the threshold to 10 or more, equivalent to low calf circumference alone, increased sensitivity from 15.9% (95% CI 9.5–25.3) to 28.0% (95% CI 19.5–38.6) and reduced the number of missed cases from 69 to 59, at a specificity of 86.8% (95% CI 81.9–90.5). This remained well below the sensitivity of age-augmented SARC-F.

Effect of obesity on tool performance

Calf circumference was strongly correlated with body mass index (r = 0.648). Low calf circumference was present in only 4.2% of participants with obesity compared with 31.1% of those without (P < 0.001;

Fig. 2a). As a result, the performance of the three tools diverged sharply by obesity status (Table 4, Fig. 2b). In participants with obesity, SARC-CalF identified only 5.7% of cases, compared with 34.3% for SARC-F and 54.3% for age-augmented SARC-F. In participants without obesity the pattern reversed for the questionnaire-based tools: SARC-CalF sensitivity was 23.4% while SARC-F fell to 14.9%. Age-augmented SARC-F was the only instrument that retained a sensitivity above 40% in both subgroups.

Sensitivity analysis with population-specific grip cut-offs

Using the higher grip thresholds proposed for Turkish older adults, the prevalence of probable sarcopenia rose to 200 of 317 participants (63.1%). All tools showed lower sensitivity, but the ordering was unchanged: 17.0% for SARC-F, 12.5% for SARC-CalF and 37.5% for age-augmented SARC-F, with the simple age rule reaching 67.5% (Table 5). SARC-CalF again did not improve on SARC-F.

Discussion

In this cohort of older Turkish outpatients, in whom SARC-F, calf circumference and grip strength were all measured at the same visit, three findings stand out. First, SARC-F identified fewer than one quarter of participants with probable sarcopenia. Second, SARC-CalF did not improve on SARC-F and numerically detected fewer cases, in contrast to reports from other populations. Third, augmenting SARC-F with age rather than with calf circumference significantly increased case detection without any additional measurement.

Our SARC-F estimates are consistent with the published range. Dodds and colleagues reported a sensitivity of 15% for a score of 4 or more in the 1946 British birth cohort [5], a national validation reported 35% against EWGSOP2 criteria [7], and a meta-analysis of SARC-F and its modified versions concluded that the instrument is better at ruling sarcopenia out than at finding cases [6]. Turkish data have likewise shown limited performance of SARC-F against functional and mass-based definitions [8].

The failure of SARC-CalF in this setting is the most clinically important finding, and its mechanism is straightforward. Calf circumference is a composite of muscle and subcutaneous fat, and in our sample it correlated strongly with body mass index ($r = 0.648$). Because more than half of participants had obesity, only 17.0% fell below the SARC-CalF cut-off, and among participants with obesity the figure was 4.2%. The 10-point calf component therefore almost never triggered in exactly the group in which weakness is common, and SARC-CalF sensitivity collapsed to 5.7% in participants with obesity. Importantly, the problem lies with the threshold rather than with calf circumference as such. The SARC-CalF score discriminated slightly better than SARC-F overall, and lowering the threshold to 10 or more, which corresponds to low calf circumference alone, almost doubled sensitivity to 28.0%. Because a total of 11 or more requires a low calf circumference and a SARC-F score of at least 1 to coincide, the published cut-point is poorly calibrated for a population in which low calf circumference is uncommon. Calf circumference therefore still carries information in this setting, but even at its best-performing threshold it did not approach the sensitivity achieved by age augmentation. The studies in which SARC-CalF outperformed SARC-F were conducted in Brazilian and Japanese populations with substantially smaller

body habitus [4, 9, 10]. Our data suggest that the incremental value of SARC-CalF is conditional on the adiposity distribution of the target population and cannot be assumed in populations where obesity is prevalent. This is consistent with wider concerns that anthropometric and mass-based markers of sarcopenia lose validity in obesity, which underpins the separate diagnostic framework for sarcopenic obesity [14, 15].

Notably, SARC-F and SARC-CalF failed in opposite subgroups. SARC-F performed better in participants with obesity (34.3% versus 14.9%), plausibly because its items capture mobility difficulty, which in this population is frequently driven by excess weight and osteoarthritis rather than by weakness alone. SARC-CalF performed better in participants without obesity, where calf circumference genuinely tracks muscle mass. Age augmentation was the only strategy that worked in both subgroups, because chronological age is related to muscle strength independently of body composition and is not distorted by adiposity.

These findings have a direct practical implication. Age requires no measurement, no equipment and no literacy, and is already known for every patient. Augmenting SARC-F with age is therefore free, whereas adding calf circumference requires a tape measure and, in this population, adds nothing. More fundamentally, grip dynamometry itself takes under a minute and directly establishes probable sarcopenia rather than estimating the probability of it. Given that the best questionnaire-based strategy still missed roughly one fifth of cases, and that grip strength carries independent prognostic information for disability and mortality beyond sarcopenia case-finding [12, 13], the most defensible approach in a geriatric clinic equipped with a dynamometer is to measure grip strength in all patients aged 65 years and older. Where resources or time are constrained, our data support testing every patient aged 70 years and older regardless of symptoms.

Strengths and limitations

The principal strength is that every participant underwent the reference standard irrespective of the screening result, so the estimates are not affected by the partial verification bias that arises when only screen-positive patients proceed to confirmatory testing. All three index tests were applied to the same individuals, permitting paired statistical comparison, and reporting follows STARD [17]. Several limitations should be noted. The study was conducted in a single geriatric outpatient clinic, and the high prevalence of obesity in this sample, while central to our findings, limits generalisability to leaner populations. The design is cross-sectional and cannot demonstrate that improved case-finding changes outcomes. We assessed probable rather than confirmed sarcopenia, since appendicular muscle mass by dual-energy X-ray absorptiometry was not available. SARC-F was administered by clinical staff rather than self-completed, which may differ from routine practice. Of 409 eligible patients, 92 were excluded for missing data, which may have introduced selection bias. Finally, the age threshold used for augmentation was derived and evaluated in the same sample, and the age-augmented instrument requires external validation before it can be recommended for general use. The alternative SARC-CalF threshold was examined post hoc and would itself require validation.

Conclusions

In older Turkish outpatients with a high prevalence of obesity, SARC-CalF did not improve upon SARC-F for detecting probable sarcopenia and performed particularly poorly in participants with obesity, because adiposity keeps calf circumference above the diagnostic cut-off. Augmenting SARC-F with chronological age was significantly more effective, required no additional measurement and was the only strategy that maintained sensitivity in both obese and non-obese participants. Because all questionnaire-based strategies still missed a substantial proportion of cases, direct measurement of handgrip strength in all older outpatients, or at minimum in all patients aged 70 years and older, is the more reliable entry point to the EWGSOP2 pathway in this population.

Abbreviations

ADL: activities of daily living; AUC: area under the receiver operating characteristic curve; BMI: body mass index; CI: confidence interval; EWGSOP2: European Working Group on Sarcopenia in Older People, second consensus; GDS: Geriatric Depression Scale; IADL: instrumental activities of daily living; MMSE: Mini-Mental State Examination; MNA-SF: Mini Nutritional Assessment Short Form; NPV: negative predictive value; PPV: positive predictive value; SARC-F: Strength, Assistance with walking, Rising from a chair, Climbing stairs and Falls questionnaire; SARC-CalF: SARC-F combined with calf circumference; STARD: Standards for Reporting of Diagnostic Accuracy Studies.

Declarations

Ethics approval and consent to participate

The study was conducted in accordance with the principles of the Declaration of Helsinki. Ethical approval for this study was obtained from the Ankara University Faculty of Medicine Human Research Ethics Committee (Approval number: İ10-785-24, Date: 21 November 2024). Informed consent was obtained from all subjects and/or their legal guardian(s).

Trial registration

Not applicable. This study is a cross-sectional diagnostic accuracy study and does not meet the ICMJE definition of a clinical trial; no prospective registration was required.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

VA and AY contributed to the conception and design of the study. ZES, HY, AAG, and OG were responsible for the acquisition of data. MGG performed the biostatistical analysis. MGG, VA, and AY contributed to the interpretation of the data. VA and ZES drafted the manuscript. HY, AAG, OG, and MGG substantively revised the work for important intellectual content. All authors read and approved the final manuscript, and agreed to be personally accountable for their own contributions and to ensure that questions related to the accuracy or integrity of any part of the work are appropriately investigated, resolved, and documented.

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Tables

Table 1 Characteristics of participants overall and by probable sarcopenia status

Characteristic	All participants (n = 317)	No probable sarcopenia (n = 235)	Probable sarcopenia (n = 82)	P value
Age (years)	70.9 (4.8)	70.0 (4.1)	73.2 (5.7)	< 0.001
Body mass index (kg/m2)	30.9 (5.6)	31.3 (5.4)	29.9 (6.1)	0.069
Calf circumference (cm)	36.6 (3.5)	36.9 (3.5)	35.7 (3.6)	0.007
Mid-upper arm circumference (cm)	29.5 (27.5-31.0)	30.0 (28.0-31.8)	28.8 (27.0-30.5)	0.043
Handgrip strength (kg)	23.9 (8.1)	26.1 (7.7)	17.6 (5.4)	< 0.001
Gait speed (m/s)	0.8 (0.2)	0.8 (0.2)	0.7 (0.2)	< 0.001
Charlson Comorbidity Index	3.3 (1.4)	3.2 (1.3)	3.7 (1.4)	0.004
Number of medications	2.5 (2.1)	2.6 (2.2)	2.2 (1.9)	0.319
SARC-F score	1.0 (0.0-2.0)	0.0 (0.0-1.5)	1.0 (0.0-2.8)	0.012
MMSE score	25.4 (3.1)	25.7 (3.0)	24.7 (3.2)	0.016
GDS score	1.0 (0.0-5.0)	1.0 (0.0-4.0)	2.5 (0.0-6.0)	0.019
MNA-SF score	14.0 (13.0-14.0)	14.0 (13.0-14.0)	14.0 (13.0-14.0)	0.280
Lawton IADL score	8.0 (8.0-8.0)	8.0 (8.0-8.0)	8.0 (7.0-8.0)	< 0.001
Katz ADL score	6.0 (5.0-6.0)	6.0 (5.0-6.0)	6.0 (5.0-6.0)	0.085
FRAIL score	0.0 (0.0-1.0)	0.0 (0.0-1.0)	1.0 (0.0-2.0)	0.017
Male sex	126 (39.7)	88 (37.4)	38 (46.3)	0.198
Obesity (BMI >= 30 kg/m2)	166 (52.4)	131 (55.7)	35 (42.7)	0.056
Low calf circumference	54 (17.0)	31 (13.2)	23 (28.0)	0.004
Slow gait (< 0.8 m/s)	183 (57.7)	129 (54.9)	54 (65.9)	0.110
Living alone	54 (17.5)	36 (15.9)	18 (22.0)	0.290
Widowed	77 (24.8)	52 (22.7)	25 (30.9)	0.190
Literate	253 (81.1)	195 (84.8)	58 (70.7)	0.009

Characteristic	All participants (n = 317)	No probable sarcopenia (n = 235)	Probable sarcopenia (n = 82)	P value
Diabetes mellitus	92 (29.4)	68 (29.2)	24 (30.0)	1.000
Hypertension	193 (61.7)	153 (65.7)	40 (50.0)	0.019
High fall risk	240 (76.4)	173 (73.9)	67 (83.8)	0.102

Data are mean (standard deviation), median (interquartile range) or n (%). Probable sarcopenia was defined as low handgrip strength using EWGSOP2 cut-offs (men < 27 kg, women < 16 kg). Low calf circumference was defined as < 34 cm in men and < 33 cm in women. BMI body mass index, GDS Geriatric Depression Scale, IADL instrumental activities of daily living, ADL activities of daily living, MMSE Mini-Mental State Examination, MNA-SF Mini Nutritional Assessment Short Form. Living alone n=308, MMSE n=299, MNA-SF n=305, Widowed n=310. Percentages are based on available data; n varies from 299 to 317 owing to missing values.

Table 2 Diagnostic accuracy of SARC-F, SARC-CalF and age-augmented SARC-F for probable sarcopenia

Screening tool	Screen positive, n (%)	Sensitivity % (95% CI)	Specificity % (95% CI)	PPV % (95% CI)	NPV % (95% CI)	AUC (95% CI)	Missed, n
SARC-F ≥4	41 (12.9)	23.2 (15.4–33.4)	90.6 (86.2–93.7)	46.3 (32.1–61.3)	77.2 (71.9–81.7)	0.587 (0.515–0.655)	63
SARC-CalF ≥11	25 (7.9)	15.9 (9.5–25.3)	94.9 (91.3–97.1)	52.0 (33.5–70.0)	76.4 (71.2–80.9)	0.635 (0.561–0.703)	69
SARC-F+Age ≥11 (≥70 years)	97 (30.6)	47.6 (37.1–58.2)	75.3 (69.4–80.4)	40.2 (31.0–50.2)	80.5 (74.7–85.2)	0.658 (0.592–0.724)	43
SARC-F+Age ≥11 (≥75 years)	43 (13.6)	30.5 (21.6–41.1)	92.3 (88.2–95.1)	58.1 (43.3–71.6)	79.2 (74.0–83.6)	0.637 (0.562–0.705)	57
SARC-F ≥4 or age ≥70 years	189 (59.6)	79.3 (69.3–86.6)	47.2 (40.9–53.6)	34.4 (28.0–41.4)	86.7 (79.8–91.5)	–	17
SARC-CalF ≥10 (post hoc)	54 (17.0)	28.0 (19.5–38.6)	86.8 (81.9–90.5)	42.6 (30.3–55.8)	77.6 (72.1–82.2)	0.635	59

Reference standard: low handgrip strength by EWGSOP2 cut-offs (n = 82 of 317). Confidence intervals for proportions were calculated by the Wilson method and for the area under the curve by bootstrap resampling. The area under the curve is not applicable to the composite rule in the final row, which is a

binary rule rather than a score. AUC area under the receiver operating characteristic curve, CI confidence interval, NPV negative predictive value, PPV positive predictive value.

Table 3 Pairwise comparison of case detection and discrimination between screening tools

Comparison	Cases detected (n of 82)	P value
SARC-F vs SARC-CalF	19 vs 13	0.286
SARC-F vs SARC-F+Age70	19 vs 39	<0.001
SARC-CalF vs SARC-F+Age70	13 vs 39	<0.001
SARC-F vs OR-rule(age70)	19 vs 65	<0.001

P values are from the exact McNemar test restricted to the 82 participants with probable sarcopenia; the second column shows the number of cases detected by each tool.

AUC comparison	Difference in AUC	P value
SARC-F+Age vs SARC-F	+0.071	0.022
SARC-F+Age vs SARC-CalF	+0.023	0.568
SARC-F vs SARC-CalF	-0.048	0.122

Differences in the area under the receiver operating characteristic curve with P values from 2000 bootstrap resamples. A positive difference favours the first-named tool.

Table 4 Sensitivity of each screening tool by obesity status

Screening tool	Sensitivity in participants with obesity % (95% CI)	Sensitivity in participants without obesity % (95% CI)
SARC-F	34.3 (20.8–50.8)	14.9 (7.4–27.7)
SARC-CalF	5.7 (1.6–18.6)	23.4 (13.6–37.2)
SARC-F+Age70	54.3 (38.2–69.5)	42.6 (29.5–56.7)

Obesity was defined as a body mass index of 30 kg/m2 or more. Values are sensitivity for probable sarcopenia with 95% Wilson confidence intervals. SARC-F+Age70 adds 10 points for age 70 years or older with a positive screen at 11 or more.

Table 5 Diagnostic accuracy using population-specific handgrip cut-offs (sensitivity analysis)

Screening tool	Screen positive, n (%)	Sensitivity % (95% CI)	Specificity % (95% CI)	PPV % (95% CI)	NPV % (95% CI)	AUC (95% CI)	Missed, n
SARC-F ≥4	41 (12.9)	17.0 (12.4–22.8)	94.0 (88.2–97.1)	82.9 (68.7–91.5)	39.9 (34.3–45.7)	0.607 (0.546–0.664)	166
SARC-CalF ≥11	25 (7.9)	12.5 (8.6–17.8)	100.0 (96.8–100.0)	100.0 (86.7–100.0)	40.1 (34.6–45.8)	0.624 (0.567–0.684)	175
SARC-F+Age ≥11 (≥70 years)	97 (30.6)	37.5 (31.1–44.4)	81.2 (73.2–87.2)	77.3 (68.0–84.5)	43.2 (36.8–49.8)	0.645 (0.584–0.702)	125
SARC-F+Age ≥11 (≥75 years)	43 (13.6)	18.0 (13.3–23.9)	94.0 (88.2–97.1)	83.7 (70.0–91.9)	40.1 (34.5–46.0)	0.635 (0.576–0.696)	164
SARC-F ≥4 or age ≥70 years	189 (59.6)	67.5 (60.7–73.6)	53.8 (44.8–62.6)	71.4 (64.6–77.4)	49.2 (40.7–57.8)	–	65

Reference standard: low handgrip strength using cut-offs proposed for Turkish older adults (men < 32 kg, women < 22 kg; n = 200 of 317). Abbreviations as in Table 2.

Figures

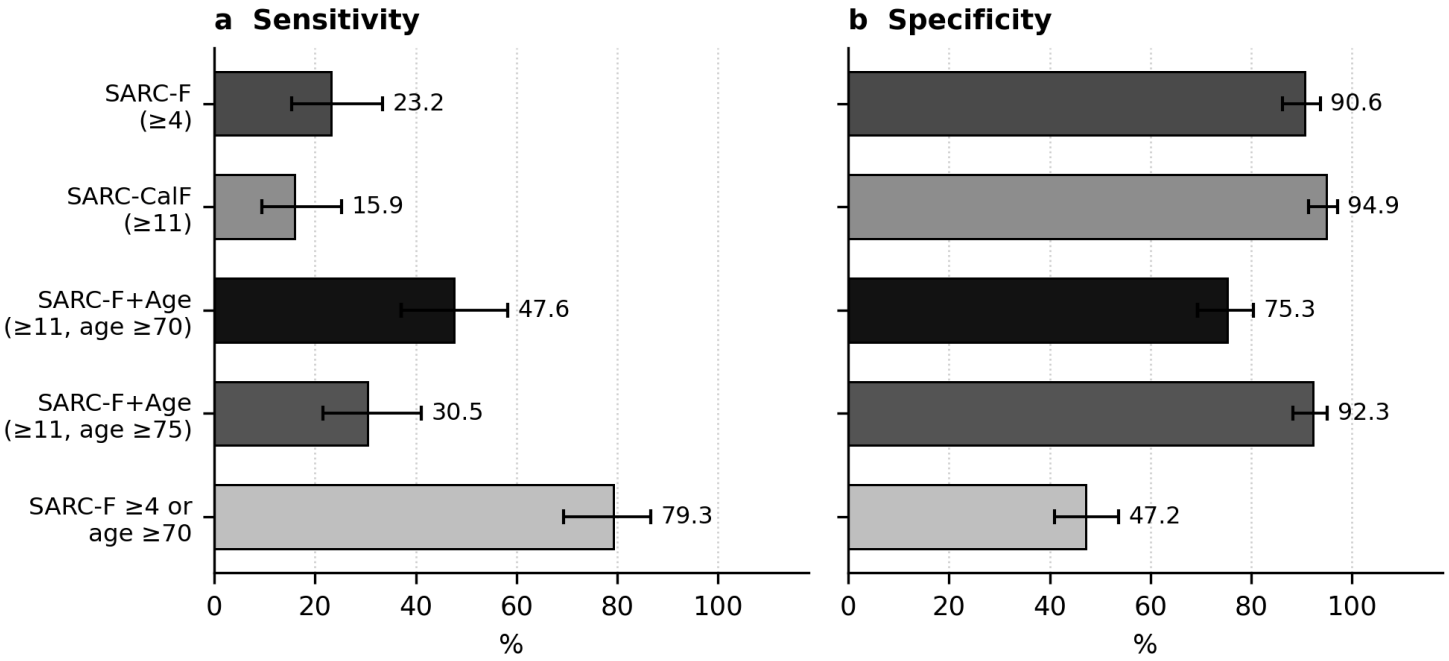


Figure 1

Diagnostic accuracy of the three screening strategies for probable sarcopenia

Sensitivity (a) and specificity (b) of each screening strategy against low handgrip strength defined by EWGSOP2 cut-offs, in 317 outpatients aged 65 years and older. Error bars are 95% confidence intervals calculated by the Wilson method. Numbers beside each bar are point estimates. SARC-F+Age applies the SARC-CalF scoring construction, adding 10 points for age at or above the stated threshold, with a positive screen at 11 or more.

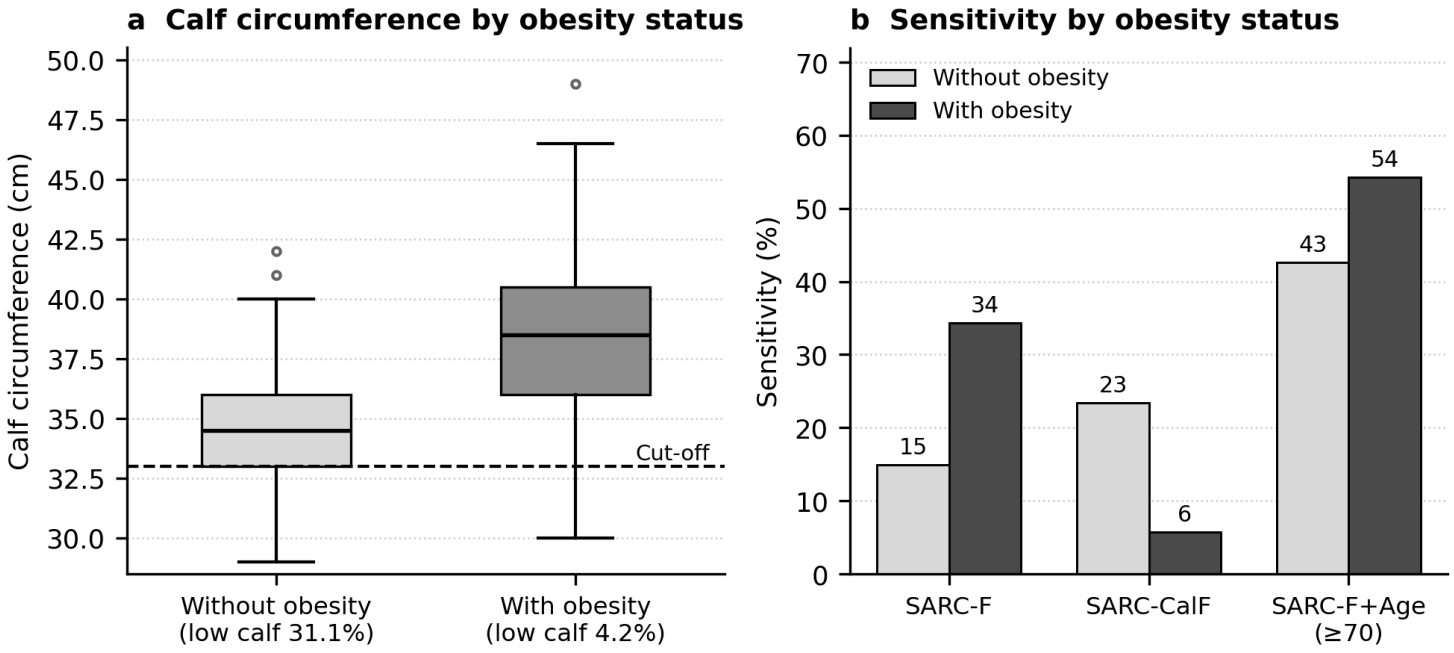


Figure 2

Effect of obesity on calf circumference and on screening tool sensitivity

Panel a shows calf circumference in participants with and without obesity, defined as a body mass index of 30 kg/m2 or more; the dashed line marks the SARC-CalF cut-off (34 cm for men, 33 cm for women; 33 cm shown for reference). Boxes show the median and interquartile range, whiskers extend to 1.5 times the interquartile range, and circles are values beyond that range. Panel b shows the sensitivity of each tool for probable sarcopenia within each subgroup. SARC-CalF sensitivity falls to 5.7% in participants with obesity, whereas age-augmented SARC-F remains above 40% in both subgroups.