ASSESSING THE RISK OF SARCOPENIA IN THE ELDERLY: THE MINI SARCOPENIA RISK ASSESSMENT (MSRA) QUESTIONNAIRE

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Abstract: *Objectives:* to validate the MSRA questionnaire proposed as prescreening tool for sarcopenia, in a population of community-dwelling elderly subjects. *Design:* observational study. *Setting:* community dwelling elderly subjects. *Participants:* 274 community dwelling elderly subjects, 177 women and 97 men, aged 66-78 years. *Measurements:* Based on EWGSOP diagnostic criteria subjects were classified as sarcopenic and non-sarcopenic. The Mini Sarcopenia Risk Assessment (MSRA) questionnaire, is composed of seven questions and investigates anamnestic and nutritional characteristics related to risk of sarcopenia onset (age, protein and dairy products consumption, number of meals per day, physical activity level, number of hospitalizations and weight loss in the last year). *Results:* 33.5% of the study population, were classified as sarcopenic. With the 7-item MSRA score, subjects with a score of 30 or less, had a 4-fold greater risk of being sarcopenic than subjects with a score higher than 30 (OR:4.20;95% CI:2.26–8.06); area under the ROC curve was 0.786 (95% CI:0.725-0.847). In a logistic regression, considering as dependent variable the probability of being sarcopenic, and as independent variables the 7 items of the questionnaire, two items (number of meals and milk and dairy products consumption) showed non-significant diagnostic power. A 5-item score was then derived and the area under the ROC curve was 0.789 (95% IC:0.728-0.851). Taking into account the cost of false positive and false negative costs and the prevalence of sarcopenia, the "optimal" threshold of the original MSRA score (based on 7 items) is 30, with a sensitivity of 0.804 and a specificity of 0.505, while the "optimal" threshold of the MSRA score based on 5 items, is 45, with a sensitivity of 0.804 and a specificity of 0.604. *Conclusion:* this preliminary study shows that the MSRA questionnaire is predictive of sarcopenia and can be suggested as prescreening instrument to detect this condition. The use of a short form of the MSRA questionnaire improves the capacity to identify sarcopenic subjects.

Key words: Sarcopenia, muscle strength, risk factor assessment.

Introduction

Sarcopenia is a condition characterized by loss of muscle mass and strength associated with physical performance reduction (1). In 2001, Janssen et al. estimated that sarcopenia results in an excessive cost to the United States health care system of nearly $ 20 billion a year, mostly due to the onset of associated disability (2). Nonetheless, sarcopenia is still underdiagnosed and undertreated (3). The sarcopenia diagnosis, on the basis of the European Working Group on Sarcopenia (EWGSOP), as well as the International Working Group on Sarcopenia (IWGS) definition, includes muscle mass, gait speed and/or handgrip measurements by trained operators, which cannot generally be performed in general practitioner, nursing homes or acute care settings. Therefore the population to be screened for sarcopenia needs to be prescreened with an easy-to-use and broadly available instrument.

Moreover, the gait speed test is the first step the EWGSOP indicates and on the IWGS flow-chart and it cannot be performed in nearly half of the elderly population, in particular those in acute care and nursing home settings (4, 5).

The SARC-F has been proposed by Malmstrom and Morley as a first level screening questionnaire for sarcopenia (6). This tool investigates five muscle functions: strength, ambulation, rising up from a chair, climbing up a set of stairs and falls; in a validation study it showed high specificity but very low sensitivity (7).

Therefore we designed and proposed the MSRA questionnaire as a prescreening tool for sarcopenia risk assessment. The aim of this study is to validate this new questionnaire in a population of community-dwelling elderly subjects.

Materials and methods

Subjects

Subjects were randomly chosen from patient lists of 11 general practitioner family doctors in the city of Verona as described elsewhere (8).

None of the subjects participated in regular physical exercise more than once weekly during the study. Subjects with renal failure, disabling knee osteoarthritis, heart failure (NYHA≥2), cancer and serious lung disease were excluded, as well as those with cognitive impairment (Mini-mental Status Examination score <24). Individuals with more than a 5% weight loss in the year previous to the study were also excluded. At baseline,

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177 women and 97 men, aged between 66 to 78 years, were considered eligible and consented to participate in the study.

All subjects gave their written informed consent to be part of the study, which was approved by the University of Verona's Ethics Committee.

Anthropometry

Subjects were weighed barefoot and wearing light indoor clothing to the nearest 0.1 kg (Salus scale, Milan, Italy), and height was measured to the nearest 0.5 cm using a stadiometer (Salus stadiometer, Milan, Italy). Body weight adjusted by stature (kg/h2) was used to give BMI.

DXA

Appendicular fat free mass (FFM) was determined using DXA and the evaluations were performed using a Hologic-QDR-2000 fan beam densitometer with software version 7.2. All scans were subsequently analyzed by a single trained investigator as described elsewhere (8).

Muscle strength measure

Maximal voluntary isometric strength of the dominant arm extensors was tested by a Spark Handheld Dynamometer model 160 (Spark, Iowa City, IA, USA) as previously reported (9).

Sex-specific tertiles of isometric arm muscle strength were created. Individuals in the lowest tertile of arm muscle strength (<9.66 kg in men and <5.33 kg in women) were considered as subjects with low muscle strength, while those in the second and third tertiles were considered subjects with normal muscle strength.

4-meter walking test

Volunteers walked a 4-meter course at their usual pace. Timing began when subjects initiate foot movement and stopped when 1 foot contacted the ground after completely crossing the 4 meters mark. Speed lower than 0.8 m/s identified participants with low physical performance. The best time of 2 attempts was recorded (9).

EWGSOP definition of sarcopenia

According to EWGSOP criteria, sarcopenia was defined as presence of low muscle mass, plus low muscle strength or low physical performance (1). Appendicular skeletal muscle mass was converted to skeletal muscle index (SMI) by dividing it by height expressed in meters squared (kg/m2) as previously suggested by Baumgartner (10). The cutoff points for SMI measured with DXA used to identify subjects with low muscle mass were <7.26 kg/m2 for men <5.5 kg/m2 for women (10).

Dietary intake

A trained dietician performed a 7-days dietary recall in order to assess the dietary habits of each subject enrolled in the study. The record data were then processed by the dietician using special software to calculate daily intake of energy, protein, fat, carbohydrate and alcohol based on the tables furnished by the Italian National Institute of Nutrition (11). From this information the answers to the questions on dietary intake have been collected.

Mini Sarcopenia Risk Assessment Questionnaire

The Mini Sarcopenia Risk Assessment (MSRA) is composed of 7 items regarding (1) general assessment (three questions related to age, physical activity level, hospitalizations and weight loss) and (2) dietary assessment (three questions related to the meals number per day, dairy product consumption and protein consumption), selected on the basis of a review of the literature regarding risk factors for muscle mass and strength loss (1, 12-20). An arbitrary score has been assigned to each item (Table 1).

Table 1
The Mini Sarcopenia Risk Assessment (MRSA) 7 and 5 items Questionnaire

	7 items	5 items
1-How old are you?	Score	Score
≥70 years	0	0
<70 years	5	5
2-Were you hospitalized in the last year?		
Yes, and more than one hospitalization	0	0
Yes, one hospitalization	5	10
No	10	15
3-What is your activity level?		
I'm able to walk less than 1000 meters	0	0
I'm able to walk more than 1000 meters	5	15
4-Do you eat 3 meals per day regularly?		
No, up to twice per week I skip a meal (for example I skip breakfast or I have only milky coffee or soup for dinner)	0	0
Yes	5	15
5-Do you consume any of the following?		
Milk or dairy products (yogurt, cheese), but not every day	0	-
Milk or dairy products (yogurt, cheese) at least once per day	5	-
6- Do you consume any of the following?		
Poultry, meat, fish, eggs, legumes, ragout or ham, but not every day	0	-
Poultry, meat, fish, eggs, legumes, ragout or ham at least once per day	5	-
7-Did you lose weight in the last year?		
>2 kg	0	0
≤2 kg	5	10

Table 2

Characteristics of the study population in males and females and in sarcopenic and non sarcopenic subjects according with the EWGSOP definition

	All n=274 (M=97;F=177)				Sarcopenic n=92 (M=28;F=64)				Non-sarcopenic n=182 (M=69;F=113)				Sig	Male=97				Female=177				Sig
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max		Mean	SD	Min	Max	Mean	SD	Min	Max	
Age (years)	71.70	2.28	66	78	72.00	1.93	68	76	71.56	2.43	66	78	<0.05	71.60	2.15	66	76	71.79	2.25	68	78	NS
Height (m)	1.61	0.091	1.40	1.90	1.61	0.08	1.40	1.86	1.61	0.09	1.41	1,90	NS	1.7	0.07	1.55	1.9	1.56	0.06	1.4	1.7	<0.001
Weight (kg)	69.92	13.23	43.30	118.90	63.15	10.31	45.40	98.70	73.35	13.25	43.30	118.90	<0.001	78.85	11.57	53	118.9	65.04	11.43	43.3	110.8	<0.001
BMI (kg/m2)	24.86	4.28	18.19	50.58	24.20	2.60	18.19	31.36	28.21	4.34	18.74	50.58	<0.001	27.3	3.55	19.79	37.11	26.63	4.63	18.19	50.58	NS
SMI (kg/m2)	6.20	1.19	3.98	9.81	5.49	0.89	3.99	7.21	6.56	1.17	3.98	9.81	<0.001	7.41	0.85	5.10	9.81	5.53	0.77	3.98	8.79	<0.001
Arm muscle strength (kg)	8.02	3.72	0.00	28.50	6.50	3.04	0.00	14.66	8.80	3.80	0.00	28.50	<0.001	10.98	3.67	0	28.5	6.41	2.58	0	13.5	<0.001
Gait speed (m/sec)	0.80	0.16	0.23	1.27	0.76	0.13	0.23	1.04	0.81	0.14	0.43	1.27	<0.01	1.08	0.2	0.56	1.58	0.95	0.18	0.29	1.31	<0.001
Total Kcal	1803.90	525.55	709.00	3829.00	1782.10	483.33	885.00	2994.00	1814.92	546.60	709.00	3829.00	NS	2184.39	487.57	1200	3829	1595.4	418.63	709	3124	<0.001
Kcal/kg/die	26.29	7.73	9.71	56.96	25.52	7.60	13.68	48.31	28.17	7.53	9.71	56.96	0.001	28.27	7.44	14.69	56.96	25.22	7.69	9.71	45.21	<0.01
Grams of proteins/die	65.69	21.52	26.60	178.60	65.21	20.97	29.90	117.40	65.93	21.85	26.60	178.60	NS	78.05	21.02	35.9	178.6	58.88	18.61	26.6	117.5	<0.001
Grams of proteins/kg/die	0.95	0.33	0.29	2.29	0.91	0.30	0.43	2.29	1.04	0.37	0.29	1.96	<0.01	1	0.31	0.49	1.9	0.93	0.35	0.29	2.29	NS
MSRA questionnaire score (7 items)	29.22	7.30	10	40	24.08	7.18	10.0	40.0	31.81	5.85	10.0	40.0	<0.001	29.7	7.6	10	40	29.0	7.2	15	40	NS
MSRA questionnaire score (5 items)	43.58	12.80	15	60	34.24	13.13	15.0	60.0	48.30	9.67	15.0	60.0	<0.001	45.4	12.6	15	60	42.6	12.8	15	60	NS

SD=standard deviation; BMI= body mass index; SMI=skeletal muscle index; Kcal= kilocalories; MSRA= Mini Sarcopenia Risk Assessment; NS= non significan

Table 3

Number and percentage of sarcopenic subjects in each category of the 7 items of the Mini Sarcopenia Risk Assessment questionnaire with Sarcopenia diagnosis according to the EWGSOP definition

1-How old are you?	Sarcopenic	Non sarcopenic	Sarcopenic (%)	p
≥70 years	71	118	37,6	0,039
<70 years	21	64	24,7	
2-Were you hospitalized in the last year?				
Yes, and more than one hospitalization	32	15	68,1	<0.001
Yes, one hospitalization	16	22	42,1	
No	44	145	23,3	
3-What is your activity level?				
I'm able to walk less than 1000 meters	27	12	69,2	<0.001
I'm able to walk more than 1000 meters	65	170	27,7	
4-Do you eat 3 meals per day regularly?				
No, up to twice per week I skip a meal (for example I skip breakfast or I have only milky coffee or soup for dinner)	16	15	51,6	0,028
Yes	76	167	31,3	
5- Do you consume any of the following?				
Milk or dairy products (yogurt, cheese), but not every day	7	7	50,0	0,244
Milk or dairy products (yogurt, cheese) at least once per day	85	175	32,7	
6- Do you consume any of the following?				
Poultry, meat, fish, eggs, legumes, ragout or ham, but not every day	26	17	60,5	<0.001
Poultry, meat, fish, eggs, legumes, ragout or ham at least once per day	66	165	28,6	
7-Did you lose weight in the last year?				
>2 kg	66	77	46,2	<0.001
≤2 kg	26	105	19,8	

Table 4
Logistic regression results when considering single items of the 7- and 5-item Mini Sarcopenia Risk Assessment questionnaire (MSRA) in relation to sarcopenic status

		MSRA 7 items			MSRA 5 items		
Item	**Category**	**Estimate**	**SE**	**p**	**Estimate**	**SE**	**P**
		-4.170	0.858	0.000	-3.400	0.589	0.000
1-How old are you?	≥70 vs < 70	0.511	0.354	0.149	0.533	0.350	0.128
2-Were you hospitalized in the last year?	>1 vs 0	1.028	0.511	0.044	1.043	0.509	0.040
	1 vs 0	1.578	0.396	0.000	1.573	0.392	0.000
3-What is your activity level?	Low vs Not low	1.481	0.418	0.000	1.437	0.417	0.001
4-Do you eat 3 meals per day regularly?	Low vs Not low	0.237	0.524	0.652	-	-	-
5- Do you consume any of the following?	Low vs Not low	0.696	0.653	0.287	-	-	-
6- Do you consume any of the following (Protein intake)?	Low vs Not low	1.191	0.431	0.006	1.349	0.387	0.000
7-Did you lose weight in the last year?	>2 kg vs ≤2 kg	1.046	0.319	0.001	1.032	0.314	0.001

SD=standard deviation; BMI= body mass index; SMI=skeletal muscle index; Kcal= kilocalories; MSRA= Mini Sarcopenia Risk Assessment; SE= standard error

Statistical Analysis

Results are reported employing percentages or means ± SD. Student's t test for unpaired data was used to compare means between sarcopenic and non-sarcopenic subjects. Percentages were compared employing Fisher's exact test. The odds ratio (OR) was employed as a measure of size effect.

The overall ability of MSRA test to discriminate subjects with sarcopenia was evaluated by means of the receiver-operating characteristic (ROC) curve, obtained plotting estimates of the true positive rate (i.e. sensitivity) against the false positive rate (i.e. 1 – specificity) for each possible score based on the MSRA questionnaire. Sensitivity was defined as the proportion of sarcopenic subjects with MSRA score equal to or below the threshold considered, while specificity was defined as the proportion of non-sarcopenic subjects with MSRA score above the threshold considered. The area under the ROC curve (AUC) was calculated as a summary measure of the overall diagnostic accuracy across the spectrum of test scores as described in Fawcett (21). Confidence intervals for the AUC, as well as comparisons between ROC curves were performed according to DeLong et al (22).

To analyze the joint role of the 7 items of the MSRA questionnaire, as well as to evaluate if assigning different weights to the considered categories leads to a better discriminating power, a logistic regression was employed, considering the probability of being sarcopenic (evaluated according to the EWGSOP criteria) as the dependent variable, and the items of the questionnaire as independent variables.

The "best" threshold for the MSRA questionnaire score for the diagnosis of sarcopenia was evaluated employing three methods (23):

1 – locating the point on the ROC curve closest to the (0,1) point;

2 – locating the point that maximizes the sum of sensitivity and specificity (i.e. the Youden's index);

3 – employing the the approach presented by Zweig et al (24) which takes into account both the prevalence of sarcopenia (P) and the ratio between the costs of false positive (FP) and false negative (FN) diagnosis; these three elements are combined to calculate a slope as follows: $\left(\frac{FP}{FN} \times \frac{1-P}{P}\right)$. The point on the ROC plot where a line with this slope touches the curve is the best operating point (25).

The costs of false positives was calculated as the cost of performing a DXA scan for appendicular fat free mass (96.08 euro) and a geriatric visit to perform gait speed and handgrip strength measurements (47 euro), for a total of 143.08 euro (24). False negative costs are based on the one month health related costs of a sarcopenic subject compared to non sarcopenic subject in the Dutch population of the MaSS study, equal to 930 euro (25).

All statistical analyses were performed using R 3.1.2 (26) and the package pROC (27).

Results

Overall, 177 women and 97 men with an average of 71.7 ±2.28 years were included in this analysis.

Considering all these subjects (n=274), 92 subjects, corresponding to 33.5% of the study population, were classified as sarcopenic according to EWGSOP criteria.

The main baseline characteristics of the study population (mean±SD) are shown in Table 2. No significant differences in sarcopenia prevalence were observed in males compared to females (28.9% vs 36.1%, p=0.232).

Table 3 shows the performance of each of the 7 items of the MSRA questionnaire in identifying sarcopenic subjects.

For each subject, the MSRA score (based on 7 items) was calculated as described in the Methods section. Figure 1 shows the percentage of sarcopenic and non-sarcopenic subjects within each category of the score. The percentage of sarcopenic

subjects is higher in the lowest categories of the MSRA score. When evaluating the overall performance of the MSRA score in identifying sarcopenic patients, the area under the ROC curve was 0.786 with a 95% confidence interval between 0.725 and 0.847.

Figure 1

Percentage of sarcopenic and non-sarcopenic subjects within each category of the MSRA score

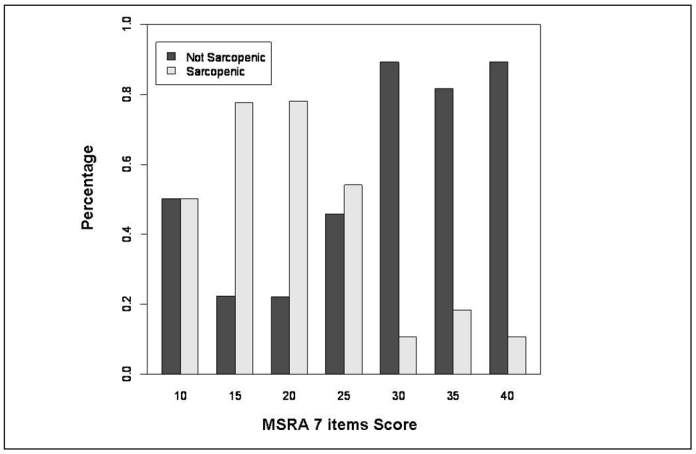
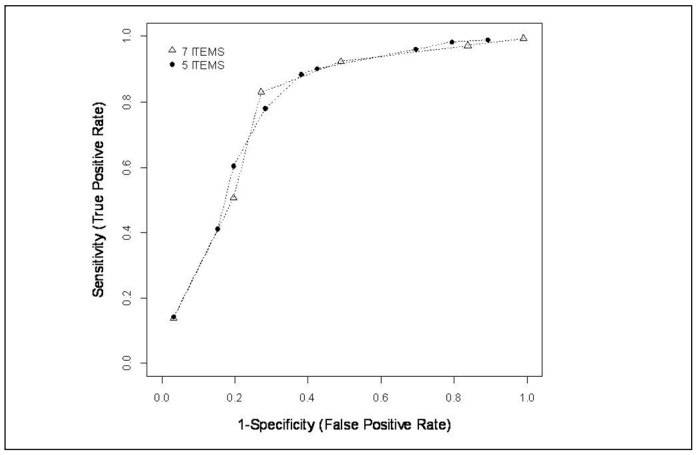


Figure 2

Percentage of sarcopenic and non-sarcopenic subjects within each category of the MSRA score



Employing a cut-off of 30 to identify subjects with sarcopenia, the sensitivity was 0.804 (74 out of 92 sarcopenic patients had a score of 30 or less) while the specificity was 0.501 (92 out of 182 non sarcopenic subjects had a score higher than 30). Therefore, subjects with a score of 30 or less, showed odds of being sarcopenic more than four times higher than that of a subject with a score higher than 30 (OR= 4.20; 95% C.I.: 2.26 – 8.06).

To analyze the joint role of the 7 considered items, as well as to evaluate if assigning weights to the considered categories, different from the original ones (showed in Table 1 under the heading "7 items") leads to an increase in the discriminating power, a logistic regression was employed, considering the probability of being sarcopenic as the dependent variable, and all the 7 items of the questionnaire as independent variables .

The results are shown in Table 4. Four out of the 7 items were jointly significantly associated with the probability of being sarcopenic; furthermore, for hospitalization, a significant trend was found. The three non-significant items were age, caloric intake and milk and dairy products intake. The last two items were then removed from the logistic regression. Even if not significant, we decided to include age in the analysis to account for this effect; in this way, the regression coefficients associated with the remaining items are adjusted for age.

The results of this second analysis are displayed in Table 4. Considering the resulting regression coefficients (showed under the heading "Estimate" in Table 4), a new score was calculated, based on 5 of the 7 items of the original MSRA questionnaire.

In order to simplify the calculation of the new score, we decided to multiply all the coefficients by 10. For example, considering the age of a subject, we can give a score of 0 to subjects up to 70 years old and 5.33 (i.e. 0.533 ×10) to subjects over 70. Analogously, we can give a score of 0 to subjects that lose weight, and a score of 10.32 (i.e. 1.032 ×10) to subjects with a stable weight.

Furthermore, considering the size of the estimated coefficients (column 6 of Table 4) as well as their associated standard errors (column 7 of Table 4), we decided to simplify the weights as reported in Table 1 under the heading "5 items".

A new MSRA score, based on these 5 items and these modified weights was then calculated. This score ranged between 15 and 60. In non-sarcopenic subjects the mean score was 48.3 (SD 9.7, median 50); in sarcopenic patients the mean score was 34.3 (SD 13.1, median 30).

Figure 2 shows the ROC curves associated both with the original score (based on 7 items) and with the new score (based on 5 items and on modified weights). The area under the ROC curve of the 5 items score was 0.789 with a 95% confidence interval between 0.728 and 0.851. Therefore, after having removed 2 items from the questionnaire, the ROC area remained substantially the same (and numerically even higher).

The threshold of 45 or less for classifying a subject as sarcopenic showed a sensitivity of 0.804 and a specificity of 0.604; these values are quite similar to those associated with a cut-off of 30 or less for the 7-item score (numerically, with the 5-item score, the specificity was even higher).

Locating the point on the ROC curve closest to the (0,1) point, the "optimal" threshold of the original MSRA score (based on 7 items) is 25, with a sensitivity of 0.728 and a specificity of 0.830, and that of the MSRA score based on 5 items is 40, with a sensitivity of 0.717 and a specificity of 0.780. By using the Youden's index, the "optimal" threshold of the original MSRA score is again 25, while the "optimal" threshold of the MSRA score based on 5 items is 35, with a sensitivity of 0.620 and a specificity of 0.885. Finally,

considering a ratio of 6.5 between the costs of false negative and of false positive results and a prevalence of sarcopenia of 0.2, the approach of Zweig et al (26) yields a slope of 0.4. The point on the ROC plot where a line of this slope touches the curve gives a threshold of 30 for the original MSRA score based on 7 items (with a sensitivity of 0.804 and a specificity of 0.505) and a threshold of 45 for the MSRA score based on 5 items (with a sensitivity of 0.804 and a specificity of 0.604).

Discussion

Our study shows that low values of the MSRA score are associated with high percentage of sarcopenic subjects and that the score reveals a high discriminant power in diagnosing sarcopenic subjects. Subjects with a score of 30 or less, shows odds of being sarcopenic more than four times higher than that of a subject with a score higher than 30.

By using the 5-item MSRA score, sensitivity was similar to that of the 7-item score, while specificity was even higher.

Sarcopenia diagnosis is based on measurement of muscle mass, gait speed and/or handgrip, evaluations that require machinery and trained operators that are not broadly available. A quick and easy-to-use questionnaire should then identify the population to be screened for the diagnosis of sarcopenia.

The MSRA questionnaire is based on seven objective and measurable parameters selected on the basis of a review of the literature regarding risk factors for muscle mass and strength loss (1, 12-20).

In line with previous reports (13-16), our data show that subjects with more than one hospitalization in the previous year are at higher risk of being sarcopenic. Similarly, and as expected, the presence of low physical activity level was a predictor of sarcopenia (17), as well as low caloric and low protein intake (18-20). A marked difference in the 7-item MSRA score between sarcopenic and non sarcopenic was evident and the area under the curve was 0.786 (95% CI: 0.725-0.847), suggesting that this tool has a potential to identify individuals with sarcopenia.

Moreover, high sensitivity makes MSRA suitable as a first line screening tool for this condition.

With a regression analysis, considering the probability of being sarcopenic as a dependent variable, we tested the discrimination power of single items initially included in the MSRA score and hospitalization in the previous year, weight loss in the previous year, physical activity level and protein consumption showed high discriminant power. On the contrary, two items, number of meals and milk and dairy products consumption, showed a non-significant diagnostic power, and were therefore excluded. Even if not significant, we decided to include age in the analysis to account for this effect, because of the narrow range of age of our study population. The resulting 5-item score showed similar sensitivity, but even higher specificity, as compared to the 7-item score. Therefore a more parsimonious version of the MSRA, with only 5 items, should be applied at least in community-dwelling elderly subjects. However the predictive power of the 7 items should be retested across a wider population, not only including community-dwelling elderly subjects.

Considering the characteristics of the MSRA score, which is quick and easily available, we individuated the best MSRA threshold for sarcopenia, taking into account prevalence of sarcopenia and the costs of false positives and false negatives. In fact other criteria to identify the optimal threshold give equal weight to sensitivity and specificity. Moreover prevalence of sarcopenia has been incorporated as a second factor, since it interacts with sensitivity and specificity in determining the actual probabilities of false positive and false negative results. Finally, for sarcopenia the relative cost of a false negative result could be considered much higher than the cost of a false positive result and therefore the selected threshold would favour sensitivity rather than specificity.

The SARC-F (28, 29) has been previously proposed and validated as prescreening questionnaire for sarcopenia. Some differences between the SARC-F and MSRA should be recognized. First, for the SARC-F questions, the answers require a subjective evaluation made by the subject or the caregiver. On the contrary, the MSRA is based on seven objective and measurable parameters, selected on the basis of the review of the literature regarding risk factors for muscle mass and strength loss (1, 12-20). Secondly, in the SARC-F the selected items are not specifically related to muscle mass or muscle strength, but more to physical function and disability (29).

The questions asked in the SARC-F may mirror too closely the physical performance and muscle strength components of the EWGSOP definition. Not surprisingly, the SARC-F seems very good at predicting the physical performance and muscle strength components of the EWGSOP definition, but quite weak in the evaluation of the muscle mass, as recently shown by Barbosa-Silva (29).

The MSRA questionnaire presents higher sensitivity compared to SARC-F, which showed a high specificity (0.94-0.99), but low sensitivity (0.04% in males, 0.10% in females) in a validation study (7). Our data seems to indicate that MSRA questionnaire shows high sensitivity, making it suitable as a first line screening tool for sarcopenia, but in order to define the predictive power and reliability of the two questionnaires, comparison studies in which both screening tests are applied for the detection of sarcopenic subjects are needed in the future.

Some potential limits in this study have to be acknowledged, especially the retrospective nature of our study.

Secondly, our study population was restricted to healthy older well-functioning men and women under the age of 80 in good health condition at baseline, and therefore did not wholly reflect a normal aging population. Moreover subjects with >5% weight loss during the previous year were excluded, leaving out potentially sarcopenic subjects.

Lastly, only community-dwelling elderly subjects were

considered in the study and subjects in nursing home, long term care facilities or bedridden were not involved. However in this population, at higher risk for inadequate caloric intake and unintentional weight loss, with higher prevalence of sarcopenia (5), screening for sarcopenia should be less important.

The construction and validation of an optimized version of the MSRA and its scoring should be part of further prospective studies or of retrospective studies in wider populations.

The MSRA questionnaire is designed to provide an inexpensive and easy-to-use questionnaire that is capable of capturing the key features of sarcopenia and rules out subjects unlikely to be sarcopenic; it is designed as a first line instrument that can be compiled also by the patient or by the caregiver, and is applicable in postal screening, phone calls or general practitioners settings as well.

In conclusion, the MSRA questionnaire shows good sensitivity and specificity and the selection of the items initially tested shows an improvement in the capacity of this prescreening tool in a community-dwelling elderly population to detect subjects with sarcopenia.

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References

1. Crutz-Jentoft AJ, Baeyens JP, Bauer JM, Boire Y, Cederholm T, Landi F, Martin FC, Michel JP, Rolland Y, Schneider SM, Topinkovà E, Vandewoude M, Zamboni M. Sarcopenia: European consensus on definition and diagnosis. Report of the European Working Group on Sarcopenia in Older People. Age and Aging. 2010; 39: 412-23.
2. Janssen I, Shepard DS, Katzmarzyc PT, Roubenoff R. The healthcare costs of sarcopenia in the United States. J Am Geriatrc Soc 2004; 52: 80-85.
3. Rolland Y, Czerwinski S, Abellan van Kan G, Morley JE, Cesari M, Onder G, Woo J, Baumgartner R, Pillard F, Boirie Y, Chumlea WMC, Vellas B. Sarcopenia: Its assessment, etiology, pathogenesis, consequences and future perspectives. J Nutr Health Aging. 2008 Aug-Sep; 12: 433–450.
4. Rossi AP, Fantin F, Micciolo R, Bertocchi M, Bertassello P, Zanandrea V, Zivelonghi A, Bissoli L, Zamboni M. Identifying sarcopenia in acute care setting patients. J Am Med Dir Assoc 2014; 15: 303.e7-12.
5. Landi F, Liperoti R, Fusco D, Mastropaolo S, Quattrociocchi D, Proia A, Russo A, Bernabei R, Onder G. Prevalence and risk factors of sarcopenia among nursing home older residents. J Gerontol A Biol Sci Med Sci. 2012; 67: 48-55.
6. Malmstrom TK, Morley JE. SARC-F: a simple questionnaire to rapidly diagnose sarcopenia. J Am Med Dir Assoc. 2013; 14: 531-2.
7. 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.
8. Zamboni M, Turcato E, Santana H, Maggi S, Harris TB, Pietrobelli A, Heymsfield SB, Micciolo R, Bosello O. The relationship between body composition and physical performance in older women. J Am Geriatr Soc 1999; 47: 1403-8.
9. Rossi AP, Fantin F, Caliari C, Zoico E, Mazzali G, Zanardo M, Bertassello P, Zanandrea V, Micciolo R, Zamboni M. Dynapenic abdominal obesity as predictor of mortality and disability worsening in older adults: A 10-year prospective study. Clin Nutr. 2016 ; 35: 199-204.
10. Baumgartner RN, Koehler KM, Gallagher D, Romero L, Heymsfield SB, Ross RR, Garry PJ, Lindeman RD. Epidemiology of sarcopenia among the elderly in New Mexico. Am J Epidemiol 1998; 147: 755-763.
11. Istituto Nazionale della Nutrizione. Tabelle di composizione degli alimenti. (National Institute of Nutrition: tables of nutritional composition). Litho Delta: Milano, 1989 (in Italian)
12. Budui SL, Rossi AP, Zamboni M The pathogenetic bases of sarcopenia. Clin Cases Miner Bone Metab. 2015; 12: 22-6.
13. Kortebein P, Ferrando A, Lombeida J, Wolfe R, Evans WJ. Effect of 10 days of bed rest on skeletal muscle in healthy older adults. JAMA 2007; 297: 1769-1774.
14. Evans WJ. Skeletal muscle loss: cachexia, sarcopenia, and inactivity. Am J Clin Nutr 2010, 91(suppl): 1123-75.
15. Renoud A, Ecochard R, Marchand F, Chapulart R, Szulc P. Predictive parameters of accelerated muscle loss in men-MINOS Study. The American Journal of Medicine 2014; 127: 554-61.
16. Alley D, Koster A, Mackey D, Cawthon P, Ferrucci L, Simonsick EM, Yu B, Hardy S, Goodpaster B, Sarkisian C, Houston DK, Kritchevsky SB, Cummings S, Lee JS, Tylavsky FA, Newman A, Harris T. Hospitalization and change in body composition and strength in a population-based cohort of older persons. J Am Geriatr Soc. 2010; 58: 2085-91.
17. Abellan Van Kan. G. Epidemiology and consequences of sarcopenia. J Nutr Health Aging 2009; 13: 708–712.
18. Houston DK, Nicklas BJ, Ding J, Harris TB, Tylavsky FA, Newman AB, Sun Lee J, Sahyoun NR, Visser M, Kritchevsky SB. Dietary protein intake is associated with lean mass change in older, community-dwelling adults: The Health Aging and Body Composition Study. Am J Clin Nutr 2008; 87: 150-5.
19. Filion ME, Barbat-Artigas S, Dupontgand S, Fex A, Karelis AD, Aubertin-Leheudre M. Relationship between protein intake and dynapenia in postmenopausal women. J Nutr Health Aging 2012; 16: 616–619.
20. Molino S, Dossena M, Buonocore D, Verri M. Sarcopenic Obesity: An Appraisal of the Current Status of Knowledge and Management in Elderly People. J Nutr Health Aging. 2016;20:780-8.
21. Fawcett T. An introduction to ROC analysis. Pattern Recogn Lett. 2006, 27:861-874.
22. DeLong ER, DeLong DM, Clarke-Pearson DL. Comparing the areas under two or more correlated receiver operating characteristic curves: a nonparametric approach. Biometrics 1988; 44: 837–845.
23. Zhou X.H, Obuchowski N.A., McClish D.K. (2011) Statistical Methods in Diagnostic Medicine. 2nd edition. John Wiley & Sons, New York.
24. Zweig MH, Campbell G. Receiver-Operating Characteristic (ROC) Plots: A Fundamental Evaluation Tool in Clinical Medicine. Clin Chem 1993; 39: 561-577.
25. Mijnarends DM, Schols JMGA, Halfens RJG, Meijers JMM, Luiking,YC, Verlaane S, Evers SMAA. Burden-of-illness of Dutch community-dwelling older adults with sarcopenia: Health related outcomes and costs. Eur J Geriatr 2016; 7: 276–284.
26. R Core Team. R: A language and environment for statistical computing. R Foundation for Statistical Computing 2014, Vienna, Austria.
27. Robin, N. Turck, A. Hainard, N. Tiberti, F. Lisacek, J.C. Sanchez, M. Müller, pROC: an open-source package for R and S+ to analyze and compare ROC curves. BMC Bioinformatics 2011; 12:77.
28. 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 Muscle Wasting 2016; 7: 28-36.
29. Barbosa-Silva TG, Menezes AM Bielemann RM, Malmstrom TK, Gonzalez MC. Enhancing the SARC-F: improving sarcopenia screening in the clinical practice. J Am Med Dir Assoc 2016; S1525-8610, 30314-0.