Evaluation of chest expansion and inspiratory capacity on non-intubated COVID-19 patients in hospital settings: an observational study

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Abstract-

Background: COVID-19 was first detected in December 2019 at Wuhan city of central Hubei province of China. The transmission of infection is mainly person to person through respiratory droplets. Fecal–oral route is possible. The presence of the virus has been confirmed in sputum, pharyngeal swabs and faces. Vertical transmission of SARS-CoV-2 has been reported and confirmed by positive nasopharyngeal swab for COVID-19. The major characteristics of COVID-19 pneumonia is that lesions in the different time phases are found simultaneously in close proximity to each other within the lung lobe, and an autopsy on the lung tissue often shows various DAD lesions, from exudative to fibrotic stage, in a pulmonary lobe. So, our objective was to evaluate the chest expansion and inspiratory capacity on non-intubated covid patients.

Methodology: An observational study was performed in 50 participants including both females and males in the age group of 18- 80 years. All the subjects were observed in COVID Intensive care units and wards of trauma center. Their informed consent was signed by themselves, assessment form and scales were filled by the therapist. The observation of participants duration was only 15 days. All participants satisfying the inclusion and exclusion criteria will be evaluated initially by the physiotherapist. Physiotherapist, those treating COVID-19 patients for respiratory care and ICU acquired weakness (ICUAW) with PPE kit as per hospital guidelines will assess the following parameters for the study. The Ethical approval was done with Ref. No.: IEC-979/03.10.2020 in AIIMS, New Delhi. Statistical analysis was performed using IBM SPSS version 25.0. The chest expansion was analyzed using Wilcoxon signed ranks test. The spirometry, demographic data correlation was analyzed by spearman's correlation test. P was set at 0.05 for all statistical analysis. The findings indicated a noticeable tendency among subjects to exhibit chest expansion during deep breaths, with a standard deviation of 0.9348142 from the normal chest expansion of 4cm. The difference in chest expansion between males and females was negligible (z = 0.194). The probability of spirometry and weight being independent variables was calculated as 0.3656. A correlation was observed between demographic factors, Spo2, and oxygen requirement level (p = -0.1456). Additionally, a significant difference in spirometry values between males and females was found through the Wilcoxon rank-sum (Mann-Whitney) test (z = 1.198).

Conclusion: The study's findings suggest that there was minimal difference in chest expansion between males and females, potentially due to reduced chest wall mobility associated with COVID-19. Additionally, there appears to be a significant difference in inspiratory capacity between male and female non-intubated COVID-19 patients in hospital settings. This implies that gender may play a role in the respiratory effects and outcomes of COVID-19 patients, particularly regarding lung function and capacity.

Key words: **Inspiratory capacity, chest expansion, Covid 19, Pulmonary rehabilitation.**

INTRODUCTION

COVID-19 was first detected in December 2019 at Wuhan city of central Hubei province of China (Wang et al., 2020; Holshue et al., 2020). On January 30, 2020 the World Health Organization (WHO) declared it as a public health emergency and on March 12, 2020 announced it as a pandemic (WHO 2020, b; Organization WHO). The number of confirmed cases in India by August 13, 2020 was > 2.3 million with > 47000 deaths.

Three stream of medical management such as prevention, treatment and rehabilitation are equally important in managing COVID-19 similar to other conditions. It was found that more than 50% patients with COVID-19 infection develop respiratory symptom and the prevalence further increases in hospitalized patients (Grant et al., 2020). The transmission of infection is mainly person to person through respiratory droplets. Fecal–oral route is possible. The presence of the virus has been confirmed in sputum, pharyngeal swabs and feces. Vertical transmission of SARS-CoV-2 has been

reported and confirmed by positive nasopharyngeal swab for COVID-19. The median incubation period of COVID-19 is 5.2 days; most patients will develop symptoms in 11.5 to 15.5 days. Therefore, it has been recommended to quarantine those exposed to infection for 14 days.

The pathological features of lungs in COVID -19 patients' show pulmonary oedema and hyaline membrane formation similar to ARDS. The histopathological pattern in early stage of COVID-19 pneumonia onset is exudative pattern; thereafter, organizing and fibrotic patterns tend to develop over time after the onset. SARS-CoV-2 consists of four main structural glycoproteins: spike (S), membrane (M), envelope (E), and nucleocapsid (N). The M, E, and N proteins are critical for viral particle assembly and release, whereas the S protein is responsible for viral binding and entry into host cells. SARS-CoV-2 is mostly transmissible through large respiratory droplets, directly infecting cells of the upper and lower respiratory tract, especially nasal ciliated and alveolar epithelial cells. In addition to the lungs, ACE2 is also expressed in various other hu-man tissues, such as the small intestine, kidneys, heart, thyroid, testis, and adipose tissue, indicating the virus may directly infect cells of other organ systems when viremia is present. Interestingly, although the S proteins of SARS-CoV-2 and SARS-Covid share 72% homology in amino acid sequences, SARS-CoV-2 has been reported to have a higher affinity for the ACE2 receptor. Following host cell binding, viral and cell mem-branes fuse, enabling the virus to enter into the cell. For many coronaviruses, including SARS-Covid, host cell binding alone is insufficient to facilitate. membrane fusion, requiring S-protein priming orc lavage by host cell proteases or transmembrane serine protease(Bohn et al., 2020).

The major characteristics of COVID-19 pneumonia is that lesions in the different time phases are found simultaneously in close proximity to each other within the lung lobe, and an autopsy on the lung tissue often shows various DAD lesions, from exudative to fibrotic stage, in a pulmonary lobe. At the same time, in few patients exhibit diffuse alveolar damage with cellular fibro myxoid exudates indicating restrictive pattern of lung disease. However, with time secretion accumulation can follow an obstructive pattern (Xu et al., 2020). Reduced chest expansion is one of the prominent signs of restrictive lung disease where a reduction in inspiratory capacity is also observed. On the other hand, in obstructive conditions either an increase or no change in inspiratory capacity is found, though can lead to reduction of chest expansion (Delgado & Bajaj, 2019). The primary features of the diseases are fever, myalgia, dyspnea and cough. The disease rapidly progresses to acute respiratory distress syndrome or pneumonia and may require ventilator support (Yang & Yang, 2020). Past studies showed a strong relationship between reduced chest expansion and pulmonary function findings (FEV1, FVC, vital capacity) (Ravi et al., 2019). In COVID-19 patients due to reduce virus contagious measures, chest wall mobility assessment by measuring tape may help to indirectly determine the pulmonary function. It was found that in disease and healthy population 4-7 cm chest wall expansion is considered to be normal (Sharma et al., 2004; Gouilly et al.,2009). Thus, in the present study, less than 4 cm reduction of chest expansion will be considered as reduce chest mobility. The reduction of chest expansion has clinical importance in terms of providing chest physiotherapy maneuver. In patients with impaired chest expansion respiratory muscle endurance training and stretching exercises can be implemented where as in patients with respiratory symptom without impaired mobility breath control, pursed lip breathing exercised are the choices (Lemaitre etal., 2013; Johansson et al., 2012). Thus, a clinical diagnosis and understanding these features in COVID-19 patients may help in targeting physiotherapy intervention. To our knowledge, we could not find studies that addressed the prevalence and severity level of impaired chest expansion in COVID-19 patients.

Thus, our first objective is to find the prevalence and severity of reduced chest expansion in COVID-19 patients. The second objective is to test the demographic factors, Spo2 and oxygen requirement level associated with reduce chest expansion and inspiratory capacity in patients admitted in hospital with COVID-19 infections.

METHODOLOGY:

An observational study was performed in 50 participants including both females and males in the age group of 18- 80 years. All the subjects were observed in COVID Intensive care units and wards of trauma center. Their informed consent (Annexure 1) was signed by themselves, assessment form (Annexure 2) with scales were filled by the therapist. The observation of participants duration was only 15 days.

Eligibility criteria:

1. **The Inclusion criteria** were:
- Non-intubated (O_2 reservoir and room air),
- Age more than 18 years,
- diagnosed case of COVID-19 infection,
- Able to follow command.

2. **The Exclusion criteria** were:
- patients under ventilator management,
- T-piece ventilation
- non-invasive mechanical ventilation, rib fracture, pneumothorax, hemothorax, flail chest, any acute trauma to

chest,

- Recent cardio-vascular surgeries, any abdominal surgeries and withdrawal of consent.

PROCEDURE:

All participants satisfying the inclusion and exclusion criteria were evaluated initially by the physiotherapist. Physiotherapist, those treating COVID-19 patients for respiratory care and ICU acquired weakness (ICUAW) with PPE kit as per hospital guidelines were assessed the following parameters for the study. The Ethical Committee meeting approval was done with Ref. No.: IEC-979/03.10.2020.

1. **Demographics and vitals:** The history of patients including age, gender, previous medical illness and duration of hospital stay, presence of respiratory symptoms, SpO2, oxygen requirement (in liter, if any) were noted.
2. **Measurement of chest expansion:** First of all, with measuring tape the expansion of lower part of chest (at the level of xiphoid process and 10th thoracic vertebra) (Moll & Wright, 1972) was measured during normal breathing. Then participant was instructed to take a deep breath as much as possible without much discomfort and the reading in tape measurement will be noted. The value after deep breath was subtracted from the chest expansion value during normal breathes to calculate chest expansion in cm.
3. **Inspiratory capacity:** It is the maximum volume of air that can be inhaled following a resting state. It was calculated from the sum of inspiratory reserve volume and tidal volume. The inspiratory capacity was measured by using calibrated standardized spirometers kept in COVID wards and ICUs. The volume of air inhaled in ml were recorded.

Outcome measures were:

1. chest expansion by inch tape and

2. Inspiratory capacity by standardized spirometer.

DATA ANALYSIS: Statistical analysis was performed using IBM SPSS version 25.0. The chest expansion was analyzed using Wilcoxon signed ranks test. The spirometry, demographic data correlation was analyzed by spearman's correlation test. P was set at 0.05 for all statistical analysis.

Result: The study involving 50 subjects, with an average age of 37.36 years, consisted of 32 males and 18 females. The findings indicated a noticeable tendency among subjects to exhibit chest expansion during deep breaths, with a standard deviation of 0.9348142 from the normal chest expansion of 4cm. The difference in chest expansion between males and females was negligible (z = 0.194). The probability of spirometry and weight being independent variables was calculated as 0.3656. A correlation was observed between demographic factors, Spo2, and oxygen requirement level (p = -0.1456). Additionally, a significant difference in spirometry values between males and females was found through the Wilcoxon rank-sum (Mann-Whitney) test (z = 1.198).

Group variable: Sex

Sex	N	Mean	SD	Spiro	Min	Max

Female	18	1363.889	498.1748	1150	750	2100
Male	32	1287.5	653.7732	900	700	2500
TOTAL	50	1315	598.2329	1100	700	2500

Two-sample Wilcoxon rank-sum (Mann–Whitney) test

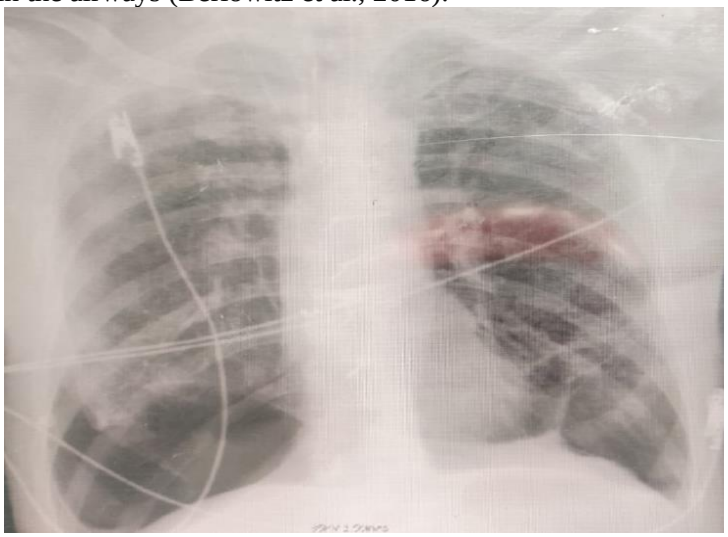
Sex	Observe	Rank Sum	Expected
Female	18	518	459
Male	32	757	816
Combined	50	1275	1275

adjusted variance 2448.00
Adjustment for ties -20.9
Adjusted variance 2427.08
H0: spiro(sex=female) = spiro(sex==male)
z = 1.198
Prob > |z| = 0.2311
Exact prob = 0.2356

Discussion:

Chest expansion:

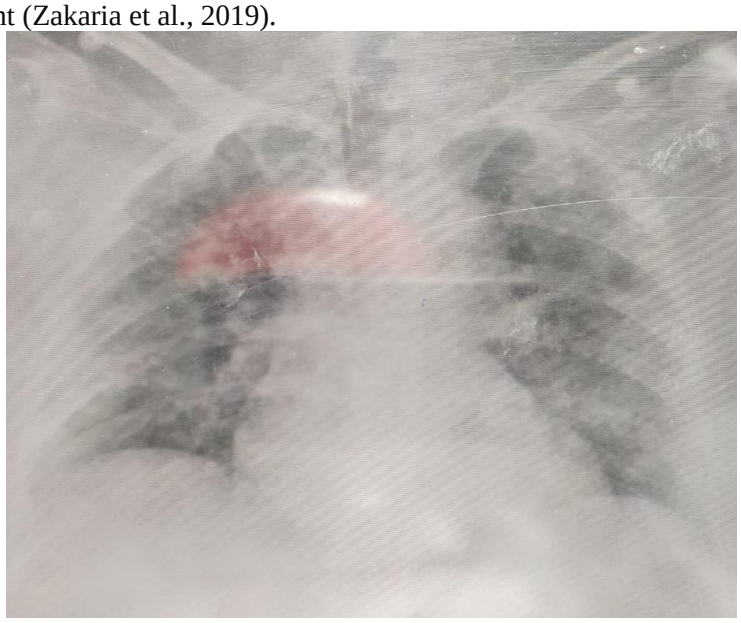
The study involving 50 patients revealed a noticeable trend towards increased chest expansion during deep breaths, with a standard deviation of 0.9348142 from the normal expansion of 4cm. Interestingly, there was minimal disparity in chest expansion between males and females (z = 0.194), which could be attributed to reduced chest wall mobility associated with COVID-19. Patients with weakened respiratory muscles often experience fatigue and breathing difficulties, hindering daily activities and necessitating significant effort to overcome. Fibrotic plaques deposition in the lungs limits chest expansion compared to normal values, potentially leading to complications such as impaired coughing and secretion accumulation in the airways (Berlowitz et al., 2016).



Assessing chest expansion is considered crucial in COVID-19 patients to evaluate pulmonary function impairment, akin to its use in other interstitial lung diseases. Declining pulmonary function can adversely affect cardiorespiratory functional capacity, underscoring the need for tailored pulmonary rehabilitation programs to restore a satisfactory quality of life (Suharti et al., 2021). Studies have shown no significant correlation between chest expansion and lung capacity in both healthy individuals and those with pulmonary diseases (Derasse et al., 2021; Amatya & Pun, 2019).

Inspiratory Capacity:

Regarding inspiratory capacity, there was a notable difference in spirometry values between males and females as indicated by the Wilcoxon rank-sum (Mann–Whitney) test ($z = 1.198$), possibly reflecting impaired diffusion capacity and restrictive ventilatory defects associated with disease severity (Mo et al., 2020). Notably, diffusion capacity, restrictive patterns, and obstructive patterns were observed in 39%, 15%, and 7% of COVID-19 patients, respectively. Spirometry, lung volumes, and diffusion capacity assessments were commonly used to evaluate respiratory function in COVID-19 patients (MADI et al., 2022) and some of the experienced technicians performed spirometry using automated testing equipment (Zakaria et al., 2019).



Participation in cardiopulmonary rehabilitation programs has been linked to improved functional status and quality of life in patients with various pulmonary diseases (Hockele et al., 2022). Therefore, physiotherapy appears to be an effective intervention for enhancing inspiratory capacity in COVID-19 patients.

Conclusion:

The study's findings suggest that there was minimal difference in chest expansion between males and females, potentially due to reduced chest wall mobility associated with COVID-19. Additionally, there appears to be a significant difference in inspiratory capacity between male and female non-intubated COVID-19 patients in hospital settings. This implies that gender may play a role in the respiratory effects and outcomes of COVID-19 patients, particularly regarding lung function and capacity.

Limitations:

1. Lack of randomization in subjects.
2. Duration and the subjects of study was less as home quarantine was preferred.
3. Gender selection is not equal male was more as compare to female.

Future recommendation:

Further research on lung capacities may be needed to explore these gender disparities and their implications for patient care and management.

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