Original Article

Comparison of cardiorespiratory parameters between 6-minute walk test and 1-minute sit to stand test in young adults with post-COVID-19: follow-up 3 months

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Background: The investigation of cardiorespiratory fitness in young adults post-coronavirus disease 2019 (COVID-19) is interesting because this information may help in understanding cardiorespiratory function in these populations. Moreover, it helps to know that these impairments possibly interfere with study, learning, and the activities of daily life in young adults post-COVID-19. This study aims to investigate and compare the cardiorespiratory parameters between 6-minute walk test (6MWT) and 1-minute sit-to-stand test (1-min-STST) in healthy young adults and post-COVID-19 and at a 3-month follow-up.

Methods: Forty-six young adults were recruited and divided into two groups including healthy young adults in one group (n=23) and post-COVID-19 patients in the other group (n=23). The young adults were assessed for cardiorespiratory parameters including heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), pulse oxygen saturation (SpO_2), rate of perceived exertion (RPE), and leg fatigue before and after performing a 6MWT and a 1-min STST at baseline and the 3-month follow-up. Test sequences were randomly assigned using the website randomizer.org.

Results: Post-COVID-19 had significantly decreased post-HR, post-SBP, post-SpO_2, post-RPE, post-leg fatigue, and increased the distance of 6MWT, and number of steps of 1-min-STST when compared with the baseline ($P<0.05$). However, all parameters of cardiorespiratory could recover and return to the values of healthy young adults by the follow-up at 3 months.

Conclusions: Post-COVID-19 who recovered from mild-COVID-19 for about 6 months recovered their cardiorespiratory parameters to the values of healthy young adults.

Keywords: Post-coronavirus disease 2019 (post-COVID-19); young adults; 6-minute walk test (6MWT); 1-minute sit-to-stand test (1-min STST); cardiorespiratory function

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Introduction

Background

The major medical problem of coronavirus disease 2019 (COVID-19) infection is respiratory dysfunction due to the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) activated respiratory tract that leads to respiratory inflammation (1,2). Furthermore, this impairment was also present after COVID-19 infection or in post-COVID-19 patients (3). Post-COVID-19 are the individuals who have a history of confirmed SARS-CoV-2 infection, usually 3 months from the onset of COVID-19 (4). Most symptoms were found in these populations including dyspnea, fatigue, cough, and muscle weakness (3,5). These symptoms cause decreased quality of life and physical activity levels in post-COVID-19 patients (3,6). A previous study reported that higher physical fitness and cardiorespiratory function were associated with lower severity of post-COVID-19 symptoms (7). In addition, the conditions of physical restrictions on maximal and submaximal exercise capacity and increased ventilator inefficiency were found in individuals with mild forms of acute illness and post-COVID-19 conditions (8,9). Therefore, the fatigue and dyspnea symptoms of post-COVID-19 individuals occurred due to a reduction in oxygen diffusion in the peripheral circulation (9,10). The symptoms of fatigue and dyspnea were mostly presented in young adults after 6 months of COVID-19 infection (11). A previous report found that lung dysfunction was associated with the duration of hospitalization and oxygen requirement in patients who had recovered from COVID-19 infection at 3 months (12). Moreover, post-COVID-19 patients still exhibited decreased maximal exercise capacity and impaired submaximal exercise performance 3 to 6 months after recovering from COVID-19 (8).

The investigation of cardiorespiratory fitness in young adults post-COVID-19 is interesting because this information may help in understanding cardiorespiratory function in these populations. Moreover, it helps to know that these impairments possibly interfere with study, learning, and the activities of daily life in young adults post-COVID-19. Cardiorespiratory fitness could be assessed using submaximal exercise tests such as the Chester step test (CST), 1-minute sit-to-stand test (1-min-STST), and 6-minute walk test (6MWT) (13-15). The 6MWT is widely used to evaluate the submaximal level of cardiorespiratory fitness in individuals who have various conditions such as chronic obstructive pulmonary disease (COPD) and metabolic dysfunction (16,17). However, this test has shown a low execution rate in some COVID-19 patients at hospital discharge (18). Therefore, it is important to look at alternatives to a 6MWT to investigate COVID-19 patients during the follow-up. The 1-min-STST was developed to investigate submaximal cardiopulmonary fitness. This test used shorter corridors than the 6MWT (19). In addition, the number of steps of 1-min-STST was positively correlated with the distance of the 6MWT (20). However, the selected test was necessary in order to provide specific information on cardiorespiratory fitness in each individual.

Rationale and knowledge gap

Although both the 6MWT and 1-min-STST were used to investigate cardiorespiratory fitness in post-COVID-19 patients (14,21), there are no reports of using the 6MWT and 1-min-STST to assess the effects of a mild-COVID-19 infection and comparing between the two tests on cardiorespiratory parameters.

Objective

Therefore, this study aims to investigate and compare cardiorespiratory parameters between 6MWT and 1-min-STST in healthy young adults and post-COVID-19 and at a 3-month follow-up. We present this article in accordance with the STROBE reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-44/rc).

Highlight box

Key findings

- Post-coronavirus disease 2019 (COVID-19) had recovered cardiopulmonary response parameters at a 6-month after COVID-19 infection.

What is known and what is new?

- The parameters of cardiorespiratory could recover and return to the values of healthy young adults by the follow-up at 3 months.
- The cardiorespiratory parameters were not statistically significantly different between the 6-minute walk test and 1-minute sit-to-stand test in healthy young adults and post-COVID-19 patients.

What is the implication, and what should change now?

- Our results confirm the post-COVID-19 who recovered from mild-COVID-19 for about 6 months recovered their cardiorespiratory parameters to the values of healthy young adults.

Methods

Study design

A cross-sectional study design was used to investigate and compare cardiorespiratory parameters including heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), pulse oxygen saturation (SpO_2), rate of perceived exertion (RPE), and leg fatigue between 6MWT and 1-min-STST in healthy young adults and post-COVID-19 and at a 3-month follow-up.

Participants

Forty-six young adults were recruited and divided into two groups including healthy young adults group (n=23) and young adults with post-COVID-19 group (n=23). The sample size was calculated using a power of 0.95, power analysis with an alpha of 0.05, and an effect size f of 0.58 (22). The participants who were recruited were 18–24 years old with or without post-COVID-19 and had polymerase chain reaction (PCR) or antigen test kit (ATK) confirmed infection with SARS-CoV-2 at less than 3 to 4 months before the evaluation procedure. The exclusion criteria are as follows participants who had cardiorespiratory diseases, neurological diseases, and musculoskeletal diseases that interfered with the performance during tests. This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). All participants provided written informed consent after being informed of the purposes and methods of the study. This study was approved by the Clinical Research Ethics Committee of the University of Phayao, Phayao, Thailand (HREC-UP-HSST 1.3/063/66).

Procedure

Participants were assessed by age, weight, height, and body mass index (BMI) for the baseline demographic data. Each participant was investigated for cardiorespiratory parameters including HR, SBP, DBP, SpO_2, RPE, and leg fatigue through a 6MWT and a 1-min STST. Test sequences were randomly assigned using the website randomizer.org. The HR and SpO_2 were measured with a finger pulse oximeter (SB200, Rossmax International Ltd., Taiwan). SBP and DBP were measured using an automatic blood pressure monitor (HEM-8712, Omron Healthcare Co., Ltd., Kyoto, Japan). Dyspnoea was assessed using the Borg rating of perceived exertion scale (6–20 scales). Leg fatigue was measured using the Borg CR10 scale.

In the 6MWT procedure, each participant was assessed and the cardiorespiratory parameters of HR, SBP, DBP, SpO_2, RPE, and leg fatigue were recorded before performing the test. Participants were instructed to walk as far as possible for 6 minutes without running for the test in the corridor space of 30 meters. The distance completed in each 6MWT was recorded (23). Subsequently, the cardiorespiratory parameters were assessed and recorded after performing the test.

In the 1-min-STST procedure, each participant was assessed and the cardiorespiratory parameters of HR, SBP, DBP, SpO_2, RPE, and leg fatigue were recorded before performing the test. Participants were instructed to sit on a chair without armrests and with a seat height of 46 centimeters and to repeatedly stand up until the hips and knees were fully extended, and then to sit down again while the arms were folded across the chest as quickly as possible for 1 minute. The number of completed actions during the test was recorded (14). After performing the test, the cardiorespiratory parameters were again assessed and recorded. There was a 30-minute interval between each test.

Both tests were performed at a 3-month follow-up. The flow chart of this study protocol is shown in *Figure 1*.

Statistical analysis

The normality of the data distribution was assessed using the Shapiro-Wilk test. Continuous variables are expressed as means and standard deviations (SDs). A paired *t*-test was used to compare cardiorespiratory parameters within the group. An independent sample *t*-test was used to compare cardiorespiratory parameters between groups and tests. IBM SPSS Statistics software, version 26.0, was used in this study, with a P value of less than 0.05 set to denote significance.

Results

The variables of age, weight, height, and BMI were not significantly different between healthy young adults and post-COVID-19. The results are presented in *Table 1*.

At the 3-month follow-up, post-COVID-19 had significantly decreased post-HR, post-SBP, post-SpO_2, post-RPE, and post-leg fatigue, and increased the distance of 6MWT when compared to the baseline ($P<0.05$). In addition, post-COVID-19 patients had significantly increased post-HR and post-RPE when compared to healthy

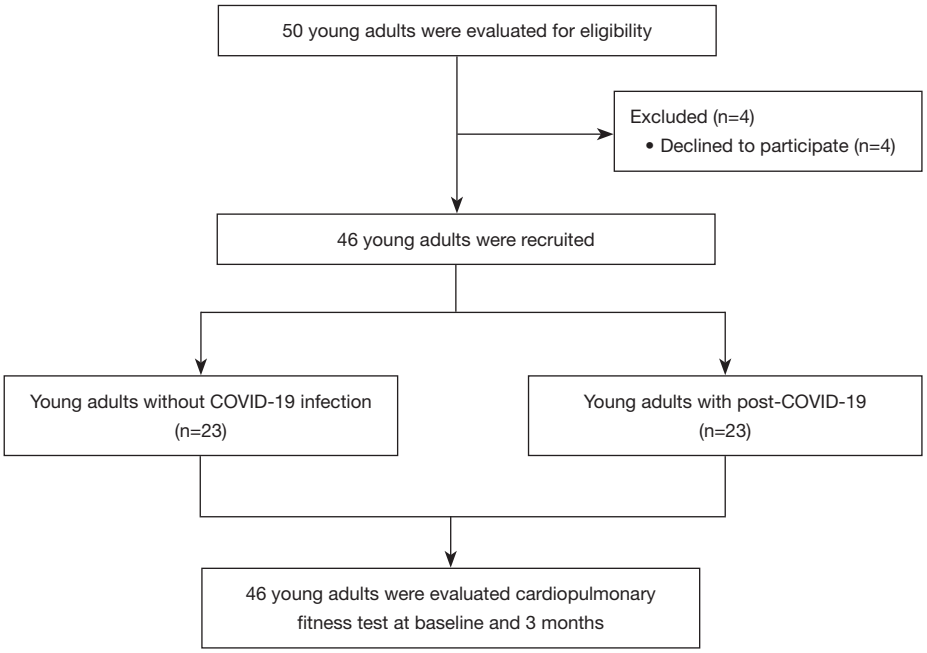

Figure 1 The flow chart of this study protocol. COVID-19, coronavirus disease 2019.

Table 1 Characteristics of the healthy young adults and post-COVID-19

Variables	Healthy young adults	Post-COVID-19	P value
Number	23	23	–
Gender			
Female	17	17	–
Male	6	6	–
Age (years)	20.43±0.59	20.13±0.55	0.08
Weight (kg)	55.00±7.15	57.13±8.34	0.18
Height (m)	1.64±0.09	1.65±0.07	0.35
BMI (kg/m^2)	20.47±1.53	20.99±1.81	0.33
Duration of post-COVID-19 (months)	–	3.39	–

Values are presented as n or mean ± SD. COVID-19, coronavirus disease 2019; BMI, body mass index; SD, standard deviation.

young adults at the baseline. However, cardiorespiratory parameters were not statistically significantly different between healthy young adults and post-COVID-19 at the 3-month follow-up (*Table 2*).

For the cardiorespiratory parameters using the 1-min-STST, the results showed that at the 3-month follow-up, post-COVID-19 had significantly decreased post-HR, post-SBP, post-SpO_2, post-RPE, post-leg fatigue and increased the number of steps of 1-min-STST when compared to baseline (P<0.05). While, post-COVID-19 had significantly increased post-HR, post-RPE, and post-leg fatigue and reduced the number of steps of 1-min-STST when compared to healthy young adults at the baseline. However, cardiorespiratory parameters and the number of steps of 1-min-STST were not statistically significantly different between healthy young adults and post-COVID-19 at the 3-month follow-up (*Table 3*).

Comparison of cardiorespiratory parameters between

Table 2 Comparison of cardiorespiratory parameters using a 6MWT between healthy young adults and post-COVID-19 at baseline and 3 months

Variables	Baseline		3 months		P value within group
	Mean ± SD	P	Mean ± SD	P	
Post-HR (bpm)		<0.001		0.86	
Healthy young adults	114.70±6.46		113.61±8.21		0.229
Post-COVID-19	122.00±7.01		114.04±8.67		<0.001
Post-SBP (mmHg)		0.27		0.88	
Healthy young adults	127.43±8.23		126.57±7.19		0.26
Post-COVID-19	130.26±8.79		126.22±8.36		0.049
Post-DBP (mmHg)		0.93		>0.99	
Healthy young adults	81.87±8.28		81.52±3.88		0.82
Post-COVID-19	82.09±8.47		81.52±7.76		0.76
Post-SpO_2 (%)		0.70		0.26	
Healthy young adults	98.22±0.80		97.91±0.67		0.07
Post-COVID-19	98.13±0.69		97.52±0.52		0.005
Post-RPE		<0.001		0.60	
Healthy young adults	9.65±01.82		9.61±2.15		0.89
Post-COVID-19	11.83±1.90		9.87±0.92		<0.001
Post-leg fatigue		0.15		0.92	
Healthy young adults	1.57±0.96		1.52±0.67		0.76
Post-COVID-19	2.02±1.12		1.54±0.75		0.04
Distance (m)		0.14		0.61	
Healthy young adults	598.91±47.23		599.04±57.36		0.98
Post-COVID-19	579.74±37.70		591.83±35.83		0.003

6MWT, 6-minute walk test; COVID-19, coronavirus disease 2019; HR, heart rate; SBP, systolic blood pressure; DBP, diastolic blood pressure; SpO_2, pulse oxygen saturation; RPE, rate of perceived exertion; SD, standard deviation.

the 6MWT and the 1-min-STST, the results showed that all cardiorespiratory parameters after performing the 6MWT were not statically significantly different when compared with the 1-min-STST in healthy young adults at the baseline and the 3-month follow-up (P>0.05). Moreover, cardiorespiratory parameters after performing the 6MWT also showed not statistically significant different when compared with the 1-min-STST in post-COVID at the baseline and the 3-month follow-up (P>0.05). Whereas the 1-min-STST significantly increased leg fatigue when compared to the 6MWT at baseline (P<0.05) (*Table 4*).

Discussion

Key findings

Our study indicated that post-COVID-19 had recovered in some of the variables of the cardiorespiratory parameters at baseline when compared with healthy young adults. In addition, the cardiorespiratory parameters in post-COVID-19 recovered to the value of healthy young adults at the 3-month follow-up. Moreover, the cardiorespiratory parameters were not statistically significantly different between the 6MWT and the 1-min-STST in both groups at the baseline and the 3-month follow-up. There is only

Table 3 Comparison of cardiorespiratory parameters using a 1-min-STST between healthy young adults and post-COVID-19 at baseline and 3 months

Variables	Baseline		3 months		P value within group
	Mean ± SD	P	Mean ± SD	P	
Post-HR (bpm)		0.02		0.75	
Healthy young adults	114.78±10.16		113.87±6.78		0.71
Post-COVID-19	119.52±7.02		114.22±6.73		0.02
Post-SBP (mmHg)		0.15		0.07	
Healthy young adults	127.87±13.56		127.43±7.92		0.85
Post-COVID-19	131.87±9.98		127.39±9.80		0.03
Post-DBP (mmHg)		0.96		0.72	
Healthy young adults	80.74±12.49		80.53±7.95		0.87
Post-COVID-19	80.87±5.56		80.91±8.27		0.98
Post-SpO_2 (%)		0.14		0.08	
Healthy young adults	98.26±0.86		98.09±0.73		0.21
Post-COVID-19	98.04±0.77		97.48±0.95		0.03
Post-RPE		<0.001		0.31	
Healthy young adults	10.04±1.64		10.13±1.06		0.77
Post-COVID-19	12.09±1.38		10.22±0.95		<0.001
Post-leg fatigue		<0.001		0.71	
Healthy young adults	1.61±0.58		1.65±0.65		0.82
Post-COVID-19	2.61±0.58		1.70±0.56		<0.001
Number of steps		0.002		0.06	
Healthy young adults	37.91±3.30		37.96±2.12		0.95
Post-COVID-19	33.96±4.68		37.26±4.00		<0.001

1-min-STST, 1-minute sit-to-stand test; COVID-19, coronavirus disease 2019; HR, heart rate; SBP, systolic blood pressure; DBP, diastolic blood pressure; SpO_2, pulse oxygen saturation; RPE, rate of perceived exertion; SD, standard deviation.

leg fatigue showed a significantly increased in the 1-min-STST when compared to the 6MWT at the baseline. These responses may be due to post-COVID-19 in this study having had mild-COVID-19 history without pneumonia during their COVID-19 infection. Therefore, our results suggested that young adults who recovered from mild-COVID-19 infection after about 6 months had recovered cardiorespiratory parameters using the 6MWT and 1-min-STST. Moreover, the 1-min-STST is an alternative test for used to evaluate cardiorespiratory fitness levels in post-COVID-19 who recovered from mild-COVID-19 infection when the 6MWT cannot be performed.

Strengths and limitations

The strength of our study includes an adequately powered sample size. In addition, we used field tests to assess the cardiorespiratory parameters in post-COVID-19 at the 3-month follow-up. However, the study may be limited by the omission of some variables that impact aerobic performance, such as oxygen uptake capacity (VO_2). Therefore, future studies should evaluate this variable. Moreover, it may be limited by additional variables that impact aerobic performance such as an anthropometric profile and activity level. Therefore, future studies should place the anthropometric profile and activity level of

Table 4 Comparison of cardiorespiratory parameters between a 6MWT and a 1-min STST in healthy young adults and post-COVID-19 at baseline and 3 months

Variables	6MWT	1-min-STST	P value
Healthy young adults group			
Post-HR (bpm)			
Baseline	114.70±6.46	114.78±10.16	0.97
3 months	113.61±8.21	113.87±6.78	0.91
Post-SBP (mmHg)			
Baseline	127.43±8.23	127.87±13.56	0.90
3 months	126.57±7.19	127.43±7.92	0.70
Post-DBP (mmHg)			
Baseline	81.87±8.28	80.74±12.49	0.72
3 months	81.52±3.88	80.52±7.95	0.59
Post-SpO_2 (%)			
Baseline	98.22±0.80	98.26±0.86	0.86
3 months	97.91±0.67	98.09±0.73	0.41
Post-RPE			
Baseline	9.65±1.82	10.04±1.64	0.45
3 months	9.61±2.15	10.13±1.06	0.30
Post-leg fatigue			
Baseline	1.57±0.96	1.61±0.58	0.85
3 months	1.52±0.67	1.65±0.65	0.50
Post-COVID-19 group			
Post-HR (bpm)			
Baseline	122.00±7.01	119.52±7.02	0.24
3 months	114.04±8.67	114.22±6.73	0.94
Post-SBP (mmHg)			
Baseline	130.26±8.79	131.87±9.98	0.57
3 months	126.22±8.36	127.39±9.77	0.66
Post-DBP (mmHg)			
Baseline	82.09±8.47	80.87±5.56	0.57
3 months	81.52±7.76	80.91±8.27	0.80
Post-SpO_2 (%)			
Baseline	98.13±0.69	98.04±0.77	0.69
3 months	97.52±0.59	97.48±0.95	0.85
Post-RPE			
Baseline	11.83±1.90	12.09±1.38	0.60
3 months	9.87±0.92	10.22±0.95	0.21
Post-leg fatigue			
Baseline	2.02±1.12	2.61±0.58	0.03
3 months	1.54±0.75	1.70±0.56	0.44

Values are presented as mean ± SD. 6MWT, 6-minute walk test; 1-min-STST, 1-minute sit-to-stand test; COVID-19, coronavirus disease 2019; HR, heart rate; SBP, systolic blood pressure; DBP, diastolic blood pressure; SpO_2, pulse oxygen saturation; RPE, rate of perceived exertion; SD, standard deviation.

participants in the inclusion criteria.

Explanations of findings

This study showed that young adults who recovered from mild-COVID-19 infection after about 3 months had increased post-HR and post-RPE after performing the 6MWT when compared to healthy young adults. However, these parameters could have recovered to equal the values of healthy young adults at the 3-month follow-up. Our results were consistent with a previous study which found that adults who had recovered from mild- to moderate-COVID-19 infection after 4 weeks had significantly increased HR and dyspnea after performing a 6MWT when compared with healthy subjects (22). These impairments cause the SARS-CoV-2-activation of the immune system during the COVID-19 infection, resulting in an imbalance of the autonomic nervous system. These responses were also presented post-COVID-19 after performing a 6MWT (24). The dyspnea presented after performing a 6MWT in post-COVID-19 was due to the disrupted lungs from SARS-CoV-2 during COVID-19 infection, which leads to lung injury and dysfunction (25,26). Furthermore, several studies found that post-COVID-19 patients recovering from COVID-19 pneumonia had increased RPE and leg fatigue and decreased distance of 6MWT and O_2 sat after performing a 6MWT (27,28). Moreover, a previous study showed that the decreased O_2 sat while performing the 6MWT was found in severe post-COVID-19 patients. These responses may be due to ventilator-activated lung injury in patients with severe respiratory failure during COVID-19 infection for several months after recovery. Therefore, post-COVID-19 dyspnea may have had different physiological correlates in mild- and severe-COVID-19 patients. Furthermore, patients with mild disease and normal gas transfer had dyspnea. This finding indicated that dyspnea is a complex symptom that may involve several other mechanisms than those of the respiratory system (29). Moreover, a previous study reported that post-COVID-19 patients who had not required hospitalization or home oxygen therapy and recovering from one month of COVID-19 infection had significantly increased blood pressure after performing cardiopulmonary exercise testing (CPET) when compared with the control group (30). Additionally, post-COVID-19 patients had increased SBP and DBP at the 1-month follow-up when compared with admission (31). The increased blood pressure may be due to SARS-CoV-2-activated renin-angiotensin-aldosterone system (RAAS) or the sympathetic nervous system (32). In contrast, blood pressure, SpO_2, leg fatigue, and distance of 6MWT were not different between groups because the post-COVID-19 in this study had recovered from only mild-COVID-19 at about 3 months before the investigation procedure.

Young adults who recovered from mild-COVID-19 infection for about 3 months had increased post-HR, post-RPE, post-leg fatigue, and decreased the number steps of 1-min-STST after performing the 1-min-STST when compared with healthy young adults. At the 3-month follow-up it was found that these parameters had recovered to the values of healthy young adults. These findings suggested that young adults who recovered from mild-COVID-19 infection for about 3 months had decreased some cardiorespiratory parameters. These findings are consistent with a previous study, which found that post-COVID-19 patients had reduced physical capacity after 1 month of COVID-19 infection (33). However, participants in our study could recover their cardiorespiratory fitness levels at about 6 months after COVID-19 infection. Moreover, several earlier studies reported that a reduction in physical capacity using the 1-min-STST was found in post-COVID-19 patients who had a history of admission to the hospital for more than 10 days or older adult patients (14,33). In addition, a previous study showed that post-COVID-19 patients had significantly decreased numbers of step for the 1-min-STST and increased dyspnea and leg fatigue after performing the 1-min-STST when compared to individuals without COVID-19 infection (28). These responses were due to post-COVID-19 patients in that study having recovered from COVID-19 pneumonia and had comorbidities such as obesity, arterial hypertension, cardiac diseases, and diabetes and having had a length of stay in hospital of about 22 days (28). This study, however, involved no patients with post-COVID-19 pneumonia with a prolonged hospital stay.

The cardiorespiratory parameters were not statistically significantly different between the 6MWT and the 1-min-STST in healthy young adults and post-COVID-19 patients. In contrast, post-COVID-19 patients had significantly increased post-leg fatigue from the 6MWT when compared to the 1-min-STST at the baseline. This response may be due to the 1-min-STST stressing lower extremities when performing the test, in contrast walking along a flat corridor as in the 6MWT (34). However, the 6MWT and the 1-min-STST provided similar cardiorespiratory results in the populations of this study.

It is crucial to consider that a more significant effort in the lower extremities is required to execute the 1-min-STST (35,36). This result was confirmed by the reported perception of leg fatigue when compared with the 6MWT. According, the 1-min-STST should not be considered in individuals who had extreme lower extremity fatigue before the evaluations. Therefore, our study indicated that the 1-min-STST could be used as an alternative in post-COVID-19 patients if the 6MWT could not be performed.

Conclusions

Post-COVID-19 recovered from mild-COVID-19 after about 6 months could recover their cardiorespiratory parameters to the values of healthy young adults.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-44/rc

Data Sharing Statement: Available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-44/dss

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study was approved by the Clinical Research Ethics Committee of the University of Phayao, Phayao, Thailand (HREC-UP-HSST 1.3/063/66). All participants provided written informed consent after being apprised of the study's protocol.

References

1. Alandijany TA, Faizo AA, Azhar EI. Coronavirus disease of 2019 (COVID-19) in the Gulf Cooperation Council (GCC) countries: Current status and management practices. J Infect Public Health 2020;13:839-42.
2. Korompoki E, Gavriatopoulou M, Hicklen RS, et al. Epidemiology and organ specific sequelae of post-acute COVID19: A narrative review. J Infect 2021;83:1-16.
3. So MKP, Chu AMY, Tiwari A. Persistent symptoms after SARS-CoV-2 infection: Long-term implications for health and quality of life. Lancet Reg Health Eur 2022;17:100373.
4. 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:e102-7.
5. Malkova A, Kudryavtsev I, Starshinova A, et al. Post COVID-19 Syndrome in Patients with Asymptomatic/Mild Form. Pathogens 2021;10:1408.
6. Delbressine JM, Machado FVC, Goërtz YMJ, et al. The Impact of Post-COVID-19 Syndrome on Self-Reported Physical Activity. Int J Environ Res Public Health 2021;18:6017.
7. Jimeno-Almazán A, Martínez-Cava A, Buendía-Romero Á, et al. Relationship between the severity of persistent symptoms, physical fitness, and cardiopulmonary function in post-COVID-19 condition. A population-based analysis. Intern Emerg Med 2022;17:2199-208.
8. Vonbank K, Lehmann A, Bernitzky D, et al. Predictors of Prolonged Cardiopulmonary Exercise Impairment After COVID-19 Infection: A Prospective Observational Study.

Front Med (Lausanne) 2021;8:773788.
9. Crameri GAG, Bielecki M, Züst R, et al. Reduced maximal aerobic capacity after COVID-19 in young adult recruits, Switzerland, May 2020. Euro Surveill 2020;25:2001542.
10. Baratto C, Caravita S, Faini A, et al. Impact of COVID-19 on exercise pathophysiology: a combined cardiopulmonary and echocardiographic exercise study. J Appl Physiol (1985) 2021;130:1470-8.
11. Blomberg B, Mohn KG, Brokstad KA, et al. Long COVID in a prospective cohort of home-isolated patients. Nat Med 2021;27:1607-13.
12. Johnsen S, Sattler SM, Miskowiak KW, et al. Descriptive analysis of long COVID sequelae identified in a multidisciplinary clinic serving hospitalised and non-hospitalised patients. ERJ Open Res 2021;7:00205-2021.
13. Torres-Castro R, Núñez-Cortés R, Larrateguy S, et al. Assessment of Exercise Capacity in Post-COVID-19 Patients: How Is the Appropriate Test Chosen? Life (Basel) 2023;13:621.
14. 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.
15. Buckley JP, Sim J, Eston RG, et al. Reliability and validity of measures taken during the Chester step test to predict aerobic power and to prescribe aerobic exercise. Br J Sports Med 2004;38:197-205.
16. 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;44:1428-46.
17. Hansen H, Beyer N, Frølich A, et al. Intra- and inter-rater reproducibility of the 6-minute walk test and the 30-second sit-to-stand test in patients with severe and very severe COPD. Int J Chron Obstruct Pulmon Dis 2018;13:3447-57.
18. Curci C, Pisano F, Bonacci E, et al. Early rehabilitation in post-acute COVID-19 patients: data from an Italian COVID-19 Rehabilitation Unit and proposal of a treatment protocol. Eur J Phys Rehabil Med 2020;56:633-41.
19. 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.
20. Vaidya T, de Bisschop C, Beaumont M, et al. Is the 1-minute sit-to-stand test a good tool for the evaluation of the impact of pulmonary rehabilitation? Determination of the minimal important difference in COPD. Int J Chron Obstruct Pulmon Dis 2016;11:2609-16.
21. Eksombatchai D, Wongsinin T, Phongnarudech T, et al. Pulmonary function and six-minute-walk test in patients after recovery from COVID-19: A prospective cohort study. PLoS One 2021;16:e0257040.
22. Omar A, Ferreira AS, Hegazy FA, et al. Cardiorespiratory Response to Six-Minute Step Test in Post COVID-19 Patients-A Cross Sectional Study. Healthcare (Basel) 2023;11:1386.
23. ATS statement: guidelines for the six-minute walk test. Am J Respir Crit Care Med 2002;166:111-7.
24. Dani M, Dirksen A, Taraborrelli P, et al. Autonomic dysfunction in 'long COVID': rationale, physiology and management strategies. Clin Med (Lond) 2021;21:e63-7.
25. Fernández-de-Las-Peñas C, Palacios-Ceña D, Gómez-Mayordomo V, et al. Fatigue and Dyspnoea as Main Persistent Post-COVID-19 Symptoms in Previously Hospitalized Patients: Related Functional Limitations and Disability. Respiration 2022;101:132-41.
26. Townsend A. Autoimmunity to ACE2 as a possible cause of tissue inflammation in Covid-19. Med Hypotheses 2020;144:110043.
27. Lombardi F, Calabrese A, Iovene B, et al. Residual respiratory impairment after COVID-19 pneumonia. BMC Pulm Med 2021;21:241.
28. Peroy-Badal R, Sevillano-Castaño A, Torres-Castro R, et al. Comparison of different field tests to assess the physical capacity of post-COVID-19 patients. Pulmonology 2024;30:17-23.
29. Sperling S, Fløe A, Leth S, et al. Fatigue Is a Major Symptom at COVID-19 Hospitalization Follow-Up. J Clin Med 2022;11:2411.
30. Miętkiewska-Szwacka K, Domin R, Kwissa M, et al. Effect of COVID-19 on Blood Pressure Profile and Oxygen Pulse during and after the Cardiopulmonary Exercise Test in Healthy Adults. J Clin Med 2023;12:4483.
31. Akpek M. Does COVID-19 Cause Hypertension? Angiology 2022;73:682-7.
32. Zuin M, Rigatelli G, Bilato C, et al. Risk of Incident New-Onset Arterial Hypertension After COVID-19 Recovery: A Systematic Review and Meta-analysis. High Blood Press Cardiovasc Prev 2023;30:227-33.
33. Belli S, Balbi B, Prince I, et al. Low physical functioning and impaired performance of activities of daily life in COVID-19 patients who survived hospitalisation. Eur Respir J 2020;56:2002096.
34. Ozalevli S, Ozden A, Itil O, et al. Comparison of the Sit-

to-Stand Test with 6 min walk test in patients with chronic obstructive pulmonary disease. Respir Med 2007;101:286-93.
35. Karloh M, Corrêa KS, Martins LQ, et al. Chester step test: assessment of functional capacity and magnitude of cardiorespiratory response in patients with COPD and healthy subjects. Braz J Phys Ther 2013;17:227-35.
36. 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;58:949-53.

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