Experimental Gerontology 112 (2018) 38–43

Contents lists available at ScienceDirect

Experimental Gerontology

journal homepage: www.elsevier.com/locate/expgero

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

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ARTICLE INFO

Section Editor: Emanuele Marzetti

Keywords:
Functional ability
Frailty
Healthy aging
Chair rising
Sarcopenia
Exercise testing

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 1804 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.

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

Abbreviations: 1RM, one repetition maximum; CI, confidence interval; CL, confidence 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

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https://doi.org/10.1016/j.exger.2018.08.006
Received 21 June 2018; Received in revised form 3 August 2018; Accepted 30 August 2018
Available online 01 September 2018
0531-5565/

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., 2016; 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., 2016; 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.

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·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.

2.1. Participants

Forty older subjects (24 women) participated in the validation substudy (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 mm Hg) 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 (1804 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.

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

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)	1804	76.5 ± 6.9	66.7–100.9
BMI (kg·m^{-2})	1804	29.5 ± 4.7	15.6–48.8
SMI (kg·m^{-2})	1378	7.2 ± 1.1	4.4–11.3
SPPB score	1665	8.6 ± 2.2	2.0–12.0
HGS (m·s^{-1})	1558	0.81 ± 0.27	0.06–1.88
5 STS time (s)	1804	14.8 ± 4.3	5.6–31.0
MMSE score	1646	24.1 ± 4.5	0.0–30.0
EQ-index	1762	0.95 ± 0.10	0.0–1.0
EQ-VAS	1756	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.