


# Use of sit-to-stand test to assess the physical capacity and exertional desaturation in patients post COVID-19

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## Abstract

We propose the use of the 1-minute sit-to-stand test (ISTST) to evaluate the physical capacity and exertional desaturation one month after discharge in a sample of patients who survived COVID-19 pneumonia. This was a cross-sectional study that collected routine data from consecutive patients admitted to the outpatient program in a public hospital in Chile. Patients were asked to complete a ISTST. Data were analyzed according to those with and without a prolonged hospital stay of >10 days. Eighty-three percent of the patients were able to complete the test (N = 50). The median age was 62.7 ± 12.5 years. The average number of repetitions in the ISTST was 20.9 ± 4.8. Thirty-two percent of patients had a decrease in pulse oxygen saturation (SpO<sub>2</sub>) ≥ 4 points. The prolonged hospital stay subgroup had a significant increase in exertional desaturation (mean difference = 2.6; 95% CI = 1.2 to 3.9; p = 0.001) and dyspnea (mean difference = 1.1; 95% CI = 0.4 to 2.1; p = 0.042) compared to the group of length of stay ≤ 10 days. In-hospital survivors of COVID-19, the ISTST showed a decrease in physical capacity at one month in those 90% who were able to complete it. The ISTST was able to discriminate between those with and without a prolonged hospital stay and was able to detect exertional desaturation in some patients.

## Keywords

SARS-CoV-2, coronavirus disease 2019, functional capacity, rehabilitation

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## Introduction

Coronavirus Disease 2019 (COVID-19) was first found in Wuhan city, China,<sup>1</sup> and evolved into a pandemic in a few weeks.<sup>2</sup> It is estimated that up to 20% of patients develop severe respiratory illness,<sup>3</sup> and some cases must be admitted to intensive care units.<sup>4</sup> Together with the pulmonary impairments related to disease,<sup>5</sup> prolonged hospital stays can seriously affect the physical condition of patients due to the negative effects of bed rest and immobility.<sup>6</sup>

The assessment of functional capacity in patients post COVID-19 after hospitalization has become an

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important issue for estimating functional consequences, disability and exertional desaturation.<sup>7–9</sup> To date, the 6-minute walk test (6MWT) and 1-minute sit-to-stand test (1STST) have been the most common tests used,<sup>10</sup> the physical capacity assessment at discharge and follow-up show a low percentage of subjects performing both tests.<sup>7,11</sup> In this context, it is a challenge for clinicians to objectify changes in physical capacity for future decision-making.

The 6MWT requires certain technical execution conditions that are not easy to meet, such as a 30-meter corridor, especially in this time of a pandemic when precautionary measures are even greater. On the other hand, patients after a prolonged hospitalization may present balance problems that may affect the correct execution of the test.

In some situations, not all the technical requirements necessary to perform the 6MWT can be fulfilled. If the distance available is less than 30 meters, it is recommended to choose tests that can be performed in minor distances, as the incremental or the endurance shuttle walking (ISWT or ESWT).<sup>12</sup> In other cases, the clinical condition of the patient does not allow a demanding effort, in which case we can use modifications of the 6MWT as the two minute walking test (2MWT).<sup>13</sup> Particularly, other exercise tests, the 1STST have emerged because can be used in a reduced space and that has shown a good correlation with the result of the 6MWT in other respiratory diseases. In patients with interstitial lung diseases (ILD), similar to pulmonary impairment produced by COVID-19,<sup>14</sup> the 1STST showed good consistency and correlated strongly with 6MWT to measure exercise-induced desaturation.<sup>15</sup> Moreover, 1STST is a reliable and valid tool to assess the physical capacity in older adults<sup>16</sup> and chronic obstructive pulmonary disease (COPD) patients.<sup>17</sup> Furthermore, the 1STST has shown a significant correlation with clinical outcomes in COPD subjects, such as 6MWT, 4-m gait speed test, and physical activity in daily life.<sup>18</sup> A recent systematic review<sup>19</sup> concluded that 1STST could be a practical, reliable, valid, and responsive alternative to measure physical capacity, and that performance is correlated with 6MWT, making it an ideal alternative for use in office settings and during routine visits.

Knowing the space and isolation limitations of patients post COVID-19, we propose the use of 1STST to evaluate the physical capacity and exertional desaturation one month after discharge in a

sample of patients who survived COVID-19 pneumonia and the success rate in the execution of this test. Our hypothesis was that patients with COVID-19 have a limitation in physical capacity, which is higher in patients with a long hospital stay (>10 days). Furthermore, we consider that 1STST may be a good test to detect exertional desaturation.

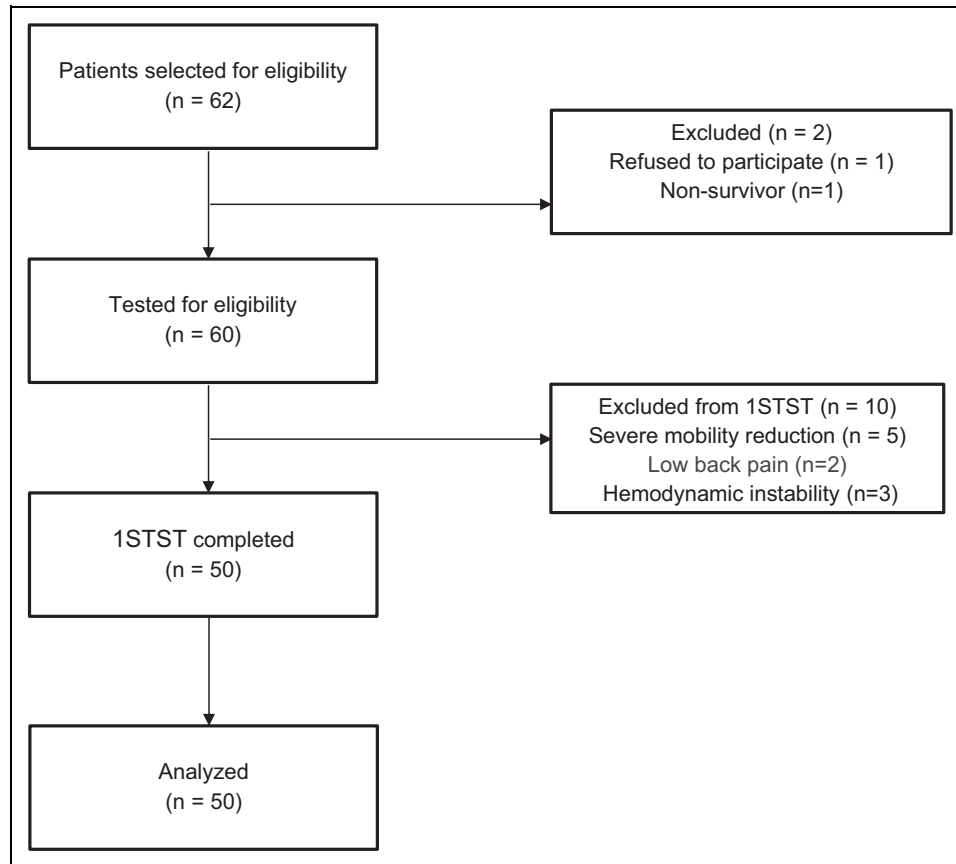
## Methods

### *Participants and design*

This was a cross-sectional study that collected routine data from consecutive patients with COVID-19 admitted to the follow-up program in the Day Hospital of the Hospital Clínico La Florida (Santiago, Chile) between August 4, 2020 and September 11, 2020 (6 weeks). The inclusion criteria were as follows: a) over 18 years of age; b) outpatients discharged from the hospital four weeks prior to evaluation; c) positive PCR assay findings for nasal and pharyngeal swab specimens<sup>20</sup> or diagnosis according to chest computed tomography scan evidence.<sup>14</sup> We excluded from the 1STST: a) Inability to perform either the test (limited mobility or any joint/mobility pain); b) hemodynamic instability (systolic blood pressure >180 mmHg or diastolic blood pressure >100 mmHg). This study was approved by the ethics committee of our institution, and all patients gave written informed consent. The investigation was performed in conformity to the ethical principles of the Declaration of Helsinki. This study was performed in accordance with the “Strengthening the Reporting of Observational Studies in Epidemiology” (STROBE) Guidelines.

### *Data collection*

At the moment of the admission, demographic characteristics, medical history, exposure history and underlying comorbidities were collected. The main outcome measures were physical capacity, assessed through the number of times that subjects were able to sit-and-stand during the 1STST. All tests were conducted in the same room, in the Day Hospital of our institution with only the presence of the researcher and the patient to avoid distractions. The test was performed with a chair of standard height (46 cm) without armrests positioned against a wall,<sup>21</sup> the same chair was used for all participants. Participants were not allowed to use their hands/arms to push the seat of the chair or their body. Participants were instructed to



**Figure 1.** Patient flow diagram.

complete as many sit-and-stand cycles as possible in 60 seconds at self-paced speed. We used the reference values based on the healthy adult population previously reported by Strassmann et al.<sup>22</sup> The 1STST has good test-retest reliability (ICC = 0.80).<sup>16,19</sup>

The modified Borg scale (0–10) was used to measure dyspnea and fatigue immediately before and after the 1STST. A finger oximeter was used to record pulse oxygen saturation (SpO<sub>2</sub>) and heart rate (HR). A desaturation level of  $\geq 4\%$  was considered clinically significant.<sup>15</sup> Patients were evaluated one month after discharge, and all measurements were taken by a single evaluator. The evaluator had previous experience in this test. We divided our sample into two subgroups according to the length of stay ( $\leq 10$  or  $> 10$  days) to determine the effects of prolonged hospital stay in physical capacity and exercise-induced oxygen desaturation. This cut-off value has been considered in previous studies to indicate long-term hospital stay in patients with COVID-19<sup>23</sup> and in patients with pneumonia.<sup>24</sup> Furthermore, this was defined considering the median hospital stay reported in previous studies, which was 10 days in patients discharged for

COVID-19<sup>25,26</sup> and considering that patients' condition worsens on the 10<sup>th</sup> day after illness onset.<sup>20,27</sup>

### Statistical analyses

The data normality was verified through a Shapiro–Wilk test. The mean and standard deviations were calculated for the quantitative variables and the percentages for the categorical variables. T-Test was used to compare continuous variables between groups, and Chi-square was used to compare the categorical variables. Statistical significance was established in  $p < 0.05$ . All statistical analyses were performed in SPSS version 22.0 (IBM Corporation, Armonk, NY). Post hoc power was calculated using the software G\*Power 3.1, with a significance level of 0.05 and an effect size of 0.98.

### Results

Sixty patients were tested for eligibility. Ten patients did not meet the criteria for the 1STST, seven due to mobility limitations and three due to hemodynamic instability (Figure 1). The median age was  $62.7 \pm$

**Table 1.** Baseline patient characteristics.

Characteristics	Total group (n = 50)	Hospital stay ≤10 days (n = 14)	Hospital stay >10 days (n = 36)	p value
<b>Age (mean ± SD)</b>	62.7 ± 12.5	58.6 ± 13.8	64.3 ± 11.9	0.157
<b>Sex, male, n (%)</b>	27 (54)	5 (35.7)	22 (61.1)	0.097
<b>BMI (mean ± SD)</b>	30.3 ± 5.3	32.4 ± 5.8	29.4 ± 4.9	0.075
<b>Days of discharge (mean ± SD)</b>	35.7 ± 8.6	32.7 ± 5.6	36.8 ± 9.3	0.125
<b>ICU stay, n (%)</b>	12 (24)	0 (0)	12 (33.3)	0.010
<b>Invasive ventilation, n (%)</b>	12 (24)	0 (0)	12 (33.3)	0.010
<b>Hospitalization days (mean ± SD)</b>	18.0 ± 12.3	6.7 ± 1.5	22.4 ± 11.9	<0.001
<b>Comorbidities, n (%)</b>				
Obesity	25 (50)	9 (64.3)	16 (44.4)	0.173
Hypertension	29 (58)	9 (64.3)	20 (55.6)	0.407
Diabetes	19 (38)	7 (50)	12 (33.3)	0.221
Cardiovascular disease	7 (14)	2 (14.3)	5 (13.9)	0.643
Stroke	2 (4.1)	0 (0)	2 (5.7)	0.506
COPD	1 (2)	1 (7.1)	0 (0)	0.280
Chronic kidney diseases	3 (6)	0 (0)	3 (8.3)	0.364
Malignancy	3 (6)	1 (7.1)	2 (5.6)	0.556
Previous smoker	5 (10)	2 (14.3)	3 (8.3)	0.433
<b>CT Patterns, n (%)</b>				
Ground-glass opacities	19 (38)	7 (50)	12 (33.3)	0.221
Consolidation	1 (2)	1 (7.1)	0 (0)	0.280
Crazy-paving pattern	1 (2)	0 (0)	1 (2.8)	0.720
Mixed	28 (56)	5 (35.7)	23 (63.9)	0.069
Without alteration	1 (2)	1 (7.1)	0 (0)	0.280
<b>CT Findings distribution, n (%)</b>				
Unilateral	2 (4)	1 (7.1)	1 (2.8)	0.061
Bilateral	47 (94)	12 (85.7)	35 (97.2)	0.186
Without alteration	1 (2)	1 (7.1)	0 (0)	0.280

BMI = body mass index; ICU = intensive care units; COPD = chronic obstructive pulmonary disease; 1STST = 1 minute sit-to-stand test; CT = computed tomography; SD = standard deviation.

12.5 years, and 27 (54%) patients were male. The baseline patient characteristics are presented in Table 1. Eighty-three percent of the patients were able to complete the test (N = 50). The average number of repetitions in the 1STST was  $20.9 \pm 4.8$ , 42% were under the 2.5th percentile of predicted value, and 90% were under the 25th percentile, in relation to the reference values.<sup>22</sup> For a multivariate analysis with ANOVA, there was no interaction ( $p > 0.05$ ) when comparing the number of repetitions in the 1STST between both groups with the subject's individual factors: sex, body mass index (BMI) and age. Thirty-two percent of patients had a decrease in  $SpO_2 \geq 4$  points. The prolonged hospital stay subgroup had a significant increase in exertional desaturation (mean difference = 2.6; 95% CI = 1.2 to 3.9;  $p = 0.001$ ) and dyspnea (mean difference = 1.1; 95% CI = 0.4 to 2.1;  $p = 0.042$ ) compared to the group of length of stay  $\leq 10$  days. The power to detect exertional desaturation

was 92%. There was no association between the number of repetitions of the 1STST with the degree of desaturation or dyspnea after the test ( $R = -0.12$ ;  $p > 0.05$ ). Table 2 shows the results of sit-to-stand and cardiorespiratory parameters. There were no significant differences in the variables studied when comparing patients with and without invasive mechanical ventilation (Supplementary material).

## Discussion

Our results are consistent with the evidence showing that patients post COVID-19 have a decrease in physical capacity one month after discharge. Additionally, patients who were hospitalized for more than ten days had more significant exertional desaturation and dyspnea.

Our results coincide with those of Belli et al.<sup>7</sup> in finding a decrease in physical capacity in patients post

**Table 2.** Results of sit-to-stand and cardiorespiratory parameters.

Characteristics	Total group (n = 50)	Hospital stay ≤10 days (n = 14)	Hospital stay >10 days (n = 36)	p value
1STST (repetitions)	20.9 ± 4.8	21.0 ± 5.1	20.8 ± 4.7	0.916
Repetitions <2.5th percentile, n (%)	21 (42)	3 (21.4)	18 (50)	0.062
Repetitions <25th percentile, n (%)	45 (90)	12 (85.7)	33 (91.7)	0.433
SpO <sub>2</sub> Baseline (%)	96.3 ± 1.4	96.3 ± 1.4	96.3 ± 1.4	0.986
SpO <sub>2</sub> Post (%)	93.6 ± 3.5	95.4 ± 1.4	92.8 ± 3.8	0.01*
Change in SpO <sub>2</sub> (points)	-2.7 ± 3.2	-0.8 ± 1.5	-3.4 ± 3.4	0.001**
Change in SpO <sub>2</sub> ≥ 4, n (%)	16 (32)	1 (7.1)	15 (41.7)	0.019*
SpO <sub>2</sub> <90% post test, n (%)	8 (16)	0 (0)	8 (22.2)	0.056
Heart rate Baseline (beats/min)	86.2 ± 11.1	89.7 ± 8.5	84.9 ± 11.6	0.112
Heart rate Post (beats/min)	106.1 ± 15.4	110.1 ± 16.5	104.6 ± 14.9	0.286
Change in Heart rate (points)	19.9 ± 11.5	20.4 ± 12.2	19.7 ± 11.4	0.842
Heart rate reserve (%)	28.9 ± 17.3	30.3 ± 20.6	28.3 ± 16.1	0.712
Dyspnea Baseline, Borg Index (0–10)	1.6 ± 1.9	1.6 ± 1.8	1.6 ± 1.9	0.984
Dyspnea Post, Borg Index (0–10)	3.9 ± 2.6	3.2 ± 2.2	4.1 ± 2.8	0.220
Change in Dyspnea (points)	2.4 ± 1.9	1.6 ± 1.4	2.7 ± 1.9	0.042*
Fatigue Baseline, Borg Index (0–10)	1.3 ± 2.1	1.4 ± 2.3	1.3 ± 2.0	0.802
Fatigue Post, Borg Index (0–10)	2.5 ± 2.8	2.1 ± 2.8	2.7 ± 2.7	0.539
Change in Fatigue (points)	2.3 ± 1.8	0.7 ± 0.8	1.5 ± 2.1	0.059

1STST = 1 minute sit-to-stand test; SpO<sub>2</sub> = pulse oxygen saturation. Data are presented as mean ± SD unless otherwise indicated. \*Statistically significant difference (p < 0.05); \*\*Statistically significant difference (p < 0.01).

COVID-19. However, Belli et al.'s values are even lower.<sup>7</sup> One possible explanation is the age of the patients. In their series, the mean age was 74 years versus 66 in our population. Obviously, the 8 years of difference determine a significant decrease not only given by the disease but also by the age of the patients.

Another essential aspect that we highlight is that the performed tests rate (i.e. % of patients who complete the 1STST) of this test in our patients is over 80%. This percentage is almost the double that reported by Belli and Simonelli.<sup>7,8</sup> The reports of both have ages of over 70 in common, so perhaps, to evaluate physical capacity in the older population, it makes sense to apply other tests that are commonly used to evaluate older adults, such as the Short Physical Performance Battery (SPPB) or the Timed Up and Go test (TUG), which in both authors showed success rates greater than 90%.<sup>7,8</sup>

Thirty-two percent of our patients showed a drop of more than 4 points in SpO<sub>2</sub> and 16% desaturated, even below 90%, in line with the increase in dyspnea. These results are lower than those shown by Fuglebjerg et al.,<sup>28</sup> who reported a desaturation of less than 90% in half of the subjects to whom she applied the 6MWT at discharge, which would explain our better results. Another difference in our results is that we did not stop the test when it dropped below 90%, since the

objective of these tests is to detect not only desaturation but also its magnitude.<sup>29</sup> The use of the 1STST showed in our results to detect the exertional desaturation, making it a good alternative tool for the 6MWT, similar to shown in other pathologies as ILD.<sup>15</sup>

On the other hand, the 6MWT needs specific technical requirements for its execution as a 30-meter corridor.<sup>12</sup> These are not easy to achieve within a hospital and much less within an ICU, especially in this time of a pandemic when rehabilitation services have had to be reconverted.<sup>30</sup> If we add to that the impairment of the balance of patients who have had prolonged hospitalizations,<sup>31</sup> and considering that the balance influences the result of the 6MWT, the 1STST appears as a valid alternative, especially because it allows to maintain safe conditions when using a chair and has proven to be an excellent follow-up tool in face-to-face or remote rehabilitation programs.<sup>10,32</sup>

We used the reference values recommended by our national guidelines for post COVID-19 rehabilitation guide.<sup>33</sup> Although these equations are for the Swiss population,<sup>22</sup> have some advantages of using them as cover a wide age range from 20 to 79 years and establishes the normality values in percentiles. On the other hand, using the Strassman values allows comparisons with previous articles that have investigated the 1STST since they have used the same values.<sup>7,34</sup>

## Limitations

Finally, our study has some limitations, such as the non-comparison with the 6MWT, mainly due to the lack of technical and safety conditions in the hospital to carry it out. In addition, the results were compared with international reference values since they are not available for our country. Furthermore, it is difficult to determine or state whether the 1STST is a test of physical capacity with no comparison to the gold standard (i.e. cardiopulmonary exercise test) and future research should delve into this aspect. Another limitation of the study was the small sample included. Due to the nature of convenience sampling, all patients who survived hospitalization and were referred to the follow-up program were included, so we cannot rule out a selection bias. To overcome this limitation, we calculated the power of the study, which was high (92%).

## Conclusions

In hospital survivors of COVID-19, the 1STST showed a decrease in physical capacity at one month in those 90% who were able to complete it. The 1STST was able to discriminate between those with and without a prolonged hospital stay and was able to detect exertional desaturation in some patients.

## Declaration of conflicting interests

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## Supplemental material

Supplemental material for this article is available online.

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