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Original Study

Enhancing SARC-F: Improving Sarcopenia Screening in the Clinical Practice

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A B S T R A C T

Objectives: To validate the (Brazilian) Portuguese-translated version of the SARC-F questionnaire and to verify its performance in the separate sarcopenia screening and muscle function evaluation contexts. In addition, by associating SARC-F to an anthropometric measurement (as an estimate of muscle mass), to test for improvements in its sarcopenia screening efficacy.
Design: Cross-sectional study.
Setting: Urban population of Pelotas, a middle-sized city in Southern Brazil.
Participants: Subsample of 179 community-dwelling elderly aged 60 years or older derived from a population-based study (*COMO VAI?*).
Measurements: Sarcopenia was evaluated using the European Working Group on Sarcopenia in Older People's diagnostic criteria: dual-energy X-ray absorptiometry, handgrip strength, and walking speed test. Participants also completed SARC-F and their calf circumference (CC) was measured. SARC-F and CC were combined into an original score. The questionnaires' performances were evaluated through receiver operating characteristic curves, sensitivity/specificity analyses, and Pearson χ^2.
Results: Sarcopenia was identified in 15 (8.4%) participants by the European Working Group on Sarcopenia in Older People's criteria. Areas under the receiver operating characteristic curves of SARC-F were 0.592 (95% confidence interval (CI) 0.445, 0.739) screening for sarcopenia and 0.779 (95% CI 0.710, 0.846) evaluating muscle function ($P < .001$). The SARC-F+CC association significantly improved SARC-F's sarcopenia screening performance [area under the curve: 0.736 (95% CI 0.575, 0.897); comparing with SARC-F alone: $P = .027$]. A substantial improvement in sensitivity was achieved without compromising the remaining parameters.
Conclusions: Despite the satisfactory performance evaluating muscle function, SARC-F alone has not achieved adequate results as a sarcopenia screening tool. However, the SARC-F+CC association significantly improved SARC-F's sarcopenia screening performance, enabling its use in the clinical practice.

Sarcopenia, according to the European Working Group on Sarcopenia in Older People (EWGSOP),[1] is defined as "the loss of muscle mass (MM), associated with the loss of muscle strength and/or performance." Considering that the elderly are the main risk group for this condition, they should be investigated for sarcopenia during routine clinical examinations.

However, an appropriate diagnosis is still difficult to obtain, as the gold standard diagnostic methods are expensive and not universally available in clinical practice. Previously proposed screening algorithms require walking capability and hand dynamometry,[1] which are not always possible or available. To determine which patients would benefit

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from a formal evaluation for sarcopenia, a simpler sarcopenia screening method would improve the global assessment of the elderly.

Malmstrom and Morley[2] recently proposed and validated SARC-F, which is a very brief and easy-to-administer sarcopenia screening questionnaire.[3] SARC-F is a symptom score based on 5 self-reported questions concerning strength, ambulation, rising up from a chair, climbing up a set of stairs, and falls.[2] Its validity has been tested in different populations with good results.[3–5] However, SARC-F questions concern only muscle function (MF) (strength and performance), without evaluating MM. Sarcopenia and MF loss are related, but distinct entities, and considering MF alone somehow diverges from the EWGSOP-proposed sarcopenia definition, which includes MM assessment.[1]

Anthropometric measurements are a cheap and practical method to estimate MM. EWGSOP consensus states that calf circumference (CC) measurement is the anthropometric method that better correlates to MM.[1] Given its simplicity and universal availability, maybe it could stand as a surrogate for MM in the sarcopenia screening context.

This pilot study had 2 main objectives. First, to validate SARC-F as a sarcopenia screening tool (as originally proposed) and as an MF evaluation tool (as hypothesized). Second, to verify if incorporating CC as a MM surrogate would improve SARC-F's sarcopenia screening results.

Methods

The proposed pilot study was based on a subsample from a cross-sectional population-based survey carried out in Pelotas, a southern Brazilian city. The main survey is known as *COMO VAI?* (Master's Consortium for Valuation of Elderly Care – *Consórcio de Mestrado Orientado para a Valorização da Atenção ao Idoso*), and ensured random and representative population sampling through multistep stratified and randomized household and individual selection. More information about the complete sampling process can be obtained elsewhere.[6]

Inclusion criteria were noninstitutionalized elderly aged 60 years or older, inhabitants of urban Pelotas. Exclusion criteria were physical and/or mental incapacity to perform the requested tests.[6] Individuals were visited in their homes between January and August 2014. The tests, questionnaires (concerning sociodemographic data), and measurements (walking test, handgrip strength, and CC) were also performed at the same time.

From the original study sample (N = 1451), all persons born in March or September (N = 241; deterministic sampling) were invited to participate in the substudy. One hundred ninety-two persons accepted the invitation and were submitted to complimentary tests at the Dr. Amilcar Gigante Epidemiologic Research Center. The study flowchart is presented in Figure 1.

Measurements

Substudy participants were submitted to total body dual-energy X-ray absorptiometry (Lunar Prodigy; GE Healthcare, Little Chalfont, United Kingdom) for appendicular skeletal muscle mass index (ASMI) estimation, defined as the total appendicular skeletal MM/height^2 (kg/m^2). Considering cut-off ASMI reference values for the young population of the same city reported elsewhere,[6] elderly men with an ASMI below 7.76 kg/m^2 and women below 5.62 kg/m^2 were defined as presenting low MM.

Muscle strength was measured using a digital hand dynamometer (Jamar Digital Plus+ Hand Dynamometer; Simmons Preston, Canada) according to the methods proposed by Roberts et al.[7] Three measurements were determined for each hand in an alternating manner, and the maximum strength was defined as the greatest of the 6 measurements. Cut-off points to define participants with low muscle strength as evaluated with handgrip were <30 kg for men and <20 kg for women.[8]

A 4-m gait speed test was applied to evaluate muscular performance. The test was applied twice, and the lower of the 2 measurements was considered to define participants with low walking speed (<0.8 m/sec).[8]

The sarcopenia diagnosis was based on dual-energy X-ray absorptiometry measurements performed in the clinic plus gait speed and handgrip strength tests conducted in the participants' households. Participants were classified as normal, presarcopenic (only low MM), sarcopenic (MM plus strength or muscular performance losses) or severely sarcopenic (MM, strength and muscular performance losses). For analytic purposes, only individuals within the clinical stages of sarcopenia (sarcopenia or severe sarcopenia) were considered positive for the syndrome, and, from here further, shall be referred simply as "sarcopenics." For the same purposes, concerning the MF evaluation, individuals with loss of muscle strength and/or loss of muscle performance, despite the MM, were considered to have "loss of MF."

Two measurements of the circumference of the right calf were performed with an inextensible tape measure (Cerscorf; Porto Alegre, Brazil) according to the methods previously described by Lohman et al.[9] The mean of the 2 measurements was considered. The cut-off points to establish low MM from the CC measurement were ≤34 cm for males and ≤33 cm for females, according to a previous study from our group.[6]

Body weight was measured using a digital scale (Tanita UM-080; Tanita, Tokyo, Japan). Standing height was measured by a standardized researcher using a fixed stadiometer (CMS Weighting Equipment; London, United Kingdom). According to Lipschitz,[10] a body mass index <22 was considered low.

The study participants answered a questionnaire regarding schooling, marital status, smoking, heart diseases, and diabetes mellitus (self-reported). Sex and skin color were observed and recorded by the interviewers. Socioeconomic status was determined according to criteria of the Brazilian Association of Research Companies (Associação Brasileira de Empresas de Pesquisa),[11] which considers the possession of certain consumer goods, the head of household's schooling and the presence of a maid. According to this scale, individuals in category A were considered the most wealthy and category E the least wealthy. Physical activity level was assessed using the domains of leisure and displacement in the International Physical Activity Questionnaire.[12] Both domains were added, and, according to guidelines, the time spent on intense activities was multiplied by 2. Individuals who reported less than 150 minutes of physical activity per week were considered inactive.[13]

To validate the original SARC-F questionnaire (Appendix 1: Table A1), it was first translated to Portuguese by the authors (T.B.-S., M.G.) (Appendix 2: Table A2), back-translated into English by a registered English translator and verified by one of the authors of the original English-language questionnaire (T.M.). Only then was it applied to the substudy participants during clinic visits.

Statistical Analyses and Ethical Concerns

Exploratory analyses were performed to determine which would be the adequate weight of the anthropometric variable to better associate CC measurement to the SARC-F questionnaire. For that purpose, CC measurement was treated as a dichotomous variable, using the aforementioned cut-off points of ≤34 cm for males and ≤33 cm for females as indicatives of low MM. Then, different values for the "positivity" of the CC measurement variable were attributed (in a range from 1 to 10), and each one was tested individually looking for the best fit [evaluated by the area under the curve (AUC)]. The best option was incorporated into a composite score, which already included the 10 possible points from the SARC-F questionnaire (hereby on, called SARC-F + CC).

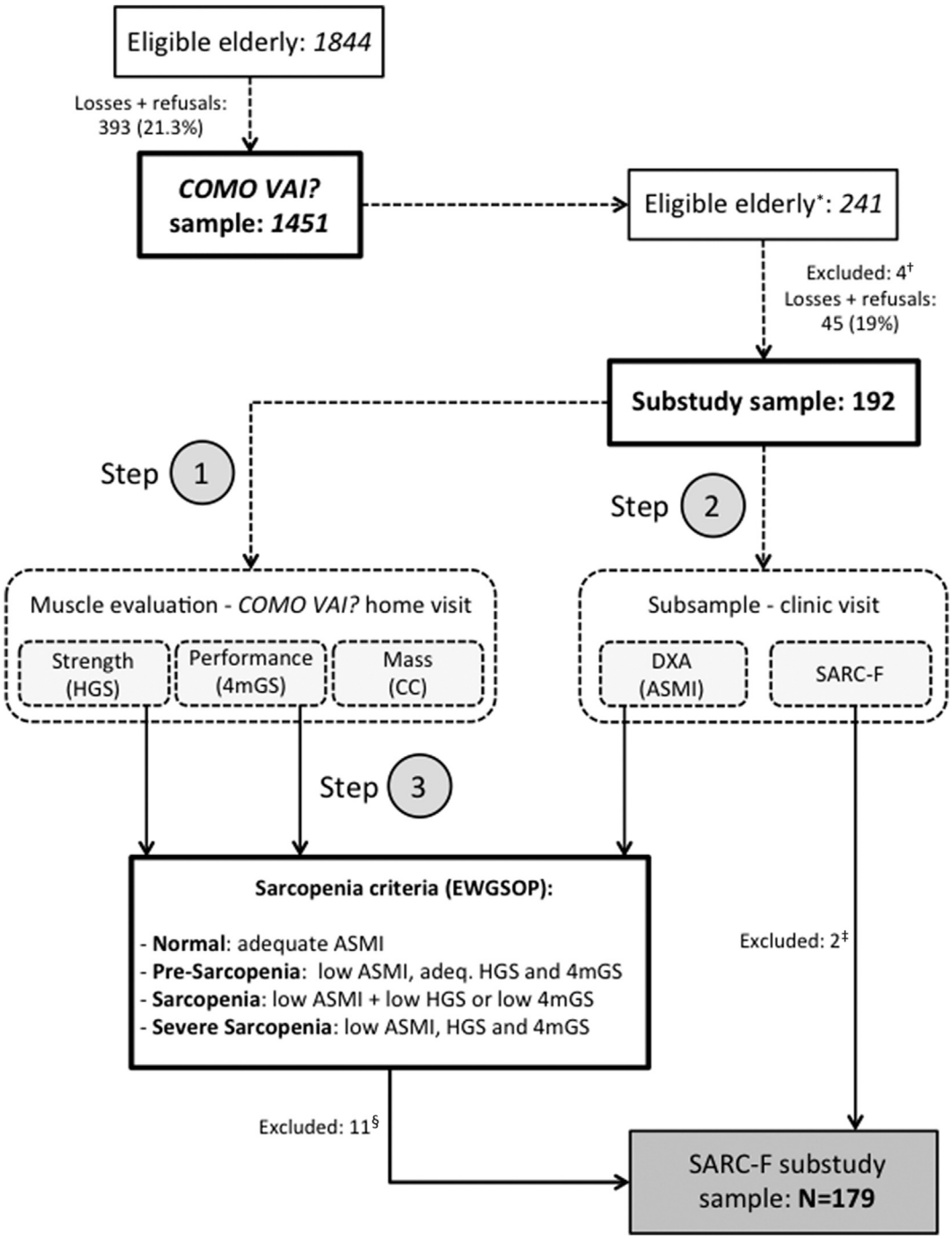

Fig. 1. Study flowchart (Pelotas, Brazil, 2014). Substudy sample chosen through deterministic sampling of the COMO VAI? study sample. Step 1: sarcopenia tests performed at the participant's home. Step 2: sarcopenia tests performed at the clinic. Step 3: sarcopenia EWGSOP criteria applied to the substudy sample. *Elderly born in March or September; †One death, 3 hospitalizations; ‡Two participants unable to answer the SARC-F questionnaire; §Eleven participants unable to perform at least 1 of the tests (DXA, HGS, and/or 4mGS). Adeq, adequate; DXA, dual X-ray absorptiometry; HGS, handgrip strength; 4mGS, 4-m gait speed test.

Cut-off points for the SARC-F Portuguese-translated questionnaire and for the SARC-F + CC score in the separate sarcopenia screening and MF evaluation contexts were determined by the Youden method. The questionnaires' performances were compared through receiver operating characteristic (ROC) curve analysis, considering the AUCs [with 95% confidence intervals (CIs)] and Pearson χ^2 test for heterogeneity. Sensitivity/specificity evaluation was also performed to better explore the results and understand its clinical screening relevance. All analyses were performed using the statistical software program Stata v 12.1 (StataCorp, College Station, TX).

Both projects (the COMO VAI? Consortium and the substudy on body composition) were approved by the Universidade Federal de Pelotas' Research Ethics Committee (Pelotas, Brazil). The participation of the individuals in the study was voluntary, and informed consent was obtained from all participants.

Results

The sample characteristics are demonstrated in Table 1. Caucasians, females, middle or upper class individuals, and persons with fewer

Table 1
Body Composition Substudy Participant Characteristics (Pelotas, 2014; N = 179)

Variables	N (%)
Sex	
Male	69 (38.6)
Female	110 (61.4)
Age	
60–69 years	103 (57.5)
70–79 years	56 (31.3)
≥80 years	20 (11.2)
Skin color	
Caucasian	145 (81.0)
Non-Caucasian	34 (19.0)
Years of study	
None	25 (14.0)
<8 years	100 (56.2)
≥8 years	53 (29.8)
Marital status	
With companion	95 (53.1)
Without companion	84 (46.9)
Economic status	
A/B	64 (37.4)
C	92 (53.8)
D/E	15 (8.8)
Smoking	
Never smoked	91 (50.8)
Previous smoker	63 (35.2)
Current smoker	25 (14.0)
Heart diseases	
No	120 (67.4)
Yes	58 (32.6)
DM	
No	126 (70.4)
Yes	53 (29.6)
Physical inactivity*	
No	64 (36.6)
Yes	111 (63.4)
Low BMI†	
No	176 (98.3)
Yes	3 (1.7)
4-m gait speed test‡	
Adequate	137 (76.5)
Slow	42 (23.5)
Handgrip strength§	
Adequate	120 (67.0)
Low	59 (33.0)
CC‖	
Adequate	133 (74.3)
Low	46 (25.7)
Sarcopenia status¶	
Normal	151 (84.4)
Presarcopenia	13 (7.3)
Sarcopenia	9 (5.0)
Severe sarcopenia	6 (3.3)
MF status**	
Normal	106 (59.2)
Loss of MF	73 (40.8)

BMI, body mass index; DM, diabetes mellitus.
*Referred physical activity time <150 minutes per week.
†BMI <22.
‡Cut-off point: <0.8 m/sec.
§Cut-off points: <30 kg males, <20 kg females.
‖Cut-off points: ≤34 cm males, ≤33 cm females.
¶Based on ASMI by dual X-ray absorptiometry analysis, handgrip strength and gait speed evaluation.
**Based on handgrip strength and gait speed evaluation.

than 8 years of education composed the majority of the sample. Of the 179 eligible participants evaluated, 15 (8.3%) were identified with sarcopenia by the gold standard EWGSOP-proposed methods.

The sample's results to the SARC-F questionnaire are presented in Appendix 1: Table A1. The ROC curve for the performance of SARC-F as a sarcopenia screening test is illustrated in Figure 2A, and the AUC was 0.592 (95% CI 0.445, 0.739). The optimal cut-off point in our sample was ≥6 (Youden index: 0.17). The sensitivity/specificity analysis is presented in Table 2. The absolute numbers are available in Appendix 3: Table A3. Only 5 (33%) out of the 15 participants with sarcopenia were identified by the questionnaire.

Concerning the SARC-F's ability to evaluate MF, the ROC curve is presented in Figure 2B, and the AUC was 0.779 (95% CI 0.710, 0.846). The optimal cut-off point was ≥4 (Youden index: 0.41). The sensitivity/specificity analysis is presented in Table 2. More details can be found in Appendix 3: Table A3. SARC-F's performance was considerably better in the MF context, being able to identify 43 (59%) out of the 73 participants presenting MF loss at the time.

Comparing the aforementioned ROC curves, SARC-F performed better as an MF evaluation tool than as a sarcopenia screening tool (AUCs = 0.779 vs 0.592, respectively; $P < .001$).

Considering the CC measurement feasibility for universal use (as a surrogate for MM), the effect of combining the CC measurement with the SARC-F questionnaire was also analyzed, evaluating MM and function in the same screening scenario. Using the methods previously mentioned, the maximum screening ability for the SARC-F + CC association was obtained with both variables adopting the same weight (SARC-F ranging from 1 to 10; CC scoring zero for absence of low MM, and 10 for presence). The resulting score, therefore, ranged from 0 to 20 (being the final score the sum of both tests), and the optimal cut-off point for sarcopenia screening was found to be ≥11 points (Youden index: 0.50) (Table 3). The derived ROC curve for sarcopenia screening is illustrated in Figure 2C, and the AUC was 0.736 (95 CI% 0.575, 0.897). More details can be found in Table 2 and Appendix 3: Table A3. The association allowed identification of 10 (66%) out of the 15 participants with sarcopenia, without significantly altering the specificity of the original test.

Finally, for sarcopenia screening, it was found that SARC-F associated to CC proved to be superior then SARC-F alone (AUCs = 0.736 vs 0.592, respectively; $P = .027$).

The formal Portuguese translations of the SARC-F questionnaire and the SARC-F + CC score are available in the Appendices 2 and 4 (Tables A2 and A4).

Discussion

In this study, the SARC-F questionnaire was evaluated by ROC curve analysis for different objectives. For this consideration, however, the adequacy in a diagnostic test evaluated by ROC curve analysis must be established. An AUC greater than 0.9 has high accuracy, whereas 0.7–0.9 indicates moderate accuracy, 0.5–0.7, low accuracy, and 0.5 a chance result. As a more intuitive alternative, it can also be considered that an AUC ≥0.75 represents an adequate test.

The observed performance of SARC-F as a screening tool for sarcopenia (AUC = 0.592) is, therefore, considered insufficient, suggesting that the SARC-F questionnaire may not be an adequate tool for sarcopenia screening in this population. However, SARC-F's performance for MF evaluation was considerably better (AUC = 0.779), which may reflect its real purpose.

Malmstrom et al[3] and Cao et al[4] validated the test in the North American and Chinese populations, respectively, through prognostic methods. Maybe the MF evaluation, which was found to be the most appropriate utility of the SARC-F in our population, better correlates with the prognostic findings investigated previously than the MM. As such, the referred prognostic evaluation of the questionnaire should present good results as the ones reported in the above-mentioned publications; however, it may not reflect the EWGSOP sarcopenia definition, which includes the MM evaluation. Such questions address the sarcopenia definition itself and are not the purpose of this article. Nevertheless, one must take this into consideration by comparing previous SARC-F validation results.

Woo et al,[5] in a previous validation study of the SARC-F in a community-dwelling sample of the Hong Kong population, reported

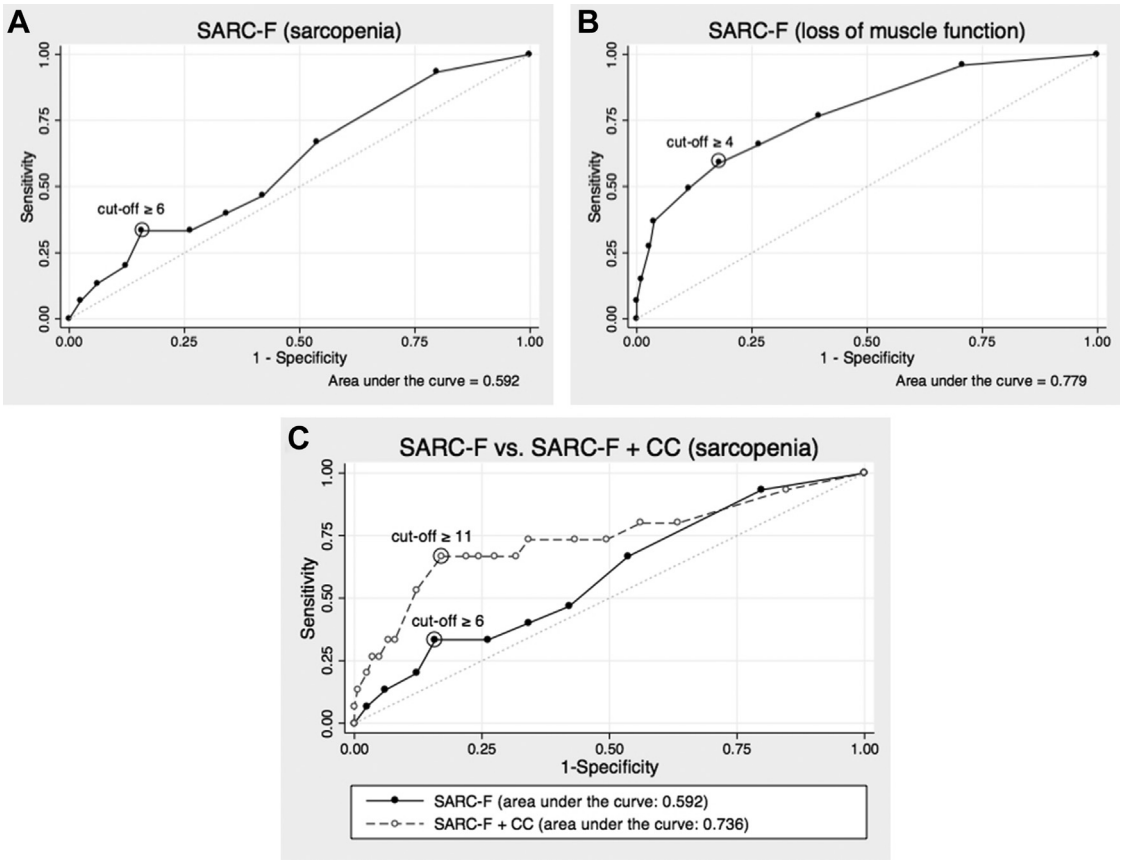

Fig. 2. ROC curves: SARC-F's performance for sarcopenia screening (A) and muscle function evaluation (B); comparison between SARC-F and SARC-F + CC as screening tools for sarcopenia (C) ($N = 179$; Pelotas, Brazil, 2014). (A) larger dot represents SARC-F's optimal cut-off score of ≥6 for sarcopenia screening; (B) larger dot represents SARC-F's optimal cut-off score of ≥4 for muscle function evaluation; (C) larger dots represent SARC-F's and SARC-F + CC's optimal cut-off scores for sarcopenia screening (≥ 6 and ≥ 11, respectively).

high specificity and low sensitivity values for the SARC-F evaluation. A sarcopenia screening test should, of course, be able to dismiss from further testing as many healthy individuals as possible, but should also guarantee diagnostic investigation for the true persons with sarcopenia. It is our opinion that, if possible, the sensitivity of the test should be improved by other associated means, such as the proposed CC measurement.

By associating the CC measurement, SARC-F's sarcopenia screening performance was improved, by doubling its sensitivity (from 33% to 66%) without compromising its specificity. This fact is also reflected in the observed AUCs, which demonstrated that the SARC-F + CC association performed better than SARC-F alone (AUCs = 0.736 vs 0.592, respectively), and, maybe, poses as an option to be considered in the sarcopenia screening scenario.

Table 2
Sensitivity/Specificity Analyses of SARC-F and SARC-F + CC in Different Contexts, Including 95% CIs (in parentheses) (Pelotas, 2014; N = 179)

Parameters (%)	SARC-F (MF)*	SARC-F (Sarcopenia)†	SARC-F + CC (Sarcopenia)‡
Sensitivity	58.9 (46.8–70.3)	33.3 (11.8–61.6)	66.7 (38.4–88.2)
Specificity	82.1 (73.4–88.9)	84.2 (77.6–89.4)	82.9 (76.3–88.4)
PPV	69.4 (56.4–80.4)	16.1 (5.5–33.7)	26.3 (13.4–43.1)
NPV	74.4 (65.5–82.0)	93.2 (87.9–96.7)	96.5 (91.9–98.8)

NPV, negative predictive value; PPV, positive predictive value.
*Loss of MF: loss of muscle strength and/or performance, cut-off ≥ 4.
†Sarcopenia: loss of muscle mass + loss of muscle strength and/or performance, cut-off ≥ 6.
‡Sarcopenia: loss of muscle mass + loss of muscle strength and/or performance, cut-off ≥ 11.

By the EWGSOP definition, sarcopenia is represented by the loss of MM with clinical repercussions (in other words, loss of MF). The proposed SARC-F + CC association only allows participants to be positive (≥11 points) if they have low MM (10 points) and at least 1 sign of MF loss (1 to 10 points). Participants who present symptoms of daily activity MF loss without low MM, by the EWGSOP definition, do not have sarcopenia, and cannot be identified as having sarcopenia by the SARC-F + CC association as well, which seems coherent.

Keeping in mind that the proposed tool poses as a screening method to prevent healthy persons from further sarcopenia testing (and, thereby, not a precise diagnostic tool), the fact that 76% of our sample would have been correctly "dismissed" must be valued. The economy that such a screening tool represents should be taken into account when considering its validity, especially in the clinical practice: with a simple questionnaire and an anthropometric measurement (which are costless and do not take more than 2 or 3 minutes to be applied), an important first-step triage is performed.

Taking this into consideration, the proposed SARC-F + CC score (or, perhaps, SARC-CalF, trying to maintain the mnemonic rule of the SARC-F questionnaire) seems promising. Two-thirds of the participants with sarcopenia in our sample would be identified by the method, and more than 80% of the healthy participants would have been correctly excluded from further testing. Positive-testing individuals should be further investigated by the gold standard methods, and the rest may, perhaps, only be clinically accompanied (and, maybe, periodically rescreened).

One of our main limitations was the small number of participants with sarcopenia in the sample. However, these are the preliminary findings of a pilot study, and to adequately evaluate the proposed

Table 3
SARC-F + CC Questionnaire

Components	Questions	Scoring
Strength	How much difficulty do you have lifting and carrying 10 pounds?	None = 0 Some = 1 A lot or unable = 2
Assistance in walking	How much difficulty do you have walking across a room?	None = 0 Some = 1 A lot, use aids or unable = 2
Rise from a chair	How much difficulty do you have transferring from a chair or bed?	None = 0 Some = 1 A lot or unable without help = 2
Climb stairs	How much difficulty do you have climbing a flight of 10 stairs	None = 0 Some = 1 A lot or unable = 2
Falls	How many times have you fallen in the past year?	None = 0 1-3 falls = 1 4 or more falls = 2
CC	Measure the patient's exposed right CC with the legs relaxed and feet 20 cm apart from each other	Females >33 cm = 0 ≤33 cm = 10 Males >34 cm = 0 ≤34 cm = 10
Sum (0–20 points) 0–10: no suggestive signs of sarcopenia at the time (consider periodical re-evaluation) 11–20: suggestive of sarcopenia (proceed with further diagnostic examinations)		

SARC-F + CC score, further studies with larger samples may be of use. Also, the validity of our findings remains to be verified in different populations, particularly concerning different corresponding ASMI cut-offs.

The use of CC has inherent limitations that should also be addressed. Circumference assessment may be influenced by factors, such as intramuscular or subcutaneous adipose tissue deposition. Very obese persons, for instance, should be evaluated with caution because their CC values will hardly be below the suggested cut-off points, which, therefore, may mask sarcopenic obesity. The proposed score might not be an adequate screening tool in these situations, and a formal diagnostic evaluation should be considered. For the general elderly population, however, CC measurement still poses as a convenient method to grossly estimate MM, and, despite its limitations, may be a useful screening anthropometric method.

In conclusion, in our sample, the SARC-F questionnaire performed fairly well for MF evaluation, but not for sarcopenia screening according to the EWGSOP-proposed criteria. Its association with the CC measurement significantly improved its sarcopenia screening ability, and, therefore, may have an important role in the sarcopenia screening scenario.

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Supplementary Data

Supplementary data related to this article can be found online at http://dx.doi.org/10.1016/j.jamda.2016.08.004.

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