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Title: The sit-to-stand muscle power test: An easy, inexpensive and portable procedure to assess muscle power in older people.

Authors: Julian Alcazar[1,2], Jose Losa-Reyna[1,2,3], Carlos Rodriguez-Lopez[1,2], Ana Alfaro-Acha[2,3], Leocadio Rodriguez-Mañas[2,4], Ignacio Ara[1,2], Francisco J. García-García[2,3,*], Luis M. Alegre PhD[2,3,*]

Affiliations:

[1] GENUD Toledo Research Group, Universidad de Castilla-La Mancha. Toledo, Spain.

[2] CIBER of Frailty and Healthy Aging (CIBERFES). Madrid, Spain.

[3] Department of Geriatrics, Hospital Virgen del Valle, Complejo Hospitalario de Toledo. Toledo, Spain.

[4] Department of Geriatrics, Hospital Universitario de Getafe. Madrid, Spain.

Corresponding authors:

*Luis M. Alegre

Email: luis.alegre@uclm.es

Institution: GENUD Toledo Research Group, Universidad de Castilla-La Mancha

Address: Avda. Carlos III, S/N, 45071, Toledo (Spain)

Phone: +34 925 268 800 (Ext: 5506)

*Francisco J. García-García

Email: franjogarcia@telefonica.net

Institution: Department of Geriatrics, Hospital Virgen del Valle, Complejo Hospitalario de Toledo

Address: Carretera de Cobisa, S/N, 45071, Toledo (Spain)

Phone: +34 646 483 601

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Abstract

Introduction: Skeletal muscle power has been demonstrated to be a stronger predictor of functional limitations than any other physical capability. However, no validated alternatives exist to the usually expensive instruments and/or time-consuming methods to evaluate muscle power in older populations. Our aim was to validate an easily applicable procedure to assess muscle power in large cohort studies and the clinical setting and to assess its association with other age-related outcomes.

Methods: Forty community dwelling older adults (70-87 years) and 1,804 older subjects (67-101 years) participating in the Toledo Study for Healthy Aging were included in this investigation. Sit-to-stand (STS) velocity and muscle power were calculated using the subject's body mass and height, chair height and the time needed to complete five STS repetitions, and compared with those obtained in the leg press exercise using a linear position transducer. In addition, STS performance, physical (gait speed) and cognitive function, sarcopenia (skeletal muscle index (SMI)) and health-related quality of life (HRQoL) were recorded to assess the association with the STS muscle power values.

Results: No significant differences were found between STS velocity and power values and those obtained from the leg press force-velocity measurements (mean difference ± 95%CI = 0.02 ± 0.05 $m \cdot s^{-1}$ and 6.9 ± 29.8 W, respectively) (both $p>0.05$). STS muscle power was strongly associated with maximal muscle power registered in the leg press exercise ($r = 0.72$; $p<0.001$). In addition, cognitive function and SMI, and physical function, were better associated with absolute and relative STS muscle power, respectively, than STS time values after adjusting by different covariates. In contrast, STS time was slightly more associated with HRQoL than STS muscle power measures.

Conclusion: The STS muscle power test proved to be a valid, and in general, a more clinically relevant tool to assess functional trajectory in older people compared to traditional STS time values. The low time, space and material requirements of the STS muscle power test, make this test an excellent choice for its application in large cohort studies and the clinical setting.

Key words: functional ability; frailty; healthy aging; chair rising; sarcopenia; exercise testing.

Abbreviations:

1RM: one repetition maximum

CI: confident interval

CL: confident limit

CV: coefficient of variation

DXA: dual x-ray absorptiometry

ES: effect size

HRQoL: health-related quality of life

ICC: intra-class correlation coefficient

MDC: minimal detectable change

MMSE: mini-mental state examination

Pmax: maximal muscle power

R^2: coefficient of determination

SEM: standard error of measurement

SMI: skeletal muscle index

SPPB: short physical performance battery

STS: sit-to-stand

TSHA: Toledo Study for Healthy Aging

1. Introduction

Functional limitations have been proven to increase mortality risk to a greater extent than multimorbidity (Landi et al., 2010), as well as costs associated with falls (Grundstrom et al., 2012) or hospitalization (Kumar et al., 2017). A new older-person-centered and integrated care model has been proposed in which health systems are encouraged to prioritize the healthy aging goals of building and maintaining functional ability (WHO 2015).

One of the main evidence-based strategies to counteract the deleterious effect of aging on functional ability is exercise (Izquierdo et al., 2016; Tak et al., 2013). Specifically, muscle power capacity has been demonstrated to be a stronger predictor of functional limitations than any other physical capability, such as muscle strength or maximal aerobic capacity (Foldvari et al., 2000; Martinikorena et al., 2016). This makes muscle power evaluation a critical tool for the management of functional trajectories in older people. A great variety of testing protocols are available in the literature using a great variety of testing instruments (Alcazar et al., 2017a). In most cases, these instruments can be relatively expensive and require periodic calibration or technical support, in some cases they are difficult to transport, and subjects must be carefully familiarized prior to testing. All these issues might prevent researchers, clinicians and other health professionals from evaluating muscle power in large sample studies (e.g. >500 subjects) or in their respective settings.

The sit-to-stand (STS) test (Csuka and McCarty 1985) is an easy, rapid, and commonly used functional performance measure that involves measuring the time taken to stand from a seated position a certain number of times or recording the number of repetitions undertaken in a given period, with low space, material and time requirements. In addition, several studies have evaluated STS muscle power by the utilization of a force platform (Alvarez Barbosa et al., 2016; Chen et al., 2012; Cheng et al., 2014; Drey et al., 2012; Fleming et al., 1991; Lacroix et al., 2015;

Lindemann et al., 2003; Lindemann et al., 2007; Regterschot et al., 2016b; Zech et al., 2012; Zech et al., 2011), a linear position transducer (Alvarez Barbosa et al., 2016; Glenn et al., 2015; Glenn et al., 2017a; Glenn et al., 2017b; Glenn et al., 2016; Gray et al., 2016; Gray and Paulson 2014; Kato et al., 2015) or a 3D accelerometer (Regterschot et al., 2016a; Regterschot et al., 2016b; Zijlstra et al., 2010). However, these procedures present the economic and technical limitations mentioned above for their applicability in large studies or in the clinical setting.

To our knowledge, only one previous study (Takai et al., 2009) (though used in additional studies, e.g.: (Fragala et al., 2014; Yanagawa et al., 2015; Yanagawa et al., 2016)) has reported an easy procedure to assess muscle power in which only the subject's body mass and leg length, chair height and the time needed to complete 10 STS repetitions were required. However, several apparent limitations in that study have not been addressed in the literature yet. First, STS muscle power values were not compared or validated against muscle power measured with a previously validated instrument; second, during the STS task the lower legs mass (shanks and feet) are not displaced, so it should not be included in the STS muscle power equation; third, performing 10 STS repetitions might be a fatiguing task for some older adults (>30-45 s), which in fact would make the test a muscular endurance test rather than a muscle power test; and fourth, the ability of the STS muscle power values to predict other age-related outcomes in comparison with the traditional STS time values was not evaluated, which might be of major clinical relevance. For these reasons, the purpose of the present study was to evaluate the validity of our STS muscle power equation against muscle power exerted by older subjects in a similar multi-joint dynamic exercise using a validated instrument, and to assess the association of STS muscle power with physical and cognitive function, sarcopenia and quality of life in a large cohort of older people.

2. Material and methods

This study was divided in two different parts: 1) the validation of our STS muscle power equation; and 2) the evaluation of the association of the obtained STS muscle power values with other age-related outcomes.

2.1 Participants

Forty older subjects (24 women) participated in the validation sub-study (Table 1). Participants were recruited through advertisements and community newsletters, and screened if they were aged ≥70 years. Older subjects with a Short Physical Performance Battery (SPPB) score <4 or unable to perform the five STS test, severe cognitive impairment (Mini-mental State Examination (MMSE) score <20), neuromuscular or joint injury, stroke, myocardial infarction or bone fracture in the previous six months, uncontrolled hypertension (>200/110 mmHg) or terminal illness were excluded. In addition, data extracted from the older participants of the Toledo Study for Healthy Aging (TSHA) (Garcia-Garcia et al., 2011) were used to evaluate the clinical relevance of the STS muscle power measures. Briefly, the TSHA is a population prospective cohort study aimed at studying the determinants and consequences of frailty in institutionalized and community-dwelling individuals aged 65 or over living in the province of Toledo, Spain. Those participants that completed the STS assessment were included in the present study (1,804 older subjects; 52.8% women) (Table 2). All the subjects gave their informed consent and the study was performed in accordance with the Helsinki Declaration and approved by the Ethical Committee of the Toledo Hospital.

Table 1. Main characteristics of the subjects participating in the validation protocol.

Variable	N	Mean ± SD	Range
Age (years)	40	77.6 ± 5.4	70.2 - 87.2
BMI ($kg \cdot m^{-2}$)	40	29.9 ± 4.3	19.5 - 43.0

SMI (kg·m^{-2})	40	7.2 ± 1.1	4.8 - 10.2
SPPB score	40	9.9 ± 2.4	4.0 - 12.0
HGS (m·s^{-1})	40	0.83 ± 0.23	0.30 - 1.22
5 STS time (s)	40	11.9 ± 4.2	6.9 - 30.0
MMSE score	40	26.2 ± 3.0	20.0 - 30.0
EQ-index	40	0.87 ± 0.12	0.51 - 1.00
EQ-VAS	40	66.8 ± 16.8	25.0 - 100.0

Note: BMI: body mass index; EQ-index: Euroqol index; EQ-VAS: Euroqol visual analogue scale; HGS: habitual gait speed; MMSE: mini-mental state examination; SD: standard deviation; SMI: skeletal muscle index; SPPB: short physical performance battery; STS: sit-to-stand.

Table 2. Main characteristics of the sub-sample of older subjects from the Toledo Study for Healthy Aging.

Variable	N	Mean ± SD	Range
Age (years)	1,804	76.5 ± 6.9	66.7 - 100.9
BMI (kg·m^{-2})	1,804	29.5 ± 4.7	15.6 - 48.8
SMI (kg·m^{-2})	1,378	7.2 ± 1.1	4.4 - 11.3
SPPB score	1,665	8.6 ± 2.2	2.0 - 12.0
HGS (m·s^{-1})	1,558	0.81 ± 0.27	0.06 - 1.88
5 STS time (s)	1,804	14.8 ± 4.3	5.6 - 31.0
MMSE score	1,646	24.1 ± 4.5	0.0 - 30.0
EQ-index	1,762	0.95 ± 0.10	0.0 - 1.0
EQ-VAS	1,756	73.0 ± 20.7	0.0 - 100.0

Note: BMI: body mass index; EQ-index: Euroqol index; EQ-VAS: Euroqol visual analogue scale; HGS: habitual gait speed; MMSE: mini-mental state examination; SD: standard deviation; SMI: skeletal muscle index; SPPB: short physical performance battery; STS: sit-to-stand.

2.2 Physical function, cognitive function and health-related quality of life

Physical function was evaluated by means of the habitual gait speed over a 3-m distance, while cognitive function was registered by the MMSE (score 0-30) (Folstein et al., 1975). Health-related quality of life (HRQoL) was measured by the EQ-5D-5L questionnaire (Herdman et al., 2011). HRQoL score was calculated using composite z-scores from the EQ-index values (obtained based on the crosswalk value set from the Spanish time trade-off valuation technique) and the subjects' self-reported health states (EQ-VAS).

2.3 Body composition

A stadiometer and scale device (Seca 711, Seca, Hamburg, Germany) was used to record the height and body mass of the participants. Skeletal muscle mass was assessed by dual energy X-ray absorptiometry (DXA) (Hologic Series QDR Discovery; Hologic Corp., Bedford, MA, USA) and analyzed using commercially available software (Physician's Viewer; APEX System Software Version 3.1.2., Bedford, MA, USA). Whole body scans were submitted to a regional analysis to determine the composition of the arm, trunk, leg and lower leg regions. The skeletal muscle index (SMI) was obtained from the ratio of the appendicular skeletal muscle mass and the height squared ($kg \cdot m^{-2}$). Leg length was measured from the whole body scans as the distance between the superior border of the great trochanter and the inferior border of the calcaneus bone of the right leg (ImageJ 1.5, National Institutes of Health, USA).

2.4 Sit-to-stand evaluation

The subjects completed five timed STS repetitions on a standardized armless chair (0.49 m height). After the cue "ready, set, go!", the subjects started to perform STS repetitions as rapidly as possible from the sitting position with their buttocks touching the chair to the full standing position, with their arms crossed over the chest. Verbal encouragement was given during the test. The STS test finished when the subjects sat on the chair after the fifth STS repetition, and the time needed to complete the task was recorded with a stopwatch to the nearest 0.01 s. The subjects were allowed to try 1-2 times with an adequate resting period (30-60 s) before the definitive STS measure was annotated. STS mean velocity ($m \cdot s^{-1}$) was calculated as the vertical distance (m) covered by the center of mass divided by the mean time (s) spent to complete the concentric phase of one STS repetition (equation 1). Vertical displacement was obtained from the difference between leg length (0.50±0.01 body height) and the height of the chair. The time spent to complete the concentric phase of one STS repetition was estimated as the tenth part of the time spent to complete the five concentric-eccentric STS repetitions (i.e. assuming that the duration of the concentric and eccentric phases is similar). Mean acceleration over the concentric displacement must be zero since initial and final velocities are zero, and thus STS mean force (N) was calculated as the body mass displaced during the test (total body mass minus shanks and feet mass) (0.90±0.01 body mass) (kg) multiplied by g ($9.81\ m \cdot s^{-2}$) (equation 2). Then, STS mean muscle power (W) was the product of STS mean velocity and STS mean force (equation 3), and relative STS mean muscle power ($W \cdot kg^{-1}$) the ratio of STS mean muscle power and total body mass (equation 4). The reliability values during STS evaluation in our laboratory have been found to be: CV (95% CI) = 5.2% (3.4 – 6.9%); ICC (95% CI) = 0.97 (0.92 – 0.99); SEM (95% CI) = 2.9 W (1.7 – 4.8 W) or 0.96% (0.55 – 1.56%).

Equation 1:

$$STS\ mean\ velocity = \frac{[Height \times 0.5 - Chair\ height]}{Five\ STS\ time \times 0.1}$$

Equation 2:

$$STS\ mean\ force = Body\ mass\ \times 0.9 \times g$$

Equation 3:

$$STS\ mean\ power = \frac{Body\ mass\ \times 0.9 \times g \times [Height \times 0.5 - Chair\ height]}{Five\ STS\ time \times 0.1}$$

Equation 4:

$$Relative\ STS\ mean\ power = \frac{0.9 \times g \times [Height \times 0.5 - Chair\ height]}{Five\ STS\ time \times 0.1}$$

2.5 Force-velocity and muscle power evaluation

A full description and validation of the force-velocity and muscle power testing procedure has been reported (Alcazar et al., 2017b). After an adequate warm-up, the subjects performed 2 sets of 1 repetition in the leg press exercise (BH Fitness, Serie TR, Spain) with increasing loads from 40% of their body mass until the one repetition maximum (1RM). Mean force and velocity data during the concentric phase of each repetition (from 100° and 90° at the hip and knee joints, respectively, to full extension) performed as fast and strongly as possible were recorded by a linear position transducer (T-Force System, Ergotech, Spain). The highest mean velocity for each load was plotted on a custom-made Microsoft Excel® template (Alcazar et al., 2017b), and a linear regression equation was fitted simultaneously during the F-V evaluation. A third repetition was performed with the loads whose highest mean velocity deviated >0.03 $m \cdot s^{-1}$ from the estimated value. This procedure showed excellent reliability (ICC: 0.91-0.99, CV: 2.6-5.6%, and SEM%: 3.3-9.2%) (Alcazar et al., 2017b). Velocity and power values exerted by the older subjects during the leg press exercise at the same intensity as during the STS repetitions, and maximal muscle power (P_{max}) were obtained from the F-V regression equation. Finally, the subjects were classified according to deficits (Alcazar et al., 2018): (i) no deficits in force or velocity (combination of tertiles 1 and 2 of force and velocity); (ii) deficit in force (tertile 3 in force and tertiles 1 or 2 in velocity); and (iii) deficit in velocity (tertile 3 in velocity and tertiles 1 or 2 in force).

2.6 Statistical analysis

All data were examined for normality of distribution with the Shapiro-Wilk`s test, and log-transformed in case of a non-uniformity result. Standard descriptive statistics were used for continuous variables and contingency tables for categorical variables. Significant differences between STS velocity and power values and those obtained from the F-V relationship were assessed with Student's t-tests for dependent samples, and mean differences with 95% confidence intervals (CI) were reported. In addition, standardization and magnitude-based inferences with 90% confidence limits (CL) were used to compare both procedures and assess the ability of our STS power values to differentiate among subjects with different F-V profiles. Briefly, the smallest worthwhile change was calculated as a standardized small effect size (ES = 0.20) multiplied by the between-subject standard deviation (Cohen 1988). Clear effects (negative/harmful effects <5%) were assessed as follows (Hopkins et al., 2009): <0.5% most unlikely; 1-5% very unlikely; 5-25% unlikely; 25-75% possibly; 75-95% likely; 95-95.5% very likely; and >99.5% most likely. Thresholds for interpreting the standardized effect (ES) were as follows (Hopkins et al., 2009): <0.2 trivial, 0.2-0.6 small, 0.6-1.2 moderate, and >1.2 large. $ICC_{2,1}$ between procedures was also calculated and assessed as (Shrout 1998): <0.40, slight; 0.41-0.60, fair; 0.61-0.80, moderate; >0.80, substantial. In addition, a Bland-Altman analysis was performed in order to assess the level of agreement between STS muscle power and leg press muscle power. Bivariate linear and quadratic regression analyses were performed to compare the magnitude of the relationship of STS time and power values with physical function, cognitive function, SMI, and HRQoL. The coefficient of determination (R^2) change was used to compare the linear and quadratic models. Regression values were assessed as (Hopkins et al., 2009): <0.1, trivial; 0.10-0.29, small; 0.30-0.49, moderate; 0.50-0.69, large; 0.70-0.89, very large; and 0.90-1.00, extremely large. A further regression analysis was conducted adjusting by different covariates (age, sex, comorbidity (Berkman et al., 1992), hospitalization during the previous 12 months, depression status (Yesavage et al., 1982) and physical activity (Washburn et al., 1993)). Statistical analyses were performed using SPSS v20 (SPSS Inc., Chicago, Illinois), and the level of significance was set at α = 0.05.

3. Results

There were not significant differences between STS velocity and power values and those exerted by the older subjects in the leg press exercise against the same load (i.e. body mass minus lower leg mass) (Table 3). Intra-subject mean differences ± 95% CI between procedures were 0.02 ± 0.05 $m \cdot s^{-1}$ for velocity and 6.9 ± 29.8 W for absolute power values, which were found to be trivial (i.e. ES <0.2).

Table 3. Comparison between velocity and muscle power values obtained from the sit-to-stand muscle power test and the leg press force-velocity relationship.

Variable	N	F-V relationship			STS test			*p*	ES	±	90% CI
		Mean	±	SD	Mean	±	SD				
Velocity ($m \cdot s^{-1}$)	40	0.26	±	0.16	0.27	±	0.08	0.517	0.10	±	0.25
Power (W)	40	177.3	±	114.5	184.3	±	77.9	0.639	0.06	±	0.22

Note: CI: confidence interval. ES: effect size. F-V: force-velocity; SD: standard deviation; STS: sit-to-stand.

ICC values were fair for velocity (ICC [95%CI] = 0.50 [0.05 – 0.74]) and moderate for muscle power (ICC [95%CI] = 0.72 [0.47 – 0.86]). In addition, a very strong correlation was found between STS power and P_{max} produced in the leg press exercise (r = 0.72; $p < 0.001$). A Bland-Altman plot is showed in Figure 1. Despite the non-significant bias between measures, there was a significant association between the difference and the average of both measures (r = 0.36; p = 0.025).

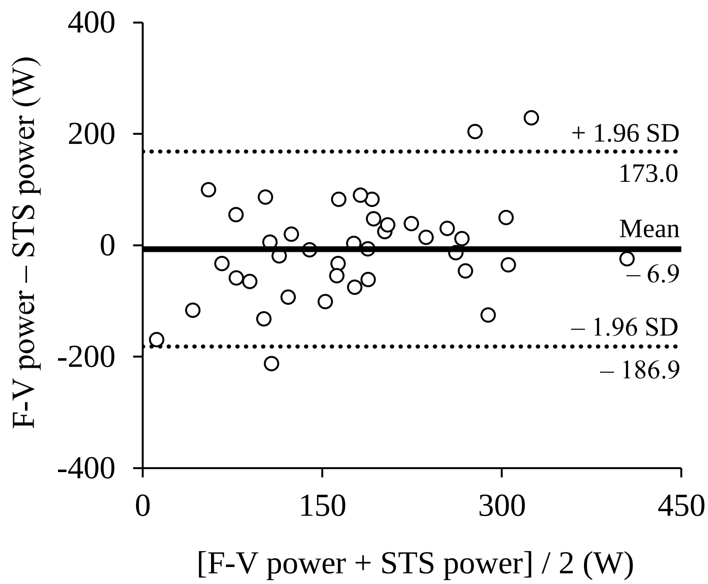

Figure 1. Bland-Altman plot for muscle power measures obtained from the sit-to-stand test and the leg press exercise. F-V: force-velocity; SD: standard deviation; STS: sit-to-stand.

A likely moderate difference in STS muscle power was found between subjects with no deficits in force or velocity and those with a force-deficit (225.0±78.6 vs. 171.2±85.8 W, respectively; ES±90%CI = 0.67±0.87), and also between the non-deficit group and the velocity-deficit group (225.0±78.6 vs. 167.2±71.1 W, respectively; ES±90%CI = 0.72±0.80), while no differences in STS muscle power were observed between the subjects with a force deficit and those with a velocity deficit in the F-V relationship (ES±90%CI = 0.05±0.91).

The unadjusted comparison of STS time against absolute and relative STS muscle power values in terms of being associated with other major age-related outcomes showed that relative STS muscle power was significantly more associated with physical function and HRQoL than STS time values (r [95% CI] = 0.45 [0.41-0.49] vs. 0.40 [0.36-0.44]; and 0.30 [0.26-0.34] vs. 0.25 [0.21-0.39], respectively) (p<0.05); while absolute STS muscle power was significantly more associated with cognitive function and SMI values than STS time (r [95% CI] = 0.29 [0.24-0.33] vs. 0.22 [0.17-0.27]; and 0.51 [0.47-0.55] vs. 0.04 [-0.01-0.09], respectively) (p<0.05). The better association of STS muscle power measures with age-related outcomes was confirmed after adjusting by different covariates (except for HRQoL, where the association was marginally greater for STS time compared to relative STS power) (Table 4).

Table 4. Adjusted regression analyses between STS measures and age-related outcomes.

Variable	Physical function		Cognitive function		SMI		HRQoL	
	Std. β	*p*	Std. β	*p*	Std. β	*p*	Std. β	*p*
STS time	-0.26	<0.001	-0.01	<0.001	0.07	0.003	-0.15	<0.001
STS $power_{abs}$	0.25	<0.001	0.16	<0.001	0.28	<0.001	0.08	<0.001
STS $power_{rel}$	0.31	<0.001	0.13	<0.001	-0.09	0.001	0.14	<0.001

$Power_{abs}$: absolute muscle power. $Power_{rel}$: relative muscle power. HRQoL: health-related quality of life. SMI: skeletal muscle index. Std.: standardized. STS: sit-to-stand. *Note:* Adjusted by age, sex, comorbidity, hospitalization, depression and physical activity.

4. Discussion

The main findings of the present study were: 1) velocity and muscle power values obtained from our proposed STS muscle power equations were similar to those exerted by the older subjects in the leg press resistance machine at an intensity equivalent to the body mass displaced during the STS task; 2) STS muscle power values showed a greater association with physical function, cognitive function and sarcopenia than traditional STS time values after considering the age, sex, comorbidity, hospitalization, depression and physical activity of the participants; and 3) STS time values were slightly more associated with quality of life compared to STS muscle power values. STS velocity and power values obtained from STS testing only differed in 0.02 $m \cdot s^{-1}$ and 6.9 W, respectively, from leg press velocity and power values obtained using a validated instrument. The Bland-Altman analysis showed a no statistically significant bias between power measures, although leg press muscle power tended to be overestimated in the subjects with lower muscle function, and underestimated in the subjects with higher muscle function. Some factors contributing to these small discrepancies might be the different range of movement and muscle activation and coordination patterns between STS actions and the leg press task. It is important to note that the range of movement during STS and the leg press repetitions was not the same due to the fact that chair height was the same for all the subjects, while the range of movement in the leg press was individually adjusted. In addition, it might be considered that the leg press exercise allows a more isolated work of the legs muscles, while during STS actions the trunk muscles might also be important and the postural control plays a major role. However, we decided to compare and validate STS muscle power values with those exerted in the leg press exercise due to the similarity between these two lower-body multi-joint tasks, and because the leg press has been shown to be the most commonly used exercise to assess leg muscle power in older people (Alcazar et al., 2017a). In any case, it is important to highlight that in the worst case (90% CL) the standardized mean differences between STS velocity and power values and those obtained from F-V relationship were small (0.05 $m \cdot s^{-1}$ (ES = 0.35) and 32.1 W (ES = 0.25), respectively). In addition, STS power was strongly associated with P_{max} evaluated in the leg press exercise (r = 0.72), and discriminated adequately between those subjects with no deficits in force or velocity and those showing a force or velocity deficit, which might be of great importance for selecting older subjects with a higher priority for power training (Alcazar et al., 2018).

Nonetheless, more important than the level of agreement between the two procedures is the level of association with other age-related outcomes. In this sense, the unadjusted regression analysis showed that compared to STS time, physical function and quality of life were better associated with relative STS muscle power, and absolute STS muscle power values were more strongly associated with cognitive function and SMI, in both the sample of 40 older subjects (data not shown) and the large cohort of older people (>1,500 subjects). In addition, after adjusting by age, sex, comorbidity, hospitalization, depression and physical activity, STS power measures were more associated with physical function, cognitive function and SMI than the traditional STS time values. In contrast, STS time was slightly more associated with HRQoL than relative STS muscle power. HRQoL is a subjective measure that depends on the subject's perception regarding different dimensions of daily life (e.g. activities of daily living or pain) (Herdman et al., 2011). Therefore, it is likely that the time needed to complete a certain task is a more important feature for the subject's perception of quality of life than the level of muscle power by itself. In any case, STS power values were also significantly and independently associated with HRQoL. Thereby, in general, the STS power measures might be considered superior to STS time values for the evaluation of physical function, cognitive function, sarcopenia and quality of life in older people, although the relevance of the STS time measure should not be underestimated, overall regarding its relationship with quality of life.

The use of better screening tools to identify earlier stages of frailty, which might be considered a public health priority (Cesari et al., 2016), might help to prevent the transition to disability by the implementation of adequate interventions. In this sense, future studies should evaluate whether STS muscle power could improve the ability of currently available frailty scales to identify pre-frail and frail older people (Fried et al., 2001; García-García et al., 2014).

Moreover, test-retest reliability of STS power values was observed to be excellent. Previous studies have also found an excellent test-retest (ICC [95%CI] = 0.89 [0.79 – 0.95]) (Tiedemann et al., 2010) and inter-rater (ICC [95%CI] = 1.00 [0.99 – 1.00]) (Wallmann et al., 2013) reliability of STS performance evaluated in a similar group of community-dwelling older adults. In addition, absolute and relative minimal detectable change (MDC) for STS time values were 2.5 s and 17.5%, respectively (Goldberg et al., 2012). Thus, MDC values would be 0.06 $m \cdot s^{-1}$ and 40.5

W to detect velocity and power gains, respectively; and 0.04 $m \cdot s^{-1}$ and 28.4 W to detect velocity and power decrements over time, respectively. Also, normative values and cut-off points should be calculated in future studies to identify adequate and harmful levels of STS velocity and power. Finally, STS-based exercise programs, which have been demonstrated to promote positive physical function gains in mobility-limited aged individuals (Rosie and Taylor 2007; Slaughter et al., 2015), might benefit from using the STS muscle power test presented in this work to better control and individualize the training stimulus in their older subjects or patients and not simply as a testing tool. On the other hand, the substitution of the previously validated methods to assess muscle power, such as those utilizing a force plate or a linear position transducer, was not the purpose of the procedures presented by this work. Instead, they would be helpful in large cohort studies where measurements are conducted far from the lab setting, or in the clinical setting, because of their easy administration and low material requirement, while maintaining their clinical relevance.

5. Conclusions

The STS muscle power test is an easy, portable and inexpensive procedure to assess muscle power in older adults. This STS muscle power test can be carried out in the clinical setting, or in other professional settings in which the economic, space or time requirements of traditional procedures and instruments can be an obstacle. Only the subject's body mass and height, the chair height and a stopwatch to record the time needed to complete five STS repetitions were required. When direct evidence on subjects' leg length and body mass minus shank and feet masses is not available, the correction factors found to estimate the displaced body mass (body mass × 0.9) and traveled vertical distance (height × 0.5 – chair height) during one STS repetition should be considered. Using this procedure, STS velocity and power values were found to be valid and more clinically relevant in regard to physical function, cognitive function and sarcopenia in comparison to traditional time measures in a large cohort of older people.

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Conflicts of interest

The authors declare no conflicts of interest.

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