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Early View

Research letter

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

Running title: Learning effect on 1-minute sit-to-stand test

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Abstract (210 words)

Background: In field tests, clinical guidelines recommend performing two tests due to the learning effect; however, in the 1-minute sit-to-stand test (1min-STST) it is not clear that this effect exists.

Objective: To determine the learning effect of the 1min-STST in post-COVID-19 patients.

Methods: A cross-sectional study was conducted in patients recovering from COVID-19 pneumonia, older than 18 years. The 1min-STST was performed twice with a difference of 30 minutes. The intraclass correlation coefficient (ICC) was used to assess the learning effect and the Bland-Altman plot was used to evaluate agreement between both tests.

Results: Forty-two patients were included (mean age 53.8±10.3 years; 52% female). Twenty-nine patients were hospitalised with a median of 15 (4-27) days. Only seven patients required ICU admission. The median of repetitions in the 1min-STST was 22 (19-25.3) and 22.5 (20-25) in the first and second tests, without significant differences. None of the physiological variables evaluated showed a significant difference between both tests. We found an ICC of 0.984 (IC95 0.971-0.992). Bland-Altman analysis showed a bias of -0.38 for the test-retest measurement error.

Conclusion: The 1min-STST is a repeatable test without differences between the first and second tests. A single test is necessary to assess exercise tolerance in post-COVID-19 patients with this field test.

Keywords: *SARS-CoV-2; post-COVID-19; field test; exercise test; learning effect; functional capacity.*

Introduction

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 six-minute walking test (6MWT) or the 1-minute sit-to-stand test (1min-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).

However, while using field tests, clinical guidelines recommend performing two tests due to the learning effect (3), but in the 1min-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 1min-STST in post-COVID-19 patients.

Methods

Design and participants

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 signed the informed consent. This study follows the recommendations of the STrengthening the Reporting of OBservational studies in Epidemiology guidelines (STROBE) (11).

Inclusion criteria were as follows: patients older than 18 years-old, diagnosis of COVID-19 by positive polymerase chain reaction (PCR) assay on severe acute respiratory syndrome

coronavirus 2 (SARS-CoV2) on nasal and pharyngeal swab specimens, pulmonary rehabilitation candidates by post-COVID-19 condition defined as individuals with a history of probable or confirmed SARS-CoV-2 infection, usually three months from the onset of COVID-19 with symptoms that last for at least two months and cannot be explained by an alternative diagnosis. Common symptoms include fatigue, shortness of breath and cognitive dysfunction, and generally have an impact on everyday functioning. Symptoms might be new onset after initial recovery from an acute COVID-19 episode or persist from the initial illness. Symptoms might also fluctuate or relapse 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.

Measurements

Anthropometric characteristics, hospitalisation history, dyspnoea through the mMRC scale, and underlying comorbidities were collected. The main outcome was physical capacity assessed by the 1min-STST.

The 1min-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/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 seconds at self-paced speed. The time between both attempts for the 1min-STST was 30 minutes. The same person performed all assessments.

The modified Borg scale (0–10) was used to measure dyspnoea and fatigue immediately before and after all tests (13). A finger oximeter was used to record pulse oxygen saturation (SpO_2) and heart rate (HR). The evaluator had previous experience in applying this test.

Using the method of Walter et al. (14) based on an estimate that uses the ICC, it is established that at least 40 individuals will be necessary, considering an acceptable reliability of p0=0.60 and an expected reliability of p1=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.

Statistical analyses

All data are expressed as means, standard deviations (SD) or median with percentile 25th and 75th 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 non-parametric variables. The intraclass correlation coefficient (ICC) was used to assess the learning effect and 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 the SPSS version 25.0 package (SPSS, Chicago, USA).

Results

We recruited 42 patients recovered from COVID-19 (mean 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 diagnosis and STST evaluation was 5.8±0.6 months. Twenty-nine patients had a history of hospitalisation with a median of 15 (4-27) days of hospitalisation. Only seven patients required ICU admission. The median mMRC score was 1 (1-2).

Regarding the physical capacity, the median (P25-P75) number of repetitions in the 1min-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 1min-STST had a significant difference between both attempts. We found an ICC of 0.984

(IC95 0.971-0.992), the Cronbach's alpha was 0.984. Bland–Altman analysis showed a bias of −0.38 for test-retest measurement error.

Discussion

This research showed that the 1min-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 an at least 20-metre – but ideally 30-metre corridor (3). Faced with this scenario, several studies have recommended performing the 1min-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 1min-STST, we have shown that only one test is required in post-COVID-19 patients and, therefore, time resources can be used in other evaluations.

Although some authors recommend carrying out two tests, its interpretation may be inadequate when using Strassman reference values, which are the most widely used, due to the authors only conducted the test once (16). 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 evaluation during the test was not recorded because there was no availability of this sophisticated equipment. However, the physiological response between tests was similar both in SpO_2 and in HR. It could be argued

that oxygen information does 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 rely on Crock et al (6), which was one of the few articles that described the evaluation in detail, and on the ERS/ATS recommendations (3) which suggest leaving 30 minutes 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.

Conclusion

This study indicates that the 1min-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 1min-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 non-clinically significant, thus more studies with more patients are needed.

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Variable	n=42
Age (years)	53.8 ± 10.3
Gender Male (n, %) Female (n,%)	 20 (48%) 22 (52%)
Weight (Kg)	84.0 ± 18.2
Height (cm)	166 (159-174)
BMI (Kg/m^2)	29.3 (26.4-33.1)
Hospitalised (n, %)	29 (70)
Length of stay (days)	15 (4-27)
ICU admission (n, %)	7 (16.7)
mMRC	1 (1-2)
Comorbidities Obesity (n,%) Systemic hypertension (n,%) Diabetes (n,%) Cardiovascular disease (n,%)	 22 (52.4%) 13 (31.0%) 9 (21.4%) 4 (9.5%)
1min-STST – First test Repetitions SpO_2 baseline (%) SpO_2 final (%) HR baseline (bpm) HR final (bpm) Dyspnoea baseline Dyspnoea final Fatigue baseline Fatigue final	 22 (19-25.3) 97 (96-98) 95 (93-97) 84 ± 15 109 ± 19 1 (0-3) 4 (3-5) 1 (0-3) 4 (3-6)
1min-STST – Second test Repetitions SpO_2 baseline (%) SpO_2 final (%) HR baseline (bpm) HR final (bpm) Dyspnoea baseline Dyspnoea final Fatigue baseline Fatigue final	 22.5 (20-25)* 96 (96-98)* 95 (93-97)* 85 ± 15* 110 ± 18* 1 (0-3)* 4 (3-5)* 2 (0-3)* 3 (2.5-5)*

Table 1. Descriptive statistics of the included patients.

Abbreviations: BMI: Body mass index; ICU: Intensive care unit; mMRC: Modified medical research council; 1min-STST: 1-minute sit-to-stand test; SpO2: Oxygen saturation; HR: Heart rate. Values are expressed as the mean ± SD if data are normally distributed or as the median (P25–P75) if data distribution is skewed. * Difference between first and second test > 0.05.