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**Original Research Article**

# Effect of physiotherapy on single breath count and breath holding time in COVID-19 patients

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## ABSTRACT

**Background:** The novel Coronavirus is known to primarily affect the respiratory system and physiotherapy treatment is integral to combat this infection. However, the assessment of pulmonary function poses a difficult challenge considering the risk of spread of infection and sanitisation of the devices used. Single breath count (SBC) and breath holding time (BHT) can be thus adopted as bedside assessment tests for pulmonary function following physiotherapy treatment.
**Method:** In this a retrospective observational study of 51 COVID-19 patients, mean age 51.7±14.56 years, on room air, admitted in the step-down units of a tertiary care hospital. Patients received standard physiotherapy treatment, within safe hemodynamic limits. Pre and post treatment session SBC was recorded in 32 patients and BHT in 19 patients. Three reading were noted and the best of three readings were used for analysis.
**Results:** The paired t test was used to analyse SBC and BHT. Mean pre and post SBC was 18.25±8.96 and 23.31±9.96 respectively with a mean difference of 5.06 and $p<0.0001$. Mean pre and post BHT were 19.37 and 23.05 seconds respectively with a mean difference of 3.68 and $p<0.0001$. Statistically significant difference in the pre and post treatment session SBC and BHT was observed, indicating a positive effect of physiotherapy treatment on pulmonary function.
**Conclusion:** Physiotherapy treatment shows significant improvement in the pulmonary function in COVID-19 patients. SBC and BHT tests can be used as assessment and prognostic tools for pulmonary function in COVID-19 patients.

**Keywords:** COVID-19, Single breath count, Breath holding time, Physiotherapy

## INTRODUCTION

The emergence of the novel coronavirus during the late 2019 led to a state of global crisis infecting millions worldwide. The ongoing pandemic is caused by the SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2) which is a zoonotic β virus belonging to the *Coronaviridae* family. The fulminant spread of the virus is attributed to its rapid human to human spread via air droplets from an infected individual or through contaminated surfaces.[1] The virus is known to primarily affect the respiratory system, mainly the lower respiratory tract producing symptoms of breathlessness, dry cough, fever and fatigue. Other frequently encountered symptoms include chest pain, thromboembolic disorders, myalgia, arthralgia, gastrointestinal disturbances and metabolic disorders due to the eventual involvement of other organ systems.[2] Severe cases have been seen to be associated with ARDS that leads to the destruction of the lung parenchyma causing diffuse alveolar damage, interstitial thickening, reduced lung perfusion causing hypoxic vasoconstriction and ventilation perfusion mismatch hampering the critical process of respiration.[3]

Physiotherapy treatment in COVID-19 patients in the form of positioning, breathing and mobility exercises and ambulatory training has shown benefits in aiding clearance of secretions, improving lung function, reducing immobility and thus aiding functional recovery.[4]

The assessment of impaired pulmonary function due to COVID-19 poses a difficult challenge since the use of spirometry or any device-oriented tests is discouraged due to the risk of cross infection and the need to sanitize the device after every use. SBC and BHT are simple beside assessment tests which can be adopted since they do not require the use of any device therefore eliminating the risk of spread of infection and also require minimal training for patients as well as the therapist.[5]

SBC is an easily performed test to assess pulmonary functioning. It is performed using a simple device (metronome). It is recorded as the individual is asked to take a deep inhalation and count numbers to the metronome beats in normal speaking voice without taking another breath. The metronome is set at a frequency of 2 counts per second. SBC is a sensitive indicator of pulmonary disorders with a strong positive correction to spirometric parameters.[6]

BHT is another simple assessment test in which the individual is asked to hold their breath as long as possible until the breaking point. The time of breath hold is recorded in seconds. It is dependent on multiple variables such as lung volumes, respiratory muscle functioning, disease states and training level and is frequently used as an indicator of pulmonary function owning to its positive correlation to spirometric indices.[7]

Thus, the need for this study was to assess whether SBC and BHT can be used as safer alternatives to gauge the change in pulmonary functional status with physiotherapy treatment in COVID-19 patients.

## METHODS

This retrospective observational study with single sitting of physiotherapy treatment session was analysed on 51 COVID-19 patients hospitalized in the COVID dedicated step-down units of Seth G. S. medical college and KEM hospital, Mumbai, India. All the patients received optimal medical care. Patients of both genders, on room air and able to perform SBC and BHT were included in this study. Mechanically ventilated patients, those on supplemental oxygen support and patients with cognitive impairments were excluded.

Depending upon the patient's status, they received standard physiotherapy care in the form of breathing exercises, positioning, in-bed and out of bed mobilization exercises, and were ambulated within safe hemodynamic limits. SBC was performed on 32 patients and BHT on 19 patients before and after single treatment session.

### *SBC*

The patient was instructed to sit upright without any back support. The patient was then instructed to take a deep breath and commence counting of serial numbers in normal speaking voice without taking another breath. The counts were timed on a metronome set at a frequency of 2 counts per second using the Metronome Beats® application, version 3.5.0 on a mobile based android operating system.[8] Three readings were recorded and the best of the three readings was considered for final analysis.

### *BHT*

The patient was instructed to sit upright without any back support. The patient was then instructed to breathe in at tidal volume and to hold the breath. The timer was set to record the timing of breath hold. The test was continued until the patient needed to exhale the air or had any deviation of respiratory muscles.[9] Three readings were recorded and the best of the three readings was considered for final analysis.

Institutional ethics committee approval was sought for this study.

The data was statistically analysed using the GraphPad prism 9 software. Since the data was normally distributed, the paired t test was used to study the effect of physiotherapy treatment on SBC and BHT in COVID-19 patients.

## RESULTS

Figure 1 shows the gender distribution of the patients comprising of 44 males (86%) and 7 females (14%) out of the 51 patients of mean age 51.7±14.56 years.

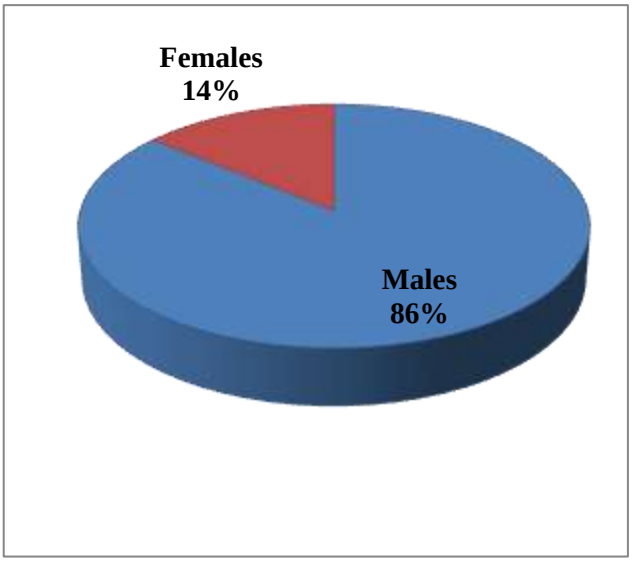


**Figure 1: Graphical representation of gender distribution of sample, (n=51).**

Out of the 51 patients, 20 patients had diabetes mellitus (45%), 11 patients had hypertension (25%) and 13 (30%) had other co-morbidities such as COPD, ischemic heart disease, previous myocardial infarction and cerebrovascular accident, haemophilia, sickle cell anaemia, hepatitis and uropathy **(**Figure 2).

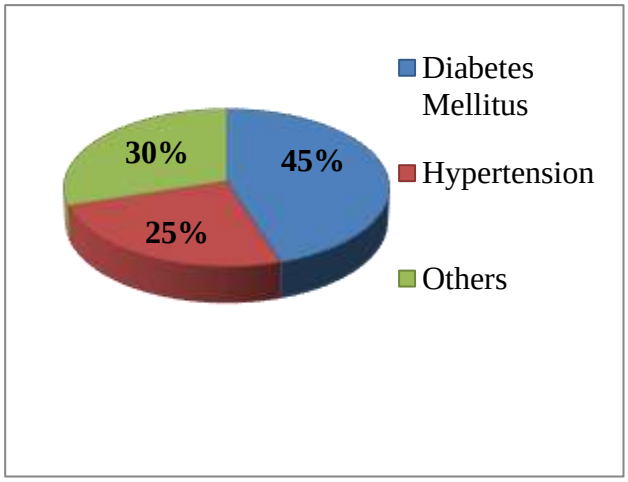


**Figure 2: Graphical representation of distribution of co-morbidities.**

Table 1 and Figure 3 show the change in SBC recorded pre and post physiotherapy treatment session. The mean pre and post SBC were 18.25±8.96 and 23.31±9.96 respectively with a mean difference of 5.06, p<0.0001and effect size 0.50 indicating a statistically significant positive difference post treatment.

**Table 1: Change in SBC with physiotherapy treatment.**

| Parameters | Pre | Post |
|---|---|---|
| **Mean** | 18.25 | 23.31 |
| **Standard deviation** | 8.96 | 9.96 |
| **Mean difference** | 5.06 | |
| **P value** | <0.001 | |
| **Effect Size** | 0.50 | |

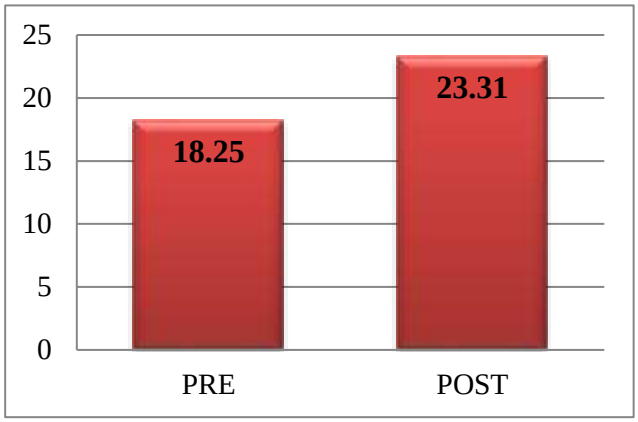


**Figure 3: Graphical representation of change in SBC with physiotherapy treatment.**

Table 2 and Figure 4 show the change in BHT recorded pre and post physiotherapy treatment session. The mean pre and post BHT were 19.37±11.12 and 23.05±10.92 seconds respectively with a mean difference of 3.68 seconds, p<0.0001 and effect size 0.30 indicating a statistically significant positive difference post treatment.

**Table 2: Change in BHT with physiotherapy treatment**

| Parameters | Pre | Post |
|---|---|---|
| **Mean** | 19.37 | 23.05 |
| **Standard deviation** | 11.12 | 10.92 |
| **Mean difference** | 3.68 | |
| **P value** | <0.001 | |
| **Effect size** | 0.30 | |

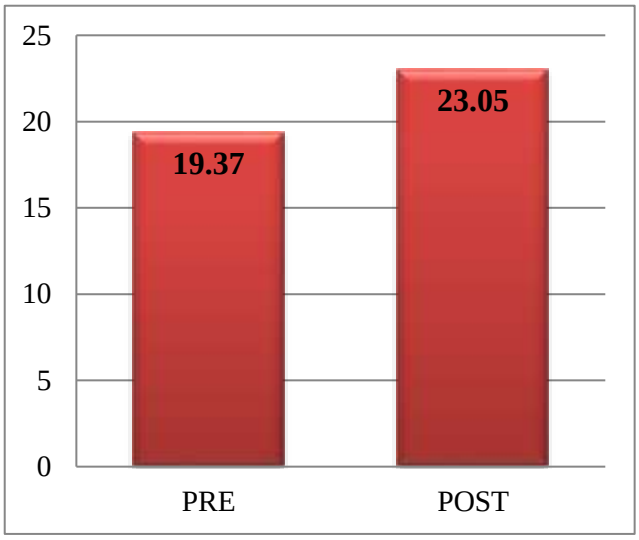


**Figure 4: Graphical representation of change in BHT with physiotherapy treatment.**

## DISCUSSION

In this retrospective observational study, we observed the effect of single sitting of physiotherapy treatment on lung function in 51 COVID-19 patients. The statistical analysis shows significant results in the outcome measures of SBC and BHT reflecting the improvement in the performance of the tests. It also indicates that with daily physiotherapy treatment sessions, the SBC and BHT performance is likely to show more improvement. Also, the outcome measures itself can be used as an exercise in combination with the physiotherapy treatment to further enhance the improvement in lung function.

Early physiotherapy intervention has been identified as an essential therapeutic tool in the management of COVID-19 patients. Assessment and evidence-based treatment of these patients should include prevention, reduction of adverse consequences of pulmonary affection due to damage of the architecture of the lung parenchyma with respect to the ongoing inflammatory

processes and long-term pulmonary and multi system impairment sequelae.[10]

SBC does not require any tool with a mouthpiece which could be of concern due to contamination of the equipment and be a possible source of spread of infection amongst individuals. However, it does require a fair degree of patient cooperation for understanding and coordinating the manoeuvre to the metronome beats.

In a co-relational study conducted on 100 healthy participants of both genders between the age group of 18-50 years; the participants were asked to perform peak expiratory flow rate (PEFR) using the mini Wright peak flow meter and SBC using a metronome. The Spearman's correlation coefficient of PEFR and SBC was 0.7048 with $p<0.001$ indicating a strong positive correlation. They thus concluded that SBC can be used as a simple, convenient and cost-effective alternative to PEFR to assess pulmonary functioning in adults.[5]

SBC has been extensively used and studied for the purpose of triaging respiratory complications and failure in neuromuscular conditions such as botulism, myasthenia gravis and Guillian-Barre syndrome. Kalita et al studied SBC and arterial blood gas (ABG) parameters in 94 GBS patients to obtain the cut off point for intubation and mechanical ventilation. They found that desired ABG values without any respiratory distress were obtained with an SBC value of 7. For SBC value of 5, the sensitivity and specificity for the need of mechanical ventilation were 90.6% and 95.2% respectively. They thus concluded that SBC was a useful non-invasive measure to guide the need for ABG analysis and respiratory function monitoring.[11] Similarly, Elsheikh et al studies 31 acetylcholine receptor antibody positive myasthenia gravis patients. They studied the correlation between SBC and forced vital capacity (FVC) ($r=0.554$, $p<0.01$), negative inspiratory force ($r=0.519$, $p<0.01$) and neck flexor strength ($r=0.519$, $p<0.01$) concluding SBC to be a reliable bedside assessment tool for monitoring respiratory function. [12]

Escossio et al analysed 516 hospitalized patients having various medical and surgical conditions and found that in the curve analysis (receiver operating characteristic/slow vital capacity=20 ml/kg) the SBC value of 21 had a sensitivity of 94.44% and specificity of 76.62%. Also, the intra class correlation coefficient for repeatability by the same examiner was 0.976 with $p>0.005$.[13]

Bartfield et al performed a pilot study on 22 patients who required a pulmonary function test and also recorded PEFR and SBC in them. This prospective correlational study was conducted to assess the correlation of SBC, PEFR and forced expiratory volume in the first second ($FEV_1$). The study showed that the correlation of SBC and $FEV_1$ was $r=0.68$ and that of PEFR and $FEV_1$ $r=0.63$. The correlation of SBC and PEFR was 0.68 thus making SBC a reasonable alternative to PEFR.[14]

Ali et al studied the correlation of spirometric indices and SBC in 67 children aged 5-18 years diagnosed with asthma, cystic fibrosis and other chronic diseases, attending clinics for routine pulmonary function tests. The correlation coefficients of SBC to PEFR ($r=0.55$), $FEV_1$ ($r=0.66$) and FVC ($r=0.71$), forced expiratory flow 25% to 75% ($r=0.44$) and $FEV_1$/FVC ($r=-0.29$), $p<0.05$ was observed for all results. The results concluded that SBC is sensitive to both obstructive and restrictive diseases and could also be easily performed by children.[15]

BHT is the time for which an individual can voluntarily hold their breath for as long as possible, until the breaking point where voluntary breath holding is no longer possible. During this time, the metabolic processes within the tissues continue to utilize $O_2$ and liberate $CO_2$ which lead to reduced $pO_2$ and elevated $pCO_2$ levels in the arterial blood; both factors being powerful respiratory stimulants. Their accumulation leads to respiratory drive stimulation which causes the inhibition of the voluntary breath holding resulting in the breaking point. BHT depends upon various elements such as the lung volumes, respiratory muscle strength, chemical alterations in $pCO_2$, $pO_2$ and H+ levels along with the present disease state and training levels.[16]

Aggarwal et al studied the correlation of BHT with post bronchodilator spirometric indices in 499 participants between the age group of 12-80 years. The participants were categorized as normal (100 participants), obstructive lung disease (263 participants) and restrictive lung disease (136 participants) on the basis of spirometry. The mean BHT in normal was 34.5612±18.7441, individuals with obstructive lung disease was 28.9198±16.9882 and restrictive lung disease was 28.3955±14.8385. The correlation of BHT to $FEV_1$ in normal was ($r=0.455$), obstructive ($r=0.438$) and restrictive ($r=0.392$). The correlation of BHT and FVC was ($r=0.447$) for normal, obstructive ($r=0.446$) and restrictive (0.366). The correlation of BHT and PEFR in normal was ($r=0.378$), obstructive ($r=0.138$) and restrictive ($r=0.316$). Further categorization of BHT with $FEV_1$was also done. They thus concluded that BHT test can be taken as a non-machine, non-technician dependent, bedside surrogate test of lung function. Individuals with BHT greater than 20 seconds should be allowed to undergo operative procedures.[17]

Slim et al conducted a study with 30 male COPD patients (mean age 65.9±11.27 years, mean $FEV_1$ 55.6±25.5%) to study the correlation of BHT with pulmonary function test and six-minute walk test (6 MWT). The mean BHT and 6 MWT distance were 21.94±7.87 seconds and 383.16±148.84m respectively. BHT showed a significant positive correlation to FVC ($r=0.63$, $p=0.02$), $FEV_1$ ($r=0.518$, $p=0.02$), DLCO/VA ($r=0.59$, $p=0.025$) and 6 MWT distance ($r=0.63$, $p<0.001$), thus indicating that it is a simple bedside assessment test which can be conveniently used to assess respiratory functioning and evaluate functional capacities in patients with COPD.[18]

Similarly, Hedhli et al studied 79 male stable COPD patients (mean age: 64.2±8 years). 6 MWT, plethysmography and BHT test were performed by the patients. The mean BHT was 24.2±8.5 seconds. There were significant positive correlations between BHT and FVC (r=0.630; p<0.001), $FEV_1$% (r=0.671; p<0.001) and the distance walked in the 6 MWT (r=0.494; p<0.001). A significant inverse correlation of BHT with total lung capacity (r=-0.328; p=0.019) and residual volume to total lung capacity ratio (r=-0.607; p<0.001) was noted. At 20.5 seconds, BHT had a sensitivity of 72% and specificity of 96% in determining COPD patients with $FEV_1$<50%.[19]

Desai et al innovatively used SBC and BHT in cases of interstitial lung disease (ILD) to study their correlation with spirometry. 18 men and 47 women ILD patients were included in this study. Spirometry, 6-minute walk test, SBC and BHT were recorded for all patients. The average of SBC and BHT was labelled as TNMC-PFT. The mean age, FVC and 6 MWD were 51.1±14.9 years, 1.3±0.5 L and 266.2±75.5 m respectively. SBC, BHT and their average (TNMC-PFT) correlated moderately with FVC (r=0.5, p<0.05) and 6 MWD (r=0.5, p<0.05). They concluded that TNMC-PFT can be a potential alternative to spirometry in ILD and in severe diseases in resource limited settings.[20]

Palaniyandi et al studied 200 patients with obstructive airway disease referred to pulmonary function testing lab for assessment. Spirometry, SBC and BHT were performed by all patients to study the correlation of SBC and BHT with standard measures of pulmonary function testing, namely $FEV_1$, FVC, $FEV_1$/FVC ratio and PEFR. SBC showed fair correlation with $FEV_1$ (r=0.426) and FVC (r=0.447). There was good correlation between BHT and $FEV_1$ (r=0.56) as well as FVC (r=0.552). BHT showed a weak correlation (r=0.193) with $FEV_1$/FVC ratio and PEFR (r=0.33). SBC also showed weak correlation with PEFR (r=0.248). All results were significant at the 95% confidence level. The authors concluded that both SBC and BHT are good tools for assessing pulmonary function in the emergency and resource limited settings.[21]

Thus, assessing SBC and BHT as surrogate measures for lung function is practical in COVID-19 patients since the use of spirometry is difficult due to the risk of spread of infection owing to difficulty in sterilisation of the equipment. However, this study was conducted to assess the change in SBC and BHT with single physiotherapy treatment session and the analysis from repeated and multiple daily physiotherapy treatment sessions with a larger sample size may yield more better results.

## CONCLUSION

SBC and BHT shows statistically and clinically significant improvement in the lung function in COVID-19 patients following single physiotherapy treatment session. These tests can be used as simple, surrogate bedside assessment tools and prognostic tests in contagious conditions like COVID-19, substituting the use of devices to measure pulmonary function.

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