Original Article

Screening Tools for Sarcopenia in Community-Dwellers: A Scoping Review

Siti N Mohd Nawi, [1,2] *MBBS, FRACP*, Kareeann SF Khow, [1,2,3] *MbChB, FRACP*, Wee Shiong Lim, [4,5] *MRCP, MMed, MHPE*, Solomon CY Yu, [1,2,3] *MBBS, FRACP, PhD*

Abstract

Introduction: Sarcopenia is characterised by a progressive and generalised loss of skeletal muscle mass, strength and/or performance. It is associated with adverse health outcomes such as increased morbidity, functional decline and death. Early detection of sarcopenia in community-dwelling older adults is important to prevent these outcomes. Our scoping review evaluates validated screening tools that are used to identify commuity-dwelling older individuals at risk of sarcopenia and appraises their performance against international consensus definitions. Materials and Methods: A systematic search on MEDLINE, PubMed and EMBASE was performed for articles that evaluated the predictive validity measures of screening tools and validated them against at least 1 internationally recognised diagnostic criterion for sarcopenia. Results: Of the 17 articles identified in our search, 8 used questionnaires as screening tool, 2 utilised anthropometric measurements, 3 used a combination of questionnaire and anthropometric measures and 1 used a physical performance measure (chair stand test). The questionnaire Strength, Assistance with walking, Rising from chair, Climbing stairs and Falls (SARC-F) has the highest specificity (94.4-98.7%) but low sensitivity (4.2-9.9%), with the 5-item questionnaire outperforming the 3-item version. When SARC-F is combined with calf circumference, its sensitivity is enhanced with improvement in overall diagnostic performance. Although equation-based anthropometric screening tools performed well, they warrant external validation. Conclusion: Our scoping review identified 6 candidate tools to screen for sarcopenia. Direct comparison studies in the community would help to provide insights into their comparative performance as screening tools. More studies are needed to reach a consensus on the best screening tool(s) to be used in clinical practice.

Ann Acad Med Singapore 2019;48:201-16

Key words: Low muscle function, Low muscle mass, Older adults, Sensitivity, Specificity

Introduction

Sarcopenia is characterised by aged-related progressive and generalised loss of skeletal muscle mass and strength.[1] It is estimated that adults lose about 3% to 5% of muscle mass every decade starting from the fourth decade of life.[2] After age 50, the rate of loss increases from 1% to 2% every year.[2] The prevalence of sarcopenia varies according to the age band, contexts and definition of sarcopenia.[3] It can range from 3% in community-dwelling adults >60 years old to 33% in those who reside in institutional care.[4]

Older people are at higher risk of sarcopenia, especially in sedentary individuals.[5] Untreated sarcopenia has been linked to significant adverse health outcomes that included heightened fall risk with resultant bone fractures, increased morbidity and mortality, functional decline and physical disability.[3] Falls are also associated with poorer quality

[1]Aged and Extended Care Services, The Queen Elizabeth Hospital, Central Adelaide Local Health Network, South Australia, Australia
[2]Adelaide Geriatrics Training and Research with Aged Care (G-TRAC Centre), University of Adelaide, South Australia, Australia
[3]National Health and Medical Research Council Centre for Research Excellence in Frailty and Healthy Ageing, University of Adelaide, South Australia, Australia
[4]Department of Geriatric Medicine, Tan Tock Seng Hospital, Singapore
[5]Institute of Geriatrics and Active Ageing, Tan Tock Seng Hospital, Singapore
Address for Correspondence: A/Prof Solomon Yu Ching Yeh, Aged and Extended Care Services, The Queen Elizabeth Hospital, 21 Woodville Road, Level 8B Main Building, Woodville South, Adelaide, South Australia 5011, Australia.
Email: solomon.yu@adelaide.edu.au

of life and early institutional care.[6] It is estimated that sarcopenia cost the United States $18.5 billion every year in direct healthcare cost. With an ageing population, the figure is projected to rise further.[1] A growing recognition of the significant impact sarcopenia has on adverse health outcomes finally led to its inclusion as a formal diagnosis—under the assigned code M62.84—in the International Classification of Diseases, 10th Revision, Clinical Modification (ICD-10-MC) in 2016.[1]

Currently, there is no "gold standard" definition of sarcopenia. In the last decade, 6 working groups have tried to reach a consensus on its definition.[3,7,8] They have recommended various cut-off values for muscle mass and have suggested different methods to measure muscle mass and muscle strength or function. In spite of the differences, they agreed that the core features of sarcopenia include the presence of low muscle mass with low muscle strength or function.[4]

The gold standard in the measurement of skeletal muscle mass is magnetic resonance imaging or computed tomography scan.[9] However, their widespread use is limited by high cost and lack of access, portability and highly trained personnel to administer them. As such, the most widely used method is measurement of fat-free mass (FFM) which is viewed as a surrogate measure of skeletal muscle mass. It has also been argued that skeletal muscle is the principal component in FFM.[10] Other methods include estimation of appendicular muscle mass with dual-energy X-ray absorptiometry (DXA) or total body electrical conductivity with bioelectrical impedance analysis (BIA).[11] A more recent method, D_3-Creatine dilution, is shown to provide more accurate measurement of functional muscle mass as it measures the creatine level in the human body.[10,12] However, more research is needed on the feasibility of its use in clinical practice.

Early detection of sarcopenia can prevent downstream adverse health outcomes. Since sarcopenia is asymptomatic in the early stage, the development of an effective screening tool to detect it has proven challenging.[1] The tool must be cheap, easy to use and has high predictive value. The difficulty is further compounded by a lack of consensus on a common definition of sarcopenia. In early 2018, the European Working Group on Sarcopenia in Older People (EWGSOP) published a revised consensus on sarcopenia.[13] It recommended the use of the 5-item questionnaire—Strength, Assistance with walking, Rising from chair, Climbing stairs and Falls (SARC-F)—as a case-finding tool to identify individuals at risk of sarcopenia and a cumulative score of ≥4 would indicate probable sarcopenia that requires intervention. However, this tool has high specificity and very low sensitivity in predicting muscle strength since only severe cases may be detected at the expense of individuals who are at risk of early sarcopenia. Within the last few years, new screening tools were developed and validated to identify individuals at risk of sarcopenia. To date, it is unclear which of these (either alone or in combination) is the most effective tool to screen for sarcopenia in the community.

As such, the objective of our scoping review is to evaluate validated screening tools that are used to identify community-dwelling older adults who are at risk of developing sarcopenia. In doing so, we critically appraise their performance against 1 of the consensus definitions. The findings will provide an updated review on the available screening tools that boast the highest sensitivity and specificity to identify community-dwelling older adults who are at risk of sarcopenia.

Materials and Methods

The scoping review is a strategy that was designed to "map" the existing literature on a particular area of interest or study. It is unlike a systematic review which seeks to address a specific research question. The scoping review is especially useful in the study of emerging topics that are often complex and involve different study designs which have not been reviewed extensively.[14] As such, it is appropriate for our present study and we used the widely accepted scoping review model advanced by Arksey and O'Malley.[15] There are 5 stages in the model: 1) identify the research questions; 2) identify relevant studies; 3) study selection; 4) chart the data; and 5) collate, summarise and report the results. We also followed the recommendation of this model to combine a broad research question with a defined scope of inquiry. In our study, the overarching research question was: What can we learn from the existing literature about the diagnostic performance of validated tools that screen for sarcopenia in community-dwelling older adults against international consensus definitions?

We performed an online search of MEDLINE (1946 and onwards), EMBASE (from 1976 onwards) and PubMed for articles published in the English language. Only studies reported in the English language were included in our scoping review. We also performed a hand search of the list of extracted articles to identify potentially relevant studies. In keeping with a scoping review, the search process was iterative to ensure that we identify as many relevant studies as possible. Articles were searched up to 31 December 2018 using the words "sarcopenia" and "screening". The search was then expanded in 2 ways. First, we used the terms "sarcopenia", "low muscle mass" and "low muscle function". We then excluded the descriptor "low" from the last 2 search terms but it did not increase the number of yielded results. Second, we expanded the term "screening" to include "screen*", "tool*", "assess*", "hand grip strength", "gait speed", "calf circumference", "diagnostic accuracy", "sensitivity" and "specificity". The titles and abstracts of all articles identified in the literature search were screened for relevance.

Primary articles were included in the scoping review when they met 2 criteria. First, they were original studies. Second, the screening tools they examined had been validated against a consensus definition for sarcopenia formulated by at least 1 of these internationally recognised working groups: EWGSOP, International Working Group on Sarcopenia (IWGS), Asian Working Group for Sarcopenia (AWGS), ESPEN Special Interest Group, Foundation for the National Institute of Health (FNIH) Sarcopenia Project and the Society for Sarcopenia, Cachexia and Wasting Disorders (SCWD).

We also included studies which reported the performance of screening tools that used predictive validity measures such as sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), accuracy or area under receiver operating characteristic curves (AUROC). Other inclusion criteria included studies on subjects with mean age ≥65 years who were community-dwellers.

We excluded studies that investigated specific disease populations such as end-stage kidney disease, end-stage heart failure, chronic obstructive lung disease, diabetes, chronic liver disease, organ transplantation, advanced cancer and neuromuscular disorders. We also excluded studies that used parameters other than appendicular skeletal muscle mass index as a surrogate measure of muscle mass. Studies that investigated screening tools to identify only low muscle mass or function were also excluded since they do not meet the definition of sarcopenia. For the purpose of this review, we excluded studies that involved participants who reside in nursing homes. Commentaries and review articles (with the exception of meta-analyses) were also excluded.

Using the inclusion and exclusion criteria outlined above, the first review author was responsible for screening the titles and abstracts of all identified articles. Duplicate articles were then removed. The second review author independently reviewed the full text of the selected articles and extracted data for analysis. Disagreements were resolved through discussion and when no consensus was reached, adjudication by a third reviewer was sought.

A form was developed to capture and synthesise the data and characteristics identified in our scoping review. The information included authors, year of publication, country of origin, publication type, aims and purpose, description of participants, article description, screening tool used, consensus definition that screening tool was validated against and predictive validity measures of screening tools. The data and results were charted and presented in tables.

Results

The clinical screening tools for sarcopenia can be divided into 4 broad categories: 1) questionnaires, 2) anthropometric measurements, 3) combination of questionnaire and anthropometric measures, and 4) physical function tests. A description of each tool is provided in Table 1.

Figure 1 presents the flow chart of our search strategy. A total of 17 studies were identified from our scoping review. Of these, 14 were cohort studies which used 1 of the 4 screening tools against at least 1 of the 6 consensus definitions of sarcopenia (Table 2). The remaining 3 studies included 1 meta-analysis on SARC-F and 2 comparative studies of the performance of various screening tools.

Two screening tools used a questionnaire: Mini Sarcopenia Risk Assessment (MSRA) and SARC-F.[16,17] MSRA is administered using either a 5-item (MSRA-5) or 7-item (MSRA-7) questionnaire.[17] Similarly, SARC-F uses a 3-item (SARC-F-3) or 5-item (SARC-F-5) questionnaire.[16] Some studies in the Chinese population used a modified version of SARC-F-5 whereby the question on "strength" was substituted with a question on "slowness" to refer to any difficulty participants may face in traversing 400 m without resting.[18] However, we did not retrieve any studies that used this modified version of SARC-F-5 that met our inclusion and exclusion criteria.

MSRA was developed by Rossi et al.[17] The first version comprised 7 (MSRA-7) items (age, hospitalisation in the preceding year, level of activity, regularity of meals, daily dairy consumption, daily calorie consumption and weight loss ≥2 kg in the preceding year). The second version comprised 5 (MSRA-5) items and omitted dairy and calorie consumptions. A score of 30 and 45 on MSRA-7 and MSRA-5, respectively, indicates sarcopenia. Compared to EWGSOP, the sensitivity and specificity of MSRA-7 were 80.4% and 50.5%, respectively. MSRA-5 showed similar sensitivity (80.4%) and slightly higher specificity (60.4%) with comparable AUROC.[17] In a validation study of a Chinese population that used AWGS as reference standard,[19] MSRA-5 displayed superior diagnostic performance against MSRA-7 with a sensitivity of 90.2% vs 86.9% and specificity of 79.6% vs 39.6%, respectively (Table 3).

SARC-F-5 was developed by Malmstrom and Morley to identify individuals at risk of sarcopenia.[16] It examines 5 domains: Strength, Assistance with walking, Rising from chair, Climbing stairs and Falls.[16] A score of ≥4 out of a maximum of 10 indicates sarcopenia risk.[16] In 8 studies that examined a questionnaire-based screening tool, 6 reported on SARC-F-5 (Tables 2 and 3).[20-25] SARC-F-5 has been translated and validated in populations of community-dwelling elderly in Brazil, China, Korea, Spain and Turkey.

Table 1. Screening Tools for Sarcopenia

Method	Tool	Criteria for Positive Screen
Questionnaire	MSRA-7 1. Age (<70 years or ≥70 years) 2. Hospitalisation in the last 1 year 3. Activity level (ability to walk 1000 m) 4. Eat 3 meals/day 5. Daily dairy consumption 6. Daily calorie consumption 7. Weight loss in the last year (>2 kg or ≤2 kg)	Total score ≤30
	MSRA-5 1. Age (<70 years or ≥70 years) 2. Hospitalisation in the last 1 year 3. Activity level (ability to walk 1000 m) 4. Eat 3 meals/day 5. Weight loss in the last year (>2 kg or ≤2 kg)	Total score ≤45
	SARC-F-5 (None = 0, Some = 1, A lot = 2) 1. Strength (difficulty lifting load of 4.5 kg) 2. Assistance with walking (difficulty crossing a room) 3. Rise from chair (difficulty in transfer) 4. Climb stairs (difficulty navigating 10 steps) 5. Falls (None = 0, 1 – 3 falls = 1, >4 falls = 2)	Total score ≥4
	SARC-F-3 1. Strength (difficulty lifting load of 4.5 kg) 2. Assistance with walking (difficulty crossing a room) 3. Climb stairs (difficulty navigating 10 steps)	Total score ≥2
Anthropometric measure	ASMM (using prediction equation based on weight, age, BMI and sex: 10.05 + 0.35 [weight] - 0.62 [BMI] - 0.02 [Age] + 5.10 [if male])	Cut-offs for low muscle mass (lowest 20% of SMI): • Men: <8.05 kg/m^2 • Women: <5.35 kg/m^2
	Grip strength (measured with hand dynamometer)	Cut-offs for low grip strength: • Men: <30 kg • Women: <20 kg
	Risk calculation based on total sum score for age, grip strength (kg) and calf circumference (cm) for both genders: • Men: 0.62 × (age - 64) - 3.09 × (grip strength in kg - 50) - 4.64 × (calf circumference in cm - 42) • Women: 0.80 × (age - 64) - 5.09 × (grip strength in kg - 34) - 3.28 × (calf circumference in cm - 42) Total sum score is used to estimate probability of sarcopenia in both genders: • Men: 1/(1 + e - [sum score/10 - 11.9]) • Women: 1/(1 + e - [sum score/10 - 12.5])	Cut-offs for sensitivity and specificity: • Men: >105 • Women: >120
Questionnaire with anthropometric measure	SARC-CalF (None = 0, Some = 1, A lot = 2) 1. Strength (difficulty lifting load of 4.5 kg) 2. Assistance with walking (difficulty crossing a room) 3. Rise from chair (difficulty in transfer) 4. Climb stairs (difficulty navigating 10 steps) 5. Falls (None = 0, 1 – 3 falls = 1, >4 falls = 2) 6. CalF (men: <34 cm, 10 points; women: <35 cm, 10 points)	Final score of: • 0 – 10: Not indicative of sarcopenia • 11 – 20: Indicative of sarcopenia
Physical performance	Chair stand test	Duration ≥13 seconds

ASMM: Appendicular skeletal muscle mass; BMI: Body mass index; CalF: Calf circumference; MSRA-5: Mini Sarcopenia Risk Assessment-5 Items; MSRA-7: Mini Sarcopenia Risk Assessment-7 Items; SARC-F-3: Strength, Assistance with walking, Rising from chair, Climbing stairs and Falls-3 Items; SARC-F-5: Strength, Assistance with walking, Rising from chair, Climbing stairs and Falls-5 Items; SARC-CalF: SARC-F with calf circumference; SMI: Skeletal muscle mass index

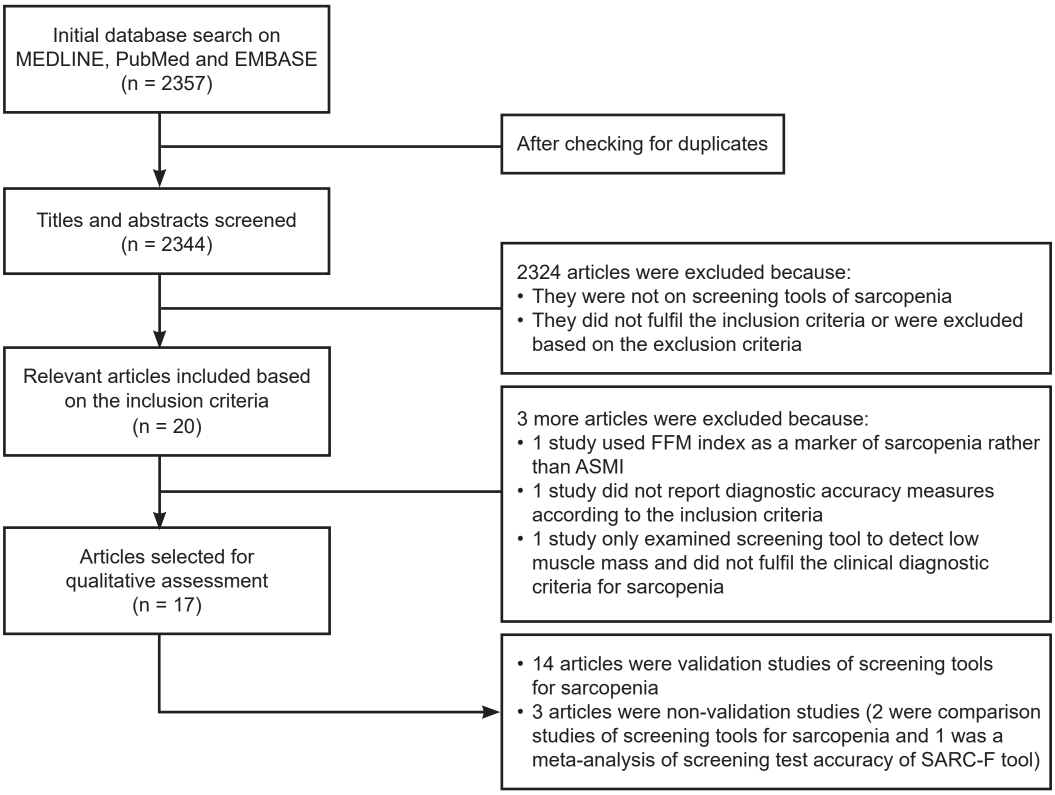

Fig. 1. Flow chart of search strategy. ASMI: Appendicular skeletal muscle mass index; FFM: Fat-free mass; SARC-F: Strength, Assistance with walking, Rising from chair, Climbing stairs and Falls

The results of these studies are comparable and consistently showed good diagnostic accuracy characterised by low sensitivity and high specificity (Table 3).

Additionally, Woo et al proposed a shorter version of SARC-F-5 after they identified 3 (SARC-F-3) domains (strength, stair climbing and assistance with walking) that predict adverse outcomes.[26] In a subsequent study of a population of Chinese subjects, SARC-F-3 was shown to have poorer diagnostic performance than SACR-F-5 (AUROC, 0.676 vs 0.894) and it was attributed to lower sensitivity (13.1% vs 29.5%).[25]

In 2018, a meta-analysis was performed with pooled findings from 7 studies that used SARC-F to evaluate 12,800 subjects.[27] Two studies were performed in Hong Kong and 1 each in Brazil, France, Japan, Mexico and South Korea.[20-23,28-30] Using the EWGSOP consensus definition as standard reference, the pooled sensitivity, specificity, positive likelihood ratio, negative likelihood ratio and diagnostic odds ratio were 21% (95% confidence interval [CI], 13-31%), 90% (95% CI, 83-94%), 2.16 (95% CI, 1.51-3.09), 0.87 (95% CI, 0.80-0.95) and 2.47 (95% CI, 1.64-3.74), respectively.[27] Similar pooled results on sensitivity and specificity were seen in studies that used IWGS and AWGS as their standard reference.[27]

Using criteria from AWGS, 1 study compared MSRA-5, MSRA-7 and SARC-F in a cohort of older Chinese participants.[31] SARC-F was shown to have a sensitivity of 29.5% and specificity of 98.1%; MSRA-7 had a sensitivity of 86.9% and specificity of 39.6%; and MSRA-5 had a sensitivity of 90.2% and specificity of 70.6%. The AUROC of SARC-F, MSRA-7 and MSRA-5 were 0.89 (95% CI, 0.86-0.92), 0.70 (95% CI, 0.65-0.74) and 0.85 (95% CI, 0.81-0.89), respectively. Overall, MSRA-5 has better sensitivity but SARC-F has better specificity. However, the diagnostic value of MSRA needs to be validated in other populations.

Our scoping review revealed 3 studies that combined SARC-F and calf circumference (SARC-CalF) as a surrogate measure of muscle mass.[30,32-34] In their study of 179 subjects aged ≥60 years old in Brazil, Barbosa-Silva et al showed that SARC-CalF (AUROC, 0.736; 95% CI, 0.575-0.897) enhanced sensitivity with a resultant increase in screening performance compared to SARC-F (AUROC, 0.592; 95% CI, 0.445-0.739; P = 0.027).[30] Similarly, a Chinese study that used AWGS criteria as the reference standard showed SARC-CalF had a sensitivity of 60.7% and specificity of 94.7% but SARC-F had a sensitivity of 29.5% and specificity of 98.1%.[33] The corresponding AUROC for SARC-CalF and SARC-F were 0.92 (95% CI, 0.89-0.94) and 0.89 (95%

Table 2. Baseline Characteristics of Screening Tools for Sarcopenia

Tool/Authors	Study Type	Study Population	Definition of Sarcopenia
Questionnaire			
MSRA			
Rossi et al[*]	Observational study, community-dwelling older adults, Italian population	Aggregate (n = 274, %): • Men: 97 (35) • Women: 177 (65) Age (years, mean ± SD): 71.7 ± 2.28	EWGSOP • SMI (DXA): men, <7.26 kg/m^2; women, <5.5 kg/m^2 • HG: men, <9.66 kg; women, <5.33 kg • GS: <0.8 m/s
Yang et al[†]	Cross-sectional study, community-dwelling older adults, Chinese population	Aggregate (n = 384, %): • Men: 160 (42) • Women: 224 (58) Age (years, mean ± SD): • Men (non-sarcopenic): 71.7 ± 5.7 • Men (sarcopenic): 77.4 ± 7.1 • Women (non-sarcopenic): 70.5 ± 5.4 • Women (sarcopenic): 74.3 ± 5.5	EWGSOP • ASMI (BIA): men, <6.28 kg/m^2; women, <5.08 kg/m^2 • HG: men, <30 kg; women, <20 kg • GS: <0.8 m/s IWGS • ASMI (BIA): men, ≤7.23 kg/m^2; women, ≤5.67 kg/m^2 • GS: <1 m/s FNIH • ASM/BMI: men, <0.78; women, <0.512 • HG: men, <26 kg; women, <16 kg • GS <0.8 m/s AWGS • ASMI: men, <7 kg/m^2; women, <5.7 kg/m^2 • HG: men, <26 kg; women, <18 kg • GS: <0.8 m/s
SARC-F			
Woo et al[‡]	Prospective cohort study, community-dwelling older adults, Chinese population	Aggregate (n = 3997, %): • Men: 1999 (50) • Women: 1998 (50) Mean age (years): • Men (sarcopenic): 75.5 • Men (non-sarcopenic): 72.3 • Women (sarcopenic): 75.4 • Women (non-sarcopenic): 72.4	EWGSOP • ASMI (DXA): men, <6.52 kg/m^2; women, <5.44 kg/m^2 • HG: men, ≤28 kg; women, ≤18 kg • GS: <0.8 m/s IWGS • ASMI: men, ≤7.23 kg/m^2; women, ≤5.67 kg/m^2 • GS: <1 m/s AWGS • ASMI: men, ≤7 kg/m^2; women, ≤5.4 kg/m^2 • HG: men, <26 kg; women, <18 kg • GS: <0.8 m/s
Parra-Rodriguez et al[§]	Cross-sectional study, community-dwelling older adults, Spanish population	Aggregate (n = 487, %): • Men: 97 (20) • Women: 390 (80) Age (years, mean ± SD): 73.2 ± 8.0	EWGSOP • ASMI (DXA): men, <6.54 kg/m^2; women, <5.37 kg/m^2 • HG: men, ≤20 kg; women, ≤12 kg • GS: <0.85 m/s IWGS • ASMI (DXA): men, ≤7.23 kg/m^2; women, ≤5.67 kg/m^2 • GS: <1 m/s AWGS • ASMI (DXA): men, ≤6.54 kg/m^2; women, ≤5.37 kg/m^2 • HG: men, ≤20 kg; women, ≤12 kg • GS: <0.8 m/s
Rolland et al[ǁ]	Prospective cross-sectional study, community-dwelling older adults, female population	Aggregate, n = 2725 Age (years, mean ± SD): 81.6 ± 4.4	FNIH • ALM: ≤0.512 m^2 • HG: ≤16 kg

ALM: Appendicular lean muscle mass; ASM: Appendicular skeletal muscle mass; ASMI: Appendicular skeletal muscle mass index; AWGS: Asian Working Group for Sarcopenia; BIA: Bioelectrical impedance analysis; BMI: Body mass index; DXA: Dual energy X-ray absorptiometry; EWGSOP: European Working Group on Sarcopenia on Older People; FNIH: Foundation for the National Institutes of Health; GS: Gait speed; HG: Hand grip; IWGS: International Working Group on Sarcopenia; MSRA: Mini Sarcopenia Risk Assessment; SARC-F: Strength, Assistance with walking, Rise from chair, Climb stairs, Falls; SD: Standard deviation

[*] Rossi AP, Micciolo R, Rubele S, Fantin F, Caliari C, Zoico E, et al. Assessing the risk of sarcopenia in the elderly: the Mini Sarcopenia Risk Assessment (MSRA) questionnaire. J Nutr Health Aging 2017;21:743-9.

[†] Yang M, Hu X, Xie L, Zhang L, Zhou J, Lin J, et al. Validation of the Chinese version of the Mini Sarcopenia Risk Assessment questionnaire in community-dwelling older adults. Medicine (Baltimore) 2018;97:e12426.

[‡] Woo J, Leung J, Morley JE. Validating the SARC-F: a suitable community screening tool for sarcopenia? J Am Med Dir Assoc 2014;15:630-4.

[§] Parra-Rodríguez L, Szlejf C, García-González AI, Malmstrom TK, Cruz-Arenas E, Rosas-Carrasco O. Cross-cultural adaptation and validation of the Spanish-language version of the SARC-F to assess sarcopenia in Mexican community-dwelling older adults. J Am Med Dir Assoc 2016;17:1142-6.

[ǁ] Rolland Y, Dupuy C, Abellan Van Kan G, Cesari M, Vellas B, Faruch M, et al. Sarcopenia screened by the SARC-F questionnaire and physical performances of elderly women: a cross-sectional study. J Am Med Dir Assoc 2017;18:848-52.

Table 2. Baseline Characteristics of Screening Tools for Sarcopenia (Cont'd)

Tool/Authors	Study Type	Study Population	Definition of Sarcopenia
Kim et al¶	Cross-sectional cohort study, community-dwelling older adults, Korean population	Aggregate (n = 1222, %): • Men: 577 (47) • Women: 645 (53) Mean age (years): • Men (non-sarcopenic): 76.5 • Men (sarcopenic): 78.3 • Women (non-sarcopenic): 75.5 • Women (sarcopenic): 77.8	EWGSOP • ASMI (DXA): men, <6.43 kg/m^2; women, <5.34 kg/m^2 • HG: men, ≤26.5kg; women, ≤16.9 kg • GS: <0.8 m/s IWGS • ASMI (DXA): men, ≤7.23 kg/m^2; women, ≤5.67 kg/m^2 • GS: <1 m/s AWGS • ASMI (DXA): men, <7 kg/m^2; women, <5.4 kg/m^2 • HG: men, ≤26 kg; women, ≤18 kg • GS: <0.8 m/s
Bahat et al#	Cross-sectional study, community-dwelling older people, Turkish population	Aggregate (n = 207, %): • Men: 67 (32) • Women: 140 (68) Age (years, mean ± SD): • Men: 75.4 ± 5.9 • Women: 74.2 ± 7.1	EWGSOP • ASMI (BIA): men, <6.28 kg/m^2; women, <5.08 kg/m^2 • HG: men, <32 kg; women, <22 kg • GS: <0.8 m/s IWGS • ASMI (BIA): men, ≤7.23 kg/m^2; women, ≤5.67 kg/m^2 • HG: men, <32 kg; women, <22 kg • GS: <1 m/s FNIH • ASM/BMI: men, <0.789; women, 0.512 • HG: men, <26 kg; women, <16 kg • GS: <0.8 m/s
Yang et al**	Cross-sectional study, community-dwelling older people, Chinese population	Aggregate (n = 384, %): • Men: 160 (42) • Women: 224 (58) Age (years, mean ± SD): • Men: 72.3 ± 6.0 • Women: 70.9 ± 5.5	AWGS • ASMI (BIA): men, <7 kg/m^2; women, <5.7 kg/m^2 • HG: men, <26 kg; women, <18 kg • GS: 0.8 m/s
MSRA vs SARC-F			
Yang et al††	Cross-sectional study, community-dwelling older people, Chinese population	Aggregate (n = 384, %): • Men: 160 (42) • Women: 224 (58) Age (years, mean ± SD): • Men: 72.3 ± 6.0 • Women: 70.9 ± 5.5	AWGS • ASMI (BIA): men, <7 kg/m^2; women, <5.7 kg/m^2 • HG: men, <26 kg; women, <18 kg • GS: <0.8 m/s
Questionnaire and Anthropometric Measures			
SARC- CalF and SARC-F			
Barbosa-Silva et al‡‡	Cross-sectional population-based study, community-dwelling older adults, Brazilian population	Aggregate (n = 179, %) • Men: 69 (38.6) • Women: 110 (61.4) Age (%): • 60 – 69 years: 103 (57.5) • 70 – 79 years: 56 (31.3) • ≥80 years: 20 (11.2)	EWGSOP • ASMI (DXA): men, <7.76 kg/m^2; women, <5.62 kg/m^2 • HG: men, <30 kg; women, <20 kg • GS: <0.8 m/s

ASM: Appendicular skeletal muscle mass; ASMI: Appendicular skeletal muscle mass index; AWGS: Asian Working Group for Sarcopenia; BIA: Bioelectrical impedance analysis; BMI: Body mass index; DXA: Dual energy X-ray absorptiometry; EWGSOP: European Working Group on Sarcopenia on Older People; FNIH: Foundation for the National Institutes of Health; GS: Gait speed; HG: Hand grip; IWGS: International Working Group on Sarcopenia; MSRA: Mini Sarcopenia Risk Assessment; SARC-F: Strength, Assistance with walking, Rise from chair, Climb stairs, Falls; SARC-CalF: SARC-F and calf circumference; SD: Standard deviation

¶Kim S, Kim M, Won CW. Validation of the Korean version of the SARC-F questionnaire to assess sarcopenia: Korean frailty and aging cohort study. J Am Med Dir Assoc 2018;19:40-5.

#Bahat G, Yilmaz O, Kılıç C, Oren MM, Karan MA. Performance of SARC-F in regard to sarcopenia definitions, muscle mass and functional measures. J Nutr Health Aging 2018;22:898-903.

**Yang M, Hu X, Xie L, Zhang L, Zhou J, Lin J, et al. SARC-F for sarcopenia screening in community-dwelling older adults: are 3 items enough? Medicine (Baltimore) 2018;97:e11726.

††Yang M, Hu X, Xie L, Zhang L, Zhou J, Lin J, et al. Comparing Mini Sarcopenia Risk Assessment with SARC-F for screening sarcopenia in community-dwelling older adults. J Am Med Dir Assoc 2019;20:53-7.

‡‡Barbosa-Silva TG, Menezes AM, Bielemann RM, Malmstrom TK, Gonzalez MC. Enhancing SARC-F: improving sarcopenia screening in the clinical practice. J Am Med Dir Assoc 2016;17:1136-41.

Table 2. Baseline Characteristics of Screening Tools for Sarcopenia (Cont'd)

Tool/Authors	Study Type	Study Population	Definition of Sarcopenia
Yang et al[§§]	Cross-sectional study, community-dwelling older people, Chinese population	Aggregate (n = 384, %) • Men: 160 (42) • Women: 224 (58) Age (years, mean ± SD): • Men (non-sarcopenic): 71.7 ± 5.7 • Men (sarcopenic): 77.4 ± 7.1 • Women (non-sarcopenic): 70.5 ± 5.4 • Women (sarcopenic): 74.3 ± 5.5	EWGSOP • ASMI (BIA): men, <6.28 kg/m^2; women, <5.08 kg/m^2 • HG: men, <30 kg; women, <20 kg • GS: <0.8 m/s IWGS • ASMI: men, ≤7.23 kg/m^2; women, ≤5.67 kg/m^2 • GS: <1 m/s FNIH • ASM/BMI: men, <0.789; women, 0.512 • HG: men, <26 kg; women, <16 kg • GS: <0.8 m/s AWGS • ASMI: men, <7 kg/m^2; women, <5.7 kg/m^2 • HG: men, <26 kg; women, <18 kg • GS: <0.8 m/s
Bahat et al[ǁǁ]	Cross-sectional study, community-dwelling older people, Turkish population	Aggregate (n = 207, %) • Men: 67 (32) • Women: 140 (68) Age (years, mean ± SD): • Men: 75.4 ± 5.9 • Women: 74.2 ± 7.1	EWGSOP • ASMI (BIA): men, <6.28 kg/m^2; women, <5.08 kg/m^2 • HG: men, <32 kg; women, <22 kg • GS: <0.8 m/s IWGS • ASMI: men, ≤7.23kg/m^2; women, ≤5.67 kg/m^2 • HG: men, <32 kg; women, <22 kg • GS: <1 m/s FNIH • ASM/BMI: men, <0.789; women, 0.512 • HG: men, <26 kg; women, <16 kg • GS: <0.8 m/s
Anthropometric Measures			
Yu et al[¶¶]	Cross-sectional study, community-dwelling older adults, Caucasian Australian population	Aggregate (from 2 cohorts) • 611 men • 375 women Age (years, mean ± SD): • Men: 72.7 ± 5.7 • Women: 73.2 ± 6.0	Low ASMI and low grip strength: • ASMI: men, <8.05 kg/m^2; women, <5.35 kg/m^2 • HG: men, <30 kg; women, <20 kg
Ishii et al[##]	Prospective cohort study, community-dwelling older adults, Japanese population	Aggregate (n = 1971, %) • Men: 977 (50) • Women: 994 (50) Age (years, mean ± SD): • Men (sarcopenic): 78.4 ± 5.5 • Men (non-sarcopenic): 72.2 ± 5.0 • Women (sarcopenic): 76.2 ± 5.8 • Women (non-sarcopenic): 71.8 ± 4.9	EWGSOP • SMI (BIA): men, <7.0 kg/m^2; women, <5.8 kg/m^2 • HG: men, <30 kg; women, <20 kg • GS: <1.26 m/s
Physical Performance			
Pinheiro et al[***]	Cross-sectional study, community-dwelling adults ≥60 years, female population	Aggregate, n = 73 Age (years, mean ± SD): 74.8 ± 9.9	EWGSOP • SMI: ≤6.75 kg/m^2 • HG (based on BMI): underweight, <11 kg; adequate, <21 kg; overweight, <14 kg • GS (based on height)

ASM: Appendicular skeletal muscle mass; ASMI: Appendicular skeletal muscle mass index; AWGS: Asian Working Group for Sarcopenia; BIA: Bioelectrical impedance analysis; BMI: Body mass index; DXA: Dual energy X-ray absorptiometry; EWGSOP: European Working Group on Sarcopenia on Older People; FNIH: Foundation for the National Institutes of Health; GS: Gait speed; HG: Hand grip; IWGS: International Working Group on Sarcopenia; SD: Standard deviation; SMI: Skeletal muscle mass index

[§§]Yang M, Hu X, Xie L, Zhang L, Zhou J, Lin J, et al. Screening sarcopenia in community-dwelling older adults: SARC-F vs SARC-F Combined With Calf Circumference (SARC-CalF). J Am Med Dir Assoc 2018;19: 277.

[ǁǁ]Bahat G, Oren MM, Yilmaz O, Kılıç C, Aydin K, Karan MA. Comparing SARC-F with SARC-CalF to screen sarcopenia in community living older adults. J Nutr Health Aging 2018;22:1034-8.

[¶¶]Yu S, Appleton S, Chapman I, Adams R, Wittert G, Visvanathan T, et al. An anthropometric prediction equation for appendicular skeletal muscle mass in combination with a measure of muscle function to screen for sarcopenia in primary and aged care. J Am Med Dir Assoc 2015;16:25-30.

[##]Ishii S, Tanaka T, Shibasaki K, Ouchi Y, Kikutani T, Higashiguchi T, et al. Development of a simple screening test for sarcopenia in older adults. Geriatr Gerontol Int 2014;14:93-101.

[***]Pinheiro PA, Carneiro JA, Coqueiro RS, Pereira R, Fernandes MH. "Chair stand test" as simple tool for sarcopenia screening in elderly women. J Nutr Health Aging 2016;20:56-9.

Table 3. Studies on Predictive Validity Measures

Screening Tool	Sensitivity, % (95% CI)		Specificity, % (95% CI)		PPV, % (95% CI)		NPV, % (95% CI)		PLR (95% CI)		NLR (95% CI)		AUROC (95% CI)/ Accuracy (%)	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
MSRA														
Rossi et al*														
EWGSOP														
C-MSRA-7	80.4		50.5		-		-		-		-		0.786 (0.725 – 0.847)	
C-MSRA-5	80.4		60.4		-		-		-		-		0.789 (0.728 – 0.851)	
Yang et al†														
EWGSOP														
C-MSRA-7	80.0 (65.4 – 90.4)		38.1 (32.9 – 43.5)		-		-		1.3 (1.1 – 1.5)		0.5 (0.3 – 1.0)		0.68 (0.63 – 0.72)	
C-MSRA-5	82.2 (67.9 – 92.0)		65.2 (59.9 – 70.3)		-		-		2.4 (1.9 – 2.9)		0.3 (0.1 – 0.5)		0.74 (0.69 – 0.78)	
AWGS														
C-MSRA-7	86.9 (75.8 – 94.2)		39.6 (34.3 – 45.2)		-		-		1.4 (1.3 – 1.6)		0.3 (0.2 – 0.6)		0.70 (0.65 – 0.74)	
C-MSRA-5	90.2 (79.8 – 96.3)		70.6 (65.3 – 75.5)				-		3.1 (2.5 – 3.7)		0.2 (0.1 – 0.3)		0.85 (0.81 – 0.89)	
IWGS														
C-MSRA-7	82.3 (73.2 – 89.3)		42.0 (36.2 – 47.9)		-		-		1.4 (1.2 – 1.6)		0.4 (0.3 – 0.7)		0.69 (0.64 – 0.73)	
C-MSRA-5	80.2 (70.8 – 87.6)		55.9 (50.0 – 61.7)		-		-		1.8 (1.5 – 2.1)		0.4 (0.2 – 0.5)		0.75 (0.71 – 0.80)	
FNIH														
C-MSRA-7	78.0 (66.3 – 87.7)		38.5 (33.1 – 44.0)		-		-		1.3 (1.1 – 1.5)		0.6 (0.3 – 0.9)		0.59 (0.54 – 0.64)	
C-MSRA-5	89.8 (79.2 – 96.2)		68.6 (63.3 – 73.6)		-		-		2.9 (2.4 – 3.4)		0.2 (0.1 – 0.3)		0.82 (0.78 – 0.86)	
SARC-F														
Woo et al‡														
EWGSOP	4.2	9.9	98.7	94.4	25.8	14.3	90.8	91.8	-	-	-	-	89.7	87.2
IWGS	3.8	8.2	99.1	94.6	54.8	25.2	78.4	82.2	-	-	-	-	78.0	78.8
AWGS	4.8	9.4	98.8	94.2	29.0	8.4	91.0	94.9	-	-	-	-	90.0	89.7

AUROC: Area under the receiver operating characteristic curve; AWGS: Asian Working Group for Sarcopenia; CI: Confidence interval; C-MSRA-5: Chinese Mini Sarcopenia Risk Assessment-5 Items; C-MSRA-7: Chinese Mini Sarcopenia Risk Assessment-7 Items; EWGSOP: European Working Group on Sarcopenia in Older People; FNIH: Foundation for the National Institutes of Health; IWGS: International Working Group on Sarcopenia; NLR: Negative likelihood ratio; NPV: Negative predictive value; PLR: Positive likelihood ratio; PPV: Positive predictive value; SARC-F: Strength, Assistance with walking, Rise from chair, Climb stairs, Falls

*Rossi AP, Micciolo R, Rubele S, Fantin F, Caliari C, Zoico E, et al. Assessing the risk of sarcopenia in the elderly: the Mini Sarcopenia Risk Assessment (MSRA) questionnaire. J Nutr Health Aging 2017;21:743-9.

†Yang M, Hu X, Xie L, Zhang L, Zhou J, Lin J, et al. Validation of the Chinese version of the Mini Sarcopenia Risk Assessment questionnaire in community-dwelling older adults. Medicine (Baltimore) 2018;97:e12426.

‡Woo J, Leung J, Morley JE. Validating the SARC-F: a suitable community screening tool for sarcopenia? J Am Med Dir Assoc 2014;15:630-4.

Table 3. Studies on Predictive Validity Measures (Cont'd)

Screening Tool	Sensitivity, % (95% CI)		Specificity, % (95% CI)		PPV, % (95% CI)		NPV, % (95% CI)		PLR (95% CI)		NLR (95% CI)		AUROC (95% CI)/ Accuracy (%)	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Parra-Rodriguez et al[§]														
EWGSOP	35.6		82.2		17.0		92.6		2.0		0.78		-	
IWGS	28.3		83.3		30.8		81.6		1.69		0.86		-	
AWGS	31.5		82.1		18.2		90.5		1.76		0.83		-	
Rolland et al[‖]														
FNIH	-	34	-	85	-	4.2	-	1.3	-	-	-	-	-	-
Kim et al[¶]														
EWGSOP	16.7	34.0	97.0	86.1	33.3	16.2	92.8	94.3	-	-	-	-	90.3	82.3
IWGS	18.9	33.0	98.0	87.7	58.3	31.3	89.2	88.5	-	-	-	-	87.9	79.7
AWGS	16.7	32.2	97.5	86.3	45.8	19.2	90.1	92.7	-	-	-	-	88.2	81.4
CFNIH	13.0	28.1	96.6	85.3	25.0	9.1	92.8	95.8	-	-	-	-	89.9	82.5
FNIHa	11.9	27.8	96.7	85.4	29.2	10.1	90.6	95.2	-	-	-	-	88.0	82.2
FNIHb	60.0	30.8	96.8	85.0	25.0	4.0	99.3	98.4	-	-	-	-	96.2	83.9
Bahat et al[#]														
EWGSOP	25 (7.1 – 59.1)		81 (75.4 – 86.2)		5.1 (1.8 – 12.1)		96.4 (93.6 – 99.2)		-		-		-	
IWGS	50 (15 – 85)		81.8 (75.9 – 86.5)		5.1 (-1.8 – 12.1)		98.8 (97.2 – 100.4)		-		-		-	
SCWD	40 (11.8 – 76.9)		81.7 (75.8 – 86.4)		5.1 (-1.8 – 12.1)		98.2 (96.2 – 100.2)		-		-		-	
FNIH	32 (15.4 – 54)		82 (76.4 – 87.2)		15.4 (4.1 – 26.7)		92.3 (88.2 – 96.3)		-		-		-	
Yang et al[**]														
AWGS														
SARC-F	15.8 (3.4 – 39.6)	35.7 (21.6 – 52)	97.8 (93.9 – 99.6)	98.3 (95.3 – 99.7)	-	-	-	-	7.4 (1.6 – 34.2)	21.7 (6.6 – 71.5)	0.8 (0.7 – 1.0)	0.7 (0.5 – 0.8)	0.859 (0.795 – 0.909)	0.909 (0.864 – 0.943)
SARC-F-3	5.3 (0.1 – 26.0)	16.7 (7.0 – 31.4)	99.2 (96.1 – 100)	96.7 (93.0 – 98.8)	-	-	-	-	7.4 (0.5 – 113.8)	13.0 (1.4 – 121.9)	1.0 (0.9 – 1.1)	0.9 (0.9 – 1.0)	0659 (0.580 – 0.732)	0.670 (0.604 – 0.731)

AUROC: Area under the receiver operating characteristic curve; AWGS: Asian Working Group for Sarcopenia; CFNIH: Chinese FNIH; CI: Confidence interval; EWGSOP: European Working Group on Sarcopenia in Older People; FNIH: Foundation for the National Institutes of Health; FNIHa: FNIH weakness and low lean mass; FNIHb: FNIH slowness with weakness and low lean mass; IWGS: International Working Group on Sarcopenia; NLR: Negative likelihood ratio; NPV: Negative predictive value; PLR: Positive likelihood ratio; PPV: Positive predictive value; SARC-F: Strength, Assistance with walking, Rise from chair, Climb stairs, Falls; SARC-F-3: Strength, Assistance with walking, Rise from chair, Climb stairs, Falls-3 Items; SCWD: Society on Sarcopenia Cachexia and Wasting Disorder

[§]Parra-Rodríguez L, Szlejf C, García-González AI, Malmstrom TK, Cruz-Arenas E, Rosas-Carrasco O. Cross-cultural adaptation and validation of the Spanish-language version of the SARC-F to assess sarcopenia in Mexican community-dwelling older adults. J Am Med Dir Assoc 2016;17:1142-6.

[‖]Rolland Y, Dupuy C, Abellan Van Kan G, Cesari M, Vellas B, Faruch M, et al. Sarcopenia screened by the SARC-F questionnaire and physical performances of elderly women: a cross-sectional study. J Am Med Dir Assoc 2017;18:848-52.

[¶]Kim S, Kim M, Won CW. Validation of the Korean version of the SARC-F questionnaire to assess sarcopenia: Korean frailty and aging cohort study. J Am Med Dir Assoc 2018;19:40-5.

[#]Bahat G, Yilmaz O, Kılıç C, Oren MM, Karan MA. Performance of SARC-F in regard to sarcopenia definitions, muscle mass and functional measures. J Nutr Health Aging 2018;22:898-903.

[**]Yang M, Hu X, Xie L, Zhang L, Zhou J, Lin J, et al. SARC-F for sarcopenia screening in community-dwelling older adults: are 3 items enough? Medicine (Baltimore) 2018;97:e11726.

Table 3. Studies on Predictive Validity Measures (Cont'd)

Screening Tool	Sensitivity, % (95% CI)		Specificity, % (95% CI)		PPV, % (95% CI)		NPV, % (95% CI)		PLR (95% CI)		NLR (95% CI)		AUROC (95% CI)/ Accuracy (%)	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
AWGS (total)														
SARC-F	29.5 (18.5 – 42.6)		98.1 (96.0 – 99.3)		-		-		15.9 (6.6 – 38.4)		0.7 (0.6 – 0.8)		0.894 (0.859 – 0.923)	
SARC-F-3	13.1 (5.8 – 24.2)		97.8 (95.6 – 99.1)		-		-		6.1 (2.3 – 16.1)		0.9 (0.9 – 1.0)		0.676 (0.627 – 0.723)	
SARC-F and SARC-CalF														
Barbosa-Silva et al††														
EWGSOP														
SARC-F ≥4	58.9 (46.8 – 70.3)		82.1 (73.4 – 88.9)		69.4 (56.4 – 80.4)		74.4 (65.5 – 82.0)		-		-		0.592	
SARC-F ≥6	33.3 (11.8 – 61.6)		84.2 (77.6 – 89.4)		16.1 (5.5 – 33.7)		93.2 (87.9 – 96.7)		-		-		0.779	
SARC-CalF	66.7 (38.4 – 88.2)		82.9 (76.3 – 88.4)		26.3 (13.4 – 43.1)		96.5 (91.9 – 98.8)		-		-		0.736	
Yang et al‡‡														
EWGSOP														
SARC-F	5.9 (0.1 – 28.7)	28.6 (13.2 – 48.7)	96.5 (92.0 – 98.9)	94.9 (90.8 – 97.5)	-	-	-	-	1.7 (0.2 – 13.6)	5.6 (2.4 – 13.0)	0.9 (0.9 – 1.0)	0.8 (0.6 – 1.0)	0.83 (0.77 – 0.88)	0.81 (0.75 – 0.86)
SARC-CalF	29.4 (10.3 – 56.0)	46.4 (27.5 – 66.1)	93.7 (88.4 – 97.1)	91.8 (87.1 – 95.3)	-	-	-	-	4.7 (1.8 – 12.3)	5.7 (3.1 – 10.5)	0.8 (0.6 – 1.0)	0.6 (0.4 – 0.8)	0.87 (0.71 – 0.92	0.90 (0.86 – 0.94)
AWGS														
SARC-F	15.8 (3.4 – 39.6)	35.7 (21.6 – 52.0)	97.8 (93.9 – 99.6)	98.3 (95.3 – 99.7)	-	-	-	-	7.4 (1.6 – 34.2)	21.7 (6.6 – 71.5)	0.8 (0.7 – 1.0)	0.7 (0.5 – 0.8)	0.86 (0.82 – 0.93)	0.90 (0.86 – 0.94)
SARC-CalF	47.4 (24.4 – 71.1)	57.1 (41.0 – 72.3)	96.5 (91.9 – 98.8)	97.3 (93.7 – 99.1)	-	-	-	-	13.3 (5.0 – 35.7)	20.8 (8.4 – 51.3)	0.6 (0.5 – 0.8)	0.4 (0.3 – 0.6)	0.88 (0.80 – 0.91)	0.93 (0.89 – 0.96)
IWGS														
SARC-F	10.3 (2.9 – 14.2)	26.3 (15.5 – 39.7)	98.3 (94.2 – 99.8)	98.2 (94.8 – 99.6)	-	-	-	-	6.2 (1.2 – 32.6)	14.7 (4.4 – 48.8)	0.9 (0.8 – 1.0)	0.8 (0.6 – 0.9)	0.77 (0.69 – 0.83)	0.82 (0.77 – 0.87)
SARC-CalF	30.8 (17.0 – 47.6)	50.9 (37.3 – 64.4)	98.4 (94.2 – 99.8)	93.4 (88.5 – 96.7)	-	-	-	-	18.6 (4.4 – 79.6)	7.7 (4.1 – 14.4)	0.7 (0.6 – 0.9)	0.5 (0.4 – 0.7)	0.80 (0.73 – 0.86)	0.86 (0.81 – 0.91)

AUROC: Area under the receiver operating characteristic curve; AWGS: Asian Working Group for Sarcopenia; CI: Confidence interval; EWGSOP: European Working Group on Sarcopenia in Older People; IWGS: International Working Group on Sarcopenia; NLR: Negative likelihood ratio; NPV: Negative predictive value; PLR: Positive likelihood ratio; PPV: Positive predictive value; SARC-F: Strength, Assistance with walking, Rise from chair, Climb stairs, Falls; SARC-CalF: SARC-F and calf circumference; SARC-F-3: Strength, Assistance with walking, Rise from chair, Climb stairs, Falls-3 Items

††Barbosa-Silva TG, Menezes AM, Bielemann RM, Malmstrom TK, Gonzalez MC. Enhancing SARC-F: improving sarcopenia screening in the clinical practice. J Am Med Dir Assoc 2016;17:1136-41.

‡‡Yang M, Hu X, Xie L, Zhang L, Zhou J, Lin J, et al. Screening sarcopenia in community-dwelling older adults: SARC-F vs SARC-F Combined With Calf Circumference (SARC-CalF). J Am Med Dir Assoc 2018;19:277.

Table 3. Studies on Predictive Validity Measures (Cont'd)

Screening Tool	Sensitivity, % (95% CI)		Specificity, % (95% CI)		PPV, % (95% CI)		NPV, % (95% CI)		PLR (95% CI)		NLR (95% CI)		AUROC (95% CI)/ Accuracy (%)	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
FNIH														
SARC-F	21.7 (7.5 – 43.7)	36.1 (20.8 – 53.8)	99.2 (96.0 – 100)	97.3 (93.9 – 99.1)	-	-	-	-	29.8 (3.6 – 47.1)	13.6 (5.2 – 35.7)	0.8 (0.6 – 1.0)	0.7 (0.5 – 0.8)	0.82 (0.75 – 0.88)	0.81 (0.76 – 0.86)
SARC-CalF	43.9 (23.2 – 65.5)	50.0 (32.9 – 67.1)	97.1 (92.7 – 99.5)	94.2 (89.8 – 97.0)	-	-	-	-	14.9 (5.1 – 43.5)	8.5 (4.4 – 16.5)	0.6 (0.4 – 0.8)	0.5 (0.4 – 0.7)	0.89 (0.83 – 0.93)	0.90 (0.85 – 0.94)
EWGSOP (total)														
SARC-F	20.0 (0.6 – 34.6)		95.6 (92.8 – 97.5)		-		-		4.5 (2.1 – 9.7)		0.8 (0.7 – 1.0)		0.81 (0.77 – 0.85)	
SARC-CalF	48.9 (33.7 – 64.2)		90.6 (86.9 – 93.5)		-		-		5.2 (3.3 – 8.1)		0.6 (0.4 – 0.8)		0.85 (0.81 – 0.89)	
AWGS (total)														
SARC-F	29.5 (18.5 – 42.6)		98.1 (96.0 – 99.3)		-		-		15.9 (6.6 – 38.4)		0.7 (0.6 – 0.8)		0.89 (0.86 – 0.92)	
SARC-CalF	60.7 (47.3 – 72.9)		94.7 (91.7 – 96.9)		-		-		11.5 (7.0 – 19.1)		0.4 (0.3 – 0.6)		0.92 (0.89 – 0.94)	
IWGS (total)														
SARC-F	19.8 (12.4 – 29.2)		98.2 (96.0 – 99.3)		-		-		11.4 (4.4 – 29.7)		0.8 (0.7 – 0.9)		0.79 (0.75 – 0.83)	
SARC-CalF	42.7 (32.7 – 53.2)		95.5 (92.4 – 97.6)		-		-		9.5 (5.3 – 16.9)		0.6 (0.5 – 0.7)		0.83 (0.79 – 0.87)	
FNIH (total)														
SARC-F	30.5 (19.2 – 43.9)		98.2 (96.0 – 99.3)		-		-		16.5 (6.8 – 39.9)		0.7 (0.6 – 0.8)		0.81 (0.77 – 0.85)	
SARC-CalF	55.9 (42.4 – 68.8)		93.5 (90.3 – 96.0)		-		-		8.6 (5.4 – 13.9)		0.5 (0.4 – 0.6)		0.89 (0.86 – 0.92)	
Bahat et al[§§]														
EWGSOP														
SARC-F	25.0 (0 – 55)		81.4 (76 – 86.8)		-		-		1.3		0.9		0.522	
SARC-CalF (<31 cm)	25.0 (0 – 55)		98 (96 – 99.9)		-		-		16.5		0.8		0.59	
SARC-CalF (<33 cm)	25.0 (0 – 55)		90 (86 – 94.5)		-		-		2.6		0.8		0.746	
FNIH														
SARC-F	31.6 (10.6 – 52.5)		82.4 (77 – 87.9)		-		-		1.8		0.8		0.701	
SARC-CalF (<31 cm)	10.5 (0.0 – 24)		98.4 (96 – 99.9)		-		-		6.7		0.9		0.712	
SARC-CalF (<33 cm)	15.7 (0.0 – 32)		90.4 (86 – 94.6)		-		-		1.6		0.9		0.682	

AUROC: Area under the receiver operating characteristic curve; AWGS: Asian Working Group for Sarcopenia; CI: Confidence interval; EWGSOP: European Working Group on Sarcopenia in Older People; FNIH: Foundation for the National Institutes of Health; IWGS: International Working Group on Sarcopenia; NLR: Negative likelihood ratio; NPV: Negative predictive value; PLR: Positive likelihood ratio; PPV: Positive predictive value; SARC-F: Strength, Assistance with walking, Rise from chair, Climb stairs, Falls; SARC-CalF: SARC-F and calf circumference

[§§]Bahat G, Oren MM, Yilmaz O, Kılıç C, Aydin K, Karan MA. Comparing SARC-F with SARC-CalF to screen sarcopenia in community living older adults. J Nutr Health Aging 2018;22:1034-8.

Table 3. Studies on Predictive Validity Measures (Cont'd)

Screening Tool	Sensitivity, % (95% CI)		Specificity, % (95% CI)		PPV, % (95% CI)		NPV, % (95% CI)		PLR (95% CI)		NLR (95% CI)		AUROC (95% CI)/ Accuracy (%)	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
IWGS														
SARC-F	50.0 (1 – 99)		81.8 (76.5 – 87.1)		-		-		2.7		0.6		0.64	
SARC-CalF (<31 cm)	50.0 (1 – 99)		98.5 (96.8 – 99.9)		-		-		33.8		0.5		0.671	
SARC-CalF (<33 cm)	50.0 (1 – 99)		90.6 (86.6 – 94.6)		-		-		5.3		0.6		0.836	
SCWD														
SARC-F	40.0 (0.0 – 82.9)		81.7 (76.3 – 87.0)		-		-		2.1		0.7		0.551	
SARC-CalF (<31 cm)	40.0 (0.0 – 82)		98.5 (96.8 – 99.9)		-		-		26.9		0.6		0.575	
SARC-CalF (<33 cm)	40.0 (0.0 – 82)		90.5 (86.5 – 94.6)		-		-		4.2		0.7		0.705	
Prediction Equation														
Yu et al[‖]														
EWGSOP	57.5 (41.0 – 72.6)	57.1 (39.5 – 73.2)	99.5 (98.3 – 99.9)	94.7 (91.6 – 96.7)	88.5 (68.7 – 97)	52.6 (36.0 – 68.7)	97.1 (95.3 – 98.2)	95.5 (92.6 – 97.4)	-	-	-	-	-	-
Score Chart Based on Gender and Calf Circumference														
Ishii et al[¶]														
EWGSOP	84.9	75.5	88.2	92.0	54.4	72.8	97.2	93.0	7.19	9.44	0.17	0.27	0.935	0.908
Chair Stand Test														
Pinheiro et al[##]														
EWGSOP	-	85.7	-	53.2	-	-	-	-	-	-	-	-	-	0.72 (0.64 – 0.80)

AUROC: Area under the receiver operating characteristic curve; CI: Confidence interval; EWGSOP: European Working Group on Sarcopenia in Older People; IWGS: International Working Group on Sarcopenia; NLR: Negative likelihood ratio; NPV: Negative predictive value; PLR: Positive likelihood ratio; PPV: Positive predictive value; SARC-F: Strength, Assistance with walking, Rise from chair, Climb stairs, Falls; SARC-CalF: SARC-F and calf circumference; SCWD: Society on Sarcopenia Cachexia and Wasting Disorder

[‖]Yu S, Appleton S, Chapman I, Adams R, Wittert G, Visvanathan T, et al. An anthropometric prediction equation for appendicular skeletal muscle mass in combination with a measure of muscle function to screen for sarcopenia in primary and aged care. J Am Med Dir Assoc 2015;16:25-30.

[¶]Ishii S, Tanaka T, Shibasaki K, Ouchi Y, Kikutani T, Higashiguchi T, et al. Development of a simple screening test for sarcopenia in older adults. Geriatr Gerontol Int 2014;14:93-101.

[##]Pinheiro PA, Carneiro JA, Coqueiro RS, Pereira R, Fernandes MH. "Chair stand test" as simple tool for sarcopenia screening in elderly women. J Nutr Health Aging 2016;20:56-9.

CI, 0.86-0.92), respectively. In contrast, the Turkish study by Bahat et al did not show an improvement in sensitivity of SARC-CalF.[32] When validated against the criteria of EWGSOP, FNIH, IWGS and SCWD, sensitivity was similar between SARC-F and SARC-CalF. However, this result was confounded by the lower prevalence of sarcopenia in the study cohort and choice of measurement instruments compared to other validation studies. Taken together, these studies support increased sensitivity with SARC-CalF which enhances AUROC and improves diagnostic accuracy compared to SARC-F.

A multivariate model was developed by Ishii et al to screen for sarcopenia and it uses 3 anthropometric variables: age, grip strength and calf circumference (Tables 1 and 2).[35] A score was assigned to each parameter and the summary score indicates the likelihood of sarcopenia. Initially, the measurements included height, weight, upper arm, thigh and calf circumference. Eventually, the model was refined to include only age, grip strength and calf circumference since they are significantly correlated to the definition of sarcopenia in terms of muscle strength and muscle mass. A score >105 and >120 in men and women, respectively, indicates sarcopenia. This screening tool has good sensitivity (75.5-84.9%) and specificity (88.2-92.0%) in both men and women according to the validation study which used EWGSOP criteria.[35]

For their anthropometric model, Yu et al developed a prediction equation (PE) based on weight, body mass index, age, and sex to estimate low muscle mass (Tables 1 and 2).[7] The equation was combined with grip strength to screen for sarcopenia and it was bench-marked against EWGSOP criteria. The sensitivity of PE in predicting sarcopenia was 57.5% and 57.1% in men and women, respectively. The specificity and NPV were, respectively, 99.5% and 97.1% in men and 94.7% and 95.5% in women, which suggest that PE can be a good "rule-out" tool.

In physical function tests, 1 study used the chair stand test to screen for sarcopenia.[36] Pinheiro et al conducted a cross-sectional study of 173 community-dwelling women aged ≥60 years old in Brazil. The participants were instructed to rise from their chairs to a standing position before resuming their seated position. They repeated the routine 5 times, all the while with their arms folded over their chests. A cut-off time of 13 seconds was used to show the best balance between sensitivity and specificity to identify sarcopenia. This screening tool was validated against EWGSOP definition of sarcopenia and it demonstrated a sensitivity and specificity of 85% and 53%, respectively.

Direct comparisons of the performance of each tool are limited. To date, only 1 study compared 5 screening tools for sarcopenia in 306 subjects (mean ± standard deviation, 74.8 ± 5.9 years; women, 59.5%).[37] The screening tools compared were the 2-stage sarcopenia screening algorithm,[9] SARC-F,[16] screening grid by Goodman et al,[38] anthropometric model by Ishii et al[35] and PE by Yu et al.[7] Depending on its definition, the prevalence of sarcopenia varied from 5.7% to 16.7%.[37] The anthropometric model by Ishii et al showed the best sensitivity (up to 100%) and NPV (up to 99.1%) irrespective of the definition used. It also had the highest AUROC (up to 0.914). In terms of specificity, the EWGSOP algorithm had the highest value (up to 91.1%). For each screening tool, PPV was <51.0% and NPV was consistently >87.0%. The results clearly showed that while each tool may reliably exclude subjects without sarcopenia, they may not be effective in screening the condition in asymptomatic, community-dwelling individuals.

Discussion

As sarcopenia is associated with adverse health outcomes, its early detection from screening of community-dwelling older adults is an attractive proposition. However, it is a challenge to do so. It is also based on the assumption that an effective, reliable and well validated screening instrument is easily available. The advent of pharmacological treatment and evidence-based management such as exercise and nutrient supplementation have helped sarcopenia screening gained prominence.[1,39] Our scoping review is therefore timely and revealed candidate screening tools that have been validated in different populations of various ethnicities. The screening tools can be broadly classified into questionnaires, anthropometric measures, physical tests or a combination of these tools.

Questionnaire-based screening tools, particularly SARC-F, are the most widely studied. This can be attributed to their feasibility and ease of use in the community. The consistent association between the finding of sarcopenia—when SARC-F is used—and clinically significant outcomes such as decline in physical performance, quality of life, hospital-isation and death[28,40] testifies to their efficacy as screening tools.[40] In pooled analyses, SARC-F showed low sensitivity but high specificity regardless of the definitions used for sarcopenia.[37] This limits its use as a screening tool since there is a high probability that individuals may have a missed diagnosis of sarcopenia. To overcome this limitation, recent studies have used SARC-CalF as a surrogate measure of muscle mass and it has shown enhanced sensitivity and more diagnostic accuracy.

SARC-F-3 has poorer diagnostic performance (attributed mainly to reduced sensitivity, especially in men) than SARC-F-5. Concerns over the modulating effect of contextual factors (such as age, gender and robustness of participants) on the reliability of SARC-F suggest that shorter versions of SARC-F require further validation before they can be used in settings that differed from those found in the original validation study.[41] Another limitation of SARC-F is the difficulty of administration in individuals with severe cognitive impairment or depression. Like SARC-F, MSRA is a questionnaire-based screening tool. However, while SARC-F bases its assessment on symptoms, MSRA is based on risk factors and it evaluates more objective and measurable parameters to examine factors that influence muscle mass instead of physical performance. Unlike SARC-F, MSRA has greater sensitivity than specificity.

For anthropometric measurement tools, external validation is warranted to ascertain if the good diagnostic accuracy reported with their use can be replicated in other study populations. In the model by Ishii et al, grip strength may spuriously enhance screening performance through circularity since grip strength is considered a key characteristic in the diagnosis of sarcopenia.[13] Other considerations in clinical practice include the feasibility of carrying out routine measurements such as weight, height and calf circumference as well as the use of complex mathematical calculations in the screening tools developed by Ishii et al and Yu et al. Additionally, there is a need for a common measurement of calf circumference since the readings may be affected by peripheral oedema and peripheral vascular disease, conditions commonly seen in the elderly.

Our findings also highlight the lack of direct comparison studies of various screening tools in the literature. Differences in demographics, outcomes and operationalisation of gold standard criteria in various studies confound interpretation of their results and limit the extent to which firm conclusions can be drawn on the comparative diagnostic performance of each tool. For example, in the operationalisation of appendicular muscle mass, Ishii et al used direct measurement of calf circumference as a surrogate measure but Yu et al employed gender-adjusted equations of gender, height and body mass index.

The psychometric properties of screening tools also vary according to the study population. For instance, SARC-F has an optimal 2-factor structure that reflects the distinction between muscle function and performance in robust health before frailty onset which is unlike the 1-factor structure reported in frail older adults.[41,42] We recommend more direct comparison studies to be conducted to better understand the impact of context on the comparative performance between different screening tools. They can also provide useful ancillary insights that inform the use of a broader screening strategy. For instance, the higher sensitivity conferred by MSRA can complement the high specificity of SARC-F as part of an overall strategy to screen sarcopenia in the community.

Our scoping review has its limitations. It is confined to studies in the English language and had excluded articles published in other languages. Studies of screening tools that were developed and validated in specific disease groups were also excluded from this review. Additionally, most screening tools were developed for use in the community and it is unclear how well they will perform in subacute settings such as institutional care and in acute care such as hospitals. In hospitals, studies also tend to focus on specific patient populations.[43]

The questions that are triggered off by our scoping review could be used to shape future research. For one, it is not clear how the screening tools identified in our review will perform against each other when they are used in the same population. Direct comparison studies are also needed to assess and compare the diagnostic accuracy of each tool in different populations including those who reside in institutional care.

Conclusion

Sarcopenia is defined by low muscle mass, muscle strength and physical function. Its diagnosis requires quantitative and qualitative measurement of muscle mass. Currently, the gold standard in measurement is highly debatable. It is unlikely that a single test which examines only 1 parameter will be adopted as the standard tool to screen for sarcopenia. Based on our scoping review of the definitions of sarcopenia by all the international working groups, 6 candidate screening tools ranging from questionnaires, anthropometric measures, physical performance and a combination of these tools have been developed to screen for sarcopenia. Direct comparison studies are needed to evaluate their performance in more diverse populations to reach a consensus on the best tool for use in clinical practice.

REFERENCES

1. Dent E, Morley JE, Cruz-Jentoft AJ, Arai H, Kritchevsky SB, Guralnik J, et al. International Clinical Practice Guidelines for Sarcopenia (ICFSR): screening, diagnosis and management. J Nutr Health Aging 2018;22:1148-61.
2. Marcell TJ. Sarcopenia: causes, consequences, and preventions. J Gerontol A Biol Sci Med Sci 2003;58:M911-6.
3. Yu S, Umapathysivam K, Visvanathan R. Sarcopenia in older people. Int J Evid Based Healthc 2014;12:227-43.
4. Cruz-Jentoft AJ, Landi F, Schneider SM, Zúñiga C, Arai H, Boirie Y, et al. Prevalence of and interventions for sarcopenia in ageing adults: a systematic review. Report of the International Sarcopenia Initiative (EWGSOP and IWGS). Age Ageing 2014;43:748-59.
5. Visvanathan R, Chapman I. Preventing sarcopaenia in older people. Maturitas 2010;66:383-8.

6. Wu TY, Chie WC, Yang RS, Liu JP, Kuo KL, Wong WK, et al. Factors associated with falls among community-dwelling older people in Taiwan. Ann Acad Med Singapore 2013;42:320-7.

7. Yu S, Appleton S, Chapman I, Adams R, Wittert G, Visvanathan T, et al. An anthropometric prediction equation for appendicular skeletal muscle mass in combination with a measure of muscle function to screen for sarcopenia in primary and aged care. J Am Med Dir Assoc 2015;16:25-30.

8. Hirani V, Blyth F, Naganathan V, Le Couteur DG, Seibel MJ, Waite LM, et al. Sarcopenia is associated with incident disability, institutionalization, and mortality in community-dwelling older men: The Concord Health and Ageing in Men Project. J Am Med Dir Assoc 2015;16:607-13.

9. Cruz-Jentoft AJ, Baeyens JP, Bauer JM, Boirie Y, Cederholm T, Landi F, et al. Sarcopenia: European consensus on definition and diagnosis: report of the European Working Group on Sarcopenia in Older People. Age Ageing 2010;39:412-23.

10. Shankaran M, Czerwieniec G, Fessler C, Wong PA, Killion S, Turner SM, et al. Dilution of oral D_3-Creatine to measure creatine pool size and estimate skeletal muscle mass: development of a correction algorithm. J Cachexia Sarcopenia Muscle 2018;9:540-6.

11. Buckinx F, Reginster JY, Dardenne N, Croisiser JL, Kaux JF, Beaudart C, et al. Concordance between muscle mass assessed by bioelectrical impedance analysis and by dual energy X-ray absorptiometry: a cross-sectional study. BMC Musculoskeletal Disord 2015;16:60.

12. Evans WJ, Hellerstein M, Orwoll E, Cummings S, Cawthon PM. D_3-Creatine dilution and the importance of accuracy in the assessment of skeletal muscle mass. J Cachexia Sarcopenia Muscle 2019;10:14-21.

13. Cruz-Jentoft AJ, Bahat G, Bauer J, Boirie Y, Bruyère O, Cederholm T, et al. Sarcopenia: revised European consensus on definition and diagnosis. Age Ageing 2019;48:16-31.

14. Webster F, Krueger P, MacDonald H, Archibald D, Telner D, Bytautas J, et al. A scoping review of medical education research in family medicine. BMC Med Educ 2015;15:79.

15. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. Int J Soc Res Methodol 2005;8:19-32.

16. Malmstrom TK, Morley JE. SARC-F: a simple questionnaire to rapidly diagnose sarcopenia. J Am Med Dir Assoc 2013;14:531-2.

17. Rossi AP, Micciolo R, Rubele S, Fantin F, Caliari C, Zoico E, et al. Assessing the risk of sarcopenia in the elderly: the Mini Sarcopenia Risk Assessment (MSRA) questionnaire. J Nutr Health Aging 2017;21:743-9.

18. Cao L, Chen S, Zou C, Ding X, Gao L, Liao Z, et al. A pilot study of the SARC-F scale on screening sarcopenia and physical disability in the Chinese older people. J Nutr Health Aging 2014;18:277-83.

19. Yang M, Hu X, Xie L, Zhang L, Zhou J, Lin J, et al. Validation of the Chinese version of the Mini Sarcopenia Risk Assessment questionnaire in community-dwelling older adults. Medicine (Baltimore) 2018;97:e12426.

20. Woo J, Leung J, Morley JE. Validating the SARC-F: a suitable community screening tool for sarcopenia? J Am Med Dir Assoc 2014;15:630-4.

21. Parra-Rodríguez L, Szlejf C, García-González AI, Malmstrom TK, Cruz-Arenas E, Rosas-Carrasco O. Cross-cultural adaptation and validation of the Spanish-language version of the SARC-F to assess sarcopenia in Mexican community-dwelling older adults. J Am Med Dir Assoc 2016;17:1142-6.

22. Rolland Y, Dupuy C, Abellan Van Kan G, Cesari M, Vellas B, Faruch M, et al. Sarcopenia screened by the SARC-F questionnaire and physical performances of elderly women: a cross-sectional study. J Am Med Dir Assoc 2017;18:848-52.

23. Kim S, Kim M, Won CW. Validation of the Korean version of the SARC-F questionnaire to assess sarcopenia: Korean frailty and aging cohort study. J Am Med Dir Assoc 2018;19:40-5.

24. Bahat G, Yilmaz O, Kılıç C, Oren MM, Karan MA. Performance of SARC-F in regard to sarcopenia definitions, muscle mass and functional measures. J Nutr Health Aging 2018;22:898-903.

25. Yang M, Hu X, Xie L, Zhang L, Zhou J, Lin J, et al. SARC-F for sarcopenia screening in community-dwelling older adults: are 3 items enough? Medicine (Baltimore) 2018;97:e11726.

26. Woo J, Yu R, Leung J. A 3-item SARC-F. J Am Med Dir Assoc 2018;19:223-8.

27. Ida S, Kaneko R, Murata K. SARC-F for screening of sarcopenia among older adults: a meta-analysis of screening test accuracy. J Am Med Dir Assoc 2018;19:685-9.

28. Woo J, Leung J, Morley JE. Defining sarcopenia in terms of incident adverse outcomes. J Am Med Dir Assoc 2015;16:247-52.

29. Ida S, Murata K, Nakadachi D, Ishihara Y, Imataka K, Uchida A, et al. Development of a Japanese version of the SARC-F for diabetic patients: an examination of reliability and validity. Aging Clin Exp Res 2017;29:935-42.

30. Barbosa-Silva TG, Menezes AM, Bielemann RM, Malmstrom TK, Gonzalez MC. Enhancing SARC-F: improving sarcopenia screening in the clinical practice. J Am Med Dir Assoc 2016;17:1136-41.

31. Yang M, Hu X, Xie L, Zhang L, Zhou J, Lin J, et al. Comparing Mini Sarcopenia Risk Assessment with SARC-F for screening sarcopenia in community-dwelling older adults. J Am Med Dir Assoc 2019;20:53-7.

32. Bahat G, Oren MM, Yilmaz O, Kılıç C, Aydin K, Karan MA. Comparing SARC-F with SARC-CalF to screen sarcopenia in community living older adults. J Nutr Health Aging 2018;22:1034-8.

33. Yang M, Hu X, Xie L, Zhang L, Zhou J, Lin J, et al. Screening sarcopenia in community-dwelling older adults: SARC-F vs SARC-F Combined With Calf Circumference (SARC-CalF). J Am Med Dir Assoc 2018;19: 277.

34. Urzi F, Šimunič B, Buzan E. Basis for sarcopenia screening with the SARC-CalF in nursing homes. J Am Med Dir Assoc 2017;18:991.

35. Ishii S, Tanaka T, Shibasaki K, Ouchi Y, Kikutani T, Higashiguchi T, et al. Development of a simple screening test for sarcopenia in older adults. Geriatr Gerontol Int 2014;14:93-101.

36. Pinheiro PA, Carneiro JA, Coqueiro RS, Pereira R, Fernandes MH. "Chair stand test" as simple tool for sarcopenia screening in elderly women. J Nutr Health Aging 2016;20:56-9.

37. Locquet M, Beaudart C, Reginster JY, Petermans J, Bruyère O. Comparison of the performance of five screening methods for sarcopenia. Clin Epidemiol 2017;10:71-82.

38. Goodman MJ, Ghate SR, Mavros P, Sen S, Marcus RL, Joy E, et al. Development of a practical screening tool to predict low muscle mass using NHANES 1999-2004. J Cachexia Sarcopenia Muscle 2013;4:187-97.

39. Rolland Y, Onder G, Morley JE, Gillette-Guyonet S, Abellan van Kan G, Vellas B. Current and future pharmacologic treatment of sarcopenia. Clin Geriatr Med 2011;27:423-47.

40. Wu TY, Liaw CK, Chen FC, Kuo KL, Chie WC, Yang RS. Sarcopenia screened with SARC-F questionnaire is associated with quality of life and 4-year mortality. J Am Med Dir Assoc 2016;17:1129-35.

41. Lim WS, Tay L, Yeo A, Yew S, Hafizah N, Ding YY. Modulating effect of contextual factors on factor structure and reliability of SARC-F. J Am Med Dir Assoc 2018;19:551-3.

42. Malmstrom TK, Miller DK, Simonsick EM, Ferrucci L, Morley JE. SARC-F: a symptom score to predict persons with sarcopenia at risk for poor functional outcomes. J Cachexia Sarcopenia Muscle 2016;7:28-36.

43. Tanaka S, Kamiya K, Hamazaki N, Matsuzawa R, Nozaki K, Maekawa E, et al. Utility of SARC-F for assessing physical function in elderly patients with cardiovascular disease. J Am Med Dir Assoc 2017;18:176-81.