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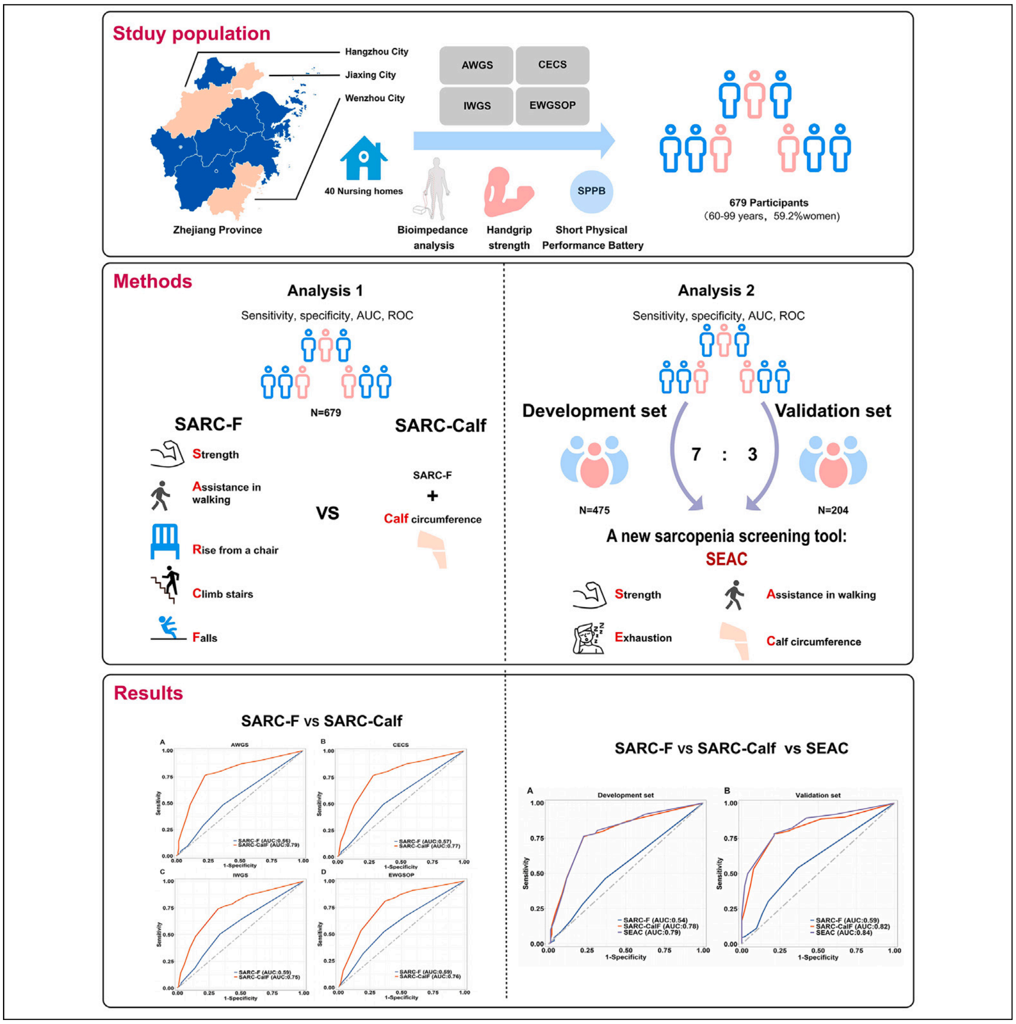

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Highlights

SARC-CalF exhibits superior diagnostic accuracy and sensitivity compared to SARC-F

The 4-item SEAC is optimal for sarcopenia screening in nursing home residents

SEAC shows promise in improving early detection and management of sarcopenia

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Development and validation of a screening tool for sarcopenia in Chinese nursing home residents

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SUMMARY

Sarcopenia, characterized by the loss of muscle mass and function, is a critical health issue in nursing home residents. Given the high prevalence of sarcopenia in care settings, effective screening is crucial. This study compared the diagnostic accuracy of two conventional sarcopenia screening tools, SARC-F and SARC-CalF, and developed an alternative tool, SEAC, specifically for nursing home residents. In a sample of 679 older adults from Zhejiang Province, SARC-CalF exhibited better sensitivity and diagnostic accuracy compared to SARC-F. The SEAC tool, incorporating strength, exhaustion, assistance in walking, and calf circumference, demonstrated the highest diagnostic accuracy and sensitivity among the three screening tools. These findings suggest that SEAC could serve as a valuable tool for large-scale sarcopenia screening in nursing homes, potentially improving early detection and management of sarcopenia in this vulnerable population.

INTRODUCTION

The last two decades have seen a growing interest in the role of sarcopenia, an independent condition with an International Classification of Diseases-10 code nowadays that inhibits active and healthy aging.[1,2] Sarcopenia is an age-related, progressive skeletal muscle disorder characterized by the accelerated loss of muscle mass and function.[3,4] It was estimated that 10%–16% of the older adults worldwide were influenced by sarcopenia.[5] Specifically, the prevalence of sarcopenia was 37% in hospitalized older patients, 41%–59% in older nursing home residents, and 9.9%–40.4% in community-dwelling older adults.[6–8] Sarcopenia is associated with a high risk of a wide range of adverse health outcomes, such as falls, functional decline, physical disability, frailty, cognitive impairment, metabolic disorders, and mortality.[3,5,9,10] The updated international clinical practice guidelines for sarcopenia state that people aged 65 and older should be screened for skeletal muscle reduction every year or after major health events.[11] Screening is particularly relevant in care settings where a higher prevalence of sarcopenia might be expected.[8,12]

According to the operational definition of Asian Working Group for Sarcopenia (AWGS),[13] the diagnosis of sarcopenia is based on the measurement of muscle mass, handgrip strength, and/or physical performance. These evaluations require specialized equipment and trained operators, making them expensive, time-consuming, and sometimes inaccessible for older adults in nursing homes.[14] Common methods for sarcopenia screening include the SARC-F (strength, assistance with walking, rise from a chair, climb stairs, and falls) questionnaire[15] and SARC-CalF (SARC-F combined with calf circumference).[16] Studies reported that both SARC-F and SARC-CalF had low to moderate sensitivity,[17,18] indicating a high risk of missed diagnosis of individuals with sarcopenia.[19] The accuracy of SARC-F and SARC-CalF in community-dwelling older adults has been investigated in many studies.[17,20–22] However, studies were scarce regarding whether these sarcopenia screening tools are suitable for nursing home residents[23,24]; otherwise, an alternative screening tool might be needed.

This study was thus aimed to compare the accuracy of SARC-F and SARC-CalF for screening sarcopenia in Chinese nursing home residents. Then, we developed and validated an alternative sarcopenia screening tool, incorporating strength, exhaustion, assistance in walking, and calf circumference (SEAC), to overcome the weakness of these two tools.

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Table 1. Basic characteristics of the total sample and by sex

Characteristics	Total (n = 679)	Men (n = 277)	Women (n = 402)	p
Age (years)	82.9 (7.0)	81.0 (7.8)	84.2 (6.0)	<0.001
Body height (cm)	152.8 (8.2)	158.9 (7.3)	148.6 (5.7)	<0.001
Body weight (kg)	55.6 (9.9)	60.0 (10.3)	52.5 (8.3)	<0.001
BMI (kg/m^2)	23.8 (3.6)	23.8 (3.7)	23.8 (3.5)	0.995
WHR	0.9 (0.1)	0.9 (0.1)	0.9 (0.1)	0.007
CC (cm)	32.8 (3.5)	33.7 (3.7)	32.1 (3.2)	<0.001
BFM (kg)	19.2 (6.6)	19.2 (7.1)	19.3 (6.3)	0.872
ASM_LL (kg)	4.9 (1.5)	6.0 (1.3)	4.1 (1.0)	<0.001
ASM_RL (kg)	5.0 (1.5)	6.1 (1.4)	4.2 (1.0)	<0.001
ASM_LA (kg)	1.6 (0.5)	2.0 (0.5)	1.4 (0.4)	<0.001
ASM_RA (kg)	1.65 (0.54)	2.0 (0.5)	1.4 (0.4)	<0.001
SMI (kg/m^2)	5.5 (1.2)	6.3 (1.0)	5.0 (0.9)	<0.001
HGS (kg)	20.7 (9.2)	26.5 (8.8)	16.7 (7.0)	<0.001
GS (m/s)	0.7 (0.3)	0.7 (0.3)	0.7(0.3)	0.006
5-time chair stand test (s)	17.4 (6.7)	16.8 (5.9)	17.9 (7.1)	0.029
SPPB score	6.8 (3.0)	7.2 (2.9)	6.6 (3.1)	0.007
Self-reported diseases, yes[a]	–	–	–	–
Hypertension	435 (64.1)	170 (61.4)	265 (65.9)	0.257
Diabetes	150 (22.1)	63 (22.7)	87 (21.6)	0.806
Cancer	27 (4.0)	11 (4.0)	16 (4.0)	1.000
Medication use, yes	577 (85.0)	238 (85.9)	339 (84.3)	0.645
Strength[a]	–	–	–	<0.001
None	431 (63.5)	198 (71.5)	233 (58.0)	–
Some	74 (10.9)	29 (10.5)	45 (11.2)	–
A lot or unable	174 (25.6)	50 (18.1)	124 (30.8)	–
Assistance in walking[a]	–	–	–	0.709
None	613 (90.3)	253 (91.3)	360 (89.6)	–
Some	48 (7.1)	18 (6.5)	30 (7.5)	–
A lot or unable	18 (2.7)	6 (2.2)	12 (3.0)	–
Climb stairs[a]	–	–	–	0.442
None	430 (63.3)	181 (65.3)	249 (61.9)	–
Some	118 (17.4)	42 (15.2)	76 (18.9)	–
A lot or unable	131 (19.3)	54 (19.5)	77 (19.2)	–
Rise from a chair[a]	–	–	–	0.984
None	598 (88.1)	244 (88.1)	354 (88.1)	–
Some	63 (9.3)	26 (9.4)	37 (9.2)	–
A lot or unable	18 (2.7)	7 (2.5)	11 (2.7)	–
Health status[a]	–	–	–	0.150
Excellent/Good	402 (59.2)	153 (55.2)	249 (61.9)	–
Fair	153 (22.5)	65 (23.5)	88 (21.9)	–
Poor/Very poor	124 (18.3)	59 (21.3)	65 (16.2)	–
Falls[a]	–	–	–	0.980
None	542 (79.8)	221 (79.8)	321 (79.9)	–
1-3 falls	116 (17.1)	47 (17.0)	69 (17.2)	–
4 or more falls	21 (3.1)	9 (3.2)	12 (3.0)	–

(*Continued on next page*)

Table 1. *Continued*

Characteristics	Total (*n* = 679)	Men (*n* = 277)	Women (*n* = 402)	*p*
Exhaustion1[a]	–	–	–	0.008
None	408 (60.1)	172 (62.1)	236 (58.7)	–
1-2 days	108 (15.9)	30 (10.8)	78 (19.4)	–
3 or more days	163 (24.0)	75 (27.1)	88 (21.9)	–
Exhaustion2[a]	–	–	–	0.242
None	435 (64.1)	179 (64.6)	256 (63.7)	–
1-2 days	118 (17.4)	41 (14.8)	77 (19.2)	–
3 or more days	126 (18.6)	57 (20.6)	69 (17.2)	–
SARC-F score[b]	1.0 (0.0, 3.0)	1.0 (0.0, 2.0)	1.5 (0.0, 3.0)	0.008
SARC-CalF score[b]	10.0 (2.0, 12.0)	10.0 (1.0, 11.0)	10.0 (2.0, 12.0)	0.024
SEAC score[b]	7.0 (3.0,9.0)	7.0 (2.0,9.0)	7.0 (3.0,9.0)	0.005
Sarcopenia by different criteria[a]	–	–	–	–
SARC-F	117 (17.2)	44 (15.9)	73 (18.2)	0.504
SARC-CalF	259 (38.1)	89 (32.1)	170 (42.3)	0.009
SEAC	424 (62.4)	165 (59.6)	259 (64.4)	0.228
AWGS	491 (72.3)	195 (70.4)	296 (73.6)	0.402
CECS	468 (68.9)	183 (66.1)	285 (70.9)	0.210
IWGS	476 (70.1)	198 (71.5)	278 (69.2)	0.572
EWGSOP	388 (57.1)	159 (57.4)	229 (57.0)	0.973

Notes: Data are expressed as mean (standard deviation) unless stated otherwise. BMI, body mass index; WHR, waist-to-hip ratio; CC, calf circumference; BFM, body fat mass; ASM_LL, appendicular skeletal muscle mass of left leg; ASM_RL, appendicular skeletal muscle mass of right leg; ASM_LA, appendicular skeletal muscle mass of left arm; ASM_RA, appendicular skeletal muscle mass of right arm; SMI, skeletal muscle index; GS, gait speed; HGS, handgrip strength; SPPB, short physical performance battery; AWGS, Asian Working Group for Sarcopenia; CECS, Chinese expert consensus on prevention and intervention for older people with sarcopenia; IWGS, International Working Group on Sarcopenia; EWGSOP, European Working Group on Sarcopenia in Older People.
[a]Data are presented as *n* (%).
[b]Data are presented as median (interquartile range).

RESULTS

Characteristics of participants

The final sample comprised 679 participants aged 60–99 years. First, the total sample was used for the comparison analysis (analysis 1). Then, the participants were randomly assigned into development (analytic sample 2, $n = 475$) and validation set (analytic sample 3, $n = 204$) in a ratio of 7 to 3, for the development and validation analysis (analysis 2), respectively. Table 1 presents the characteristics of the study population stratified by sex. The mean age of 679 participants was 82.9 (standard deviation [SD] = 7.0) years, with a higher proportion of women (59.2%) in the sample. Women were significantly older than men (mean age: 84.2 vs. 81.0, $p < 0.001$). Compared to women, men had significantly larger calf circumference (CC), handgrip strength (HGS), gait speed (GS), waist-to-hip ratio (WHR), and skeletal muscle index. Table S1 shows that the basic characteristics of the development and validation sets were not significantly different.

Prevalence of sarcopenia

Table 1 shows the prevalence of sarcopenia in the total sample, men, and women by different criteria. The median scores for SARC-F, SARC-CalF, and SEAC were respectively 1, 10, and 7 in the total sample. The prevalence of sarcopenia according to SARC-F, SARC-CalF, and SEAC were respectively 17.2%, 38.1%, and 62.4% in the total sample. However, the prevalence of sarcopenia ranged from 57.1% to 72.3% by the AWGS, the Chinese expert consensus on prevention and intervention for older people with sarcopenia (CECS), the International Working Group on Sarcopenia (IWGS), and the revised European Working Group on Sarcopenia in Older People (EWGSOP) criteria.

Comparison of SARC-F and SARC-CalF in the total sample

Table 2 shows the sensitivities, specificities, and the area under the receiver-operating characteristics curves (AUCs) of SARC-F and SARC-CalF by different diagnostic criteria for sarcopenia in the total sample. Regardless of the reference standards, SARC-CalF showed a similar specificity to but a higher sensitivity than that of SARC-F. For example, according to the AWGS criteria, the specificities of SARC-F and SARC-CalF were respectively 85.6% and 89.4%, but their sensitivities were respectively 18.3% and 48.7%.

Table 2. Sensitivity/specificity analyses and receiver-operating curve models for SARC-F and SARC-CalF validation against different reference criteria in the total sample (*N* = 679)

	Sensitivity (%)	Specificity (%)	PLR	NLR	Cutoff point	AUC
AWGS	–	–	–	–	–	–
SARC-F	18.3 (15.0–22.0)	85.6 (79.8–90.3)	1.3 (0.9–1.9)	1.0 (0.9–1.0)	≥4	0.56 (0.51–0.61)[a]
SARC-CalF	48.7 (44.2–53.2)	89.4 (84.0–93.4)	4.6 (3.0–7.0)	0.6 (0.5–0.6)	≥11	0.79 (0.76–0.83)
CECS	–	–	–	–	–	–
SARC-F	18.6 (15.2–22.4)	85.8 (80.3–90.2)	1.3 (0.9–1.9)	0.9 (0.9–1.0)	≥4	0.57 (0.52–0.61)[a]
SARC-CalF	49.4 (44.7–54.0)	86.7 (81.4–90.1)	3.7 (2.6–5.3)	0.6 (0.5–0.6)	≥11	0.77 (0.73–0.81)
IWGS	–	–	–	–	–	–
SARC-F	18.7 (15.3–22.5)	86.2 (80.7–90.6)	1.4 (0.9–2.0)	0.9 (0.9–1.0)	≥4	0.59 (0.54–0.63)[a]
SARC-CalF	48.3 (43.7–52.9)	85.7 (80.1–90.2)	3.4 (2.4–4.8)	0.6 (0.5–0.7)	≥11	0.75 (0.71–0.79)
EWGSOP	–	–	–	–	–	–
SARC-F	20.4 (16.5–24.7)	86.9 (82.5–90.6)	1.6 (1.1–2.2)	0.9 (0.9–1.0)	≥4	0.59 (0.55–0.63)[a]
SARC-CalF	53.4 (48.2–58.4)	82.1 (77.2–86.4)	3.0 (2.3, 3.9)	0.6 (0.5–0.6)	≥11	0.76 (0.72, 0.80)

Notes: AWGS, Asian Working Group for Sarcopenia; CECS, Chinese expert consensus on prevention and intervention for older people with sarcopenia; IWGS, International Working Group on Sarcopenia; EWGSOP, European Working Group on Sarcopenia in Older People; PLR, positive likelihood ratio; NLR, negative likelihood ratio; AUC, area under the receiver-operating characteristic curve.
Data are presented with the 95% CI in parentheses.
[a]Significantly different with SARC-CalF ($p < 0.05$).

The receiver operating characteristic (ROC) curves of SARC-F and SARC-CalF against different reference standards in the total sample are depicted in Figure 1. Regardless of the reference standards, SARC-CalF had a larger AUC (ranged from 0.75 to 0.79) than that of SARC-F (0.56–0.59). For example, by the AWGS criteria, the AUCs for SARC-CalF and SARC-F were respectively 0.79 (95% confidence interval [CI] 0.76–0.83) and 0.56 (95% CI 0.51–0.61), significantly different from one another ($p < 0.001$).

Comparison of SARC-F, SARC-CalF, and SEAC in the development and validation sets

Table 3 and Table 4 present the sensitivities, specificities, and AUCs of SARC-F, SARC-CalF, and SEAC by different reference standards in the development and validation sets. In the development set, an optimal statistical cutoff of the SEAC was achieved at 6 against different reference standards (sensitivity: 73.7%–79.4%; specificity: 60.1%–77.2%). In the validation set, the sensitivity of SEAC ranged from 75.0% to 84.3%, and the specificity ranged from 67.5% to 79.0%. Regardless of the reference standards, SEAC had the highest sensitivity among the three tools. The AUC of SEAC was moderate (0.74–0.79) in the development set and moderate to high (0.80–0.84) in the validation set. Regardless of the reference standards, SEAC had the largest AUC among the three tools. Figure 2 shows the ROC curves of SARC-F, SARC-CalF, and SEAC in the development set and validation set based on AWGS diagnostic criteria. As demonstrated in Table S2, regardless of age, SEAC showed larger AUC compared with SARC-F and SARC-CalF. The sensitivity of SEAC was the highest among these three screening tools.

Inter-rater reliability and test-retest reliability of SEAC

Tables S3 and S4 present the inter-rater reliability and test-retest reliability of SEAC. The intraclass correlation coefficients were respectively 0.901 (95% CI: 0.792–0.954) and 0.952 (95% CI: 0.892–0.979).

DISCUSSION

The findings of our study indicated that SARC-CalF had higher sensitivity but similar specificity compared with SARC-F. In addition, SARC-CalF demonstrated superior diagnostic accuracy. The SEAC tool developed and validated in this study included strength, exhaustion, assistance in walking, and calf circumference and had the best diagnostic accuracy and the highest sensitivity among the three screening tools (SARC-F, SARC-CalF, and SEAC) in both development and validation sets against different reference standards. Furthermore, SEAC demonstrated strong inter-rater reliability and test-retest reliability. This study developed and validated a straightforward sarcopenia screening tool based on previous efforts dedicated to this subject,[13,14,25,26] which filled the lacuna of a concordant optimized evaluating and screening tool for older nursing home residents.[27–29]

Inconsistent with some previous findings, SARC-F was found to be insufficiently sensitive in this study. As a pioneering tool for sarcopenia screening, SARC-F has been reported to have excellent specificity and diagnostic accuracy, making it effective for predicting sarcopenia-related adverse outcomes and guiding therapeutic interventions.[15,19,22,30] However, its sensitivity (18.3%–20.4%) was unsatisfactorily low in this study, restricting its use in Chinese nursing home residents due to the high risk of missed diagnoses. Despite its high specificity (85.6%–86.9%), SARC-F may not be the optimal choice for early sarcopenia screening among this vulnerable population.[17,19,22,31]

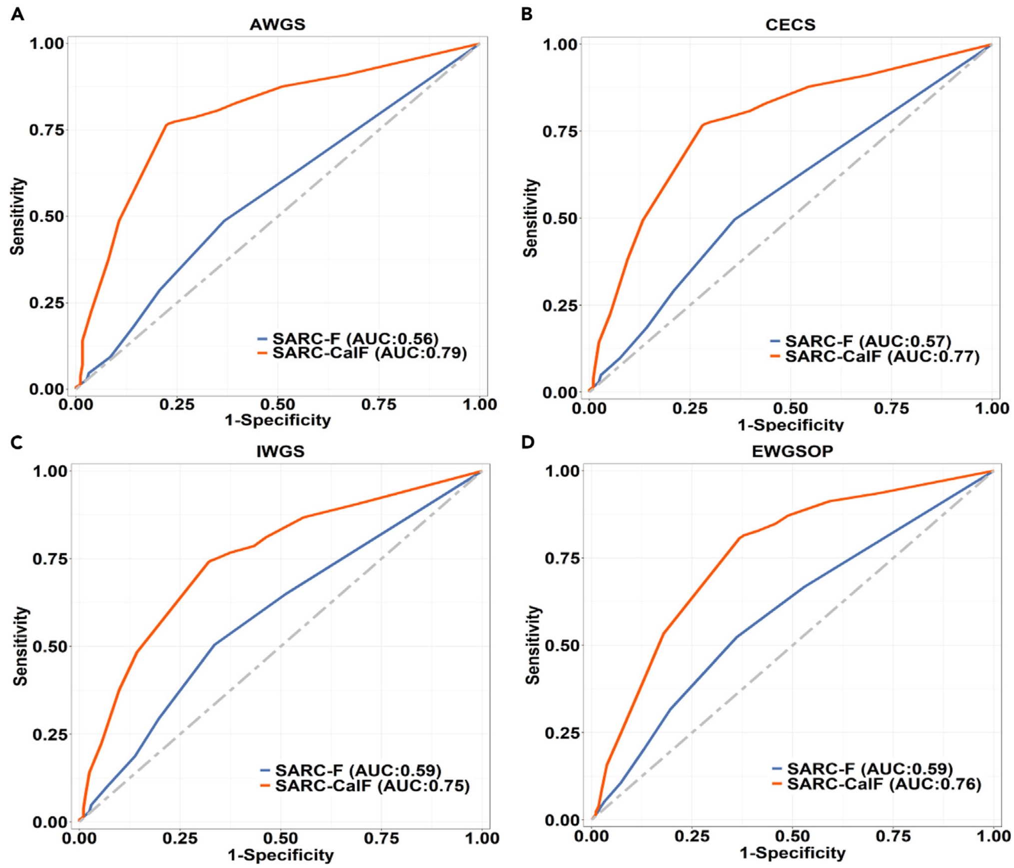

Figure 1. The ROC curves of SARC-F and SARC-CalF against different reference criteria in the total sample

(A) AWGS criteria, (B) CECS criteria, (C) IWGS criteria, and (D) EWGSOP criteria. SARC-F, 5-item questionnaire that includes strength, assistance walking, rise from a chair, climb stairs, and falls; SARC-CalF, SARC-F combined with calf circumference; AUC, area under the receiver-operating characteristic curve.

Previous studies have also compared the accuracy of SARC-F and SARC-CalF in community-dwelling older adults. However, only a few studies have explored whether these sarcopenia screening tools are suitable for nursing home residents. Several studies from China, Brazil, and Poland reported that SARC-Calf significantly improved the sensitivity and diagnostic accuracy of SARC-F for screening sarcopenia.[23,32–34] In a Turkish study sample of community-dwelling older adults, SARC-Calf was not superior over SARC-F in sensitivity but in specificity.[20] The reason why SARC-Calf showed different sensitivity may be vast differences in the study populations.[17,20] Briefly, the diagnostic accuracy of SARC-F increased with the inclusion of calf circumference, as demonstrated in both our study and previous studies. Our study demonstrated that SARC-CalF had low to moderate sensitivity (48.3%–53.4%) in nursing home residents, suggesting that it would still have a high risk of missed sarcopenia diagnoses, which makes it unsuitable for care facilities with a high prevalence of sarcopenia cases.[17,19,22,31]

Several recent studies aimed to increase the sensitivity and utility of SARC-F as a screening tool by applying lower cutoffs, adding extra items, or combining with other screening tests,[35,36] such as Ishii,[27] mini sarcopenia risk assessment (MSRA),[28] and U-TEST,[29] to adapt to different populations. The Ishii scoring includes grip strength measurement, which requires professional operators and is time-consuming. MSRA is a 7- or 5-item self-report questionnaire, which exhibited a low to moderate sensitivity and moderate diagnostic accuracy in a recent study of nursing home residents in Chengdu City, China. U-TEST was designed for orthopedic patients, which may not be suitable for nursing home residents without fractures. In contrast, SEAC proposed in this study is easy to use, is time efficient, and diagnoses sensitively. It demonstrated an AUC comparable to that of SARC-CalF, with moderate to high sensitivity (75.0%–84.3%)—the highest among these three screening tools. SEAC also exhibited good inter-rater reliability (0.90) and test-retest reliability (0.95). Taken together, SEAC appears to be the optimal choice among the three sarcopenia screening tools for older nursing home residents.

This study marks an inaugural attempt to develop and validate an alternative sarcopenia screening tool specifically for nursing home residents.[27–29] It has extended beyond conventional sarcopenia screening tools by introducing the SEAC tool with enhanced sensitivity. Although it exhibited the lowest specificity for sarcopenia prediction among the evaluated tools, its high sensitivity makes it particularly useful for initial screening in nursing home settings, where early identification of sarcopenia is crucial. This could ensure that participants at risk are not overlooked, despite some falsely identified positive cases.

Table 3. Sensitivity/specificity analyses and receiver-operating curve models for SARC-F, SARC-CalF, and SEAC validation against different reference criteria in the development set (*N* = 475)

	Sensitivity (%)	Specificity (%)	PLR	NLR	Cutoff point	AUC
AWGS	–	–	–	–	–	–
SARC-F	16.9 (13.0–21.2)	85.3 (78.2–90.7)	1.1 (0.7–1.8)	1.0 (0.9–1.1)	≥4	0.54 (0.49–0.60)[b]
SARC-CalF	46.6 (41.2–52.1)	88.2 (81.6–93.1)	4.0 (2.5–6.4)	0.6 (0.5–0.7)	≥11	0.78 (0.74–0.83)
SEAC	76.4 (71.5–80.8)	77.2 (69.2–84.0)	3.4 (2.4–4.6)	0.3 (0.2–0.4)	≥6[a]	0.79 (0.74–0.83)
CECS	–	–	–	–	–	–
SARC-F	17.0 (13.1–21.6)	85.5 (79.0–90.7)	1.2 (0.7–1.9)	1.0 (0.9–1.1)	≥4	0.55 (0.50–0.60)[b]
SARC-CalF	47.1 (41.5–52.7)	85.5 (79.0–90.1)	3.2 (2.2–4.9)	0.6 (0.5–0.7)	≥11	0.76 (0.71–0.80)
SEAC	76.2 (71.1–80.7)	71.1 (63.1–78.1)	2.6 (2.0–3.4)	0.3 (0.3–0.4)	≥6[a]	0.76 (0.72–0.81)
IWGS	–	–	–	–	–	–
SARC-F	17.1 (13.2–21.7)	85.8 (79.1–91.0)	1.2 (0.8–1.0)	1.0 (0.9–1.0)	≥4	0.57 (0.52–0.63)[b]
SARC-CalF	46.2 (40.1–51.7)	84.4 (77.6–89.9)	3.0 (2.0–4.4)	0.6 (0.6–0.7)	≥11	0.74 (0.69–0.78)
SEAC	73.7 (68.6–78.4)	66.9 (58.7–74.4)	2.2 (1.8–2.8)	0.4 (0.3–0.5)	≥6[a]	0.74 (0.69–0.79)
EWGSOP	–	–	–	–	–	–
SARC-F	19.9 (15.2–25.1)	88.5 (83.3–92.5)	1.7 (1.1–2.7)	0.9 (0.8–0.9)	≥4	0.59 (0.54–0.64)[b]
SARC-CalF	50.6 (44.4–56.7)	81.3 (75.3–86.3)	2.7 (2.0–3.7)	0.6 (0.5–0.7)	≥11	0.75 (0.70–0.79)
SEAC	79.4 (74.0–84.1)	60.1 (53.1–66.8)	2.0 (1.7–2.4)	0.3 (0.3–0.4)	≥6[a]	0.76 (0.72–0.80)

Notes: AWGS, Asian Working Group for Sarcopenia; CECS, Chinese expert consensus on prevention and intervention for older people with sarcopenia; IWGS, International Working Group on Sarcopenia; EWGSOP, European Working Group on Sarcopenia in Older People; PLR, positive likelihood ratio; NLR, negative likelihood ratio; AUC, area under the receiver-operating characteristic curve.
Data are presented with the 95% CI in parentheses.
[a]The Youden's index (YI, YI = sensitivity + specificity − 1) was used to determine the optimum cutoff point(s).
[b]Significantly different with SEAC ($p < 0.05$).

Limitations of the study

This study is limited to the following aspects. First, we used bioimpedance analysis (BIA) to estimate muscle mass instead of the "gold standard" devices (i.e., dual-energy X-ray absorptiometry [DXA], computed tomography, or magnetic resonance imaging). However, BIA has been proven to be comparable to DXA[37] and is recommended as a practical and cost-effective alternative for measuring muscle mass by EWGSOP and AWGS. Second, our study was cross-sectional and compared with only SARC-F, SARC-CalF, and SEAC. Third, our study was conducted among Chinese older adults only. Further studies are needed to justify the SEAC application in other populations and settings to broaden its generalizability. Finally, future studies may explore the potential links between sarcopenia screening tool and other health outcomes, such as cognitive decline and cardiovascular disease, to further enhance the utility of the SEAC tool. This would provide compelling evidence for muscle strengthening in the management of comorbidities among older adults.[38,39]

Conclusions

The 4-item SEAC developed by this study appears to be the optimal choice for screening sarcopenia in Chinese older nursing home residents. Given that age-related, progressive loss of muscle mass and function leads to severe consequences such as falls, frailty, and mortality, dramatically increasing healthcare costs, early screening with this tool may detect sarcopenia in vulnerable populations like nursing home residents for timely interventions and healthy aging.

RESOURCE AVAILABILITY

Lead contact

Further information regarding this manuscript and requests should be directed to the lead contact, Zuyun Liu, PhD (Zuyun.liu@outlook.com).

Materials availability

The SEAC tool generated in this study is available from the lead contact with a completed Materials Transfer Agreement.

Data and code availability

- All data reported in this paper will be shared by the lead contact upon request.
- This paper does not report original code.
- Any additional information required to reanalyze the data reported in this paper is available from the lead contact upon request.

Table 4. Sensitivity/specificity analyses and receiver-operating curve models for SARC-F, SARC-CalF, and SEAC validation against different reference criteria in the validation set (*N* = 204)

	Sensitivity (%)	Specificity (%)	PLR	NLR	Cutoff point	AUC
AWGS	–	–	–	–	–	–
SARC-F	21.7 (15.4–29.1)	86.5 (74.2–94.4)	1.6 (0.8–3.4)	0.9 (0.8–1.0)	≥4	0.59 (0.51–0.68)[a]
SARC-CalF	53.3 (45.0–61.4)	92.3 (81.5–97.9)	6.9 (2.7–18.0)	0.5 (0.4–0.6)	≥11	0.82 (0.76–0.88)[a]
SEAC	77.0 (69.5–83.4)	79.0 (65.2–89.0)	3.6 (2.1–6.2)	0.3 (0.2–0.4)	≥6	0.84 (0.79–0.90)
CECS	–	–	–	–	–	–
SARC-F	22.1 (15.6–29.7)	86.4 (75.0–94.0)	1.6 (0.8–3.3)	0.9 (0.8–1.0)	≥4	0.61 (0.53–0.69)[a]
SARC-CalF	54.5 (46.0–62.8)	89.8 (79.2–96.2)	5.4 (2.5–11.6)	0.6 (0.5–0.7)	≥11	0.81 (0.75–0.87)[a]
SEAC	77.9 (70.3–84.4)	74.6 (61.6–85.0)	3.1 (2.0–4.8)	0.3 (0.2–0.4)	≥6	0.84 (0.78–0.89)
IWGS	–	–	–	–	–	–
SARC-F	22.1 (15.8–29.7)	87.3 (75.5–94.7)	1.7 (0.8–3.7)	0.9 (0.8–1.0)	≥4	0.62 (0.53–0.70)[a]
SARC-CalF	53.0 (44.7–61.2)	89.1 (77.8–95.9)	4.9 (2.2–10.5)	0.5 (0.4–0.6)	≥11	0.78 (0.72–0.85)
SEAC	75.0 (61.0–86.0)	75.0 (68.6–80.9)	3.0 (1.9–4.9)	0.3 (0.2–0.5)	≥6	0.80 (0.74–0.86)
EWGSOP	–	–	–	–	–	–
SARC-F	21.5 (14.5–29.9)	83.1 (73.3–90.5)	1.3 (0.7–2.3)	0.9 (0.8–1.1)	≥4	0.59 (0.51–0.67)[a]
SARC-CalF	59.5 (50.2–68.3)	84.3 (74.7–91.4)	3.8 (2.3–6.4)	0.5 (0.4–0.6)	≥11	0.79 (0.72–0.86)
SEAC	84.3 (76.6–90.3)	67.5 (56.3–77.4)	2.6 (1.9–3.6)	0.2 (0.2–0.4)	≥6	0.81 (0.75–0.87)

Notes: AWGS, Asian Working Group for Sarcopenia; CECS, Chinese expert consensus on prevention and intervention for older people with sarcopenia; IWGS, International Working Group on Sarcopenia; EWGSOP, European Working Group on Sarcopenia in Older People; PLR, positive likelihood ratio; NLR, negative likelihood ratio; AUC, area under the receiver-operating characteristic curve.
Data are presented with the 95% CI in parentheses.
[a]Significantly different with SEAC ($p < 0.05$).

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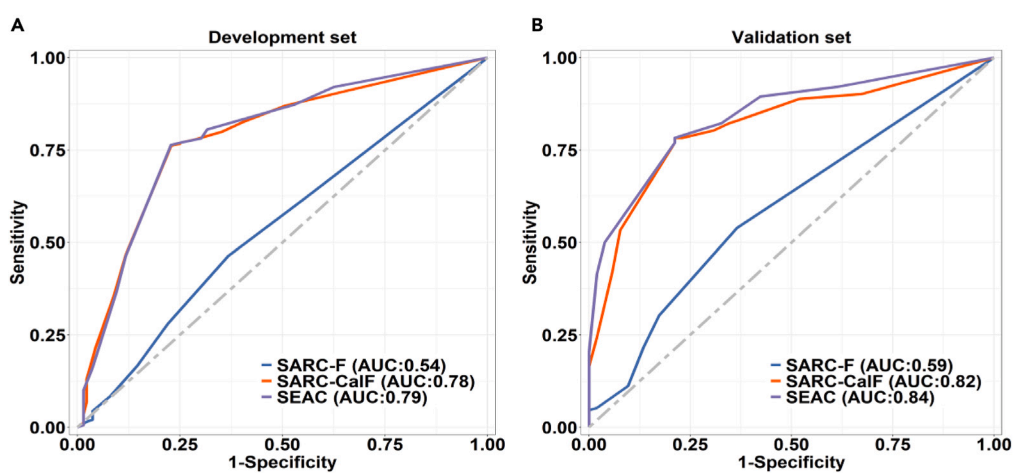

Figure 2. The ROC curves of SARC-F, SARC-CalF, and SEAC in the development set and validation set based on the AWGS diagnostic criteria
(A) Development set and (B) validation set. AWGS, Asian Working Group for Sarcopenia; SARC-F, 5-item questionnaire that includes strength, assistance walking, rise from a chair, climb stairs, and falls; SARC-CalF, SARC-F combined with calf circumference; SEAC, 4-item questionnaire that includes strength, exhaustion, assistance in walking, and calf circumference; AUC, area under the receiver-operating characteristic curve.

AUTHOR CONTRIBUTIONS

Z.L. and X. Liu designed and supervised the study. K.S., X.W., J.Y., W.C., X.J., D.L., H.L., W.H., H.T., W.G., and B.Z. contributed to data collection. K.S., X.W., J.Y., and W.C. analyzed the data. Z.L., X. Liu, K.S., X.W., X. Lyu, L.W., and J.S. interpreted the results. K.S., X.W., and J.Y. drafted the manuscript. All authors revised the manuscript. Z.L. and X. Liu took responsibility for the accuracy of the data analysis and the content of the article. All authors read and approved the submitted version of the manuscript.

DECLARATION OF INTERESTS

The authors declare no competing interests.

STAR★METHODS

Detailed methods are provided in the online version of this paper and include the following:

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SUPPLEMENTAL INFORMATION

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REFERENCES

1. Cruz-Jentoft, A.J., Baeyens, J.P., Bauer, J.M., Boirie, Y., Cederholm, T., Landi, F., Martin, F.C., Michel, J.P., Rolland, Y., Schneider, S.M., et al. (2010). Sarcopenia: European consensus on definition and diagnosis: Report of the European Working Group on Sarcopenia in Older People. Age Ageing *39*, 412–423. https://doi.org/10.1093/ageing/afq034.
2. Coll, P.P., Phu, S., Hajjar, S.H., Kirk, B., Duque, G., and Taxel, P. (2021). The prevention of osteoporosis and sarcopenia in older adults. J. Am. Geriatr. Soc. *69*, 1388–1398. https://doi.org/10.1111/jgs.17043.
3. Cruz-Jentoft, A.J., and Sayer, A.A. (2019). Sarcopenia. Lancet (London, England) *393*, 2636–2646. https://doi.org/10.1016/s0140-6736(19)31138-9.
4. Bhasin, S., Travison, T.G., Manini, T.M., Patel, S., Pencina, K.M., Fielding, R.A., Magaziner, J.M., Newman, A.B., Kiel, D.P., Cooper, C., et al. (2020). Sarcopenia Definition: The Position Statements of the Sarcopenia Definition and Outcomes Consortium. J. Am. Geriatr. Soc. *68*, 1410–1418. https://doi.org/10.1111/jgs.16372.
5. Yuan, S., and Larsson, S.C. (2023). Epidemiology of sarcopenia: Prevalence, risk factors, and consequences. Metabolism *144*, 155533. https://doi.org/10.1016/j.metabol.2023.155533.
6. Ligthart-Melis, G.C., Luiking, Y.C., Kakourou, A., Cederholm, T., Maier, A.B., and de van der Schueren, M.A.E. (2020). de van der Schueren MAE. Frailty, Sarcopenia, and Malnutrition Frequently (Co-)occur in Hospitalized Older Adults: A Systematic Review and Meta-analysis. J. Am. Med. Dir. Assoc. *21*, 1216–1228. https://doi.org/10.1016/j.jamda.2020.03.006.
7. Shen, Y., Chen, J., Chen, X., Hou, L., Lin, X., and Yang, M. (2019). Prevalence and Associated Factors of Sarcopenia in Nursing Home Residents: A Systematic Review and Meta-analysis. J. Am. Med. Dir. Assoc. *20*, 5–13. https://doi.org/10.1016/j.jamda.2018.09.012.
8. Mayhew, A.J., Amog, K., Phillips, S., Parise, G., McNicholas, P.D., de Souza, R.J., Thabane, L., and Raina, P. (2019). The prevalence of sarcopenia in community-dwelling older adults, an exploration of differences between studies and within definitions: a systematic review and meta-analyses. Age Ageing *48*, 48–56. https://doi.org/10.1093/ageing/afy106.
9. Beeri, M.S., Leugrans, S.E., Delbono, O., Bennett, D.A., and Buchman, A.S. (2021). Sarcopenia is associated with incident Alzheimer's dementia, mild cognitive impairment, and cognitive decline. J. Am. Geriatr. Soc. *69*, 1826–1835. https://doi.org/10.1111/jgs.17206.
10. Roubenoff, R., and Hughes, V.A. (2000). Sarcopenia: current concepts. J. Gerontol. A Biol. Sci. Med. Sci. *55*, M716–M724. https://doi.org/10.1093/gerona/55.12.m716.
11. Dent, E., Morley, J.E., Cruz-Jentoft, A.J., Arai, H., Kritchevsky, S.B., Guralnik, J., Bauer, J.M., Pahor, M., Clark, B.C., Cesari, M., et al. (2018). International Clinical Practice Guidelines for Sarcopenia (ICFSR): Screening, Diagnosis and Management. J. Nutr. Health Aging *22*, 1148–1161. https://doi.org/10.1007/s12603-018-1139-9.
12. Churilov, I., Churilov, L., MacIsaac, R.J., and Ekinci, E.I. (2018). Systematic review and meta-analysis of prevalence of sarcopenia in post acute inpatient rehabilitation. Osteoporos. Int. *29*, 805–812. https://doi.org/10.1007/s00198-018-4381-4.
13. Chen, L.K., Woo, J., Assantachai, P., Auyeung, T.W., Chou, M.Y., Iijima, K., Jang, H.C., Kang, L., Kim, M., Kim, S., et al. (2020). Asian Working Group for Sarcopenia: 2019 Consensus Update on Sarcopenia Diagnosis and Treatment. J. Am. Med. Dir. Assoc. *21*, 300–307.e2. https://doi.org/10.1016/j.jamda.2019.12.012.
14. Cruz-Jentoft, A.J., Bahat, G., Bauer, J., Boirie, Y., Bruyère, O., Cederholm, T., Cooper, C., Landi, F., Rolland, Y., Sayer, A.A., et al. (2019). Sarcopenia: revised European consensus on definition and diagnosis. Age Ageing *48*, 16–31. https://doi.org/10.1093/ageing/afy169.
15. Malmstrom, T.K., and Morley, J.E. (2013). SARC-F: a simple questionnaire to rapidly diagnose sarcopenia. J. Am. Med. Dir. Assoc. *14*, 531–532. https://doi.org/10.1016/j.jamda.2013.05.018.
16. Barbosa-Silva, T.G., Menezes, A.M.B., Bielemann, R.M., Malmstrom, T.K., and Gonzalez, M.C.; Grupo de Estudos em Composição Corporal e Nutrição COCONUT (2016). Enhancing SARC-F: Improving Sarcopenia Screening in the Clinical Practice. J. Am. Med. Dir. Assoc. *17*, 1136–1141. https://doi.org/10.1016/j.jamda.2016.08.004.

17. Voelker, S.N., Michalopoulos, N., Maier, A.B., and Reijnierse, E.M. (2021). Reliability and Concurrent Validity of the SARC-F and Its Modified Versions: A Systematic Review and Meta-Analysis. J. Am. Med. Dir. Assoc. *22*, 1864–1876.e16. https://doi.org/10.1016/j.jamda.2021.05.011.
18. Miller, J., Wells, L., Nwulu, U., Currow, D., Johnson, M.J., and Skipworth, R.J.E. (2018). Validated screening tools for the assessment of cachexia, sarcopenia, and malnutrition: a systematic review. Am. J. Clin. Nutr. *108*, 1196–1208. https://doi.org/10.1093/ajcn/nqy244.
19. Huang, L., Shu, X., Ge, N., Gao, L., Xu, P., Zhang, Y., Chen, Y., Yue, J., and Wu, C. (2023). The accuracy of screening instruments for sarcopenia: a diagnostic systematic review and meta-analysis. Age Ageing *52*, afad152. https://doi.org/10.1093/ageing/afad152.
20. Bahat, G., Oren, M.M., Yilmaz, O., Kılıç, C., Aydin, K., and Karan, M.A. (2018). Comparing SARC-F with SARC-CalF to Screen Sarcopenia in Community Living Older Adults. J. Nutr. Health Aging *22*, 1034–1038. https://doi.org/10.1007/s12603-018-1072-y.
21. Woo, J., Leung, J., and Morley, J.E. (2014). Validating the SARC-F: a suitable community screening tool for sarcopenia? J. Am. Med. Dir. Assoc. *15*, 630–634. https://doi.org/10.1016/j.jamda.2014.04.021.
22. Ida, S., Kaneko, R., and Murata, K. (2018). SARC-F for Screening of Sarcopenia Among Older Adults: A Meta-analysis of Screening Test Accuracy. J. Am. Med. Dir. Assoc. *19*, 685–689. https://doi.org/10.1016/j.jamda.2018.04.001.
23. Yang, M., Lu, J., Jiang, J., Zeng, Y., and Tang, H. (2019). Comparison of four sarcopenia screening tools in nursing home residents. Aging Clin. Exp. Res. *31*, 1481–1489. https://doi.org/10.1007/s40520-018-1083-x.
24. Urzi, F., Šimunič, B., and Buzan, E. (2017). Basis for Sarcopenia Screening With the SARC-CalF in Nursing Homes. J. Am. Med. Dir. Assoc. *18*, 991.e5–991.e10. https://doi.org/10.1016/j.jamda.2017.07.011.
25. Cui, H., Wang, Z., Wu, J., Liu, Y., Zheng, J., Xiao, W., He, P., Zhou, Y., Wang, J., Yu, P., et al. (2023). Chinese expert consensus on prevention and intervention for elderly with sarcopenia (2023). Aging Med. *6*, 104–115. https://doi.org/10.1002/agm2.12245.
26. Fielding, R.A., Vellas, B., Evans, W.J., Bhasin, S., Morley, J.E., Newman, A.B., Abellan van Kan, G., Andrieu, S., Bauer, J., Breuille, D., et al. (2011). Sarcopenia: an undiagnosed condition in older adults. Current consensus definition: prevalence, etiology, and consequences. International working group on sarcopenia. J. Am. Med. Dir. Assoc. *12*, 249–256. https://doi.org/10.1016/j.jamda.2011.01.003.
27. Ishii, S., Tanaka, T., Shibasaki, K., Ouchi, Y., Kikutani, T., Higashiguchi, T., Obuchi, S.P., Ishikawa-Takata, K., Hirano, H., Kawai, H., et al. (2014). Development of a simple screening test for sarcopenia in older adults. Geriatr. Gerontol. Int. *14*, 93–101. https://doi.org/10.1111/ggi.12197.
28. Rossi, A.P., Micciolo, R., Rubele, S., Fantin, F., Caliari, C., Zoico, E., Mazzali, G., Ferrari, E., Volpato, S., and Zamboni, M. (2017). Assessing the Risk of Sarcopenia in the Elderly: The Mini Sarcopenia Risk Assessment (MSRA) Questionnaire. J. Nutr. Health Aging *21*, 743–749. https://doi.org/10.1007/s12603-017-0921-4.
29. Kamitani, T., Wakita, T., Wada, O., Mizuno, K., and Kurita, N. (2021). U-TEST, a simple decision support tool for the diagnosis of sarcopenia in orthopaedic patients: the Screening for People Suffering Sarcopenia in Orthopedic cohort of Kobe study (SPSS-OK). Br. J. Nutr. *126*, 1323–1330. https://doi.org/10.1017/s0007114521000106.
30. Malmstrom, T.K., Miller, D.K., Simonsick, E.M., Ferrucci, L., and Morley, J.E. (2016). SARC-F: a symptom score to predict persons with sarcopenia at risk for poor functional outcomes. J. Cachexia Sarcopenia Muscle *7*, 28–36. https://doi.org/10.1002/jcsm.12048.
31. Lu, J.L., Ding, L.Y., Xu, Q., Zhu, S.Q., Xu, X.Y., Hua, H.X., Chen, L., and Xu, H. (2021). Screening Accuracy of SARC-F for Sarcopenia in the Elderly: A Diagnostic Meta-Analysis. J. Nutr. Health Aging *25*, 172–182. https://doi.org/10.1007/s12603-020-1471-8.
32. Yang, M., Hu, X., Xie, L., Zhang, L., Zhou, J., Lin, J., Wang, Y., Li, Y., Han, Z., Zhang, D., et al. (2018). Screening Sarcopenia in Community-Dwelling Older Adults: SARC-F vs SARC-F Combined With Calf Circumference (SARC-CalF). J. Am. Med. Dir. Assoc. *19*, 277.e1–277.e8. https://doi.org/10.1016/j.jamda.2017.12.016.
33. Barreto de Lima, A., Dos Santos Ribeiro, G., Henriques-Neto, D., Rúbio Gouveia, É., and Baptista, F. (2023). Diagnostic performance of SARC-F and SARC-CalF in screening for sarcopenia in older adults in Northern Brazil. Sci. Rep. *13*, 11698. https://doi.org/10.1038/s41598-023-39002-y.
34. Krzymińska-Siemaszko, R., Deskur-Śmielecka, E., Kaluźniak-Szymanowska, A., Murawiak, M., and Wieczorowska-Tobis, K. (2023). Comparison of Diagnostic Value of the SARC-F and Its Four Modified Versions in Polish Community-Dwelling Older Adults. Clin. Interv. Aging *18*, 783–797. https://doi.org/10.2147/cia.S408616.
35. Bahat, G., Erdoğan, T., and İlhan, B. (2022). SARC-F and other screening tests for sarcopenia. Curr. Opin. Clin. Nutr. Metab. Care *25*, 37–42. https://doi.org/10.1097/mco.0000000000000801.
36. Ozkok, S., Oren, M.M., Aydin, C.O., Ozalp, H., Kilic, C., Koc, Y., Dogan, H., Eryigit, O.Y., Karan, M.A., and Bahat, G. (2023). Clinical validation of SARC-F by proxy as a practical tool to evaluate sarcopenia in dependent older adults. J. Geriatr. Oncol. *14*, 101630. https://doi.org/10.1016/j.jgo.2023.101630.
37. Harmelen, R.V., Verreijen, A.M., and Weijs, P.J. (2012). Sensitivity and Specificity of BIA versus DEXA for Assessment of Low Appendicular Skeletal Muscle Mass in the Diagnosis of Sarcopenic Obesity, p. 1.
38. Ma, P., Li, R., Zeng, L., Hong, C., Li, Y., Liang, S., Zhu, H., Cui, H., Wang, J., He, J., et al. (2024). Association between sarcopenia-related markers and cholelithiasis: A prospective and Mendelian randomization study. Environ. Toxicol. *39*, 3473–3480. https://doi.org/10.1002/tox.24215.
39. Tang, Z., Zhou, G., Xiao, Y., Liu, H., Chen, X., and Shen, M. (2024). Allergic Phenotypes and Sarcopenia: Evidence from Observational Studies and Mendelian Randomization Analysis. Phenomics (Cham, Switzerland) *4*, 46–50. https://doi.org/10.1007/s43657-023-00110-4.
40. Tian, D., Yan, H.J., Huang, H., Zuo, Y.J., Liu, M.Z., Zhao, J., Wu, B., Shi, L.Z., and Chen, J.Y. (2023). Machine Learning-Based Prognostic Model for Patients After Lung Transplantation. JAMA Netw. Open *6*, e2312022. https://doi.org/10.1001/jamanetworkopen.2023.12022.
41. Li, J., Zuo, R., Schoepf, U.J., Griffith, J.P., 3rd, Wu, S., Zhou, C., Chen, X., Tan, W., Zhou, Z., Gao, H., et al. (2023). Development and validation of a nonenhanced CT based radiomics model to detect brown adipose tissue. Theranostics *13*, 1584–1593. https://doi.org/10.7150/thno.81789.
42. Dobbin, K.K., and Simon, R.M. (2011). Optimally splitting cases for training and testing high dimensional classifiers. BMC Med. Genom. *4*, 31. https://doi.org/10.1186/1755-8794-4-31.
43. Merchant, R.A., Seetharaman, S., Au, L., Wong, M.W.K., Wong, B.L.L., Tan, L.F., Chen, M.Z., Ng, S.E., Soong, J.T.Y., Hui, R.J.Y., et al. (2021). Relationship of Fat Mass Index and Fat Free Mass Index With Body Mass Index and Association With Function, Cognition and Sarcopenia in Pre-Frail Older Adults. Front. Endocrinol. *12*, 765415. https://doi.org/10.3389/fendo.2021.765415.
44. Yao, R., Yao, L., Yuan, C., and Gao, B.L. (2022). Accuracy of Calf Circumference Measurement, SARC-F Questionnaire, and Ishii's Score for Screening Stroke-Related Sarcopenia. Front. Neurol. *13*, 880907. https://doi.org/10.3389/fneur.2022.880907.
45. Janssen, I., Heymsfield, S.B., Baumgartner, R.N., and Ross, R. (2000). Estimation of skeletal muscle mass by bioelectrical impedance analysis. J. Appl. Physiol. *89*, 465–471. https://doi.org/10.1152/jappl.2000.89.2.465.
46. Reijnierse, E.M., de Jong, N., Trappenburg, M.C., Blauw, G.J., Butler-Browne, G., Gapeyeva, H., Hogrel, J.Y., McPhee, J.S., Narici, M.V., Sipilä, S., et al. (2017). Assessment of maximal handgrip strength: how many attempts are needed? J. Cachexia Sarcopenia Muscle *8*, 466–474. https://doi.org/10.1002/jcsm.12181.
47. Duchowny, K.A., Ackley, S.F., Brenowitz, W.D., Wang, J., Zimmerman, S.C., Caunca, M.R., and Glymour, M.M. (2022). Associations Between Handgrip Strength and Dementia Risk, Cognition, and Neuroimaging Outcomes in the UK Biobank Cohort Study. JAMA Netw. Open *5*, e2218314. https://doi.org/10.1001/jamanetworkopen.2022.18314.
48. Guralnik, J.M., Simonsick, E.M., Ferrucci, L., Glynn, R.J., Berkman, L.F., Blazer, D.G., Scherr, P.A., and Wallace, R.B. (1994). A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. J. Gerontol. *49*, M85–M94. https://doi.org/10.1093/geronj/49.2.m85.
49. Guralnik, J.M., Ferrucci, L., Pieper, C.F., Leveille, S.G., Markides, K.S., Ostir, G.V., Studenski, S., Berkman, L.F., and Wallace, R.B. (2000). Lower Extremity Function and Subsequent Disability: Consistency Across Studies, Predictive Models, and Value of Gait Speed Alone Compared With the Short Physical Performance Battery. J. Gerontol. A Biol. Sci. Med. Sci. *55*, M221–M231. https://doi.org/10.1093/gerona/55.4.M221.
50. Whitney, S.L., Wrisley, D.M., Marchetti, G.F., Gee, M.A., Redfern, M.S., and Furman, J.M. (2005). Clinical measurement of sit-to-stand performance in people with balance disorders: validity of data for the Five-Times-Sit-to-Stand Test. Phys. Ther. *85*, 1034–1045.
51. Lian, R., Jiang, G., Liu, Q., Shi, Q., Luo, S., Lu, J., and Yang, M. (2023). Validated Tools for Screening Sarcopenia: A Scoping Review.

J. Am. Med. Dir. Assoc. *24*, 1645–1654. https://doi.org/10.1016/j.jamda.2023.06.036.

52. Gao, Q., Hu, K., Yan, C., Zhao, B., Mei, F., Chen, F., Zhao, L., Shang, Y., Ma, Y., and Ma, B. (2021). Associated Factors of Sarcopenia in Community-Dwelling Older Adults: A Systematic Review and Meta-Analysis. Nutrients *13*, 4291. https://doi.org/10.3390/nu13124291.
53. Wang, J., Gong, X., Zhong, W., Zhou, Y., and Lou, M. (2021). Novel Prehospital Triage Scale for Detecting Large Vessel Occlusion and Its Cause. J. Am. Heart Assoc. *10*, e021201. https://doi.org/10.1161/jaha.121.021201.
54. Power, L., Mullally, D., Gibney, E.R., Clarke, M., Visser, M., Volkert, D., Bardon, L., de van der Schueren, M.A.E., and Corish, C.A.; MaNuEL Consortium (2018). A review of the validity of malnutrition screening tools used in older adults in community and healthcare settings - A MaNuEL study. Clin. Nutr. ESPEN *24*, 1–13. https://doi.org/10.1016/j.clnesp.2018.02.005.
55. van Bokhorst-de van der Schueren, M.A.E., Guaitoli, P.R., Jansma, E.P., and de Vet, H.C.W. (2014). A systematic review of malnutrition screening tools for the nursing home setting. J. Am. Med. Dir. Assoc. *15*, 171–184. https://doi.org/10.1016/j.jamda.2013.10.006.
56. Linden, A. (2006). Measuring diagnostic and predictive accuracy in disease management: an introduction to receiver operating characteristic (ROC) analysis. J. Eval. Clin. Pract. *12*, 132–139. https://doi.org/10.1111/j.1365-2753.2005.00598.x.
57. DeLong, E.R., DeLong, D.M., and Clarke-Pearson, D.L. (1988). Comparing the areas under two or more correlated receiver operating characteristic curves: a nonparametric approach. Biometrics *44*, 837–845.
58. Hajian-Tilaki, K. (2018). The choice of methods in determining the optimal cut-off value for quantitative diagnostic test evaluation. Stat. Methods Med. Res. *27*, 2374–2383. https://doi.org/10.1177/0962280216680383.
59. Koo, T.K., and Li, M.Y. (2016). A Guideline of Selecting and Reporting Intraclass Correlation Coefficients for Reliability Research. J. Chiropr. Med. *15*, 155–163. https://doi.org/10.1016/j.jcm.2016.02.012.

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STAR★METHODS

KEY RESOURCES TABLE

REAGENT or RESOURCE	SOURCE	IDENTIFIER
Software and algorithms		
R software (version 4.2.3)	R Foundation for Statistical Computing	RRID: SCR_001905; https://www.r-project.org/

EXPERIMENTAL MODEL AND STUDY PARTICIPANT DETAILS

The current study is derived from a subcohort of the ongoing ZheJiang Longitudinal Study of Healthy Aging (JASHA) in Zhejiang Province, China. The JASHA covers multi-dimensional aging phenotypes including muscle health, physical function, cognitive function, brain health, and mental health. In this study, the sample was recruited from forty nursing homes in 3 cities (Hangzhou, Wenzhou, Jiaxing) of Zhejiang Province, China. Participants were included if they met the following inclusion criteria: (1) $\geq$60 years old; (2) being able to communicate and ambulate (with/without assistance); (3) signing a written informed consent. The exclusion criteria included: (1) severe illness; (2) technical aspects that would preclude assessment with bioimpedance analysis (BIA), such as severe edema, implantable pacemaker, and implantable medical metal materials; (3) other reasons that would prevent the participants from completing the study. All participants completed questionnaires, including demographic, health-related questions, SARC-F, SARC-CalF, physical performance tests, anthropometric evaluations, and body composition measurement. These measurements were conducted on the same day for each participant. A total of 853 participants who initially met the inclusion criteria participated in the study. We excluded those who discontinued the study (N = 65), had severe illness (N = 4) and technical aspects that would preclude assessment with BIA (N = 89), and had missing values on skeletal muscle mass (N = 9), calf circumference (CC) (N = 1), and SARC-F (N = 6). The final sample comprised 679 participants aged 60–99 years. The mean age of 679 participants was 82.9 (SD = 7.0) years, with a higher proportion of women (59.2%) in the sample. Women were significantly older than men (mean age: 84.2 vs. 81.0, $p < 0.001$). First, the total sample was used for the comparison analysis (analysis 1). Then, the participants were randomly assigned into development (analytic sample 2, n = 475) and validation set (analytic sample 3, n = 204) in a ratio of 7 to 3, for the development and validation analysis (analysis 2), respectively[40–42] (Figure S1). The screening tool was administered to 29 participants to evaluate the inter-rater reliability and to 24 participants to evaluate test-retest reliability at two-week intervals.

Ethics statement

The protocol of this study was approved by the Ethics Committee of the Interdisciplinary Center for Social Sciences, Zhejiang University (202306-02). All participants in this study provided written informed consent by themselves or their representatives.

METHOD DETAILS

Socio-demographics

Socio-demographics, self-rated overall health status, and self-reported disease and medication use information were collected through interviews with questionnaires.

Anthropometric measurements

CC was measured in a sitting position with the knee and ankle at a right angle. The measurements were taken to the nearest 0.1 cm at the greatest circumference on both legs using a nonelastic but flexible measuring tape, and the highest value was adopted for further analysis.[43,44] Body height and weight were measured using an ultrasonic height and weight instrument (Runcobo CP30B: Shenzhen Yolanda Technology Co., Ltd.). The body mass index (BMI) was calculated using the formula: BMI (kg/m^2) = body weight/height.[2] Waist circumference was measured at the umbilical level, while hip circumference was measured at the level of trochanter major using a tape measure (both nearest 0.1 cm). Waist to hip ratio (WHR) is the ratio of those two measurements (waist/hip).

Measurement of skeletal muscle mass, muscle strength, and physical performance

Muscle mass was measured using a BIA device (Runcobo CP10A: Shenzhen Yolanda Technology Co., Ltd.) to estimate the total appendicular skeletal muscle mass (ASM) and body fat mass (BFM). The skeletal muscle index (SMI) was calculated based on the equation[45]: SMI (kg/m^2) = ASM/height.[2] Muscle strength was defined by handgrip strength (HGS)[13] assessed using a handheld dynamometer (WCS100). Participants gripped the dynamometer with maximum effort while standing. Trained investigators measured HGS three times for each hand, and the highest value from either hand was used for the analyses.[46,47] Physical performance was evaluated using the Short Physical Performance Battery (SPPB), the 5-time chair stand test, and gait speed (GS) with the 6-meter walk test.[48] The SPPB is a group of measures that combines the results of the GS, 5-time chair stand and standing balance tests. The scores range from 0 (worst performance) to 12 (best performance).[49] GS was assessed with the 6-meter walk test at the participant's usual walking speed. For the 5-time chair stand test, the participants were asked to rise 5 times quickly as possible with their arms crossed on their chest. Walkers and canes were accepted, if necessary.[50] For tests of standing balance, participants attempted to maintain the side-by-side, semi-tandem, and tandem positions for 10 s.[49]

Reference diagnostic criteria for sarcopenia

Reference diagnosis criteria for sarcopenia used in this study included the following: (1) the revised Asian Working Group for Sarcopenia (AWGS)[13]; (2) the Chinese Expert Consensus on prevention and intervention for older people with Sarcopenia (CECS)[25]; (3) the International Working Group on Sarcopenia (IWGS)[26]; and (4) the revised European Working Group on Sarcopenia in Older People (EWGSOP).[14] Details of these criteria are presented in Table S5. The primary outcome of this study was sarcopenia defined according to the AWGS criteria. Secondary outcomes included sarcopenia defined by the CECS, the IWGS, and the EWGSOP criteria.

Screening tools for sarcopenia

The flow chart of developing the 4-item SEAC sarcopenia screening tool is shown in Figure S2. First, we collected and reviewed existing sarcopenia screening tools in the literature.[19,51] Based on the literature and framework of defining sarcopenia,[13] we constructed an initial 16-item screening scale (Table S6) incorporating factors associated with sarcopenia.[52]. Second, we discussed the content of the sarcopenia screening scale and decided to maintain a 9-item scale (Table S7). Third, using logistic regression analysis with sarcopenia (defined by AWGS criteria) as the dependent variable and the 9 candidate items as independent variables, we identified three significant items: Strength (Odds ratio (OR): 1.77, 95% CI: 1.08–2.91), Exhaustion1 (OR: 1.90, 95% CI: 1.06–3.47), and Calf Circumference (OR: 8.04, 95% CI: 5.51–11.89) (Table S8). ORs were mutually adjusted for age, sex and 9 candidate items. Furthermore, 1 item related to physical performance was recuperated, ensuring the SEAC tool encompasses three sarcopenia-related components (muscle strength, muscle mass, and physical performance), thereby providing a comprehensive assessment of sarcopenia.[4] The diagnostic value of different physical performance-related item combinations with sarcopenia was determined by receiver operating curve (ROC) analysis, which was found to be maximized by including the *Assistance in walking* (Table S9).[53] This above process yielded a 4-item SEAC (***S****trength*, ***E****xhaustion*, ***A****ssistance in walking*, and ***C****alf circumference*) scale. The SARC-F, SARC-CalF and SEAC scales are presented in Table S10. For the SARC-F, a total score of $\geq$4 indicates sarcopenia.[15] For the SARC-CalF, a total score of $\geq$11 indicates sarcopenia.[16] For the SEAC, a total score of $\geq$6 indicates sarcopenia.

QUANTIFICATION AND STATISTICAL ANALYSIS

The basic characteristics of the study participants were summarized in total and by sex. Continuous variables with normal or skewed distributions were presented respectively as mean (standard deviation [SD]) and median (inter-quartile range [IQR]). Categorical variables were presented as number (percentage). One-way analysis of variance, Mann-Whitney test, and χ^2 test were used to compare sex differences.

Different criteria were adopted as the reference standards (Table S5). For the comparison analysis (analysis 1), the receiver operating characteristics (ROC) curve was used to compare the diagnostic accuracy of the SARC-F and SARC-CalF in the total sample. The area under the ROC curve (AUC) (high >0.80, moderate $\geq$0.60 to $\leq$0.80, low <0.60),[54,55] and 95% confidence interval (CI) were calculated. A larger AUC indicates a better overall diagnostic accuracy.[56] The difference of the AUC of each two ROC curves was compared using the DeLong method.[57] The diagnostic value included sensitivity and specificity (high $\geq$80%, moderate $\geq$50% to <80%, and low <50%),[54] positive likelihood ratio (PLR), and negative likelihood ratio (NLR). For the development and validation analysis (analysis 2), the ROC curve was used to compare the diagnostic accuracy of the SEAC respectively with the SARC-F and SARC-CalF in the development and validation sets. Youden's index was used to determine the optimum cutoff point of SEAC.[58] To validate the diagnostic accuracy of the SEAC across different age groups, subgroup analyses by age (<80 and $\geq$80 years) were conducted using the AWGS as the reference standard. Additionally, the inter-rater reliability and test-retest reliability of SEAC were reported as intraclass correlation coefficient (ICC) values (excellent $\geq$0.90, good $\geq$0.75 to <0.90, moderate $\geq$0.50 to <0.75, and poor <0.50).[59] All statistical analyses were conducted using R Version 4.2.3 (R Foundation for Statistical Computing, Vienna, Austria). A two-tailed $p < 0.05$ was considered statistically significant.