Access this article online
Quick Response Code:

Website:
https://eurasianjpulmonol.org
DOI:
10.14744/ejp.2024.1105

The role of one-minute sit-to-stand test in monitoring patients with COVID-19 pneumonia

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Received: 02-12-2023
Revised: 22-01-2024
Accepted: 04-03-2024
Published: 16-07-2024

Abstract:

BACKGROUND AND AIM: This study aims to explore the relationship between pulmonary function parameters, disease severity, and one-minute sit-to-stand test (1MSTST) in patients recovering from Coronavirus Disease 2019 (COVID-19) pneumonia at the one-year mark. We investigated whether the 1MSTST could provide a feasible substitute for traditional pulmonary function tests, especially during pandemic conditions.

METHODS: We conducted a retrospective cohort study at a state hospital, collecting data from patients diagnosed with COVID-19 pneumonia from November 2020 to June 2021. This included demographic, clinical, and laboratory data, as well as results from pulmonary function tests and the 1MSTST. Correlation analyses were used to assess the relationships among these variables.

RESULTS: The study included 97 patients with a median age of 55. Pulmonary function tests showed mean Forced Expiratory Volume in the first second (FEV_1) and Forced Vital Capacity (FVC) values of 2.4±0.8 L and 3.0±0.9 L, respectively. The median score for the 1MSTST was 11 (range: 10–13). Over half (52.6%) of the patients required oxygen therapy, and some needed intensive care or mechanical ventilation. Positive correlations were found between FEV_1, FVC values, and 1MSTST performance ($r=0.35$, $p<0.001$; $r=0.32$, $p=0.001$, respectively). Lower C-reactive protein (CRP) levels and a younger age were linked to better performance on the 1MSTST.

CONCLUSIONS: Improved pulmonary function parameters were found to correlate with enhanced performance in the 1MSTST, underscoring its potential as an alternative assessment tool for monitoring recovery from COVID-19. Additionally, lower CRP levels and a younger age were linked to better 1MSTST outcomes, highlighting the influence of inflammatory and age-related factors. These findings could assist physicians in evaluating and monitoring patients with post-COVID syndrome.

Keywords:

One-minute-sit-to-stand test, Post – COVID syndrome, pulmonary function test

How to cite this article: Koç Ç, Sökücü SN, Satıcı C, Aktı S. The role of one-minute sit-to-stand test in monitoring patients with COVID-19 pneumonia. Eurasian J Pulmonol 2024;26:128-135.

Introduction

Coronavirus Disease 2019 (COVID-19) emerged in Wuhan, China, and quickly escalated into a global pandemic. Initially, patient assessments relied on data from the previous MERS-CoV (Middle East respiratory syndrome coronavirus) pandemic. Although the number of new COVID-19 diagnoses has recently declined, the pandemic continues to have a significant impact. Some patients experience persistent symptoms and long-term complications after the acute phase of the infection or hospitalization, a condition known as long COVID-19 syndrome.[1] The long-term assessment of functional capacities in hospitalized COVID-19 patients is increasingly critical. Research indicates that patients may experience pulmonary sequelae and persistent impairment of respiratory function after discharge.[2] Pulmonary function tests (PFT) and six-minute walking test (6MWT) have proven useful for evaluating these post-COVID-19 pulmonary sequelae.[3] However, there are some challenges in applying the PFT and 6MWT for assessing functional capacity during the post-COVID-19 period. Ideally, a polymerase chain reaction (PCR) test should be conducted before administering a PFT to prevent the re-infection of other patients. Additionally, performing PCR and PFT may be impractical in primary care settings. The 6MWT also poses operational challenges, such as the requirement for a 30-meter lane, which is difficult to secure during pandemic restrictions.

As an alternative to both PFT and 6MWT, one-minute sit-to-stand test (1MSTST) is preferable because it does not require a PCR test or a large area. There was a strong correlation between the 6MWT and the 1STST in patients with Chronic Obstructive Pulmonary Disease (COPD)[4] and interstitial lung disease.[5] However, despite its ease of performance, data on the correlation between pulmonary function tests and the 1MSTST during the post-COVID-19 period are limited. There are few studies demonstrating the role of the 1MSTS in triaging and planning care for both mild and severe COVID-19 patients.[6,7]

In this context, our study aims to evaluate the correlation between pulmonary function, disease severity, and 1MSTST among COVID-19 patients in the first year. We believe the results of our study may offer a practical approach for evaluating patients in future pandemics.

Materials and Methods

Study design and settings

We conducted a retrospective cohort study at a State Hospital, which has operated as a pandemic hospital since the outbreak began. Our research complied with the Helsinki Declaration. The Tokat Gaziosmanpaşa University Clinical Research Ethics Committee approved the study protocol (Approval number: 83116987-584, Date: 22.09.2022).

Study population

During the outbreak, management strategies were frequently updated and altered. Following Health Ministry guidelines, any suspected case aged over 50 years or having any comorbidity such as cardiopulmonary disease, diabetes mellitus, hypertension, chronic renal disease, immunosuppressive conditions, malignancy, or presenting with tachycardia (pulse>125/min), tachypnea (respiratory rate>22/min), hypotension (<90/60 mmHg), or hypoxemia (Spo_2<93%) was hospitalized (Health Ministry Board, 2020). We retrospectively enrolled patients diagnosed with COVID-19 pneumonia at our center from November 1, 2020, to June 1, 2021. The study included all patients over 18 years old with COVID-19 confirmed by PCR on nasopharyngeal swabs who were hospitalized at our hospital. Pregnant patients were excluded. Out of 1,391 patients hospitalized with a diagnosis of COVID-19, 1,138 tested positive for the virus via PCR test. Among 895 patients with positive test results who had complete data available, 97 patients who could be reevaluated in the first year were included in this study.

Data collection

Data collected included hospitalization date, demographic information (age, gender), duration of hospitalization, hemogram, C-reactive protein (CRP), D-dimer, troponin, and ferritin levels. Information was also recorded on whether the patients received oxygen therapy, non-invasive mechanical ventilation, invasive mechanical ventilation therapy during their hospitalization, and whether they were transferred to the intensive care unit or died during follow-up. Severity scores of thorax Computed Tomography (CT) scans taken at the first admission of the patients were calculated.

The patients were re-evaluated and asked to perform a one-minute sit-to-stand test and a pulmonary function test in the first year after their discharge from the hospital. The degree of dyspnea was evaluated using the Borg dyspnea scale before and after the one-minute sit-to-stand test.

Definitions

The 1MSTST is conducted using a standard-height, armless chair. Participants are required to perform as many sit-to-stand actions as they can within one minute, without using their upper limbs. Each complete cycle of standing up and sitting back down is counted as one repetition, and the total number of repetitions within the minute is recorded.[8] Dyspnea is assessed before and after the test using a modified Borg score.

In evaluating the severity of thoracic CT scans, each of the five lobes receives a score ranging from 0 to 4. The final score is the aggregate of the scores for each lobe, with possible totals ranging from 0 (indicative of regular CT scans) to 20.[9]

Data analysis and statistical methods

Data analysis was carried out using IBM Statistical Package for the Social Sciences (SPSS) version 25.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics for continuous parameters were presented as means and standard deviations when normally distributed, and as medians with interquartile ranges when distributions were not normal. Categorical variables were described using numbers and percentages. The relationships between continuous parameters was analyzed using either Pearson or Spearman correlation methods, depending on their distribution. A p-value of less than 0.05 was considered statistically significant.

Results

The study included 97 patients. The median age was 55 years (range: 45.5–63), and 37% of the participants were female.

Laboratory parameters are shown in Table 1. The mean forced expiratory volume in one second (FEV_1) was 2.4 liters (±0.8), with the mean percentage of predicted FEV_1 being 81.7% (±20.3%). The mean forced vital capacity (FVC) was 3.0 liters (±0.9), and the median percentage of predicted FVC values was 83% (70–91%). The median FEV_1/FVC ratio was 81% (76–86%). Regarding the clinical status of the patients, the median radiologic severity score for all participants was 6 (range 5–8), and the median score for the sit-to-stand test was 11 (range: 10–13) (Table 1).

Table 1: Demographic, clinical, and laboratory findings of patients with COVID-19

Variable	All patients (n=97)
Gender (female), n (%)	37 (38.1)
Age, years (median, IQR)	55 (45.5–63)
Radiological severity score	6 (5–8)
Oxygen therapy usage	51 (52.6)
NIMV usage	4 (4.1)
IMV usage	1 (1)
Pulmonary function test (1st year post-discharge)	
FEV_1 (L) (mean±SD)	2.4±0.8
FEV_1 (%) (mean±SD)	81.7±20.3
FVC (L) (mean±SD)	3±0.9
FVC (%) (median, IQR)	83 (70–91)
FEV_1/FVC ratio (median, IQR)	81 (76–86)
Laboratory parameters	
Hemoglobin (g/dL) (mean±SD)	13.5±1.8
Hematocrit (L/L) (mean±SD)	40.7±4.6
WBC count (cells/µL) (median, IQR)	6.2 (4.7–7.7)
Platelet count (10^3 cells /µL) (median, IQR)	209 (170–251)
Neutrophil count (cells/mm^3) (median, IQR)	4.4 (2.9–5.7)
Neutrophil (%) (median, IQR)	72 (65.4–77.7)
Lymphocyte count (cells/mm^3) (median, IQR)	1.3 (1–1.7)
Lymphocyte (%) (median, IQR)	19.9 (14.6–26.1)
D-dimer (ng/mL) (median, IQR)	0.2 (0.1–0.4)
Troponin (ng/L) (median, IQR)	4.6 (2.4–8.8)
CRP (mg/L) (median, IQR)	61.2 (20.6–93.2)
Ferritin (ng/L) (median, IQR)	276.8 (104.5–626.8)

IQR: Interquartile range, NIMV: Noninvasive mechanical ventilation, IMV: Invasive mechanical ventilation, FEV_1: Forced Expiratory Volume in the first second, FVC: Forced Vital Capacity, SD: Standard deviation, WBC: White blood cell, CRP: C-reactive protein

A significant majority of the patients, 52.6% (n=51), required oxygen therapy. A smaller subset, 4.1% (n=4), were admitted to the Intensive Care Unit (ICU). Additionally, the same percentage (4.1%, n=4) received noninvasive mechanical ventilation (NIMV) treatment, and 1% (n=1) underwent invasive mechanical ventilation (IMV) (Table 1).

The sit-to-stand test scores were higher among male patients, averaging 12 (ranging from 10.2 to 14) compared to 10 (ranging from 8 to 12.5) for females (p=0.005). There was no significant difference in sit-to-stand test scores based on the type of respiratory support received. Correlation analysis revealed that FEV_1 and FVC values were weakly but positively correlated with sit-to-stand test scores (r=0.35, p<0.001; r=0.32, p=0.001, respective-

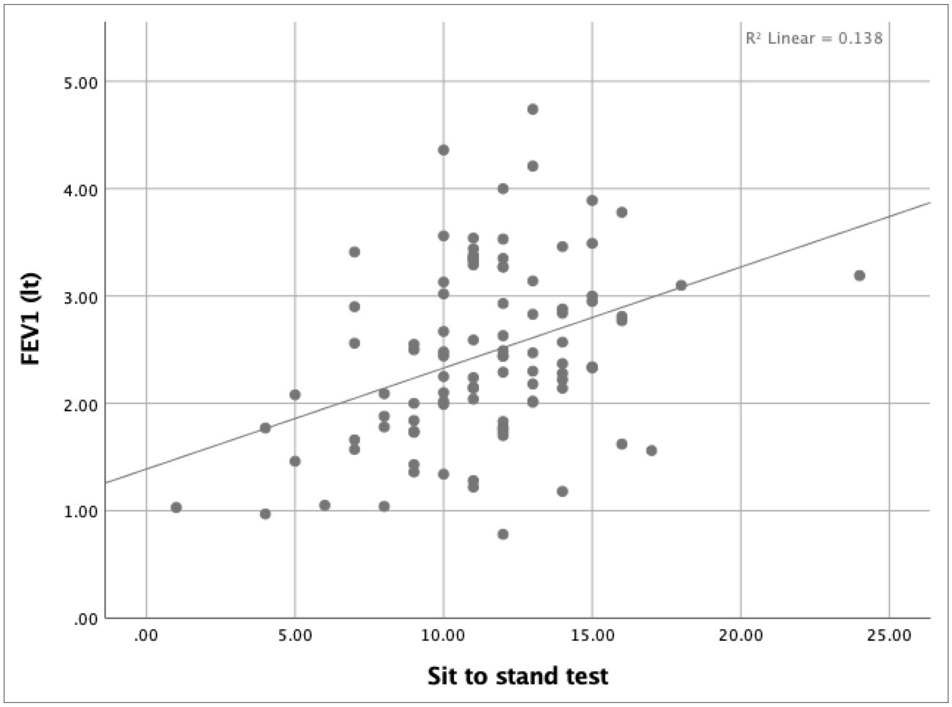

Figure 1: Correlation between FEV_1 (Liters) and sit-to-stand test

FEV_1: Forced Expiratory Volume in the first second

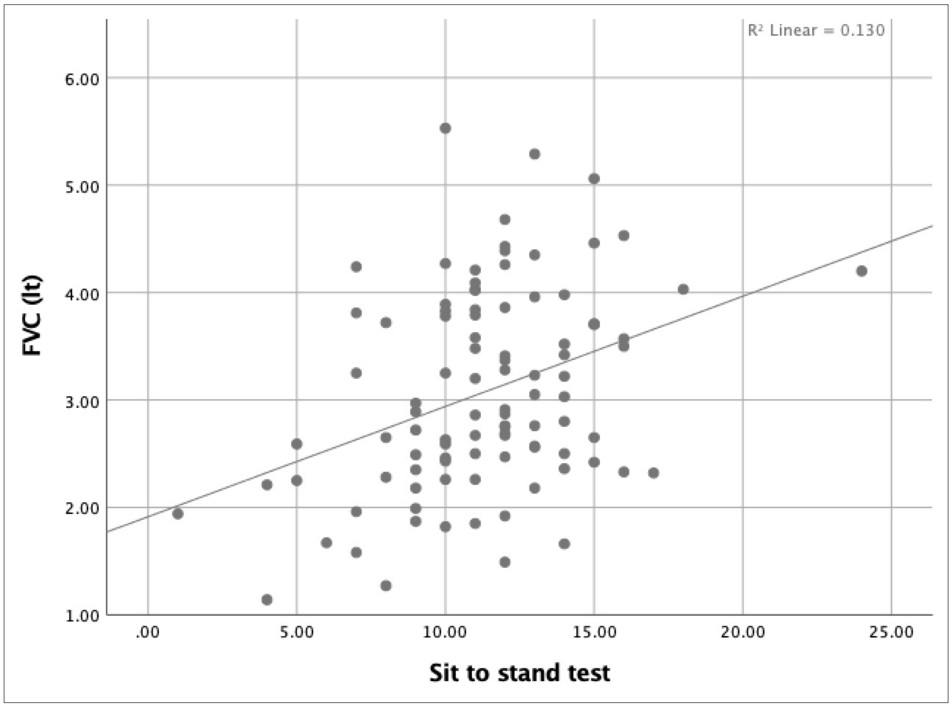

Figure 2: Correlation between FVC and sit-to-stand test

FVC: Forced Vital Capacity

ly) [Figs. 1, 2]. Higher levels of CRP and older age were negatively correlated with sit-to-stand test performance [Figs. 3, 4]. No correlations were found between the sit-to-stand test scores and gender, radiological severity score, other laboratory parameters, or additional pulmonary function test metrics (p>0.05) (Table 2).

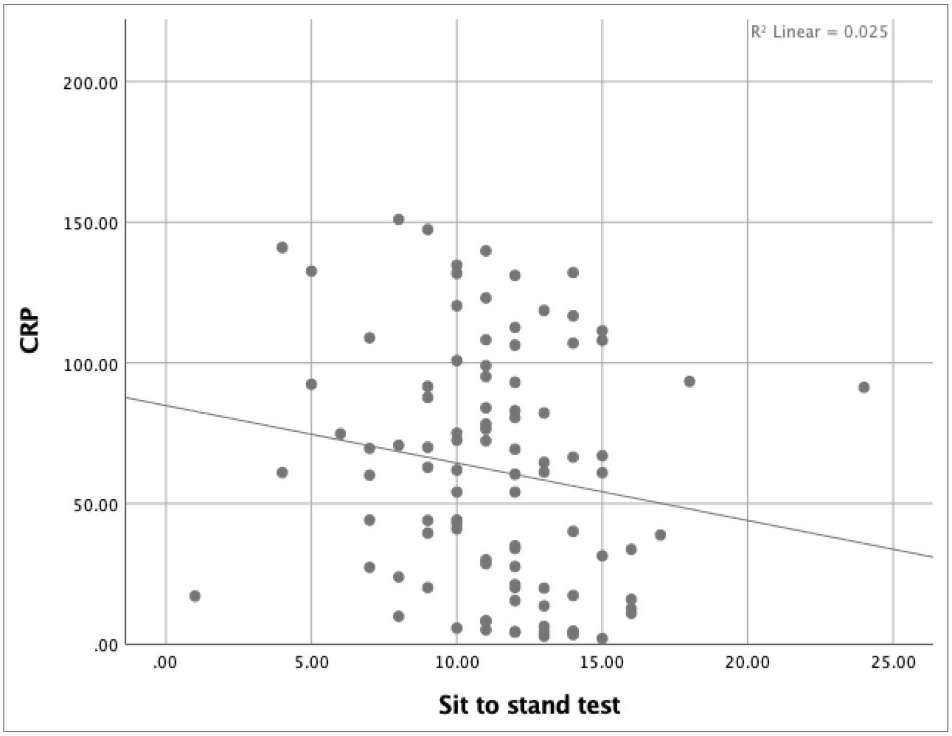

Figure 3: Correlation between CRP and sit-to-stand test

CRP: C-reactive protein

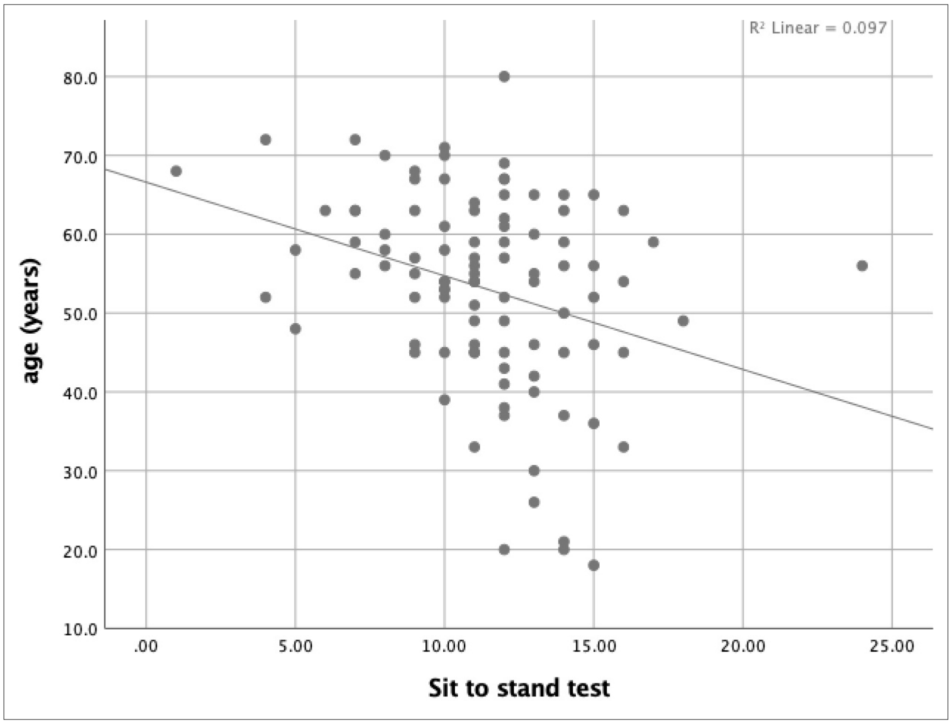

Figure 4: Correlation between age and sit-to-stand test

Additionally, for patients with lower radiologic severity scores, there was a negative correlation between CRP levels and the 1MSTS scores (r=-0.3, p=0.03), and between age and 1MSTS (r=-0.29, p=0.049). A positive correlation was also noted between FEV_1 and 1MSTS scores (r=0.32, p=0.02) (Table 3).

Table 2: Correlation between sit-to-stand test and other parameters

	r correlation coefficient	p
Radiological severity score	-0.02	0.78
Age (years)	**-0.32**	**0.001**
Laboratory parameters		
WBC count (cells/µL)	-0.008	0.93
Hemoglobin (g/dL)	0.10	0.30
Hematocrit (L/L)	0.10	0.32
Platelet	0.02	0.77
Neutrophil count (cells/mm^3)	-0.04	0.66
Neutrophil (%)	-0.13	0.19
Lymphocyte count (cells/mm^3)	0.19	0.06
Lymphocyte (%)	0.01	0.91
D-dimer (ng/mL)	-0.10	0.33
Troponin (ng/L)	-0.06	0.54
CRP (mg/L)	**-0.22**	**0.02**
Ferritin (ng/L)	0.03	0.73
Pulmonary function test		
FEV_1 (L)	**0.35**	**<0.001**
FEV_1 (%)	0.16	0.11
FVC (L)	**0.32**	**0.001**
FVC (%)	0.12	0.22
FEV_1/FVC ratio	0.06	0.50

WBC: White blood cell, CRP: C-reactive protein, FEV_1: Forced Expiratory Volume in the first second, FVC: Forced Vital Capacity

Table 3: Correlation analysis by radiological severity score

	r correlation coefficient	p
Radiological severity score		
≤6		
CRP	-0.3	**0.03**
Age	-0.36	0.08
FEV_1	0.36	0.08
FVC	0.37	0.06
>6		
CRP	-0.23	0.11
Age	-0.29	**0.049**
FEV_1	0.32	**0.02**
FVC	0.23	0.11

CRP: C-reactive protein, FEV_1: Forced Expiratory Volume in the first second, FVC: Forced Vital Capacity

Discussion

In our study conducted over one year, we explored the relationship between pulmonary functions, disease severity, and the 1MSTST among COVID-19 patients. We found that FEV_1 and FVC values were positively correlated with better performance on the sit-to-stand test. This suggests that the sit-to-stand test could serve as an alternative follow-up tool for patients with post-COVID syndrome who are unable to perform spirometric maneuvers, especially under pandemic conditions.

In our research examining the relationship between the sit-to-stand test and pulmonary function tests in post-COVID patients, we found a correlation similar to that observed in the 6MWT studies for COPD and other respiratory diseases.[10–12] This underscores the potential of functional performance tests to offer valuable insights into respiratory health and functional capacity. Both the 6MWT and the 1MSTST assess physical abilities; the 6MWT evaluates the distance walked over six minutes, reflecting cardiovascular and muscular endurance, while the 1MSTST measures sit-to-stand transitions in one minute, highlighting lower limb strength and mobility. These tests offer valuable insights into individuals' physical conditions and their capacity for daily activities. During the COVID-19 era, their advantages are particularly notable, including the ability to be conducted in non-clinical settings, cost-effectiveness, being radiation-free, and closely simulating real-world activities. Unlike more complex pulmonary function tests, the 6MWT and 1MSTST provide practical and comprehensive evaluations, crucial during the pandemic to minimize exposure and conserve resources.

Several studies have explored the connection between pulmonary function tests and outcomes of COVID-19 infection. One study demonstrated that non-critically ill patients showed no significant changes in pulmonary function, as measured by PFTs, before and after COVID-19 infection. However, this finding was nuanced by the suggestion that certain pre-existing lung conditions, such as interstitial lung disease and cystic fibrosis, might contribute to diminished lung function following infection.[13] Another study highlighted that a significant number of patients, including those with initially mild symptoms, exhibited compromised pulmonary function at a three-month follow-up. Notably, patients with residual CT lesions displayed significantly reduced pulmonary function.[2]

Consistent with these observations, our study demonstrated a link between pulmonary function tests and physical performance in individuals recovering from COVID-19. We specifically identified a correlation between PFT metrics (mainly FEV_1 and FVC) and the 1MSTST. These assessments provide valuable insights into respiratory health and functional ability. By evaluating physical performance, these tests offer a holistic assessment critical in the current pandemic context. They represent practical, cost-effective methods that reduce exposure and conserve resources. Notably, our research favored the 1MSTST over traditional PFTs due to its adaptability beyond clinical settings, cost-effectiveness, lack of radiation, and its reflection of real-world activities. This choice aligns with the evolving needs of the healthcare industry in the wake of COVID-19.

While other studies highlight the role of CT severity scores in indicating disease severity and progression in post-COVID-19 patients, our research did not find a significant correlation between CT severity scores and patients' health status.[14,15] Instead, our findings suggest CRP as a significant marker. This aligns with existing literature linking systemic inflammation, age-related changes, and physical capabilities.

Our findings also showed that better performance on the 1MSTST was associated with lower CRP levels and younger age. CRP, an inflammation marker, typically increases in response to infection or other health issues. We found CRP correlated with functional parameters in COVID-19 patients both during the acute phase and chronic phases.[16] The association between lower CRP levels and improved test performance suggests that reduced inflammation may enhance the ability to complete the test effectively. Moreover, a younger age correlated with better test results likely reflects the benefits of greater muscle strength, flexibility, and overall physical capacity. The literature indicates a clear independent association between respiratory failure and mortality rates in the youngest and oldest patient groups.[17] Additionally, it has been documented that individuals under 20 years of age, regardless of gender, experience lower rates of symptomatic long COVID-19 (2.8%).[18] Unlike respiratory function tests, which require multiple attempts to meet acceptable standards, a single trial of the 1MSTST is sufficient to assess functional capacity in COVID-19 patients.[19]

These findings are consistent with existing research that links systemic inflammation, age-related changes, and physical capabilities.[20] The sensitivity of the 1MSTST to these factors emphasizes its effectiveness in capturing the multifaceted aspects of recovery beyond simple pulmonary function measures. Our study significantly contributes to the discussion on post-COVID-19 assessment tools. Given the constraints of the pandemic, the 1MSTST stands out as a practical alternative to traditional methods such as pulmonary function tests and the 6MWT. Its simplicity, independence from PCR testing, and minimal spatial requirements make it suitable for various clinical settings, including primary care facilities.

Limitations

Our study's limitations include its retrospective and single-center design. The exclusion of patients with missing data and those unable to perform spirometric maneuvers and sit-to-stand tests (e.g., patients with orthopedic issues) may introduce selection bias. Additionally, the small sample size and the inclusion of only patients with follow-up data limit the generalizability of our findings.

Conclusion

Our research found that better pulmonary function parameters correlate with improved performance in the 1MSTST, highlighting its potential as an alternative tool for assessing post-COVID-19 recovery. Lower CRP levels and younger age are associated with better performance in the 1MSTST, emphasizing the influence of inflammatory and age-related factors. Our findings can assist physicians in evaluating and monitoring patients with post-COVID syndrome.

Ethics Committee Approval

The study was approved by the Tokat Gaziosmanpaşa University Clinical Research Ethics Committee (No: 83116987-584, Date: 22/09/2022).

Authorship Contributions

Concept – Ç.K.; Design – Ç.K., C.S.; Supervision – Ç.K., C.S., S.N.S.; Funding – Ç.K., S.A.; Materials – Ç.K., S.A.; Data collection &/or processing – Ç.K., S.A.; Analysis and/or interpretation – Ç.K., C.S., S.N.S.; Literature search – Ç.K., C.S.; Writing – Ç.K.; Critical review – S.N.S., C.S.

Conflicts of Interest

There are no conflicts of interest.

Use of AI for Writing Assistance

No AI technologies utilized.

Financial Support and Sponsorship

Nil.

Peer-review

Externally peer-reviewed.

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