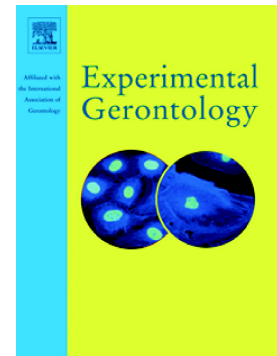


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Diagnostic accuracy of the five times stand-to-sit test for the screening of global muscle weakness in community-dwelling older women

Jaqueline Mello Porto, PhD¹; Melise Jacon Peres-Ueno, PhD¹; Roberta de Matos Brunelli Braghin, PhD¹; Gabriela Martins Scudilio²; Daniela Cristina Carvalho de Abreu, PhD³

¹ Post-doctoral fellow, Program in Rehabilitation and Functional Performance, Ribeirão Preto School of Medicine, University of São Paulo (USP), Ribeirão Preto (SP), Brazil.

² Undergraduate student of the Physiotherapy Course, Department of Health Sciences, Ribeirão Preto School of Medicine, University of São Paulo (USP), Ribeirão Preto (SP), Brazil.

³ Associate Professor, Department of Health Sciences, Ribeirão Preto School of Medicine, University of São Paulo (USP), Ribeirão Preto (SP), Brazil.

Corresponding author: Melise Jacon Peres Ueno, Department of Health Sciences, Ribeirão Preto School of Medicine, University of São Paulo, Address: Avenida Bandeirantes, 3900; Ribeirão Preto, SP, Brazil, CEP: 14049-900, Phone number: +55 16 3602-4413 / 3058, Fax: +55 163602-4413, e-mail: meliseperes@hotmail.com

Diagnostic accuracy of the five times stand-to-sit test for the screening of global muscle weakness in community-dwelling older women

Abstract

Background: Although the 5 times stand-to-sit test (5TSST) is indicated for screening for muscle weakness in older adults, its validity is based only on the correlation with quadriceps muscle strength or with the muscle strength of a few muscle groups of the lower limbs. Thus, the objective of the present study was to verify whether in independent older women, the 5TSST can really estimate global muscle strength, considering the sum of muscle strength of the trunk, hip, knee and ankle, which are important for functional activities. **Methods:** 119 independent older women participated in this cross-sectional study, undergoing the 5TSST and an isometric muscle strength assessment of the trunk, hip, knee and ankle, using an isokinetic dynamometer. The accuracy of the 5TSST for the discrimination of older women with reduced global muscle strength was evaluated by an ROC curve. **Results:** The ROC curve showed that the 5TSST may discriminate older women with reduced global muscle strength with moderate accuracy (AUC = 0.783; 95% CI = 0.681 – 0.886; $p < 0.001$). The 5TSST score with the best accuracy (sensitivity: 80.0% and specificity: 61.8%) to evaluate global muscle strength was 11.64 seconds. **Conclusion:** 5TSST can be used to identify reduced global muscle strength in independent older women, standing out as an accessible tool for the screening of muscle weakness.

Keywords: peak torque; muscle strength; aging; functional capacity

1.1 INTRODUCTION

Muscle weakness in older adults, especially in the lower limbs, has been considered as an important risk factor for negative health outcomes, such as falls, functional decline, hospitalization, loss of independence and quality of life [1, 2]. Thus, effective methods of screening for muscle weakness are extremely necessary for the earliest possible detection of vulnerable older adults who need a more detailed assessment and subsequent intervention.

In this sense, the European Working Group on Sarcopenia in Older People (EWGSOP) [1] recommends grip strength or the 5 times stand-to-sit test (5TSST) for muscle weakness screening in older adults. Previous studies have proven the validity of grip strength to estimate global muscle strength [3, 4]. In the impossibility of obtaining grip strength, due to the lack of a manual dynamometer or due to the presence of dysfunction in the hands, an alternative for screening muscle weakness is the 5TSST. However, the validity of this test to estimate lower limb muscle strength is supported only by the high correlation with the muscle strength of the knee extensors [1, 2, 5] or correlation with few muscle groups of the lower limb [5].

Thus, the objective of the present study was to verify whether in independent older women, the 5TSST can really estimate global muscle strength, considering the sum of muscle strength of muscle groups of the trunk, hip, knee and ankle, which are important for functional activities. The initial hypothesis of the present study was that the 5TSST is capable of discriminating community-dwelling older women with reduced global muscle strength, being a simple and reproducible tool for muscle weakness screening that can be used in different health contexts.

2. METHODS

2.1 Study design and sample

This was a cross-sectional study that included 119 independent older women, 60 to 80 years old, who agreed to sign free and informed consent forms. The researchers recruited the participants in the community and at events for older adults held by the University of São Paulo (Ribeirão Preto). Evaluations were carried out from March 2017 to May 2018 and the study was approved by the local Human Research Ethics Committee (CAAE: 62209916.5.0000.5440).

The ineligibility criteria were: (1) low scores on the 10-point Cognitive Screener (10-CS) according to the level of education [6], since the participant would need to understand and correctly follow the commands to properly perform the muscle tests and the 5TSST; (2) self-report of symptomatic musculoskeletal conditions (e.g., daily pain, recent fractures, symptomatic tendonitis) that could impair functional and muscle strength tests; (3) presence of neurological diseases (e.g., Parkinson disease, stroke sequelae); (4) complaints of dizziness; (5) uncontrolled heart disease; (6) deficits of protective sensitivity in the feet [17]. Participants could still be excluded if they did not complete the tests proposed because they withdrew their consent to participate or did not attend the second day of evaluation.

2.2 Procedures

Evaluations were performed by three trained researchers over two days: day 1) sample characterization, execution of the five times stand-to-sit test (5TSST) and familiarization with isometric contractions of the trunk and lower limb by the isokinetic dynamometer (Biodex System 4 Pro, New York, USA) to minimize learning effects; day 2) isometric peak torque of the trunk and dominant lower limb (member of choice

to kick a ball). Between the first and second days of evaluation there was a period of 2 to 7 days to allow muscle recovery [8].

For the sample characterization, the researchers collected the following information: age, weight, height, body mass index (BMI), number of comorbidities and level of physical activity (International Physical Activity Questionnaire – Short Form - IPAQ) [9]. For the 5TSST, participants performed the task of getting up and sitting down as quickly as possible from an armless chair, with their arms crossed across their chests. Constant verbal commands were given during the test and the time to perform the test was recorded. The 5TSST was repeated twice to allow familiarization and the shortest time (the best performance) was considered for statistical analyses. The 5TSST shows excellent test-retest reliability (ICC = 0.81) [2].

Global muscle strength considered the sum of the isometric peak torque (PT) of the following muscle groups [4, 10]: trunk flexors and extensors; hip flexors, extensors, abductors and adductors; knee flexors and extensors; ankle plantar flexors and dorsiflexors. The PT of each muscle group was measured with a calibrated isokinetic dynamometer (Biodex System 4 Pro, New York, USA) and normalized by body mass (Nm.kg^{-1}) [11]. A 5-minute warm-up was performed on an exercise bike to prepare the muscles, followed by 5 maximum voluntary isometric contractions for each muscle group, with 5 seconds of duration and 30 seconds of rest. The protocol and positioning for the evaluation of each muscle group were previously described by Porto et al. [4].

2.3 Statistical analysis

All statistical analyses were run using SPSS (SPSS Inc., version 17.0) and the level of significance was set at $p \leq 0.05$. Means, standard deviations and frequencies were used to characterize the sample.

In order to verify the association between global muscle strength (dependent variable) and performance in the 5TSST (independent variable), multivariate linear regression adjusted according to age, height, weight, number of comorbidities and level of physical activity was performed. In addition, univariate regression analysis was performed to verify the association between 5TSST and peak torque of each trunk, hip, knee and ankle muscle group evaluated.

Since there is no normality value for global muscle strength, following previous methodologies [12, 13], after multivariate linear regression analysis, participants were divided into quartiles according to global muscle strength, and those who occupied the lowest quartile (PT of 7.71 Nm.kg^{-1} or lower) were considered to have reduced global muscle strength. On the other hand, older women who occupied the three higher quartiles were considered as without reduced global muscle strength. The T-Test was performed to verify the differences between older women with and without reduced global muscle strength.

The accuracy of the 5TSST for the discrimination of older women with reduced global muscle strength was evaluated by the receiver operating characteristic (ROC) curve, considering the area under the ROC curve (AUC), sensitivity and specificity. An AUC higher than 0.9 indicates high accuracy; between 0.9 and 0.7, it indicates moderate accuracy; 0.7 and 0.5, it indicates low accuracy; below 0.5, it indicates a random result. The 5TSST cut-off point to discriminate reduced global muscle strength was determined by the Youden Index (sensitivity + specificity - 1), which ranges from 0 to 1, being considered as the value with the highest Youden Index (closest to 1) [14].

3. RESULTS

A total of 119 older women were evaluated: 155 older women were contacted, 28 refused to participate and 8 were excluded (2 with daily pain in the knee and spine, 2 missed the second day of evaluation and 4 did not complete the proposed tests). There was no occurrence of adverse events during the assessments. Older women considered as with reduced global muscle strength had higher weight ($p = 0.016$) and BMI ($p = 0.001$), worse performance on the 5TSST ($p < 0.001$), lower peak torque of each muscle group (trunk, hip, knee and ankle) ($p < 0.001$) and lower global muscle strength ($p < 0.001$), which indicates that they were allocated to the correct groups (with or without reduced global muscle strength) (Table 1).

Multivariate linear regression analysis resulted in statistically significant model ($p < 0.001$; WILK'S $\lambda = 0.645$; $\eta^2 = 0.355$), i.e., there is an association between 5TSST and global muscle strength in older women. There was also an association between 5TSST and peak torque of all trunk, hip, knee and ankle muscle groups evaluated (Table 2). The ROC curve showed that the 5TSST may discriminate older women with reduced global muscle strength with moderate accuracy (AUC = 0.783; 95% CI = 0.681 – 0.886; $p < 0.001$) (Figure 1). The 5TSST score with the best accuracy (sensitivity: 80.0% and specificity: 61.8%) to evaluate global muscle strength was 11.64 seconds.

4. DISCUSSION

The present study demonstrated that the 5TSST can be used to identify reduced global muscle strength in independent older women, being an accessible tool for the quick screening of muscle weakness.

The 5TSST has been recommended by the World Health Organization to assess the locomotor capacity domain (capacity to move from one place to another) of intrinsic

capacity, which corresponds to “all the physical and mental capacities that an individual can draw on” [15]. Furthermore, the 5TSST is associated with gait speed in older adults, which indicates that the 5TSST can be used to screen physical function performance [16]. Makizako et al. [17] also identified in their prospective cohort study ($n = 4335$) that the 5TSST is a good predictor of future disability in community-dwelling older adults, considered as needing care in 8 possible categories (grooming/bathing, eating, toileting, transferring, assistance with instrumental activities of daily life, behavioral problems, rehabilitation and medical services).

In addition, the 5TSST has been suggested in the literature to assess lower limb muscle strength and power, as it involves a high demand for strength generated at high speed (muscle power) to complete the task [18, 19]. Ribeiro et al. [18] demonstrated that the power of the quadriceps muscle influences the performance of the 5TSST, i.e., the greater the muscle power, the shorter the time to complete the test.

The present study confirms that 5TSST can also be used to screen for muscle weakness in clinical practice as suggested by the European Working Group on Sarcopenia in Older People (EWGSOP) [1]. Our results corroborate previous studies that demonstrated an association between standing and sitting tests with lower limb muscle strength. Lord et al. [5] identified that the isometric strength (assessed by load cell) of knee flexors and extensors and ankle dorsiflexors is associated with the 5TSST. Jones, Rikli and Beam [20] identified a correlation between the 30-second stand-to-sit test and lower limb muscle strength assessed by leg press in older adults of both sexes.

Despite the importance of lower limb muscle strength for performing the 5TSST, the present study also included the muscle strength of the trunk flexors and extensors, as they are important muscle groups for the functional capacity of older adults, including for the task of standing up and sitting down [21]. Older adults with

lower muscle strength seem to adopt compensatory strategies for standing up, characterized by a more dynamic use of the trunk, e.g., greater trunk flexion to stand up and greater trunk extension with greater angular velocity after seat-off [21].

In order to identify limited mobility in older adults within the concept of intrinsic capacity, the World Health Organization suggests a cutoff point of 14 seconds [15]. The EWGSOP suggests a cutoff point of 15 seconds to detect low strength [1]. However, Bohannon [22] suggested in his meta-analysis the normality values for the 5TSST of 11.4 seconds for the age group from 60 to 69 years and 12.6 seconds for the age group from 70 to 79 years. From the ROC curve, we detected a similar cutoff point (11.64 seconds) to identify a reduction in global muscle strength in women between 60 and 80 years old.

Our study has the strength of performing a rigorous standardized protocol to assess muscle strength through an isokinetic dynamometer (gold standard method), including muscle groups of the trunk and lower limb to consider the global muscle strength. The study limitations were: (1) the sample did not include participants older than 80 years, who could present worse performance in the functional and muscle strength tests; (2) results cannot be extrapolated to older men, frail individuals or older adults with mobility impairment; in fact, men and women have different levels of muscle strength [1], so it would be important to perform the analysis separately in older women and men. However, as our convenience sample was composed of older women, future studies should investigate whether the results replicate for older men; (3) there is no reference value for the global muscle strength, so we considered older women with reduced global muscle strength to be those with PT equal to or less than the lowest quartile of global muscle strength, following a previous methodology [12, 13].

5. CONCLUSION

The 5TSST can be used to identify reduced global muscle strength in independent older women, being an accessible tool for the screening of muscle weakness. As it consists of a quick, simple, inexpensive test that requires little space and equipment (only a chair and a stopwatch), the 5TSST can be applied in different health care centers, such as medical clinics and basic health units, for the detection as early as possible of older adults who would benefit from a more detailed assessment of muscle strength and subsequent intervention.

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TABLES

Table 1. Sample characterization. Values are presented as means (standard deviations) and frequencies.

Variable	Total sample (n = 119)	Reduced GMS (n = 30)	Non-reduced GMS (n = 89)
Age (years)	68.42 (4.88)	70.00 (5.76)	67.88 (4.46)
Weight (kg)	66.42 (12.27)	72.20 (17.80)	64.46 (10.22)*
Height (m)	1.54 (0.06)	1.53 (0.06)	1.55 (0.05)
Body mass index (kg.m ⁻²)	27.77 (4.67)	30.70 (5.79)	26.78 (3.78)*
5 times stand-to-sit test (s)	12.28 (2.96)	14.68 (4.26)	11.47 (1.78)*
Level of physical activity (METs/week)	1285.94 (259.63)	1296.38 (1271.22)	1287.76 (838.02)
Global muscle strength (Nm.kg ⁻¹) 1)	9.44 (2.48)	4.15 (0.81)	6.94 (1.29)*
Trunk flexors PT (Nm.kg ⁻¹)	0.81 (0.29)	0.53 (0.19)	0.91 (0.26)*
Trunk extensors PT (Nm.kg ⁻¹)	2.38 (0.69)	1.67 (0.40)	2.62 (0.60)*
Hip flexors PT (Nm.kg ⁻¹)	0.47 (0.16)	0.29 (0.12)	0.53 (0.12)*
Hip extensors PT (Nm.kg ⁻¹)	1.04 (0.37)	0.69 (0.17)	1.15 (0.35)*
Hip abductors PT (Nm.kg ⁻¹)	0.70 (0.20)	0.51 (0.10)	0.77 (0.19)*
Hip adductors PT (Nm.kg ⁻¹)	0.69 (0.25)	0.47 (0.18)	0.76 (0.22)*
Knee flexors PT (Nm.kg ⁻¹)	0.69 (0.23)	0.44 (0.13)	0.77 (0.19)*
Knee extensors PT (Nm.kg ⁻¹)	1.47 (0.43)	1.00 (0.27)	1.63 (0.34)*
Ankle dorsiflexors PT (Nm.kg ⁻¹) 1)	0.35 (0.11)	0.25 (0.08)	0.39 (0.10)*

Ankle plantar flexors PT	0.46 (0.16)	0.90 (0.34)*
(Nm.kg ⁻¹)	0.79 (0.36)	

GMS: global muscle strength. PT: peak torque. *: $p < 0.05$ according to T-Test.

Table 2. Association between the five times stand-to-sit test, global muscle strength and trunk, hip, knee and ankle peak torque.

Independent variables (predictors)	Dependent variables		
5 times stand-to-sit test	Multivariate associations	WILK'S λ; η^2	p-value
	Global muscle strength	0.645; 0.355	<0.001 [#]
5 times stand-to-sit test	Univariate associations	Beta; η^2	p-value
	Trunk flexors	-0.043; 0.198	<0.001*
	Trunk extensors	-0.106; 0.226	<0.001*
	Hip flexors	-0.022; 0.222	<0.001*
	Hip extensors	-0.041; 0.121	<0.001*
	Hip abductors	-0.016; 0.064	0.007*
	Hip adductors	-0.020; 0.066	0.006*
	Knee flexors	-0.032; 0.186	<0.001*
	Knee extensors	-0.062; 0.240	<0.001*
	Ankle dorsiflexors	-0.011; 0.090	0.001*
	Ankle plantar flexors	-0.044; 0.139	<0.001*

[#]p < 0.05 according to multivariate linear regression analysis; *p < 0.05 according to univariate linear regression analysis.

FIGURE

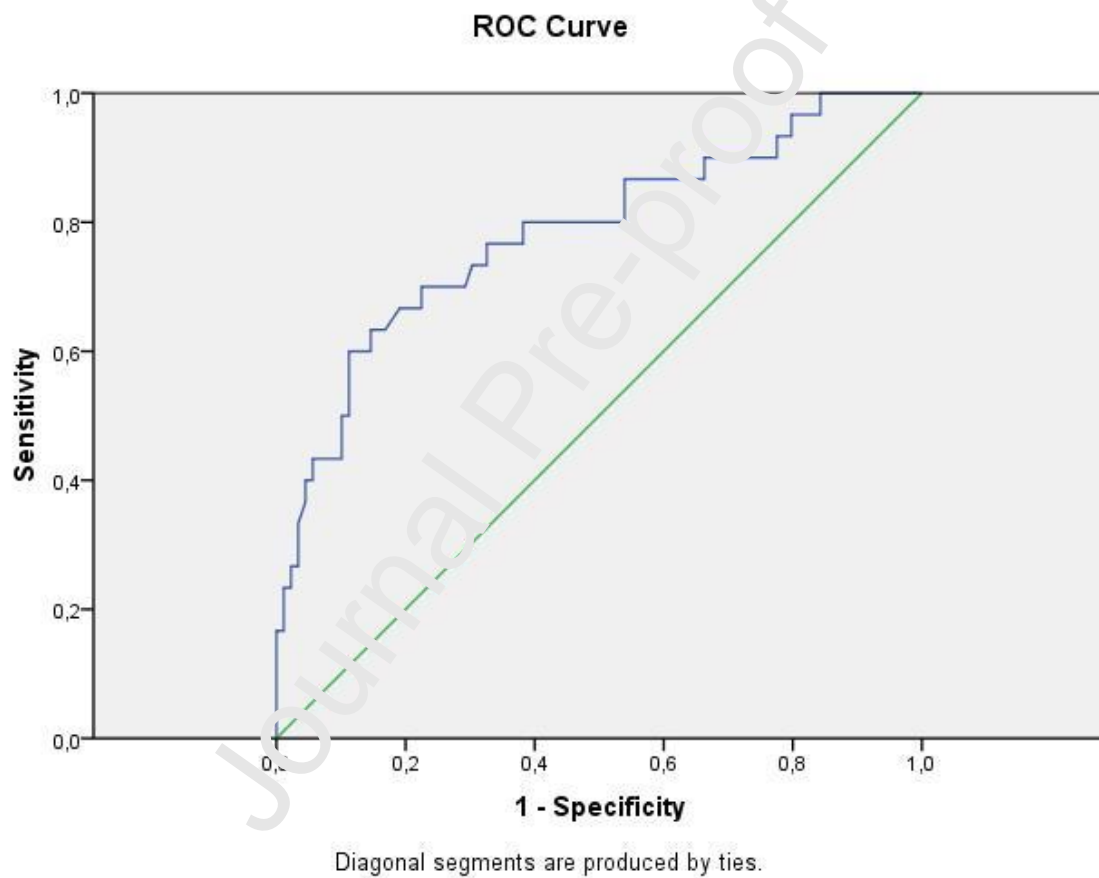


Figure 1. ROC curve for the 5 times stand-to-sit test as a discriminator of reduced global muscle strength in older women.

AUTHORSHIP STATEMENT

Jaqueline Mello Porto: Conceptualization, Methodology, Project administration, Formal analysis, Investigation, Writing - Original Draft, Writing - Review & Editing, Visualization.

Melise Jacon Peres-Ueno: Investigation, Writing - Review & Editing, Visualization.

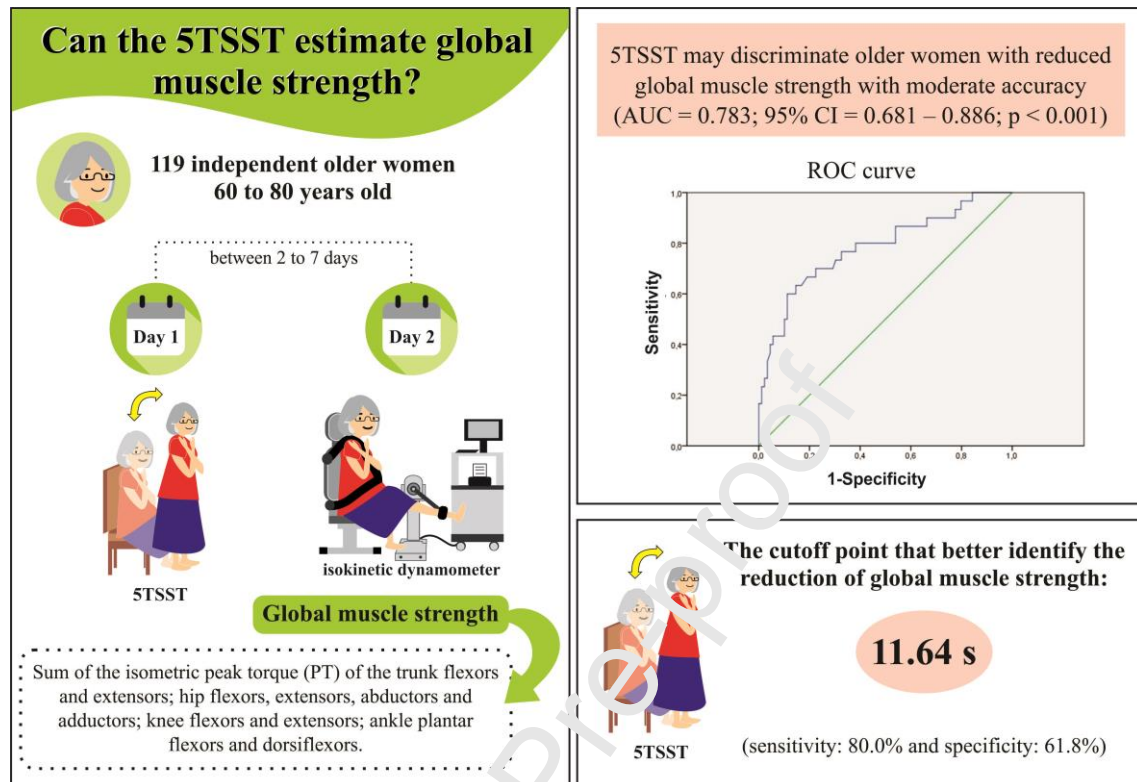
Roberta de Matos Brunelli Braghin: Methodology, Project administration, Formal analysis, Investigation.

Gabriela Martins Scudilio: Methodology, Project administration, Formal analysis, Investigation.

Daniela de Abreu: Conceptualization, Methodology, Project administration, Formal analysis, Investigation, Writing - Original Draft, Writing - Review & Editing, Visualization. Project administration, Supervision

Previous Interactions: We have had no previous interactions about this manuscript with the following Editorial Board Member.

Graphical abstract



HIGHLIGHTS

- The 5 times stand-to-sit test (5TSST) is tool for the screening of muscle weakness
- The 5TSST can estimate global muscle strength in independent older women
- The cutoff point that identify the reduction of global muscle strength is 11.64 s

Can the 5TSST estimate global muscle strength?



119 independent older women
60 to 80 years old

between 2 to 7 days



5TSST



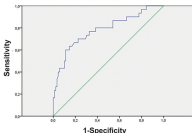
isokinetic dynamometer

Global muscle strength

Sum of the isometric peak torque (PT) of the trunk flexors and extensors; hip flexors, extensors, abductors and adductors; knee flexors and extensors; ankle plantar flexors and dorsiflexors.

5TSST may discriminate older women with reduced global muscle strength with moderate accuracy (AUC = 0.783; 95% CI = 0.681 – 0.886; $p < 0.001$)

ROC curve



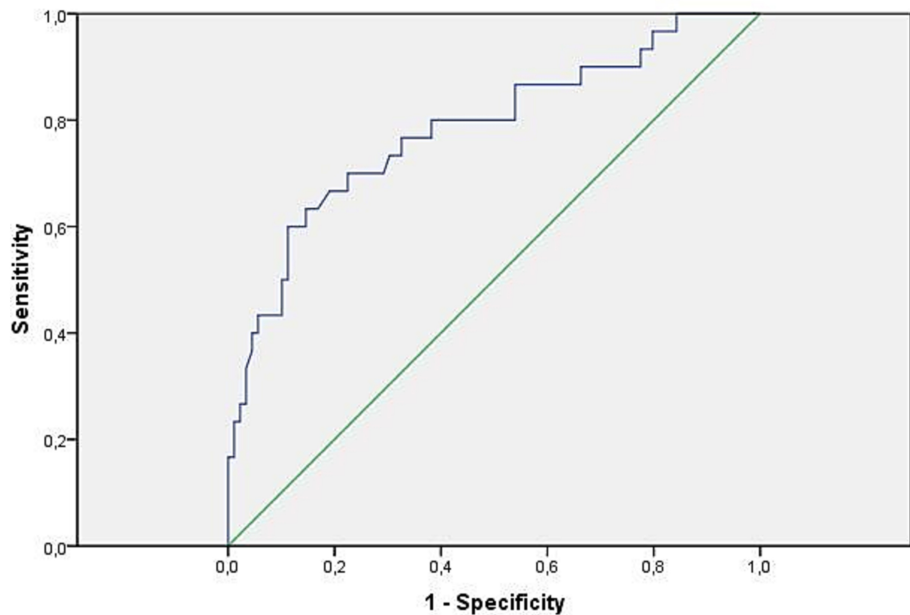
5TSST

The cutoff point that better identify the reduction of global muscle strength:

11.64 s

(sensitivity: 80.0% and specificity: 61.8%)

ROC Curve



Diagonal segments are produced by ties.

Figure 1