Original Article

Correlation of Single Breath Count Test with Peak Expiratory Flow Rate in Adult Patients Post COVID-19 Infection

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Abstract

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Background : The utilization of spirometry has garnered significant attention recently due to its potential role in transmitting COVID-19. There is a critical need for a straightforward bedside assessment capable of accurately measuring respiratory function without relying on equipment and minimizing the risk of airborne transmission. This study was aimed to know the correlation between Single Breath Count Test (SBCT) values and Peak Expiratory Flow Rate (PEFR) values in adult patients recovering from COVID-19.

Methods : This study presents a cross-sectional design with consecutive subject recruitment. The SBCT was administered using a metronome, while PEFR was measured using a Mini Wright Peak Flow Meter on a sample of 38 participants, comprising 18 men and 20 women.

Results : Statistical analysis using Pearson's parametric correlation test revealed a significant relationship between SBCT and PEFR ($p < 0.05$), with a moderate positive correlation observed ($r = 0.516$).

Conclusion : This research demonstrates a significant, moderate positive correlation between SBCT and PEFR in adult post-COVID-19 patients, indicating that higher SBCT values correspond to higher PEFR measurements.

Keywords : Post COVID-19, Single Breath Count Test (SBCT), Peak Expiratory Flow Rate (PEFR).

INTRODUCTION

On March 11, 2020, the World Health Organization (WHO) announced that Coronavirus Disease 2019 (COVID-19) had become a global pandemic.[1] The data from the distribution map of confirmed COVID-19 cases in Indonesia indicate that the highest prevalence is observed among adults aged 31 to 45.[2] Various studies have demonstrated that the lungs are the organs most significantly affected by COVID-19.3 A systematic review and meta-analysis by Torres *et al*. identified various pulmonary function impairments in patients recovering from COVID-19. Notably, diffusion capacity abnormalities were observed in 39% of patients, while restrictive and obstructive patterns were found in 15% and 7% of cases, respectively.[3] The limited use of the gold standard for inspiratory function testing during the pandemic has hindered the objective assessment of these pulmonary function impairments. This limitation arises from the need to prevent airborne transmission, as procedures capable of generating droplets or aerosols in suspected COVID-19 patients, referred to as aerosol-generating procedures (AGPs), have been restricted.[4] Therefore, there is a need for a simple bedside examination that can accurately measure respiratory function without the use of equipment and with minimal potential for airborne transmission.[5]

The Single Breath Count Test (SBCT) serves as an alternative method for assessing respiratory function, offering several advantages. It is cost-effective, easy for patients to perform, and does not require the use of a mouthpiece. Consequently, it eliminates the risk of equipment contamination or the transmission of infectious diseases.[6] The SBCT has been shown to exhibit a strong correlation with forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV1) values obtained from spirometry, as well as with Peak Expiratory Flow Rate (PEFR) measurements.[7] This study was conducted to investigate whether there is a correlation between the results of the SBCT and PEFR values in adult patients following COVID-19 infection.

METHODS

This study employed a cross-sectional design to evaluate the SBCT and PEFR in adult patients who had recovered from COVID-19. Subject recruitment was conducted at Dr. Cipto Mangunkusumo General Hospital and Persahabatan General Hospital between June 2023 and July 2023. Data were collected using consecutive sampling after receiving ethical clearance from the Ethics Commission of the Faculty of Medicine, University of Indonesia, and the Ethics Commission of Persahabatan General Hospital Number 32/KEPK-RSUPP/03/2023. The study included adult participants diagnosed with COVID-19 who had recovered, as well as controls from RSUPN Cipto Mangunkusumo and RSUP Persahabatan, provided they met the inclusion criteria, did not meet the exclusion criteria, and consented to participate by signing an informed consent form. Sampling continued until the required sample size was achieved.

The inclusion criteria for participation were: age between 18 and 60 years, a history of COVID-19 infection confirmed by PCR swab testing more than six months prior, classification as having mild, moderate, or severe symptoms during the infection, and fulfillment of recovery criteria, including completion of isolation and issuance of a monitoring completion statement (verified through healthcare facility records or the PeduliLindungi application). Recovery was confirmed by a physician's assessment at the healthcare facility or by the attending specialist. Additionally, participants were required to test negative for COVID-19 antigen swabs within 24 hours prior to the study, provide informed consent, and demonstrate normal cognitive function (MoCA-INA score ≥ 26).

Exclusion criteria encompassed individuals unable to comprehend or follow research instructions, those with contraindications for peak expiratory flow rate testing (e.g., myocardial infarction within the past week, abdominal or thoracic surgery within the past month, head surgery within the past three months, pneumothorax within the past two weeks, hemoptysis, respiratory tract infections, or dementia), and those undergoing active tuberculosis treatment. Individuals with a history of severe or unstable chronic obstructive pulmonary disease (COPD), severe or uncontrolled asthma, uncontrolled chronic cardiorespiratory conditions, or a Brinkman smoking index >600 were also excluded.

The researchers provided participants with detailed explanations of the study's objectives and potential benefits. Willing participants signed an informed consent form, and the researchers completed a research status form based on anamnesis and physical examination. Cognitive assessments using the MoCA-INA and COVID-19 antigen swab tests were performed to confirm eligibility. Subsequently, SBCT and PEFR measurements were conducted on eligible participants. All collected data were subjected to statistical analysis.

Data analysis was performed using IBM SPSS (Statistical Package for the Social Sciences) for Apple, version 20.0. The analysis included univariate, bivariate, and multivariate approaches. Univariate analysis was used to describe the characteristics of the studied variables and their distribution patterns. Bivariate analysis assessed the relationship between independent and dependent variables. The normality of data distribution was evaluated using the Kolmogorov-Smirnov or Shapiro-Wilk test, with normality assumed if $p > 0.05$. For numeric variables, Pearson correlation was applied to normally distributed data, while Spearman

correlation was used for non-normal distributions. When the independent variable was categorical and the dependent variable numeric, an independent t-test was used for normally distributed data, and the Mann-Whitney U test was applied for non-normal distributions. Statistical significance was defined as $p < 0.05$.

Multivariate analysis was conducted to identify factors most strongly associated with the dependent variable. Variables with $p < 0.25$ in the bivariate analysis were selected and further analyzed for their association with PEFR values. Results were considered statistically significant if $p < 0.05$. Hypothesis testing included significance values (p), correlation strength (r), and confidence intervals (CI). A significance level of < 0.05 and a 95% confidence interval were applied for hypothesis testing.

RESULTS

The study included 38 participants, 18 males (47.4%) and

TABLE 1
Characteristics of the Study Subjects

Variable		Frequency
Age (years), median		37.16 (23–57)
Sex, n (%)	Male	18 (47.4)
	Female	20 (52.6)
Body weight (kg), median		67.5 (48–107)
Body height (cm), median		162 (153–182)
Body mass index (kg/m^2), n (%)	Underweight	1 (2.6)
	Normal	11 (28.9)
	Overweight	8 (21.1)
Risk of Obesity	Obesity I	11 (28.9)
	Obesity II	7 (18.4)
Education level, n (%)	Senior high school	17 (44.7)
	Undergraduate	21 (55.3)
Job, n (%)	Laborer/employee/staff	37 (97.4)
	Family worker/volunteer worker	1 (2.6)
Annual household income, n (%)	High	37 (97.4)
	Low	1 (2.6)
Physical activity, n (%)	Light	32 (84.2)
	Moderate	6 (15.8)
The onset of COVID-19, n (%)	6 months – 1 year	8 (21.1)
	1 year – 2 years	22 (57.9)
	>2 year	8 (21.1)
Severity of COVID-19 infection, n (%)	Low	32 (84.2)
	Moderate	6 (15.8)
Brinkman Index, n (%)	Non-smoker	30 (78.9)
	Mild smoker	6 (15.8)
	Heavy smoker	2 (5.3)
Comorbid, n (%)	Hypertension	2 (5.3)
	None	36 (94.7)

TABLE 2
Results of SBCT Measurements

Variable		Frequency
Sex	Male	50 (±11)
	Female	40 (±11)
The onset of COVID-19	6 months – 1 year	47 (±13)
	1 year – 2 years	44 (±12)
	>2 years	44 (±10)
Severity of COVID-19 infection	Mild	45 (±11)
	Severe	44 (±15)
Brinkman Index	Non-smoker	–
	Mild smoker	43 (±11)
	Heavy smoker	52 (±14)
	Physical activity	47 (±14)
	Light	45 (±12)
	Moderate	43 (±14)

TABLE 3
Results of PEFR Measurements

Variable		PEFR (L/minute) (n=38)
Sex	Male	507.22 (±87.84)
	Female	372.50 (±67.81)
The onset of COVID-19	6 months – 1 year	412.50 (±95.43)
	1 year – 2 years	440.00 (±109.63)
	>2 years	450.00 (±98.56)
Severity of COVID-19 infection	Mild	433.75 (±94.49)
	Moderate	450.00 (±149.93)
Brinkman Index	Non-smoker	–
	Mild smoker	413.00 (±92.48)
	Heavy smoker	533.33 (±112.01)
	Physical activity	495.00 (±7.07)
	Light	435.62 (±104.20)
	Moderate	440.00 (±103.73)

20 females (52.6%). The demographic characteristics of subjects are summarized in Table 1.

The mean SBCT measurement for male subjects was reported to be 50, with the lowest value recorded at 27 and the highest at 70. For female subjects, the mean SBCT measurement was observed to be 40, with the lowest and highest values being 22 and 60, respectively. Regarding the time since COVID-19 onset, the group with an onset of 6 months to 1 year demonstrated a higher mean SBCT value (47) compared to other groups. In terms of disease severity, the mean SBCT values for mild and moderate COVID-19 cases were found to be similar, with

TABLE 4
Correlation between SBCT and PEFR

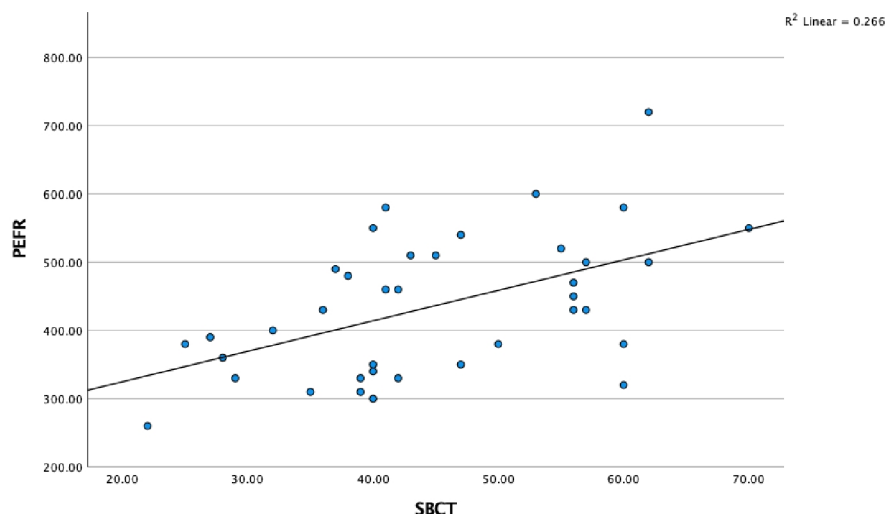| Variable	Mean (SB)	Correlation Coefficient (r)	*p-value*
SBCT	44.97 (±11.87)	0.516	0.001
PEFR	436.32 (±102.73)		

Figure 1. Correlation between SBCT and PEFR

averages of 45 and 44, respectively. When categorized by the Brinkman Index, the highest mean SBCT value was observed in the light smoker group, with a mean of 52. In relation to physical activity levels, the mean SBCT value for the light physical activity group was reported to be 45, while for the moderate physical activity group, it was slightly lower at 43. The SBCT measurement results are summarized in Table 2.

The mean PEFR for male subjects was reported to be 507.22 L/min, with the minimum and maximum values recorded as 350 L/min and 720 L/min, respectively. For female subjects, the mean PEFR was observed to be 372.5 L/min, with the lowest and highest values being 260 L/min and 520 L/min, respectively. In terms of the time since COVID-19 onset, the group with an onset exceeding two years was found to have a higher mean PEFR value (450 L/min) compared to other groups. Regarding the severity of COVID-19, the moderate severity group demonstrated a slightly higher mean PEFR (450 L/min) compared to the mild severity group. When analyzed by the Brinkman Index, the highest mean PEFR was observed in the light smoker category, with a value of 533 L/min. Concerning physical activity levels, the mean PEFR for the light physical activity group was nearly identical to that of the moderate physical activity group, at 435 L/min and 440 L/min, respectively.

The Pearson parametric correlation analysis conducted between SBCT and PEFR revealed a statistically significant relationship between the two variables ($p < 0.05$). This suggests that higher SBCT values are associated with higher PEFR values, demonstrating a moderate positive correlation (r = 0.516).

DISCUSSION

This study identified a statistically significant moderate positive correlation between the Single Breath Count Test (SBCT) and Peak Expiratory Flow Rate (PEFR) in adult patients recovering from COVID-19 (r = 0.516, $p < 0.05$), indicating that as SBCT values increased, PEFR values also tended to increase. Notably, male patients demonstrated higher mean SBCT and PEFR values compared to females, which may reflect sex-based differences in lung function and post-infection recovery.

These findings are consistent with previous studies. Bhandare *et al*. reported a stronger correlation (r = 0.7048) between SBCT and PEFR in healthy adults, suggesting a robust association. Bartfield *et al*. also found SBCT to be moderately correlated with both PEFR (r = 0.68) and FEV☐ (r = 0.68), proposing it as a viable alternative to traditional spirometry. Escossio *et al*. demonstrated high sensitivity (94.44%) and specificity

(76.62%) of SBCT in hospitalized patients, while also noting excellent intra-rater reliability (ICC = 0.976). Other studies by Ali *et al.*, Kalita *et al.*, and Elsheikh *et al.* have further validated SBCT's utility across a variety of respiratory conditions, including asthma, Guillain-Barré Syndrome, and myasthenia gravis, showing moderate to strong correlations with various spirometry indices and respiratory measures.

This study enhances the evidence supporting SBCT as a simple, safe, and effective approach to evaluate ventilatory capacity. Its benefits include ease of use, cost-effectiveness, and low risk of cross-infection, which is especially pertinent in post-pandemic clinical environments. Additionally, it doesn't necessitate specialized equipment and is generally well-received by patients, making it particularly appropriate for resource-limited settings or during outbreaks.

Notably, this is the first study to investigate SBCT in adult patients recovering from COVID-19, providing new insights into post-viral pulmonary evaluation. A significant strength of the methodology was the consistent administration of both tests by the same examiner, which minimized variability.

The Limitation of this study is distribution of sex among smokers and non-smokers was not even, potentially introducing bias. Moreover, the number of underweight participants was small, and a handful of subjects initially had trouble with the testing technique; however, all completed the assessments after receiving guidance.

Overall, these findings reinforce the role of SBCT as a practical screening tool for post-COVID-19 pulmonary function and highlight the need for further studies to explore its applicability across broader patient populations and pulmonary conditions.

CONCLUSION

A moderate positive correlation was found between SBCT and PEFR in post-COVID-19 adults, with higher values observed in male patients. SBCT offers a safe, simple, and practical method for lung function assessment in post-pandemic care. Further studies are needed to validate its use across broader pulmonary conditions.

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