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Pulmonary function and quality of life after COVID-19: A tertiary care study in India

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Abstract:
COVID-19 may cause persistent pulmonary abnormalities affecting respiratory function and daily activities after recovery. Therefore, it is of interest to assess the pulmonary function, exercise tolerance and quality of life among adults with previous COVID-19 attending a tertiary care centre. Participants underwent pulmonary function testing, six-minute walk testing and validated quality of life assessment. Patients with post-COVID-19 lung damage showed reduced pulmonary function, exercise capacity and quality-of-life scores compared with those having minimal residual lung involvement. Thus, data shows the persistent functional burden of post-COVID-19 lung damage and emphasize the need for structured follow-up and pulmonary rehabilitation.

Keywords: COVID-19, post-COVID syndrome, pulmonary function test, six-minute walk test, exercise tolerance, quality of life (QoL), pulmonary rehabilitation

Background:
Coronavirus disease 2019 (COVID-19), caused by SARS-CoV-2, can produce persistent respiratory symptoms and functional limitations beyond the acute infection **[1]**. Post-COVID-19 pulmonary abnormalities may include ground-glass opacities, interstitial changes and fibrotic lesions, contributing to prolonged respiratory impairment **[2]**. Residual lung damage can reduce lung volumes, impair gas exchange and diffusion capacity and consequently limit exercise tolerance **[3].** Pulmonary function tests (PFTs) and the six-minute walk test (6MWT) is useful for assessing persistent respiratory and functional impairment after COVID-19 **[4].** Patients with residual pulmonary abnormalities may experience reduced health-related quality of life and impaired physical functioning **[5]**. Pulmonary rehabilitation and structured follow-up may improve functional recovery and quality of life in patients with persistent post-COVID-19 respiratory impairment **[6]**. Therefore, it is of interest to evaluate the impact of post-COVID-19 lung damage on pulmonary function, exercise tolerance and quality of life among patients attending a tertiary care centre.

Materials and Methods:
This hospital based observational study was conducted in the Department of Physiology, Shyam Shah Medical College, Rewa, Madhya Pradesh, over a period of 18 months. Adult patients with a previous history of laboratory confirmed COVID-19 infection who attended the outpatient or follow-up services with persistent respiratory symptoms were enrolled consecutively after fulfilling the eligibility criteria. Demographic and clinical details were recorded for all participants. Residual post COVID-19 lung damage was assessed using high-resolution computed tomography (HRCT) of the chest. Pulmonary function was evaluated using standardized spirometry, exercise tolerance was assessed using the six-minute walk test (6MWT) and health-related quality of life was measured using a validated quality of life questionnaire. The collected clinical, radiological and functional parameters were analyzed to determine the impact of post-COVID-19 lung damage on pulmonary function, exercise tolerance and quality of life.

Inclusion criteria:
[1] Adults aged 18 years or older with previous RT-PCR or rapid antigen-confirmed COVID-19 infection
[2] Patients with persistent respiratory symptoms or radiological evidence of post-COVID-19 lung involvement at least 12 weeks after recovery
[3] Patients willing to participate and provide written informed consent

Exclusion criteria:
[1] Patients with pre-existing chronic respiratory diseases diagnosed before COVID-19 infection, such as chronic obstructive pulmonary disease, bronchial asthma, or interstitial lung disease
[2] Patients with severe cardiovascular, neurological, or musculoskeletal disorders that could interfere with pulmonary function testing or exercise assessment
[3] Patients unable to perform spirometry or the six-minute walk test reliably

Statistical analysis:
Statistical analysis was performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation, whereas categorical variables were presented as frequencies and percentages. Comparisons between study groups were performed using the independent t-test and Chi-square test, as appropriate. A p-value of <0.05 was considered statistically significant.

Results:
A total of 120 patients with a history of COVID-19 were included in the study to assess residual pulmonary damage, pulmonary function, exercise tolerance, and quality of life. The mean age of the participants was 52.8 ± 13.6 years, and males accounted for 72 (60%) patients, while females accounted for 48 (40%). The largest age group was 41–60 years, comprising 58 (48.3%) participants, followed by patients aged over 60 years (34; 28.4%) and those aged 18–40 years (28; 23.3%). Regarding the severity of previous COVID-19 infection, 56 (46.7%) patients had experienced moderate disease, 32 (26.7%) had mild disease, and 32 (26.6%) had severe disease. High-resolution computed tomography (HRCT) revealed residual lung damage in 68 (56.7%) patients, whereas 52 (43.3%) had no significant residual abnormalities. These findings indicate that residual radiological abnormalities were present in more than half of the study population during follow-up **(Table 1)**. Pulmonary function testing showed significant differences between patients with and without residual lung damage. The mean forced vital capacity

(FVC) was substantially lower in patients with lung damage (68.5 ± 10.9%) than in those without lung damage (84.7 ± 8.4%; p < 0.001). Similarly, the mean forced expiratory volume in one second (FEV_1) was lower in the lung damage group (70.2 ± 11.6%) compared with the group without residual damage (86.9 ± 9.2%; p < 0.001). These findings indicate reduced pulmonary function among patients with persistent radiological abnormalities. The FEV_1/FVC ratio was also lower in patients with lung damage (79.6 ± 5.3%) than in those without lung damage (82.1 ± 4.8%), with a statistically significant difference (p = 0.021). Furthermore, the mean diffusing capacity of the lungs for carbon monoxide (DLCO) was markedly reduced in patients with residual lung damage (61.8 ± 12.4%) compared with those without damage (81.6 ± 10.1%; p < 0.001). The reduction in DLCO suggests impaired pulmonary gas transfer, which may contribute to persistent breathlessness and reduced functional capacity following COVID-19 **(Table 2)**. Exercise tolerance was assessed using the six-minute walk test. Patients with residual lung damage achieved a mean walking distance of 342 ± 58 m, whereas patients without significant lung damage achieved 438 ± 49 m. This difference was statistically significant (p < 0.001), demonstrating reduced exercise capacity among patients with persistent pulmonary abnormalities. The shorter walking distance may reflect limitations in pulmonary gas exchange, ventilatory function, and overall physical performance. However, the six-minute walk distance alone cannot establish the specific mechanism responsible for exercise limitation **(Table 3)**. Quality-of-life assessment also revealed substantial differences between the two groups. Patients with residual lung damage had a mean quality-of-life score of 54.6 ± 11.2, compared with 76.9 ± 9.4 among those without significant lung damage (p < 0.001). As higher scores indicate better quality of life, these findings demonstrate poorer perceived well-being among patients with residual pulmonary involvement. The lower scores may reflect the combined effects of persistent respiratory symptoms, reduced physical endurance, and limitations in daily activities. Overall, the findings suggest that residual post-COVID-19 lung damage is associated with poorer pulmonary function, reduced exercise tolerance, and diminished quality of life **(Table 3)**. The distribution of pulmonary impairment further illustrated the clinical burden of persistent respiratory abnormalities. Mild pulmonary impairment was the most frequently observed category, whereas severe impairment occurred in a smaller proportion of patients **(Figure 1)**. In addition, nearly two-fifths of participants were reported to have poor quality of life, highlighting the potential long-term effects of post-COVID-19 respiratory sequelae on daily functioning and general well-being **(Figure 2)**.

Table 1: Demographic and clinical characteristics of the study participants

Variable		Frequency (n=120)	Percentage (%)
Age (years)	18–40	28	23.3%
	41–60	58	48.3%
	>60	34	28.4%
Gender	Male	72	60%
	Female	48	40%
Severity of previous COVID-19	Mild	32	26.7%
	Moderate	56	46.7%
	Severe	32	26.6%
Residual lung damage on HRCT	Present	68	56.7%
	Absent	52	43.3%

Table 2: Pulmonary function test findings according to lung damage

Parameter	Lung Damage Present (n=68)	Lung Damage Absent (n=52)	p-value
FVC (%)	68.5 ± 10.9	84.7 ± 8.4	<0.001
FEV_1 (%)	70.2 ± 11.6	86.9 ± 9.2	<0.001
FEV_1/FVC (%)	79.6 ± 5.3	82.1 ± 4.8	0.021
DLCO (%)	61.8 ± 12.4	81.6 ± 10.1	<0.001

Table 3: Exercise tolerance and quality of life

Variable	Lung Damage Present (n=68)	Lung Damage Absent (n=52)	p-value
Six-minute walk distance (m)	342 ± 58	438 ± 49	<0.001
Quality-of-life score	54.6 ± 11.2	76.9 ± 9.4	<0.001

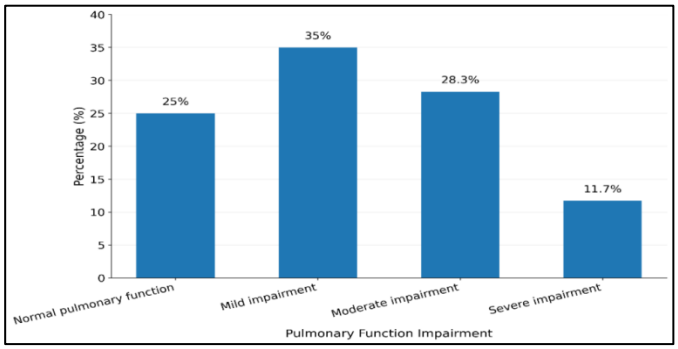


Figure 1: Distribution of pulmonary function impairment among study participants

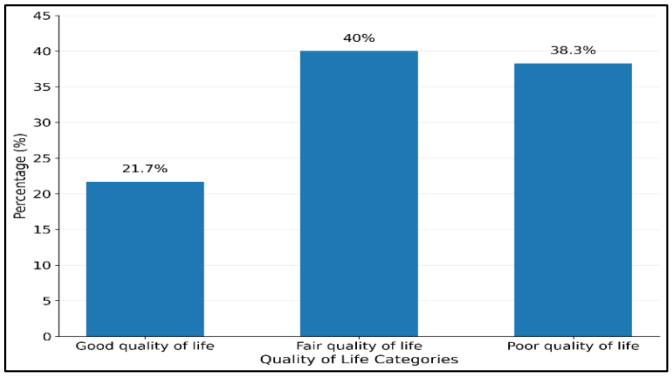


Figure 2: Distribution of quality of life categories among study participants

Discussion:

The present study demonstrated that post-COVID-19 lung damage was associated with impaired pulmonary function, reduced exercise tolerance and poorer quality of life. Patients with residual pulmonary involvement showed lower pulmonary function test parameters and shorter six-minute walk distances, indicating persistent respiratory dysfunction even after clinical recovery. Similar observations have been reported in previous studies, which described restrictive ventilatory defects and impaired diffusion capacity as common long-term sequelae

following moderate-to-severe COVID-19 infection **[7, 8].** Reduced exercise tolerance was another important finding of the present study. Patients with post-COVID-19 lung damage exhibited diminished functional capacity, which may be attributed to persistent pulmonary inflammation, impaired gas exchange and physical deconditioning following acute illness. Earlier investigations have also demonstrated significantly lower six-minute walk distances among COVID-19 survivors, particularly in those with residual radiological abnormalities, emphasizing the importance of functional assessment during follow-up **[9, 10].** The present study also found that persistent pulmonary abnormalities adversely affected health-related quality of life. Reduced physical performance and ongoing respiratory symptoms may limit daily activities and contribute to decreased overall well-being. Comparable findings have been reported in recent studies, where patients with residual pulmonary impairment experienced significantly poorer quality-of-life scores than those with complete recovery, highlighting the importance of multidisciplinary follow-up and pulmonary rehabilitation **[11, 12].** The findings of the present study indicate that residual pulmonary abnormalities following COVID-19 continue to influence respiratory function, physical performance and overall well-being even after apparent clinical recovery **[13, 14]**. These observations are consistent with recent literature and emphasize the importance of structured follow-up, comprehensive functional assessment and pulmonary rehabilitation to optimize long-term patient outcomes **[15, 16].**

Conclusion:

Post-COVID-19 lung damage is associated with persistent impairment in pulmonary function, exercise tolerance and quality of life despite clinical recovery. Routine assessment of respiratory function, exercise capacity and quality of life can facilitate early identification of persistent sequelae. Timely follow-up and pulmonary rehabilitation may improve long-term respiratory function, functional status and overall well-being.

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