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

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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

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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 ⩾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±SD 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	
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	
Obesity	22 (52.4%)
Systemic hypertension	13 (31.0%)
Diabetes	9 (21.4%)
Cardiovascular disease	4 (9.5%)
1-min STST	
First test	
Repetitions	22 (19–25.3)
Baseline S_{pO_2} (%)	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_{pO_2} (%)	96 (96–98)#
Final S_{pO_2} (%)	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±SD, 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 ⩾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_{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 Crook *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.

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