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ORIGINAL ARTICLE

The Utility Of 1-Minute Sit-To-Stand Test to Detect Exercise-Induced Oxygen Desaturation in Outpatient Assessment of Post COVID-19 Patients

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ABSTRACT

Introduction: 6-min-walk-test (6MWT) is the gold standard for assessing exercise-induced impairment of gas exchange, but it is technically challenging in a busy outpatient clinic. The aim of this study was to compare the 1-minute sit-to-stand test (1MSTST) with the 6MWT in assessment of exercise-induced oxygen desaturation in post COVID-19 patients in an outpatient setting. **Methods:** A total of 447 outpatient post COVID-19 patients were recruited from post COVID-19 clinic. A set of 6MWT and 1MSTST were performed on the same day. **Results:** A total of 447 sets were performed at a mean of 160 days post discharge. Majority were in COVID-19 infection category 4 (n=251, 56%), 5 (n=118, 26%) and 3 (n=6, 15%). A total of 19% (n=89) of patients remained symptomatic (mMRC >1). There were no significant differences between nadir SpO2 of 6MWT and 1STST (p=0.075). Bland-Altman plots showed good agreement between nadir SpO2 for 6MWT and 1MSTST (Mean differences=0.028). 1MSTST could detect oxygen desaturation $\geq$4% with sensitivity of 76.8% and specificity of 42.4% compared to 6MWT. There was no clinically significant SpO2 difference during 6MWT and 1STS between symptomatic and asymptomatic patients at baseline, nadir, and recovery; the differences were <1%. However, there were lesser 6MWT distance and 1MSTST repetition between symptomatic and asymptomatic patients; 47m ($p < 0.001$) and 3 repetition ($p < 0.001$) respectively. **Conclusion:** There is a good agreement of nadir SpO2 and sensitivity to detect oxygen desaturation $\geq$ 4% between 6MWT and 1MSTST. 1MSTST is a useful screening test to screen exercise-induced oxygen desaturation during outpatient assessment.

KEYWORDS: COVID-19, 1-minute-sit-to-stand-test, 6-minute-walk-test

INTRODUCTION

The COVID-19 pandemic has led to an unprecedented surge in hospitalised patients with viral pneumonia. Ranging from atypical pneumonia to acute respiratory distress syndrome [1] with high prevalence of venous thromboembolic disease and pulmonary embolism, the highest mortality [1] is in the 5% treated in ICU [2]. Persistent clinical symptoms in survivors are as high as 87% [3] with protracted radiological abnormalities in 47% survivors after a mean follow-up of about 60 days post symptom onset [4]. You et al [5] recorded residual lung abnormalities including ground glass opacities (GGO) in 73% of post-COVID-19 survivors but early at a mean of 40 days after discharge from hospital. The more severe the lung injury the greater is the fibroblastic response leading to pulmonary fibrosis [6]. The optimal time for follow-up imaging to assess for radiological clearance is not known, but current guidelines of British Thoracic Society recommend assessment at 12-week to ensure that non-resolving findings are addressed sufficiently early [7].

Post discharge assessment of these patients, especially those in more severe categories therefore has to be comprehensive and systematic. Testing methods that can be used include oxygen spirometry, lung function test and 6MWT including 1MSTST. Oximetry will elucidate immediate resting oxygenation, but exertional oxygen status requires it employed together with 6-min walk test (6MWT). The 6MWT is the gold standard exercise test and has been validated for most chronic lung diseases [8]. In patients with interstitial lung disease and pulmonary embolism, the 6MWT is commonly used to evaluate exercise tolerance (distance walked) and alterations in gas exchange, the lowest oxygen saturation or SpO2 nadir [9].

The 6MWT test is sensitive, reproducible, easy to perform, and does not use any specialized equipment. However, it does require a 30-m corridor, which is uncommon in health centres and office practices. Shorter corridors require more turns, which is likely to distort the test results, especially the total distance travelled [10, 11]. To overcome these technical and spatial limitations, several additional exercise tests, such as the 1-min sit-to-stand test (1MSTST), are currently being evaluated [12, 13]. The 1MSTST requires only a chair and is easy to perform, making it feasible for use in the clinical setting especially in COVID-19 pandemic. Studies to date have shown the 1MSTST to be well tolerated, sensitive, and reproducible in chronic obstructive pulmonary disease (COPD) and cystic fibrosis patients [14]. However, its validity has never been investigated in post COVID-19 patients.

To the best of our knowledge, there is no study that has specifically used 1MSTST and 6MWT to assess exertional desaturation in post-covid infection patients. Our study aims to assess the utility of 1MSTST in comparison to 6MWT in assessment of post COVID-19 patients.

MATERIALS AND METHODS

Patients

We enrolled all post COVID-19 patients who visited our COVID-19 clinic from March 2021 till December 2021 and consented to participate in the study. Our COVID-19 clinic has been specifically set up to assess and follow-up post COVID-19 patients. The inclusion criteria for the study were post COVID-19 patients who were in categories 3, 4 or 5 of disease based on WHO criteria [15]. Category 3 (moderate illness) was defined as individuals who show evidence of lower respiratory disease during clinical assessment or imaging and who have an oxygen saturation measured by pulse oximetry (SpO_2) ≥94% on room air at sea level. Category 4 (severe illness) was defined as individuals who have SpO_2 <94% on room air at sea level, a ratio of arterial partial pressure of oxygen to fraction of inspired oxygen (PaO_2/FiO_2) <300 mm Hg, a respiratory rate >30 breaths/min, or lung infiltrates >50%. Category 5 (critical illness) was defined as individuals who have respiratory failure, septic shock, and/or multiple organ dysfunction. Category 5 patient would be admitted and managed in ICU setting. The exclusion criteria were patients with known pre-existing chronic lung diseases, other causes for the current symptoms than COVID-19, and inability to perform both 6MWT and 1MSTST.

Study Design

Once consented, all eligible post COVID-19 patients performed 6MWT followed by the 1MSTST, or vice versa, on the same day during clinic follow-up. The tests were all supervised by our respiratory physiotherapist. Each patient was allowed a resting period of a minimum of 30 minutes between exercises to accommodate for total recovery before the next test. Every patient performed both tests with the same physiotherapist.

1MSTST

The 1MSTST was performed as previously described [16] with a chair of standard height (46 cm) without arm rests positioned against a wall. The patient was seated upright on the chair with knees and hips flexed at 90°, feet placed flat on the floor a hip-width apart, and arms position can be either held stationary by placing their hands on their hips or place on their thigh as a support to stand up. Patients were asked to perform repetitions of standing upright and then sitting down in the same position at a self-paced speed (safe and comfortable) as many times as possible for 1 min. Patients were permitted to rest during the 1-min period. The number of repetitions was recorded. The modified Borg scale (0–10) was used to assess dyspnea and fatigue immediately before and after each test. A finger oximeter (WristOx2TM Model 3150, Nonin, Plymouth, MN, USA) was connected throughout the test for continuous recording of SpO2 and heart rate (HR). Desaturation ⩾4% was considered clinically significant [17].

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6MWT

The 6MWT was performed in accordance with international recommendations [18]. Patients were asked to walk as far as possible in a 30-meter indoor corridor at our centre. They were allowed to stop during the test if necessary. Dyspnoea was assessed before and after the test, and SpO2 and HR were monitored continuously, as described for the 1MSTST. Desaturation ⩾4% was considered clinically significant [17].

Statistical Analysis

Categorical variables were expressed as number (n) and percentage (%) Continuous variables are expressed as the mean ± standard deviation (SD). Comparisons between paired 6MWT and 1MSTS were performed using paired t-test for continuous variables. Comparison between groups were performed using independent t-test for continuous variable. Agreement between to 6MWT and 1MSTST were performed using Bland – Altman plot. Comparison of significant oxygen desaturation detected by 6MWT and 1MSTST were performed using a Chi-square test. Data were analysed using IBM SPSS software, version 26 (IBM, Armonk, NY, USA) and all statistical tests were performed with a significant level of 0.05.

RESULTS

Demography and clinical characteristic

Results were described in Table 1. A total of 455 post COVID-19 patients attended post COVID-19 clinic in UiTM Sg Buloh campus between March and December 2021. Eight patients were excluded due to missing data and remaining 477 patients were included in the study. Mean age was 51 years old and majority were men (60%). Mean length of hospital stay during acute COVID-19 infection was 14 days and majority were categorized as COVID-19 category 4 (56%) followed by COVID-19 category 5 (26%). Assessments were performed on 160 days since hospital discharge with majority remained symptomatic (mMRC≥1) n= 258 (58%). Oxygen desaturation ≥4% during 6MWT was detected in 29.5% (n =132) of the patients with SpO2 at baseline of 97%, nadir of 94%, and recovery of 97%. Mean distance of 6MWT was 393 (75) meters. Oxygen desaturation ≥4% during 1MSTS was detected in 28.9% (n=129) of the patients with SpO2 at baseline of 97%, nadir of 94%, and recovery of 97%. Mean repetition of 1MSTST was 21 (5) times.

Table 1 Demography and clinical characteristic of all patients in the study (N=447)

Categories	n (%)	Mean (SD)
Patient Details		
Age in years		51 (13)
Gender		
Male	268 (60)	
Female	179 (40)	
Clinical Details		
Length of hospital admission during COVID-19 infection, days		14 (17)
COVID-19 WHO severity categories		
Category 3	66 (14.8)	
Category 4	251 (56.2)	
Category 5	118 (26.4)	
Days after discharge when assessment done, days		160 (112)
mMRC dyspnoea scale at assessment		
0	189 (42.3)	
1	169 (37.8)	
2	52 (11.6)	
3	32 (7.2)	
4	5 (1.1)	

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Oxygen desaturation ≥4% during 6MWT		
Yes	132 (29.5)	
No	315 (70.5)	
6-minute-walk-test (6MWT)		
Baseline SpO2, %		97 (2)
Nadir SpO2, %		94 (3)
Recovery SpO2, %		97 (2)
Distances, m		393 (75)
Oxygen desaturation ≥4%during 1MSTS		
Yes	129 (28.9)	
No	318 (71.1)	
1-minute-sit-to-stand-test (1MSTS)		
Baseline SpO2, %		97 (1)
Nadir SpO2, %		94 (3)
Recovery SpO2, %		97 (1)
Repetitions, times		21 (5)

Comparison between Oxygen Saturation during 6MWT and 1MSTST

There was no significant difference between nadir SpO2 during 6MWT and 1MSTST (p=0.075) (Table 2). There was good agreement between nadir SpO2 during 6MWT and 1MSTST (Mean differences = 0.028) (Figure 1). 1MSTST could detect oxygen desaturation ≥4% with sensitivity of 76.8% and specificity of 42.4% compared to 6MWT (Table 3). There was good correlation between SpO2 and 6MWT or 1MSTST at baseline; r=0.592, p=0.001, nadir; r=0.543, p=0.001, and recovery; r= 0.653, p=0.001 (Table 4).

Table 2 Differences of SpO2 at nadir between 6MWT and 1MSTST

	6MWT, mean (SD)	1MSTST, mean (SD)	Mean difference, (SD)	p-value
Nadir Sp02, %	94 (3)	94 (3)	-0.2 (2.8)	0.075

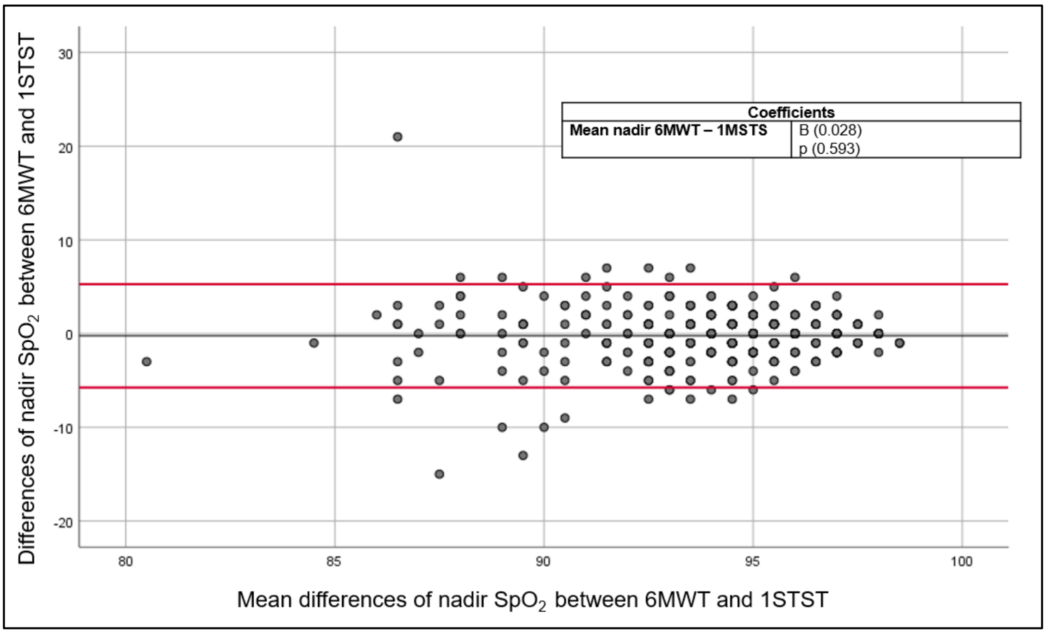

Figure 1 Bland-Altman plots showed good agreement between nadir SpO2 for 6MWT and 1MSTST

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Table 3 Sensitivity and specificity of oxygen desaturation ≥4% between 1MSTST and 6MWT

		Oxygen desaturation ≥4% during 6MWT, n (%)		Total
		Yes	**No**	
Oxygen desaturation ≥4% during 1MSTST, n (%)	Yes	56 (42.4)	73 (23.2)	129 (28.9)
	No	76 (57.6)	242 (76.8)	318 (71.1)
Total		132 (100.0)	315 (100.0)	447 (100.0)

Table 4 Correlation between 6MWT and 1MSTST

	r-value	**p-value**
Baseline Sp02	0.592	0.001
Nadir Sp02	0.543	0.001
Recovery Sp02	0.653	0.001
Distance 6MWT and repetition 1MSTS	0.469	0.001

Note: Statistical analysis used was Pearson Correlation

Comparison of 6MWT and 1MSTST between Symptomatic (mMRC >1) Patients and Asymptomatic (mMRC 0-1) Patients

Results were described in Table 5. There was no clinically significant SpO2 difference during 6MWT and 1MSTST between symptomatic and asymptomatic patients at baseline, nadir, and recovery; the differences were <1%. However, there were lesser 6MWT distance and 1MSTST repetition between symptomatic and asymptomatic patients; 47m ($p < 0.001$) and 3 repetition ($p < 0.001$) respectively.

Table 5 Comparison of 6MWT and 1MSTST between symptomatic (mMRC >1) patients and asymptomatic (mMRC 0-1) patients

	Symptomatic Mean (SD) N=89	**Asymptomatic Mean (SD) N=358**	**Mean difference (SD)**	**p-value**
Baseline Sp02 6MWT, %	96 (2)	97 (2)	-0.3	0.140
Nadir Sp02 6MWT, %	93 (4)	94 (3)	-0.7	0.065
Recovery Sp02 6MWT, %	96 (2)	96 (2)	-0.4	0.083
Distance 6MWT, m	355 (87)	402 (70)	-47	0.001
Baseline Sp02 1MSTS, %	97 (1)	97 (1)	-0.3	0.054
Nadir Sp02 1MSTS, %	94 (3)	94 (3)	-0.6	0.100
Recovery Sp02 1MSTS, %	96 (2)	97 (1)	-0.2	0.160
Repetition, times	18 (6)	21 (5)	-3	0.001

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DISCUSSION

There is an increasing realisation that post COVID 19 infection follow up is important to ensure more severe categories of COVID patients are adequately assessed and monitored [19] but unfortunately guidance to help clinicians is severely lacking [7] When patients are discharged from hospital care, as part of ambulatory oxygenation assessment, Food and Drug Administration approved home oximetry devices were thought to be helpful, but this approach is actually lacking sound evidence [20, 21]. In practice, for patients with persistent dyspnoea, evaluation using serial PFTS and 6MWT have been suggested at regular intervals (6-monthly) for up to a year [22] and again this approach is untested.

The British Thoracic Society (BTS) in the UK has put forth a guideline for the evaluation of COVID survivors for up to 3 months after discharge [7] that is based on admission disease severity and whether or not patients had received an ICU care. In the BTS guideline, patients should follow algorithms designed for severe and mild-to moderate COVID-19 survivors. In short, the guidelines advocate that all patients are recommended to undergo a clinical assessment and a chest radiograph at 3 months, others such as PFTs, 6MWT, including sputum analysis and cardiac assessment are subject to assessment at the time. If clinically warranted, patients should be tested and investigated as appropriate.

Further invasive tests (such as high-resolution computed tomography of the thorax, computed tomographic pulmonary angiogram or formal cardiac assessment) would depend on the assessment at 3 months. This also includes the need to identify and address other problems that may arise from long term sequelae affecting other systems such as psychiatry, thromboembolic complications, and any rehabilitation issues [7] Patients deemed to pose greater risk of problems such as those who survived severe COVID-19 (severe pneumonia), multiple comorbidities and elderly are planned for earlier assessment at 4 to 6 weeks.

Although the cases of COVID 19 in our part of the world is much less than many other countries especially in the west or comparatively in Asia, the local upsurge has strained resources in the care of other COVID unrelated respiratory patients in our clinic significantly [23]. The utilisation of simpler tests such as 1MSTST in a busy outpatient clinic will help chest physicians assess and stratify post COVID-19 patients within the resources of time and staff they have.

The mMRC dyspnoea scale has been studied extensively in a variety of respiratory conditions [24] as well as post COVID-19 patients [25]. Dyspnoea is the commonest symptoms among post COVID-19 patients [26–29]. In COVID-19 patients, a mMRC dyspnoea scale >1 has high sensitivity, 98% but low sensitivity (<50%) to detect hypoxaemia [30]. Therefore, post COVID-19 patients with subjective dyspnoea should have objective assessment of hypoxia. In our study, dyspnoeic post COVID-19 patients have lower SpO2 and exercise endurance both in 6MWT and 1MSTST. These were not surprising as dyspnoea in post COVID-19 patients may persist and resolving slowly in most patients over two to three months and sometimes longer [5, 30-33].

Our study results showed that there was no difference between 6MWT and 1MSTST when nadir SpO2 was the parameter, and when patient symptoms were analysed at baseline, nadir, and recovery. We have found that a simple 1MSTS test supervised by a trained respiratory physiotherapist detects oxygen desaturation as well as 6MWT in the COVID-19 category 3 and above follow up. Both tests were a good measure of exercise capacity among the patients who underwent them. The clear advantages of 1MSTST were in the ease of its implementation and that only a brief explanation it required before the test was conducted on the patients. 1MSTST should be utilized as a screening tool especially in asymptomatic patients; as a rule out test. For those who were symptomatic patients and 1MSTST did not detect oxygen desaturation, this group of patients should proceed to 6MWT for a confirmatory test. These recommendations were due to high sensitivity but low specificity of 1MSTST in comparison to 6MWT.

The comparison of 6MWT and 1MSTST between symptomatic patients and asymptomatic patients showed no clinically significant SpO2 difference at baseline, nadir, and recovery, but there were lesser 6MWT distance and 1MSTST repetition. These findings may not be attributed to oxygen saturation alone, as other confounding factors including

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co-morbidities and functional status during the recovery may influence these results. However, we do not include these data during our study. The other limitation of our study was in the number of patients upon which the analysis was carried out, but we believe nonetheless that the trend noticed in this study would likely prevail, that is comparable with 6MWT.

CONCLUSION

There is a good agreement of nadir SpO2 and sensitivity to detect oxygen desaturation > 4% between 6MWT and 1MSTST. 1MSTST is a useful screening test to screen exercise-induced oxygen desaturation during outpatient assessment.

Conflict of interest

Authors declare none.

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We would like to thank all the patients who had participated in the study.

Authors' Contribution

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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