International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

To Study the Pulmonary Function Changes in Post COVID-19 Discharged Patients and their Correlation with Disease Severity

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Abstract: ***The study aimed to assess pulmonary function changes in post COVID-19 discharged patients and their correlation with disease severity. A single-center, hospital based, observational, cross-sectional study was conducted on ICMR laboratory-confirmed non-critical COVID-19 cases. The study assessed pulmonary function using EasyOneR Air with TrueFlowTM technology at one-month and three-month intervals after clinical recovery. Results are showed that moderate and severe cases had significant pulmonary function impairments. Notably, 43.8 of mild cases and 68.8 of moderate cases demonstrated improved outcomes. The study highlights the importance of monitoring pulmonary function in post-COVID–19 patients for appropriate management and rehabilitation.***

Keywords: Pulmonary Function, COVID-19, EasyOneR, TrueFlowTM

1. Introduction

The COVID-19 pandemic has exploded since cases were first reported in China on December 2019.

Coronavirus disease 2019 (COVID-19), which is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), was first reported in December 2019 in China, quickly spread to countries across five continents, and was declared a pandemic by the World Health Organization (WHO) on March 11, 2020.

The symptoms of COVID-19 range from mild flu-like symptoms to respiratory system failure. The epidemiology of the infection indicates that the majority of patients develop milder forms of the disease, while 14% of those infected have a severe form, and a smaller percentage (5%) become critically ill [2]. Among patients who have required hospitalization, 14.2% required care in the intensive care unit and 12.2% received mechanical ventilation, and the mortality in this group was approximately 24.5% [3]. Pulmonary manifestations are the most common due to the route of entry of the virus, which uses angiotensin-converting enzyme 2 receptors present in type 2 pneumocytes, leading to a subsequent inflammatory response [4].

The demographic profile and risk factors for COVID-19 show a wide spectrum around the world, and the factors responsible for the occurrence of different clinical forms and variability of symptoms are not yet understood. Moreover, health issues that persist for more than four weeks after COVID-19 infection, known as post-COVID conditions, are still not well understood, and present a major challenge to health systems worldwide given the high number of individuals affected by the disease and who recover after varying periods of hospitalization [5].

To date, few studies have evaluated the clinical evolution and the occurrence of structural and functional post-COVID conditions in the lungs of individuals who survive the severe form of the disease, mainly because it is a new and recent disease. Initial studies described possible long-term complications of COVID-19 including cardiovascular, pulmonary, metabolic, and neuropsychiatric sequelae based on data from the severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS) epidemics[6]. Recent publications have described the persistence of symptoms, especially fatigue and dyspnea, approximately two months after the onset of symptoms, associated with a decrease in patients' quality of life [7, 8], as well as altered respiratory function after discharge [9, 10].

Its transmission occur primarily through respiratory secretions, and, to a lesser extent, contact with contaminated surfaces. Most transmission occur through droplets; covering coughs and sneezes and maintaining a distance of six feet from others can reduce the risk of transmission.

Clinical Presentation The estimated Incubation period for COVID-19 is up to 14 days from the time of exposure with a median I. P of 4 to 5 days. The spectrum of illness ranges from asymptoatic infection to severe pneumonia with ARDS and death. Disease was categorised in to-

1) Mild-No pneumonia, mild illness defined by variety of signs and symptoms (eg; fever, cough, sore throat, malaise, headache, muscle pain) without shortness of breath, dyspnoea on exertion or abnormal imaging, respiratory rate < 24, Spo2 > 94%, No evidence of hypoxemia
2) Moderate having symptoms and radiographic evidence of pneumonia with no requirements of supplemental oxygen, spo2 > 94%.
3) Severe-Having pneumonia including one of the following RR > 30 breath/min, severe respiratory distress, Spo2 < 94 % measured by pulse oximeter, Pao2/Fio2 < 300 or lung infiltrates > 50%.
4) Critical cases-Respiratory failure requiring mechanical ventilation, septic shock, other organ failure requiring ICU admission.

A recent report portrayed that discharged patients with COVID-19 pneumonia still have residual abnormalities in chest CT scans with ground glass opacity as the most common pattern. Persistent impairments of pulmonary function and exercise capacity have been known to last for months OR even years in the recovered survivors.

It's worth noting that evidence about pulmonary function tests among COVID-19 patients is currently showing that 6 week respiratory rehabilitation can improve respiratory function, quality of life and anxiety of older patients. Until now, there is only a few reports in regard to pulmonary function in discharged COVID-19 survivors.

When a patient with the corona virus he is declared negative, the symptoms during COVID-19 infection do not immediately disappear, the symptoms can even continue for months.

More than 50 % people who have been infected with COVID-19 will feel persistent symptoms after COVID-19 such as chronic fatigue shortness of breath, chest pain, and decreased sensitivity to smell.

Persistent symptoms due to inflammation and post acute COVID-19 organ damage that can continue for months are referred to as post COVID-19 syndrome or long COVID.

Approximately 50 to 70 % of patients hospitalized express some symptoms of COVID-19 for up to 3 months after completing treatment and being discharged from the hospital (Morenzo-Perez et al., 2021).

This persistent symptoms that are well do not disappear immediately, but can be relieved by various exercises. Various researchers have conducted research on actions that can be taken during the rehabilitation period to reduce the symptoms so long. WHO states that there are many actions that can be taken do in the post Covid rehabilitation process including breathing exercises and physical exercise after discharge from the hospital (WHO Europe, 2020).

Therefore, we aimed at assessing respiratory functions in three intervals, in one month gap for three months after clinical recovery and discharge from hospital. This study aims to describe the characteristics of pulmonary function changes in these subjects.

Post-Acute Coronavirus (COVID-19) Syndrome

Coronavirus disease 2019 (COVID-19), the viral illness caused by the novel coronavirus SARS-CoV-2 has resulted in significant morbidity and mortality across the world since the first cases were identified in Wuhan China, in December 2019. Although the majority of the patients who contract COVID-19 are asymptomatic or have mild to moderate disease, approximately 5% to 8% of infected patients develop hypoxia, bilateral lung infiltrates, decreased lung compliance requiring non-invasive ventilation (NIV) or mechanical ventilatory support.1[1] The management of COVID-19 infection is mainly supportive. Although many therapeutics such as antiviral drugs (remdesevir), monoclonal antibodies (e. g., bamlanivimab/etesevimab, casirivimab/imdevimab), anti-inflammatory drugs (e. g., dexamethasone), immunomodulatory agents (e. g., baricitinib, tocilizumab) is available under emergency use authorization (EUA) for the management of COVID-19, the utility of these treatments varies based on the timing and severity of illness and/or certain risk factors.[12]

Post-acute COVID-19 is a syndrome characterized by the persistence of clinical symptoms beyond four weeks from the onset of acute symptoms. The Center for Disease Control (CDC) has formulated "post-Covid conditions" to describe health issues that persist more than four weeks after being infected with COVID-19. These include

- Long Covid (which consists of a wide range of symptoms that can last weeks to months) or persistent post-Covid syndrome (PPCS)
- Multiorgan effects of COVID-19
- Effects of COVID-19 treatment/hospitalization

Pulmonary Manifestations

- Dyspnea, cough, oxygen dependence, difficulty to wean from mechanical ventilation or NIV, fibrotic lung changes, decreased diffusion capacity, and reduced endurance are the common pulmonary sequelae seen in patients with post-acute COVID-19 syndrome.
- Dyspnea is the predominant pulmonary symptom (40% to 50% prevalence at 100 days) in post-acute COVID-19. At a 6-month follow-up, the average 6-minute walking distance was significantly lower than the standard reference because of shortness of breath. About 6% of patients continue to require supplemental oxygen at 60-day follow-up.

2. Aim and Objectives

Aim

This study aims to assess pulmonary function changes in post C9VID-19 discharged patients using the EasyOne[R] Air utilizing TrueFlow[TM] technology at one month and three-month intervals after clinical recovery. The research also intends to correlate these changes with the severity of the disease, providing valuable insights into the long-term impact of COVID-19 on lung health.

Objectives

1) To study the the influence of corona virus disease 2019 on pulmonary function changes in post covid-19 discharged patients
2) To assess respiratory function in two intervals at the time of one month and three months after clinical recovery and discharge from the hospital.
3) To study its relation with severity of the disease.
4) To study the progression respiratory function changes associated with COVID-19, whether changes persisting or improving.

3. Materials and Methods

Study Design: A single centre, hospital based, observational, cross sectional study.

Study site: Department of Respiratory Medicine, Indraprastha Apollo hospitals, New Delhi, both indoor and OPD patients

Inclusion criteria

1) Patients with ICMR laboratory confirmed RT-PCR/ Geneexpert positive non critical COVID-19 cases.
2) All participants were categorised as mild illness (mild clinical symptoms without pneumonia manifestations in imaging), moderate (having symptoms and pneumonia manifestations in imaging, with no requirement for supplemental oxygen); and severe (having radiographic evidence of pneumonia, meeting any of the following: respiratory rate > 30/min; oxygen saturation < 93% at a rest rate; severe respiratory distress; > 50% lesions progression within 24 to 48 hrs in lung imaging).
3) Patients Guardians given informed written consent for the same.

Exclusion criteria

1) Critical cases
2) Patient unable to perform breathe holding or diffusion capacity testing
3) Patients/ guardians refusing consent
4) Patients who had previous history of chronic lung diseases like-Asthma/COPD, any restrictive lung diseases like lung fibrosis.

Sample size calculation

The sample size of the observational study was the number of patients they were receiving in their study who are presenting to their hospital, indraprastha Apollo hospital, during the time period from 25th of august 2020 to 25th of June 2021.

Statistical Analysis:

This observational, cross-sectional study was conducted at the department of respiratory medicine Indraprastha Apollo Hospitals, New Delhi, on ICMR laboratory-confirmed non-critical COVID-19 cases. Participants were categorised into mild, moderate, and severe clinical types based on clinical and radio graphic evidence. Pulmonary function tests work performed using the EasyOneR Air with TrueFlowTM technology at one-month and three-month intervals after clinical recovery. Statistical analysis involved Microsoft Excel and SPSS version 27.0, with descriptive statistics and chi-square tests for categorical variables. A p-value 0.05 was considered statistically significant.

4. Result and Analysis

Table: Distribution of Clinical Types

In our study, 16 (20.0%) patients were Mild Clinical Types, 50 (62.5%) patients were Moderate Clinical Types and 14 (17.5%) patients were Severe Clinical Types.

Distribution of mean FEV1 (% of_predicted)-x: Clinical Types

In MildClinical Types, the mean FEV1 (% of predicted)-x (mean± s. d.) of patients was 62.7500± 6.1482.
In Moderate Clinical Types, the mean FEV1 (% of predicted)-x (mean± s. d.) of patients was 71.1600 ± 8.1800.
In SevereClinical Types, the mean FEV1 (% of predicted)-x (mean± s. d.) of patients was 57.0000 ± 10.3775.
Difference of mean FEV1 (% of predicted)-x with three Clinical Types was statistically significant (p<0.0001).

Distribution of mean FEV1 (%of of predicted)-y: Clinical Types

In MildClinical Types, the mean FEV1 (%of of predicted)-y (mean± s. d.) of patients was 85.2500 ± 26.6421.
In Moderate Clinical Types, the mean FEV1 (%of of predicted)-y (mean± s. d.) of patients was 75.5400 ± 3.0184.

In SevereClinical Types, the mean FEV1 (%of of predicted)-y (mean± s. d.) of patients was 65.0000 ± 11.4152.
Difference of mean FEV1 (%of of predicted)-y with three Clinical Types was statistically significant (p=0.0003).

Distribution of mean FVC (% of predicted)-x: Clinical Types

In MildClinical Types, the mean FVC (% of predicted)-x (mean± s. d.) of patients was 58.2500 ± 2.0494.
In Moderate Clinical Types, the mean FVC (% of predicted)-x (mean± s. d.) of patients was 67.4200 ± 9.6110.
In SevereClinical Types, the mean FVC (% of predicted)-x (mean± s. d.) of patients was 47.0000 ± 6.2265.
Difference of mean FVC (% of predicted)-x with three Clinical Types was statistically significant (p<0.0001).

Distribution of mean FVC (% of predicted)-y: Clinical Types

In MildClinical Types, the mean FVC (% of predicted)-y (mean± s. d.) of patients was 80.7500 ± 22.5433.
In Moderate Clinical Types, the mean FVC (% of predicted)-y (mean± s. d.) of patients was 74.2400 ± 7.3694.
In SevereClinical Types, the mean FVC (% of predicted)-y (mean± s. d.) of patients was 56.5000 ± 11.9341.
Difference of mean FVC (% of predicted)-y with three Clinical Types was statistically significant (p<0.0001).

Distribution of mean FEV1/FVC-x: Clinical Types

In MildClinical Types, the mean FEV1/FVC-x (mean± s. d.) of patients was 83.9313 ± 4.7648.
In Moderate Clinical Types, the mean FEV1/FVC-x (mean± s. d.) of patients was 102.4200 ± 10.9621.
In SevereClinical Types, the mean FEV1/FVC-x (mean± s. d.) of patients was 104.3500 ± 12.0898.
Difference of mean FEV1/FVC-x with three Clinical Types was statistically significant (p<0.0001).

Distribution of mean FEV1/FVC-y: Clinical Types

In MildClinical Types, the mean FEV1/FVC-y (mean± s. d.) of patients was 79.5875 ±.7173.
In Moderate Clinical Types, the mean FEV1/FVC-y (mean± s. d.) of patients was 102.9600 ± 11.6092.
In SevereClinical Types, the mean FEV1/FVC-y (mean± s. d.) of patients was 96.0000 ± 14.5285.
Difference of mean FEV1/FVC-y with three Clinical Types was statistically significant (p<0.0001

Distribution of mean DLCO-x: Clinical Types

In Mild Clinical Types, the mean DLCO-x (mean± s. d.) of patients was 53.2500 ± 2.0494.
In Moderate Clinical Types, the mean DLCO-x (mean± s. d.) of patients was 56.4000 ± 10.2877.
In SevereClinical Types, the mean DLCO-x (mean± s. d.) of patients was 26.0000 ± 4.1510.
Difference of mean DLCO-x with three Clinical Types was statistically significant (p<0.0001

Distribution of mean DLCO-y: Clinical Types

In MildClinical Types, the mean DLCO-y (mean± s. d.) of patients was 56.3750 ± 3.0741.

In Moderate Clinical Types, the mean DLCO-y (mean± s. d.) of patients was 61.0400 ± 11.7716.

In SevereClinical Types, the mean DLCO-y (mean± s. d.) of patients was 33.5000 ± 2.5944.

Difference of mean DLCO-y with three Clinical Types was statistically significant (p<0.0001).

of mean DLCO/Va-y with three Clinical Types was statistically significant (p<0.0001).

Distribution of mean TLC-x: Clinical Types

In MildClinical Types, the mean TLC-x (mean± s. d.) of patients was 70.7500 ± 14.3457.

In Moderate Clinical Types, the mean TLC-x (mean± s. d.) of patients was 70.6400 ± 14.2195.

In SevereClinical Types, the mean TLC-x (mean± s. d.) of patients was 38.0000 ± 9.3397.

Difference of mean TLC-x with three Clinical Types was statistically significant (p<0.0001).

Distribution of mean TLC-y: Clinical Types

In MildClinical Types, the mean TLC-y (mean± s. d.) of patients was 77.1875 ± 30.2285.

In Moderate Clinical Types, the mean TLC-y (mean± s. d.) of patients was 75.2800 ± 14.7787.

In SevereClinical Types, the mean TLC-y (mean± s. d.) of patients was 49.5000 ± 11.9341.

Difference of mean TLC-y with three Clinical Types was statistically significant (p<0.0001).

Table: Distribution of mean of all parameters

	Number	Mean	SD	Minimum	Maximum	Median
BMI (kg/m2)	80	24.4750	3.9399	20.4000	32.2000	22.1000
DLCO-x	80	50.4500	14.1143	22.0000	71.0000	53.0000
DLCO/Va-x	80	88.4500	19.7169	46.0000	112.0000	88.0000
TLC-x	80	64.9500	18.2991	29.0000	85.0000	69.0000
RV/TLC-x	80	100.8875	33.8758	57.0000	157.0000	98.0000
FEV1 (% ofpredicted)-x	80	67.0000	9.9365	47.0000	85.0000	68.0000
FVC (% of predicted)-x	80	62.0125	11.2154	41.0000	79.0000	64.0000
FEV1/FVC-x	80	99.0600	12.7026	78.7000	116.0000	93.0000
DLCO-y	80	55.2875	13.9340	31.0000	74.0000	59.0000
DLCO/Va-y	80	91.9000	22.8377	41.0000	118.0000	91.0000
TLC-y	80	71.1500	20.8242	38.0000	103.0000	74.0000
RV/TLC-y	80	92.1250	23.7995	51.0000	134.0000	84.0000
FEV1 (%of of predicted)-y	80	75.6375	14.1647	54.0000	108.0000	75.0000
FVC (% of predicted)-y	80	72.4375	14.6519	45.0000	100.0000	72.0000
FEV1/FVC-y	80	97.0675	14.2298	78.8000	117.0000	90.0000

In above table showed that the mean BMI (kg/m2) (mean± s. d.) of patients was 24.4750± 3.9399.

In above table showed that the mean DLCO-x (mean± s. d.) of patients was 50.4500± 14.1143.

In above table showed that the mean DLCO/Va-x (mean± s. d.) of patients was 88.4500± 19.7169.

In above table showed that the mean TLC-x (mean± s. d.) of patients was 64.9500± 18.2991.

In above table showed that the mean RV/TLC-x (mean± s. d.) of patients was 100.8875± 33.8758.

In above table showed that the mean FEV1 (% of predicted)-x (mean± s. d.) of patients was 67.0000± 9.9365.

In above table showed that the mean FVC (% of predicted)-x (mean± s. d.) of patients was 62.0125± 11.2154.

In above table showed that the mean FEV1/FVC-x (mean± s. d.) of patients was 99.0600± 12.7026.

In above table showed that the mean DLCO-y (mean± s. d.) of patients was 55.2875± 13.9340.

In above table showed that the mean DLCO/Va-y (mean± s. d.) of patients was 91.9000± 22.8377.

In above table showed that the mean TLC-y (mean± s. d.) of patients was 71.1500± 20.8242.

In above table showed that the mean RV/TLC-y (mean± s. d.) of patients was 92.1250± 23.7995.

In above table showed that the mean FEV1 (%of of predicted)-y (mean± s. d.) of patients was 75.6375± 14.1647.

In above table showed that the mean FVC (% of predicted)-y (mean± s. d.) of patients was 72.4375± 14.6519.

In above table showed that the mean FEV1/FVC-y (mean± s. d.) of patients was 97.0675± 14.2298. 0.0001).

Association between PFT Interpretation-x: Clinical Types

In MildClinical Types, 9 (56.3%) patients had Restrictive lung disorder with mild diffusion restriction and 7 (43.8%) patients had Restrictive lung disorder with moderate diffusion restriction.

In Moderate Clinical Types, 16 (32.0%) patients had Restrictive lung disorder with mild diffusion restriction and 34 (68.0%) patients had Restrictive lung disorder with moderate diffusion restriction.

In SevereClinical Types, 7 (50.0%) patients had Restrictive lung disorder with moderate diffusion restriction and 7 (50.0%) patients had Restrictive lung disorder with severe diffusion restriction.

Association of PFT Interpretation-x vs Clinical Types was statistically significant (p<0.0001).

Chi-square value: 42.0548; **p-value:** <0.0001.

Association between PFT Interpretation-y: Clinical Types

In Mild Clinical Types, 9 (56.3%) patients had Mild diffusion restriction at PFT Interpretation-y and 7 (43.8%)

patients had Restrictive lung disorder with moderate diffusion restriction at PFT Interpretation-y.

In Moderate Clinical Types, 34 (68.0%) patients had Restrictive lung disorder with mild diffusion restriction at PFT Interpretation-y and 16 (32.0%) patients had Restrictive lung disorder with moderate diffusion restriction at PFT Interpretation-y.

In Severe Clinical Types, 7 (50.0%) patients had Restrictive lung disorder with moderate diffusion restriction at PFT Interpretation-y and 7 (50.0%) patients had Restrictive lung disorder with severe diffusion restriction at PFT Interpretation-y.

Association of PFT Interpretation-y vs Clinical Types was statistically significant ($p<0.0001$).

Chi-square value: 90.5533; **p-value:** <0.0001

Table: Association between Outcome: Clinical Types
In MildClinical Types, 9 (56.3%) patients had Improved in Outcome and 7 (43.8%) patients had No significant change in Outcome.

In Moderate Clinical Types, 34 (68.0%) patients had Improved in Outcome and 16 (32.0%) patients had No significant change in Outcome.

In SevereClinical Types, 14 (100.0%) patients had No significant change in Outcome.

Association of Outcome vs Clinical Types was statistically significant ($p<0.0001$).

Chi-square value: 20.3947; **p-value:** <0.0001.

5. Discussion

A single centre, hospital based, observational, cross sectional study was conducted in the department of Respiratory Medicine, Indraprastha Apollo hospitals, New Delhi, both indoor and OPD patients from 25th of August 2020 To 25th Of June 2021.

Patients with ICMR laboratory confirmed RT-PCR/ Gene-expert positive non critical COVID-19 cases and Patients/ Guardians given informed written consent for the same were included in this study.

In our study, 4 (5.0%) patients were ≤30years old, 13 (16.3%) patients were 31-40years old, 26 (32.5%) patients were 41-50years old, 22 (27.5%) patients were 51-60years old and 15 (18.8%) patient were >60 years old. The mean Age (mean± s. d.) of patients was 51.1375± 13.4011 yrs.25 (31.3%) patients were Female and 55 (68.8%) patient were male.

It was found that, 41 (51.3%) patients had Non-obese BMI, 9 (11.3%) patients had Obese BMI and 30 (37.5%) patients had Overweight BMI. The mean BMI (mean± s. d.) of patients was 24.4750± 3.9399 kg/m2.

We found that, 16 (20.0%) patients had Mild restriction at PFT Spirometry Finding-x, 34 (42.5%) patients had Moderate Restriction at PFT Spirometry Finding-x, 23 (28.8%) patients had Moderately severe Restriction at PFT Spirometry Finding-x and 7 (8.8%) patients had Severe restriction at PFT Spirometry Finding-x.

Our study showed that, 25 (31.3%) patients had Restrictive lung disorder with mild diffusion restriction, 48 (60.0%) patients had Restrictive lung disorder with moderate diffusion restriction and 7 (8.8%) patients had Restrictive lung disorder with severe diffusion restriction.

In our study, 57 (71.3%) patients had Mild restriction at PFT Spirometry Finding-y, 7 (8.8%) patients had Moderately severe restriction at PFT Spirometry Finding-y, 9 (11.3%) patients had Normal spirometry at PFT Spirometry Finding-y and 7 (8.8%) patients had Severe restriction at PFT Spirometry Finding-y.

It was found that, 9 (11.3%) patients had Mild diffusion restriction at PFT Interpretation-y, 34 (42.5%) patients had Restrictive lung disorder with mild diffusion restriction at PFT Interpretation-y, 30 (37.5%) patients had Restrictive lung disorder with moderate diffusion restriction at PFT Interpretation-y and 7 (8.8%) patients had Restrictive lung disorder with severe diffusion restriction at PFT Interpretation-y.

In our study, the mean DLCO-x (mean± s. d.) of patients was 50.4500± 14.1143. The mean DLCO/Va-x (mean± s. d.) of patients was 88.4500± 19.7169. The mean TLC-x (mean± s. d.) of patients was 64.9500± 18.2991. The mean RV/TLC-x (mean± s. d.) of patients was 100.8875± 33.8758. The mean FEV1 (% of predicted)-x (mean± s. d.) of patients was 67.0000± 9.9365. The mean FVC (% of predicted)-x (mean± s. d.) of patients was 62.0125± 11.2154. The mean FEV1/FVC-x (mean± s. d.) of patients was 99.0600± 12.7026. The mean DLCO-y (mean± s. d.) of patients was 55.2875± 13.9340. The mean DLCO/Va-y (mean± s. d.) of patients was 91.9000± 22.8377. The mean TLC-y (mean± s. d.) of patients was 71.1500± 20.8242. The mean RV/TLC-y (mean± s. d.) of patients was 92.1250± 23.7995. The mean FEV1 (%of of predicted)-y (mean± s. d.) of patients was 75.6375± 14.1647. The mean FVC (% of predicted)-y (mean± s. d.) of patients was 72.4375± 14.6519. The mean FEV1/FVC-y (mean± s. d.) of patients was 97.0675± 14.2298.

Our study showed that in Mild Clinical Types, 14 (87.5%) patients were 41-50years old, 1 (6.3%) patients were 51-60years old and 1 (6.3%) patient were >60 years old. In Moderate Clinical Types, 4 (8.0%) patients were ≤30years old, 10 (20.0%) patients were 31-40years old, 8 (16.0%) patients were 41-50years old, 15 (30.0%) patients were 51-60years old and 13 (26.0%) patient were >60 years old. In Severe Clinical Types, 3 (21.4%) patients were 31-40years old, 4 (28.6%) patients were 41-50years old, 6 (42.9%) patients were 51-60years old and 1 (7.1%) patient were >60 years old. It was statistically significant ($p<0.0001$).

We observed that In Mild Clinical Types, 9 (56.3%) patients had Moderate Restriction at PFT Spirometry Finding-x and

7 (43.8%) patients had Moderately severe Restriction at PFT Spirometry Finding-x. In Moderate Clinical Types, 16 (32.0%) patients had Mild restriction at PFT Spirometry Finding-x, 25 (50.0%) patients had Moderate Restriction at PFT Spirometry Finding-x and 9 (18.0%) patients had Moderately severe Restriction at PFT Spirometry Finding-x. In Severe Clinical Types, 7 (50.0%) patients had Moderately severe Restriction at PFT Spirometry Finding-x and 7 (50.0%) patients had Severe restriction at PFT Spirometry Finding-x. This was statistically significant (p<0.0001).

Present study showed that in Mild Clinical Types, 9 (56.3%) patients had Restrictive lung disorder with mild diffusion restriction and 7 (43.8%) patients had Restrictive lung disorder with moderate diffusion restriction. In Moderate Clinical Types, 16 (32.0%) patients had Restrictive lung disorder with mild diffusion restriction and 34 (68.0%) patients had Restrictive lung disorder with moderate diffusion restriction. In Severe Clinical Types, 7 (50.0%) patients had Restrictive lung disorder with moderate diffusion restriction and 7 (50.0%) patients had Restrictive lung disorder with severe diffusion restriction. This was statistically significant (p<0.0001).

Our study showed that in Mild Clinical Types, 7 (43.8%) patients had Moderate restriction at PFT Spirometry Finding-y and 9 (56.3%) patients had Normal spirometry at PFT Spirometry Finding-y. In Moderate Clinical Types, 50 (100.0%) patients had Mild restriction at PFT Spirometry Finding-y. In Severe Clinical Types, 7 (50.0%) patients had Mild restriction at PFT Spirometry Finding-y and 7 (50.0%) patients had Severe restriction at PFT Spirometry Finding-y. It was statistically significant (p<0.0001).

We examined that in Mild Clinical Types, 9 (56.3%) patients had Mild diffusion restriction at PFT Interpretation-y and 7 (43.8%) patients had Restrictive lung disorder with moderate diffusion restriction at PFT Interpretation-y. In Moderate Clinical Types, 34 (68.0%) patients had Restrictive lung disorder with mild diffusion restriction at PFT Interpretation-y and 16 (32.0%) patients had Restrictive lung disorder with moderate diffusion restriction at PFT Interpretation-y. In SevereClinical Types, 7 (50.0%) patients had Restrictive lung disorder with moderate diffusion restriction at PFT Interpretation-y and 7 (50.0%) patients had Restrictive lung disorder with severe diffusion restriction at PFT Interpretation-y. This was statistically significant (p<0.0001).

Our study showed that In Mild Clinical Types, the mean Age (yrs) (mean± s. d.) of patients was 47.3125± 6.1830. In Moderate Clinical Types, the mean Age (yrs) (mean± s. d.) of patients was 52.7600± 15.7837. In Severe Clinical Types, the mean Age (yrs) (mean± s. d.) of patients was 49.7143± 8.8268. This was not statistically significant (p=0.3381).

Present study showed that in Mild Clinical Types, the mean DLCO-x (mean± s. d.) of patients was 53.25± 2.05. In Moderate Clinical Types, the mean DLCO-x (mean± s. d.) of patients was 56.40± 10.29. In Severe Clinical Types, the mean DLCO-x (mean± s. d.) of patients was 26.00± 4.1510. This was statistically significant (p<0.0001).

We observed that in Mild Clinical Types, the mean DLCO/Va-x (mean± s. d.) of patients was 79.0625 ± 19.9816. In Moderate Clinical Types, the mean DLCO/Va-x (mean± s. d.) of patients was 95.3600 ± 11.8058. In Severe Clinical Types, the mean DLCO/Va-x (mean± s. d.) of patients was 74.5000 ± 29.5758. This was statistically significant (p<0.0001).

We examined that in Mild Clinical Types, the mean FEV1 (% of predicted)-x (mean± s. d.) of patients was 62.7500± 6.1482. In Moderate Clinical Types, the mean FEV1 (% of predicted)-x (mean± s. d.) of patients was 71.1600 ± 8.1800. In Severe Clinical Types, the mean FEV1 (% of predicted)-x (mean± s. d.) of patients was 57.0000 ± 10.3775. It was statistically significant (p<0.0001).

In our study in Mild Clinical Types, the mean FVC (% of predicted)-x (mean± s. d.) of patients was 58.2500 ± 2.0494. In Moderate Clinical Types, the mean FVC (% of predicted)-x (mean± s. d.) of patients was 67.4200 ± 9.6110. In Severe Clinical Types, the mean FVC (% of predicted)-x (mean± s. d.) of patients was 47.0000 ± 6.2265. This was statistically significant (p<0.0001).

Our study showed that in Mild Clinical Types, the mean FEV1/FVC-x (mean± s. d.) of patients was 83.9313 ± 4.7648. In Moderate Clinical Types, the mean FEV1/FVC-x (mean± s. d.) of patients was 102.4200 ± 10.9621. In Severe Clinical Types, the mean FEV1/FVC-x (mean± s. d.) of patients was 104.3500 ± 12.0898. It was statistically significant (p<0.0001).

We found that In Mild Clinical Types, the mean DLCO-y (mean± s. d.) of patients was 56.3750 ± 3.0741. In Moderate Clinical Types, the mean DLCO-y (mean± s. d.) of patients was 61.0400 ± 11.7716. In Severe Clinical Types, the mean DLCO-y (mean± s. d.) of patients was 33.5000 ± 2.5944. It was statistically significant (p<0.0001).

Our study showed that in Mild Clinical Types, the mean DLCO/Va-y (mean± s. d.) of patients was 84.5000 ± 20.4939. In Moderate Clinical Types, the mean DLCO/Va-y (mean± s. d.) of patients was 99.4200± 15.4340. In Severe Clinical Types, the mean DLCO/Va-y (mean± s. d.) of patients was 73.5000 ± 33.7268 which was statistically significant (p<0.0001).

Present study showed that In Mild Clinical Types, the mean FEV1 (%of of predicted)-y (mean± s. d.) of patients was 85.2500 ± 26.6421. In Moderate Clinical Types, the mean FEV1 (%of of predicted)-y (mean± s. d.) of patients was 75.5400 ± 3.0184. In Severe Clinical Types, the mean FEV1 (%of of predicted)-y (mean± s. d.) of patients was 65.0000 ± 11.4152 which was statistically significant (p=0.0003).

We found that in Mild Clinical Types, the mean FVC (% of predicted)-y (mean± s. d.) of patients was 80.7500 ± 22.5433. In Moderate Clinical Types, the mean FVC (% of predicted)-y (mean± s. d.) of patients was 74.2400 ± 7.3694. In Severe Clinical Types, the mean FVC (% of predicted)-y (mean± s. d.) of patients was 56.5000 ± 11.9341. It was statistically significant (p<0.0001).

We also found that In Mild Clinical Types, the mean FEV1/FVC-y (mean± s. d.) of patients was 79.5875 ±.7173. In Moderate Clinical Types, the mean FEV1/FVC-y (mean± s. d.) of patients was 102.9600 ± 11.6092. In Severe Clinical Types, the mean FEV1/FVC-y (mean± s. d.) of patients was 96.0000 ± 14.5285. It was statistically significant ($p<0.0001$).

It was found that in Mild Clinical Types, 9 (56.3%) patients had improved in Outcome and 7 (43.8%) patients had No significant change in Outcome. In Moderate Clinical Types, 34 (68.0%) patients had improved in Outcome and 16 (32.0%) patients had No significant change in Outcome. In Severe Clinical Types, 14 (100.0%) patients had No significant change in Outcome which was statistically significant ($p<0.0001$).

6. Summary and Conclusion

In our study, 4 (5.0%) patients were ≤30years old, 13 (16.3%) patients were 31-40years old, 26 (32.5%) patients were 41-50years old, 22 (27.5%) patients were 51-60years old and 15 (18.8%) patient were >60 years old.

In our study, 25 (31.3%) patients were Female and 55 (68.8%) patient were male.

In our study, 16 (20.0%) patients had Mild restriction at PFT Spirometry Finding-x, 34 (42.5%) patients had Moderate Restriction at PFT Spirometry Finding-x, 23 (28.8%) patients had Moderately severe Restriction at PFT Spirometry Finding-x and 7 (8.8%) patients had Severe restriction at PFT Spirometry Finding-x.

In our study, 25 (31.3%) patients had Restrictive lung disorder with mild diffusion restriction, 48 (60.0%) patients had Restrictive lung disorder with moderate diffusion restriction and 7 (8.8%) patients had Restrictive lung disorder with severe diffusion restriction.

In our study, 9 (11.3%) patients had Mild diffusion restriction at PFT Interpretation-y, 34 (42.5%) patients had Restrictive lung disorder with mild diffusion restriction at PFT Interpretation-y, 30 (37.5%) patients had Restrictive lung disorder with moderate diffusion restriction at PFT Interpretation-y and 7 (8.8%) patients had Restrictive lung disorder with severe diffusion restriction at PFT Interpretation-y.

In our study, 43 (53.8%) patients had Improved in Outcome and 37 (46.3%) patients had No significant change in Outcome.

In our study, 16 (20.0%) patients were Mild Clinical Types, 50 (62.5%) patients were Moderate Clinical Types and 14 (17.5%) patients were Severe Clinical Types.

Higher age group (>50 years) was more affected in moderate and severe disease which was statistically significant.

Males were more affected in moderate and severe disease which was statistically significant.

In PFT Spirometry Finding-x, Severe restriction was more in moderate and severe disease. PFT Spirometry Finding-x was significantly associated with severity of the disease.

Both PFT Interpretation-x and PFT Interpretation-y were significantly associated with severity of the disease.

Poor outcome was observed in severe disease followed by mild and moderate disease which was statistically significant.

DLCO-x was less in severe disease compared to mild and moderate disease which was statistically significant. DLCO-y was less in severe disease followed by mild and moderate disease which was statistically significant.

DLCO/Va-x was less in severe disease followed by mild and moderate disease which was statistically significant. DLCO/Va-y was less in severe disease followed by mild and moderate disease which was statistically significant.

Both TLC-x and TLC-y were less in severe disease compared to mild and moderate disease which was statistically significant.

FEV1 (% of predicted)-x was less in severe disease followed by mild and moderate disease which was statistically significant.

FEV1 (% of predicted)-y was less in severe disease followed by moderate and mild disease which was statistically significant.

FVC (% of predicted)-x was less in severe disease followed by mild and moderate disease which was statistically significant.

FVC (% of predicted)-y was less in severe disease followed by moderate and mild disease which was statistically significant.

Influence of corona virus disease 2019 on pulmonary function was changed in post covid-19 discharged patients

The respiratory function changes were improved associated with COVID-19 in Mild and Moderate cases mainly, and not in Severe cases.

Majority of patients in our study were advised to practice deep breathing exercises, incentive spirometry and Yoga. We observed improvement in symptoms of Post COVID patients, of Mild and Moderate disease category. Various research studies support this observation are.1) Senthil & Sivabackiya, 2020[21] 2) Liu et al., 2020[22] 3) Zha et al., 2020[23]

Senthil & Sivabackiya, (2020) [21] explain the case report of a 72-year-old male with COVID-19 and diabetes mellitus who complained of difficulty breathing even while sleeping. In this research is patience agreed and follow the intervention consisting of percussion technique on pulmonary, deep breathing and thorax mobility exercises that would perform for 30 minutes every two times a week. This breathing exercise is implemented out for three weeks.

This exercise consist of pulmonary percussion with shaking and vibration manually by the physiotherapist for 10 minutes and then followed by the breathing exercises, thorax mobility and incentive spirometry exercises. This breathing exercise intervention has shown significant presence in the restoration of ability.

Liu et al., (2020) [22] Study conducted to identify the effects of respiratory rehabilitation, activity daily living (ADL), quality of life and psychological status in elderly patients with COVID-19 after being discharged from the hospital. The rehabilitation program consist of a respiratory rehabilitation two sessions per week for six weeks, once a day for 10 minutes. The intervention include respiratory muscle training, cough exercise, diaghramatic training, Stretching exercise and home exercise. Breathing muscle exercises are performed three sets with 10 times breaths in each set using a commercial hand held device.

Breathing exercise and physical exercise after COVID-19 are part of the pulmonary rehabilitation program which has been shown to have a positive impact on repairing damage due to lung disease by COVID-19 pneumonia.

7. Limitations of the study

In spite of every sincere effort my study has lacunae.

- The notable short comings of this study are:
- The sample size was small. Only 80 cases are not sufficient for this kind of study.
- The study has been done in a single centre.
- The study was carried out in a tertiary care hospital, so hospital bias cannot be ruled out.

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Abbreviation

PFT: Pulmonary Function Test
FEV1: Forced Expiratory Volume IN 1 Second
FVC: Forced Vital Capacity
DLCO: Diffusion Capacity of Lungs for Carbon Monoxide
DLCO/Va DLCO/ALVEOLAR Volume = Transfer Coefficient for the Diffusion of Carbon Monoxide
TLC: Total Lung Capacity
RV: Residual Volume
BMI: Body Mass Index
M: Male
F: Female
SPO2: Peripheral Capillary Oxygen Saturation
X: First Month
Y: Third Month
CT: Computed Tomography
PCR: Polymerase Chain Reaction.

List of Keywords
COVID-19, pulmonary function, discharged patients, disease severity, respiratory function, post-Covid conditions, long COVID, EasyOneR Air, TrueFlowTM technology, rehabilitation.