

Is there a learning effect on 1-min sit-to-stand test in post-COVID-19 patients?

Copyright ©The authors 2022

This version is distributed under the terms of the Creative Commons Attribution Non-Commercial Licence 4.0. For commercial reproduction rights and permissions contact permissions@ersnet.org

Received: 20 April 2022 Accepted: 27 June 2022 To the Editor:

Due to the sequelae of the coronavirus disease 19 (COVID-19), clinical guidelines have had to develop follow-up programmes focused on imaging, lung function, symptoms and physical capacity [1, 2]. To assess functional capacity, field tests are recommended, such as the 6-min walking test (6MWT) or the 1-min sit-to-stand test (STST) [3, 4]. The advantage of these tests is that they have been widely demonstrated to be useful in assessing functional capacity in respiratory chronic diseases and can be performed in low-resource settings [5].

While using field tests, clinical guidelines recommend performing two tests due to the learning effect [3] but in the 1-min STST, it is not clear that this effect exists. Some authors have described a learning effect in respiratory patients with an increase from 0.8 to 2 repetitions in favour of the second test [6, 7]. However, other authors have described that there is no learning effect [8]. Given the increasing use of this test [9, 10], it is important to know if it is necessary to carry out a second test for an adequate assessment of functional capacity. Our objective was to determine the existence of learning effect on the 1-min STST in post-COVID-19 patients.

We conducted a cross-sectional analysis in patients recovering from COVID-19 pneumonia admitted to the follow-up programme in the Hospital Virgen de la Torre (Madrid, Spain) between March and May of 2021. Ethics committee approval was obtained and all patients gave informed consent. This study follows the recommendations of the Strengthening the Reporting of Observational Studies in Epidemiology guidelines [11].

Inclusion criteria were as follows: patients older than 18 years; diagnosis of COVID-19 by positive PCR assay of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) on nasal and pharyngeal swab specimens; and pulmonary rehabilitation candidates by post-COVID-19 condition, defined as individuals with a history of probable or confirmed SARS-CoV-2 infection, usually 3 months from the onset of COVID-19 with symptoms that lasted for ≥2 months and cannot be explained by an alternative diagnosis. Common symptoms included fatigue, shortness of breath and cognitive dysfunction, and generally had an impact on everyday functioning. Symptoms could be new-onset after initial recovery from an acute COVID-19 episode or persist from the initial illness. Symptoms may also have fluctuated or relapsed over time [12]. Exclusion criteria were the following: presence of locomotor or cognitive impairment before the infection; refusal to participate; and any pre-existing condition, such as orthopaedic or neurological comorbidities, limiting the ability to perform the standard field test.

Anthropometric characteristics, hospitalisation history, dyspnoea on the modified Medical Research Council (mMRC) dyspnoea scale and underlying comorbidities were collected. The main outcome was physical capacity assessed by the 1-min STST.

The 1-min STST was performed with a standard-height chair (46 cm) without armrests and placed against a wall. Participants were not allowed to use their hands or arms to push against the chair seat or their body. Participants were instructed to complete as many sit-to-stand cycles as possible in 60 s at a self-paced speed. The time between both attempts of the 1-min STST was 30 min. The same person performed all assessments.







Shareable abstract (@ERSpublications)

The 1-min sit-to-stand test is a repeatable field test without differences between the first and second tests. Hence, conducting one attempt of the 1-min STST would be enough to evaluate functional capacity in patients recovered from #COVID19. https://bit.ly/3y3ycAP

Cite this article as: Sevillano-Castaño A, Peroy-Badal R, Torres-Castro R, et al. Is there a learning effect on 1-min sit-to-stand test in post-COVID-19 patients? *ERJ Open Res* 2022; 8: 00189-2022 [DOI: 10.1183/23120541.00189-2022].

The modified Borg scale (0-10) was used to measure dyspnoea and fatigue immediately before and after all tests [13]. A fingertip pulse oximeter was used to record peripheral oxygen saturation (S_{pO_2}) and heart rate. The evaluator had previous experience in applying this test.

Using the method of Walter *et al.* [14] based on an estimate that uses the intraclass correlation coefficient (ICC), it was established that \geq 40 individuals would be necessary, considering an acceptable reliability of p_0 =0.60 and an expected reliability of p_1 =0.80, together with a power of 90% and a level of significance of 5%, due to the nature and characteristics of the study; a loss of 5% of the sample is assumed.

All data are expressed as mean±sp or median (interquartile range) depending on the distribution. The distribution was analysed using the Shapiro–Wilk test. Differences between groups were evaluated using Student's t-test for normally distributed variables or a Mann–Whitney U-test for nonparametric variables. The ICC was used to assess the learning effect and a Bland–Altman plot was used to evaluate agreement between both tests. The level of significance was set at p<0.05. All statistical analysis was performed with SPSS version 25.0 (SPSS Inc., Chicago, IL, USA).

We recruited 42 patients recovered from COVID-19 (mean±sD age 53.8±10.3 years; 52% female). The baseline characteristics of the patients are presented in table 1. The mean time between COVID-19

TABLE 1 Descriptive statistics of the included patients	
Patients n	42
Age (years)	53.8±10.3
Sex	22 (122()
Male	20 (48%)
Female	22 (52%)
Weight (kg)	84.0±18.2
Height (cm)	166 (159–174)
BMI (kg·m ⁻²)	29.3 (26.4–33.1)
Hospitalised	29 (70%)
Length of stay (days)	15 (4–27)
ICU admission	7 (16.7%)
mMRC scale score	1 (1–2)
Comorbidities	22 /52 40/
Obesity	22 (52.4%)
Systemic hypertension	13 (31.0%)
Diabetes	9 (21.4%)
Cardiovascular disease	4 (9.5%)
1-min STST	
First test	00 (10 05 0)
Repetitions	22 (19–25.3)
Baseline S _{pO₂} (%)	97 (96–98)
Final S_{pO_2} (%)	95 (93–97)
Baseline heart rate (beats per min)	84±15
Final heart rate (beats per min)	109±19
Baseline dyspnoea score	1 (0–3)
Final dyspnoea score	4 (3–5)
Baseline fatigue score	1 (0–3)
Final fatigue score	4 (3–6)
Second test	#
Repetitions	22.5 (20–25)#
Baseline S _{pO2} (%)	96 (96–98)#
Final S _{pO₂} (%)	95 (93–97)#
Baseline heart rate (beats per min)	85±15 [#]
Final heart rate (beats per min)	110±18 [#]
Baseline dyspnoea score	1 (0-3)#
Final dyspnoea score	4 (3–5)#
Baseline fatigue score	2 (0–3)#
Final fatigue score	3 (2.5–5)#

Data are presented as mean \pm so, n (%) or median (interquartile range), unless otherwise stated. BMI: body mass index; ICU: intensive care unit; mMRC: modified Medical Research Council; STST: sit-to-stand test; S_{pO_2} : oxygen saturation. $^{\#}$: difference between first and second test p>0.05.

diagnosis and STST evaluation was 5.8 ± 0.6 months. 29 patients had a history of hospitalisation with a median (interquartile range) of 15 (4–27) days of hospitalisation. Only seven patients required intensive care unit (ICU) admission. The median mMRC score was 1 (1–2).

Regarding the physical capacity, the median number of repetitions in the 1-min STST was 22 (19–25.3) and 22.5 (20–25) in the first and second tests, respectively, without significant differences (p=0.093). None of the physiological variables evaluated during the 1-min STST had a significant difference between the attempts. We found an ICC of 0.984 (95% CI 0.971–0.992); the Cronbach's α was 0.984. Bland–Altman analysis showed a bias of -0.38 for test–retest measurement error.

This research showed that the 1-min STST is a repeatable test without differences between the first and second attempt.

Ideally, patients can be evaluated with incremental exercise tests that achieve maximal exercise capacity. However, their use is not widespread because they require sophisticated equipment (as in the cardiopulmonary exercise test). The most used field test to assess physical capacity in chronic respiratory diseases is the 6MWT, a submaximal test [5, 15]. However, the pandemic has taught us that it is not always that easy to carry it out since certain special conditions are needed for its development, such as a \geq 20 m, but ideally 30 m, corridor [3]. Faced with this scenario, several studies have recommended performing the 1-min STST. However, several field tests, such as the 6MWT, present a learning effect, and that is why the standard operating procedures indicate conducting two tests. In the case of the 1-min STST, we have shown that only one test is required in post-COVID-19 patients and, therefore, time can be spent on other evaluations.

Although some authors recommend carrying out two 1-min STSTs, their interpretation may be inadequate when using reference values of Strassman *et al.* [16], which are the most widely used, due to the fact that those authors only conducted the test once. Our results are in concordance and showed that the difference between the two tests was only 0.38 repetitions, which may suggest that conducting only one attempt would be enough.

Our study has some limitations. Oxygen kinetics during the test were not recorded because there was no availability of the sophisticated equipment needed. However, the physiological response between tests was similar both in $S_{\rm PO_2}$ and in heart rate. It could be argued that oxygen kinetics do not provide additional information to accomplish the objective of the study. Finally, the rest time between both tests is not clear. In our protocol, we relied on the study by $C_{\rm ROOK}$ *et al.* [6], which was one of the few articles that described the evaluation in detail, and on the European Respiratory Society/American Thoracic Society recommendations [3], which suggest leaving 30 min between both tests for the 6MWT. In any case, we compared the baseline variables of both repetitions and we did not find significant differences, which suggests that the patients were already rested.

This study indicates that the 1-min STST is a repeatable test in post-COVID-19 patients and possible small differences in subsequent tests are of minimal clinical importance; however, larger studies are needed to draw definitive conclusions. Hence, conducting one attempt of the 1-min STST would be enough to evaluate functional capacity in patients recovered from COVID-19. The majority of relevant studies are small, and differences in subsequent repetitions are also small and not clinically significant; thus, more studies with more patients are needed.

Ana Sevillano-Castaño^{1,10}, Renata Peroy-Badal o^{1,2,10}, Rodrigo Torres-Castro o^{3,4,5,6}, Elena Gimeno-Santos o^{5,6,7}, Pablo García Fernández o², Cristina Garcia Vila¹, Aranzazú Ariza Alfaro¹, Rosalia De Dios Álvarez^{1,2}, Jordi Vilaró o^{4,8} and Isabel Blanco o^{5,6,9}

¹Hospital Virgen de La Torre - Hospital Universitario Infanta Leonor, Madrid, Spain. ²Departamento de Radiología, Rehabilitación y Fisioterapia, Universidad Complutense de Madrid, Madrid, Spain. ³Dept of Physical Therapy, Faculty of Medicine, University of Chile, Santiago, Chile. ⁴International Physiotherapy Research Network (PhysioEvidence). ⁵Dept of Pulmonary Medicine, Hospital Clínic, University of Barcelona, Barcelona, Spain. ⁶Institut d'Investigacions Biomèdiques August Pi i Sunyer (IDIBAPS), Barcelona, Spain. ⁷Barcelona Institute for Global Health (ISGlobal), Barcelona, Spain. ⁸Facultad de Ciencias de la Salud Blanquerna, Global Research on Wellbeing (GRoW), Universidad Ramon Llull, Barcelona, Spain. ⁹Biomedical Research Networking Center on Respiratory Diseases (CIBERES), Madrid, Spain. ¹⁰Both authors contributed equally.

Corresponding author: Rodrigo Torres-Castro (klgorodrigotorres@gmail.com)

Provenance: Submitted article, peer reviewed.

Conflict of interest: The authors declare they have no conflict of interest.

Support statement: The study was supported by grant from the Instituto de Salud Carlos III (ISCiii), co-funded by the European Union (ERDF/ESF, "A way to make Europe"/"Investing in your future") (PI21/0555).

References

- Sibila O, Molina-Molina M, Valenzuela C, et al. Documento de consenso de la Sociedad Española de Neumología y Cirugía Torácica (SEPAR) para el seguimiento clínico post-COVID-19 [Spanish Society of Pulmonology and Thoracic Surgery (SEPAR) consensus for post-COVID-19 clinical follow-up]. Open Respir Arch 2020; 2: 278–283.
- 2 Antoniou KM, Vasarmidi E, Russell A-M, et al. European Respiratory Society statement on long COVID-19 follow-up. Eur Respir J 2022; 60: 2102174.
- 3 Holland AE, Spruit MA, Troosters T, et al. An official European Respiratory Society/American Thoracic Society technical standard: field walking tests in chronic respiratory disease. Eur Respir J 2014; 44: 1428–1446.
- 4 Bohannon RW, Crouch R. 1-minute sit-to-stand test: systematic review of procedures, performance, and clinimetric properties. *J Cardiopulm Rehabil Prev* 2019; 39: 2–8.
- 5 Spruit MA, Singh SJ, Garvey C, et al. An official American Thoracic Society/European Respiratory Society statement: key concepts and advances in pulmonary rehabilitation. Am J Respir Crit Care Med 2013; 188: e13–e64.
- 6 Crook S, Büsching G, Schultz K, et al. A multicentre validation of the 1-min sit-to-stand test in patients with COPD. Eur Respir J 2017; 49: 1601871.
- 7 Tarrant BJ, Robinson R, Le Maitre C, et al. The utility of the sit-to-stand test for inpatients in the acute hospital setting after lung transplantation. Phys Ther 2020; 100: 1217–1228.
- 8 Reychler G, Boucard E, Peran L, *et al.* One minute sit-to-stand test is an alternative to 6MWT to measure functional exercise performance in COPD patients. *Clin Respir J* 2018; 12: 1247–1256.
- 9 Núñez-Cortés R, Rivera-Lillo G, Arias-Campoverde M, et al. Use of sit-to-stand test to assess the physical capacity and exertional desaturation in patients post COVID-19. Chron Respir Dis 2021; 18: 1479973121999205.
- 10 Simonelli C, Paneroni M, Vitacca M, et al. Measures of physical performance in COVID-19 patients: a mapping review. *Pulmonology* 2021; 27: 518–528.
- 11 von Elm E, Altman DG, Egger M, et al. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. Int J Surg 2014; 12: 1495–1499
- 12 Soriano JB, Murthy S, Marshall JC, et al. A clinical case definition of post-COVID-19 condition by a Delphi consensus. *Lancet Infect Dis* 2022; 22: e102–e107.
- 13 Johnson MJ, Close L, Gillon SC, et al. Use of the modified Borg scale and numerical rating scale to measure chronic breathlessness: a pooled data analysis. Eur Respir J 2016; 47: 1861–1864.
- 14 Walter SD, Eliasziw M, Donner A. Sample size and optimal designs for reliability studies. *Stat Med* 1998; 17: 101–110.
- 15 Spruit MA, Holland AE, Singh SJ, et al. COVID-19: interim guidance on rehabilitation in the hospital and post-hospital phase from a European Respiratory Society- and American Thoracic Society-coordinated international task force. Eur Respir J 2020; 56: 2002197.
- Strassmann A, Steurer-Stey C, Lana KD, et al. Population-based reference values for the 1-min sit-to-stand test. Int J Public Health 2013; 58: 949–953.