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Original Research Article

Retrospective Analysis of Pulmonary Function Trends in Post-COVID Individual across Age Groups

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Abstract

Background: Coronavirus disease 2019 (COVID-19) primarily affects the respiratory system, and increasing evidence suggests that pulmonary dysfunction may persist even after clinical recovery. Assessment of post-COVID pulmonary function is essential to understand long-term respiratory sequelae, particularly across different age groups.

Objectives: To retrospectively analyze pulmonary function trends in post-COVID individuals across various age groups using spirometric parameters.

Materials and Methods: This retrospective observational study was conducted in the Department of Physiology, Sri Krishna Medical College and Hospital, Muzaffarpur, from September 2021 to April 2022. Pulmonary function test records of 100 post-COVID individuals aged ≥18 years were analyzed. Spirometric parameters including forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), and FEV_1/FVC ratio were recorded and compared across age groups.

Results: The study population showed a male predominance with a higher proportion of middle-aged and elderly individuals. Mean values of FVC and FEV_1 were reduced compared to predicted values, while the FEV_1/FVC ratio remained largely preserved. An age-wise decline in pulmonary function was observed, with elderly individuals demonstrating significantly lower lung volumes. The restrictive pattern of ventilatory impairment was the most common abnormality observed.

Conclusion: Persistent pulmonary function impairment is evident in post-COVID individuals, with greater involvement in older age groups. Routine pulmonary function testing and age-specific follow-up strategies are essential to identify residual lung dysfunction and improve long-term respiratory outcomes.

Keywords: COVID-19, Pulmonary function test, Spirometry, Post-COVID sequelae, Age-related lung impairment.

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Introduction

The coronavirus disease 2019 (COVID-19), caused by the severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), introduced and continues to exert unprecedented strains on global health systems since emerging in late 2019. COVID-19 is a multisystem disease; however, the respiratory system is the most severely impacted organ system [1]. The virus is predominate targeting the respiratory epithelium via angiotensin-converting enzyme-2 (ACE-2) receptors, resulting in varying degrees of pulmonary involvement, presenting as mild upper respiratory tract symptoms to severe manifestations such as viral pneumonia, atelectasis, acute respiratory distress syndrome (ARDS), and respiratory failure [2]. Even in the absence of acute respiratory distress syndrome (ARDS), COVID-19 phenomelogical studies have suggested that surviving patients continue to present with disabling respiratory symptoms and concern over long COVID syndrome. With the increasing number of patients recovering from COVID-19, health care providers' focus has shifted from acute management to evaluation of disease sequelae (post COVID syndrome) [3]. Pulmonary sequelae in COVID syndrome are of most concern given the the disease's direct effect on lung parenchyma. Reports describe and and objective exercise intolerance as well as symptoms such as dyspnea, cough, and chest tightness weeks to months after COVID-19 recovery [4]. The clinical manifestations may represent persistent structural

and functional changes within the lungs, even in patients that were asymptomatic or had a mild disease prior to the COVID-19 infection. Various imaging studies have shown residual ground-glass opacities, interstitial thickening, and fibrosis, possibly leading to long-term pulmonary function impairment [5].

Pulmonary function testing (PFT) is an unobtrusive, objective way to measure lung mechanics and functional ability after recovering from COVID-19. Forced Vital Capacity (FVC), forced expiratory volume (one second) (FEV_1), and FEV_1/FVC metrics yield scores that measure lung hyperinflation, and ventilation patterns [6]. Studies regarding post- COVID patients have shown that post-infectious outcomes frequently include some form of restrictive lung defect. Nevertheless, and despite similar lung volume and diffusion capacity, insufficient fractures to speak to the extent, and a variety of other post COVID effects. That phenomenon includes some of the poorer outcomes experienced during hospitalization among patients that are older. Age is a significant predictor of most poor outcomes during COVID-19 and as a result, post-infectious outcomes [7]. Age-related immune function decline, associated comorbidities, and a decreased physiological reserve all contribute to infection severity, length of hospitalization, and mortality. The elderly may have other pulmonary issues as well, since aging lungs are structurally different and worse-functioning: more elastic recoil, more chest wall compliance, and stronger respiratory muscles [8]. These factors contribute to the increased risk among the elderly of suffering prolonged pulmonary dysfunction. Post-infectious outcomes can include incomplete lung repair, which is a particular risk among older people.

The disease severity and speed of the clinical recovery of younger patients and middle age adults are in general better than older patients [9]. However, recent studies suggest there may be instances of COVID-19 related subclinical pulmonary deficits even in these younger age groups. Studies show patients who are asymptomatic, or have mild symptoms, and have clinically recovered from COVID-19 have decreased spirometric values indicating possible persistent lung dysfunction [10]. This highlights the importance of a thorough and systematic lung assessment in all age groups after COVID-19, and not solely after considering those who are older, or have more severe COVID-19 symptoms [11]. The evaluation of lung function in individuals post COVID-19 is crucial for identifying unrecognized lung deficits, and also for informing appropriate rehabilitation and management frameworks. The early identification of lung damage facilitates the initiation of interventions aimed at the lung such as pulmonary rehabilitation, breathing retraining, and the adoption of lifestyle changes, which may mitigate the risk of developing a chronic respiratory disease [12]. Additionally, chronic respiratory disease interventions may be necessary in order to determine a person's ability to perform high physical demands at work or to improve the overall quality of life.

Materials and Methods

Study Design: The present study was a retrospective observational study conducted to evaluate pulmonary function trends in individuals who had recovered from COVID-19 infection. The retrospective design allowed analysis of existing clinical and pulmonary function records collected during routine post-COVID evaluation.

Study Setting: The study was carried out in the Department of Physiology, Sri Krishna Medical College and Hospital (SKMCH), Muzaffarpur, a tertiary care teaching hospital catering to a large and diverse patient population.

Study Duration: The study covered a period of eight months, from September 2021 to April 2022, during which pulmonary function testing of post-COVID individuals was routinely performed.

Study Population and Sample Size: The study population comprised post-COVID individuals who had undergone pulmonary function testing at the Department of Physiology during the study period. A total of 100 participants with complete and eligible records were included in the final analysis.

Inclusion Criteria

Individuals were included in the study if they met the following criteria:

- Age 18 years and above
- Documented confirmation of COVID-19 infection by RT-PCR or rapid antigen test
- Clinical recovery from COVID-19 with completion of isolation period
- Availability of complete pulmonary function test records

Exclusion Criteria

Participants were excluded from the study if they had:

- A history of pre-existing respiratory diseases such as asthma, chronic obstructive pulmonary disease, or interstitial lung disease
- Smoking history, as smoking can independently affect pulmonary function
- Incomplete or missing clinical or spirometry records

Data Collection: Relevant data were collected retrospectively from hospital records, pulmonary function test registers, and patient case files. The collected variables included demographic details

such as age and sex, clinical history related to COVID-19 infection and recovery, and pulmonary function parameters recorded during spirometry testing.

Pulmonary Function Testing: Pulmonary function testing was performed using standard spirometry equipment following American Thoracic Society (ATS) guidelines.

Each participant performed at least three acceptable and reproducible maneuvers, and the best values were recorded. The spirometric parameters analyzed included forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), and FEV_1/FVC ratio. Values were expressed as percentages of predicted normal values.

Statistical Analysis: The collected data were entered into Microsoft Excel and analyzed using appropriate statistical software. Continuous variables were expressed as mean ± standard deviation. Comparative analysis of pulmonary function parameters across different age groups was performed using suitable statistical tests. A p-value <0.05 was considered statistically significant.

Results

Demographic Characteristics

Table 1: Age and Sex Distribution of Study Participants (n = 100)

Age Group (years)	Male (n)	Female (n)	Total (n)	Percentage (%)
18–30	10	8	18	18%
31–45	18	14	32	32%
46–60	20	12	32	32%
>60	12	6	18	18%
Total	**60**	**40**	**100**	**100%**

The study encompassed 100 individuals post-COVID. There was a male predominance at 60% compared to 40% females.

Most participants were in the middle-aged categories 31-45 years and 46-60 years which accounted for 32% of the total sample each. Younger adults (18-30 years) and older adults (>60 years) accounted for 18% each. This distribution illustrates the increased post-COVID period utilization of healthcare and subsequent retention in the middle-aged demographic. The representation of all adult age brackets afforded valuable inter-age comparisons in the pulmonary function data.

Pulmonary Function Parameters

Table 2: Mean Pulmonary Function Parameters of Study Participants

Parameter	Mean ± SD	% Predicted (Mean)
FVC (L)	2.82 ± 0.61	78%
FEV_1 (L)	2.36 ± 0.52	80%
FEV_1/FVC (%)	83.6 ± 5.4	—

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Age-wise Comparison of Pulmonary Function

Table 3: Age-wise Distribution of Pulmonary Function Parameters

Age Group (years)	FVC (% predicted)	FEV_1 (% predicted)	FEV_1/FVC (%)
18–30	88 ± 6	90 ± 5	84.2 ± 4.8
31–45	82 ± 7	84 ± 6	83.7 ± 5.1
46–60	75 ± 8	77 ± 7	83.1 ± 5.6
>60	68 ± 9	70 ± 8	82.4 ± 6.0

An observable decrease in pulmonary function is age related. Spirometric values in younger people (18-30 years) showed almost no abnormal values, while there was a further decrease in FVC (forced vital capacity) and FEV_1 (forced expiratory volume in 1 second) with age. In the elderly (over sixty years) the decline in lung volumes was the most severe. FEV_1 and FVC were still preserved in all groups despite the reductions. Aging positively correlated with lung recovery after COVID, with older individuals sustaining greater lung damage.

Pattern of Pulmonary Impairment

Table 4: Pattern of Pulmonary Function Abnormalities

Pattern of Impairment	Number of Participants	Percentage (%)
Normal	38	38%
Restrictive	52	52%
Obstructive	6	6%
Mixed	4	4%
Total	**100**	**100%**

The most frequently noted abnormality was the restrictive pattern of pulmonary impairment, which was noted in over half of the participants (52%). Pulmonary function was normal in 38% of the subjects, most of whom were in the younger age categories. Obstructive and mixed patterns were seen in only 10% of the cases, which is a relatively small number. The majority of restrictive defects strengthens the assertion that the involvement of the lungs post-COVID primarily relates to the parenchyma and the compliance of the lungs and not the airways, which may be attributed to residual inflammation and/or fibrotic changes.

Discussion

Principal Findings: The current retrospective study investigates the trends of pulmonary functions in individuals with post COVID across different age groups and persistent respiratory impairment post recovery from COVID-19. The study highlighted the significant lung volume reductions indicated by decreases in FVC and FEV_1 with aging. Younger individuals had almost normal values for the spirometry.

The older age groups particularly those above 60 had significantly lower levels of pulmonary function. Another notable finding is the FEV_1/FVC ratio that most participants had.

This suggests a primarily restrictive ventilatory pattern, as opposed to obstructive airway disease. The post COVID involvement of lungs appears to be primarily on the lung parenchyma and compliance with age as a significant factor to consider on the residual pulmonary impairment.

Comparison with Existing Literature: Because of the relevance of the current research to the prior research demonstrating ongoing pulmonary function impairment in post-COVID-19 patients, it can be examined. While analyzing this research, there have been many studies that indicate a decrease in lung volumes, more specifically FVC and FEV_1, during follow-up evaluations which suggest a restrictive defect pattern. For example, during the course of the [13] research, post discharge recovered COVID-19 patients had their pulmonary functions, more specifically diffusion capacity and lung volumes, reduced at the three month mark of that study, while the elderly population had increased deficits. Likewise, post-COVID patients had persistent restrictive changes and a decline in exercise ability, leading to the inability to fully recover the pulmonary system, even after the clinical infection had been resolved, [14] studied this same phenomenon. This phenomenon of having less pulmonary recovery being age-related has been pointed out in many studies. For example, in a study conducted by [15] during their investigations of a larger cohort, it was discovered that older patients presented more severe long term respiratory sequelae in comparison to younger patients; this finding was line with the age-wise decline in the current study. Despite the fact that there have been studies that have described obstructive or mixed ventilatory patterns, it is important to note that in the current study there is no history of lung disease or a history of smoking, and, therefore, the restrictive impairment is in fact in alignment with the literature that demonstrates, post-COVID pulmonary dysfunction, is directed towards the parenchyma of the lung rather than the other structures of the airway.

Pathophysiological Explanation: The underlying pathophysiological mechanisms that explain the persistent pulmonary dysfunction in individual post-COVID cases may be due to more than one alteration. Infection by the SARS-CoV-2 virus causes diffuse damage to the alveoli, injury to endothelium, microvascular thrombosis, and the presence of acute inflammation and inflammatory cells in the lung parenchyma.

Persistent inflammation and abnormal scarring of the lung may cause thickening of interstitial tissues and fibration of lung tissues, which in turn may lead to decreased pulmonary compliance and volumes. The age-related decline of the immune system and of the cell renewal systems strongly compounds these phenomena in the elderly. All these mechanisms explain the obstructive ventilatory defects found in the pulmonary function tests in post-COVID patients.

Clinical Implications: It is of great importance, clinically, that pulmonary function impairment after recovery from COVID-19 persists. Systematic evaluation of pulmonary function post COVID-19, especially in older individuals, can help detect lung

dysfunction that may be present but not readily apparent. The purpose of early detection is to allow the commencement of pulmonary rehabilitation, respiratory physiotherapy, and respiratory improvement exercises to potentially enhance lung function and improve the quality of life for the individual. The results of this study highlight the importance of developing post COVID rehabilitation programs and tailored strategies to manage individual in order to avert chronic and long standing issues affecting the respiratory system.

Conclusion

The current retrospective study affirms that pulmonary function abnormalities persist even post recovery from the infection with COVID-19. Evaluation of spirometry parameters show the presence of pulmonary deficits as evidenced by the absence of lung volumes, more specifically the forced vital capacity (FVC) and the forced expiratory volume (FEV_1). Even after the clinical recovery, there still is pulmonary deficiency. The predominance of restrictive patterns of ventilation suggests the involvement of lung parenchyma, as there is no obstruction of the airways in post COVID individuals. An interesting aspect of the study is the functional pulmonary parameter decline in relation to the age of the assessed post COVID individuals. The younger individuals presented with comparatively better and more preserved spirometric parameters, whereas with the older populations, there was a significant loss of lung volumes, and especially with the cohort older than 60 years of age, there was a significant loss of lung volumes. This variability with age is a predictor of loss of post COVID respiratory sequelae, of which the older individuals are more susceptible and significant loss of lung volumes more specifically, the vital capacity and forced expiratory volume in one second (FEV_1). There remains an absence of lung volumes, pulmonary deficits, Even after clinical recovery, There still is pulmonary deficiency. From a clinical standpoint, the lungs of post COVID individuals need to be assessed more so than the other age groups that are older, specifically the older individuals. This provides the lung function and will identify any deficits that remain. Once this is complete, the pulmonary rehabilitation can be instituted along with follow up care so that the respiratory function and overall quality of life can be improved. There is a need for age specific post COVID management and the study provides sufficient information for the clinical practice of respiratory post COVID care as well as for research.

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