**ABSTRACT**

**Background:** COVID-19 survivors often result in persistent symptoms, even months after being discharged, that lead to decreased lung function. Incentive spirometry is commonly used in pulmonary rehabilitation as it encourages the patient to take slow and deep inspiration through visual feedback. This study aimed to analyze the effects of incentive spirometry exercise on pulmonary function in COVID-19 survivors.

**Method:** Twenty COVID-19 survivors aged 18-59 were enrolled in the study and divided randomly into two groups; ten survivors in the experimental group that received incentive spirometry exercise and ten survivors in the control group that received diaphragmatic breathing exercise. Both exercises were performed five times daily, with ten repetitions each for four weeks. Peak expiratory flow (PEF) was measured by a peak flow meter before and after the treatment in both groups. The data were analyzed statistically.

**Result:** There was a significant increase in pulmonary function in the experimental group ($p=0.001$) and control group ($p=0.001$). However, the two groups had no significant difference in pulmonary function ($p=0.198$). The incentive spirometry exercise shows a more significant effect on pulmonary function rather than diaphragmatic breathing.

**Conclusion:** Incentive spirometry exercise could be an alternative therapy to improve the pulmonary function of COVID-19 survivors.

**Keywords:** COVID-19 survivors, incentive spirometry, peak expiratory flow (PEF).


**INTRODUCTION**

Coronavirus disease 2019 (COVID-19) is a global health problem that could cause long-term symptoms. Patients with COVID-19 usually recover and return to normal health; however, some patients may have symptoms that last for weeks or even months after recovery. In recovered COVID-19 patients, pulmonary fibrosis can occur, leading to impaired lung function. In addition, there are also Long COVID complaints such as fatigue, dyspnea, cough, anxiety, cognitive impairment, and myalgia.

Pulmonary rehabilitation in post-COVID-19 patients is essential because it can reduce the impact of sequelae on patients, improve lung function, reduce dyspnea during activities, and reduce anxiety and depression to enhance the quality of life (QoL). Diaphragmatic breathing and incentive spirometry are among the ways to assist patients in recovering from such complaints.

Diaphragmatic breathing is a type of breathing exercise to strengthen the diaphragm, reduce the work of breathing and improve ventilation efficiency. Diaphragmatic breathing techniques by breathing slowly and deeply through the nose using the diaphragm with a minimum movement of the chest, while one hand placed on the chest and the other on the abdomen to confirm visually that their movement is appropriate.

Incentive spirometry is a breathing exercise using a device to sustain maximal inspiration that provides visual feedback when the patient inhales and sustains the inflation. The use of incentive spirometry in respiratory muscle exercise has been shown effective in maintaining or increasing inhaled lung volume, preventing lung infection after surgery, and improving sputum expectoration. As a non-invasive and cost-effective pulmonary rehabilitation intervention, breathing exercises can be a valuable tool for a healthcare system overwhelmed by the COVID-19 pandemic.

Telerehabilitation is a delivery method to spread a more comprehensive range of information and higher the involvement of patients. Telerehabilitation involves providing rehabilitation information and communication technology that enables intervention to be delivered through real-time (e.g., video conference) and store-forward (e.g., digital images) consultation formats. Telerehabilitation can reach more patients, including those with difficulty accessing a healthcare center and those isolated at home due to COVID-19; it also reduces transmission between healthcare providers and...
patients.\textsuperscript{16} Exercise programs delivered via telerehabilitation may improve functional capacity, lower limb performance, dyspnea and the physical component of quality of life in patients with COVID-19 in the acute phase and people with post-COVID-19 conditions.\textsuperscript{16}

A spirometry test is the most common pulmonary function test and should be conducted safely with general infection prevention.\textsuperscript{17} An acceptable and reproducible parameter for evaluating respiratory functions, even in those with recent pulmonary decompensation history, is the peak expiratory flow (PEF) testing. Personal devices for PEF evaluation using a peak flow meter allow an outpatient follow-up to prevent the patient-to-patient transmission and repeated measure sampling.\textsuperscript{18} This study aimed to determine the effectiveness of incentive spirometry exercise in improving pulmonary function in COVID-19 survivors.

\section*{METHODS}

\subsection*{Participants}

This research applied hybrid telerehabilitation conducted from October 2021 to October 2022. Sample collection was taken using consecutive sampling, where the subjects who met the inclusion criteria were included in the study. The population was post-COVID-19 patients admitted to Medical Rehabilitation Outpatient Clinic, Dr. Soetomo General Academic Hospital after hospitalization. This study included participants who met the criteria, including adults aged 18-59 years, post-hospital treatment due to COVID-19 infection and had negative swab based on PCR test, Mini-Mental State Examination (MMSE) score 24-30, hemodynamically stable (conscious, normal heart rate, normal respiratory rate, normal blood pressure or treated by medication), and had a telecommunication device with video call application. The participants who already received an inspiratory muscle strengthening exercise (threshold IMT, incentive spirometry), a history of other lung diseases (COPD, asthma, tuberculosis, lung cancer, etc.), severe heart disease, neurology disruption, visual and hearing impairments and condition of the nose and mouth that interfere the use of tools were excluded from this study. The participants were considered to drop out of this study if they could not do the exercise for three consecutive days, did not want to carry on with the program, quit the program, got sick, or died. A total of 20 COVID-19 survivors met the inclusion criteria in this study.

\subsection*{Study Design and Treatment}

This study was experimental with a randomized pretest and posttest control group design. The participants were divided randomly into two groups; the experimental and the control group. The experimental group received incentive spirometry exercise every day, five times a day, ten repetitions each, 1-2 hours rest between exercises, for four weeks. The control group received diaphragmatic breathing exercises five times daily, ten repetitions each, 1-2 hours rest between exercises, for four weeks. This study applied a hybrid telerehabilitation method. The exercise was carried out at the subject’s home, monitored by a family member every day and two times a week by the researcher via video conference. Before the treatment, baseline data were collected where subjects conducted a physical examination, received information about the treatment, how to perform it at home, and had an explanation about safety protocols during exercise at home. Each subject received a pulse oximeter (Elitech\textsuperscript{\textregistered}) to measure their pulse and oxygen saturation (SpO\textsubscript{2}) during exercise at home and was educated about the measurements that should be done and complaints that should be reported before and after exercise. At home, the subjects measured their pulse, SpO\textsubscript{2}, and Borg Scale Rating of Perceived Exertion (RPE), identified any complaints before and after exercise, and wrote them in an exercise diary. Subjects had to report to the family member and researcher if there was any abnormality. Telerehabilitation compliance was measured by filling out an exercise diary each time they performed exercises monitored by a family member, supervised by the researcher two times a week via video conference, and weekly evaluations to evaluate the exercise achievement.

\subsection*{Incentive Spirometry}

Incentive spirometry exercises were performed in a sitting position by holding the device, exhaling normally then closing the lips tightly around the mouthpiece. Then, the subject performed maximal inspiration by taking long, deep, and slow breaths. When the subject took a deep breath, the balls in the chamber lifted. After maximal inhalation, the subject held their breath for 3-5 seconds, then removed the mouthpiece and exhaled slowly. Incentive spirometry exercises were prescribed daily, five times a day, ten repetitions each, 1-2 hours rest between exercises, for four weeks. The device used in this study is Flow-based Incentive Spirometry (TriFlo RESPIOMETER\textsuperscript{\textregistered}).

\subsection*{Diaphragmatic Breathing}

Diaphragmatic breathing was performed by sitting upright, where the subject placed one hand on the chest and one hand on the abdomen. The subject breathed in slowly through his nose so the stomach moved out, causing the hand to rise. The hand on the chest should remain as still as possible. When exhaled, the hand on the abdomen moved down to its original position. Diaphragmatic breathing was prescribed five times a day, ten repetitions each, 1-2 hours rest between exercises, for four weeks.

\subsection*{Data Collection}

The pre-and post-exercise data collections were carried out offline, while the exercises were performed at the subject’s home with online supervision. This study used peak expiratory flow (PEF) to assess pulmonary function. The data was measured before and after the program to determine whether there was a difference between them. PEF was measured by using a peak flow meter. The technique was standing up straight, moving the marker to the bottom of the numbered scale, then taking a deep breath while placing the mouthpiece in the subject’s mouth. Then, the subject blew out as hard and fast as possible in a single blow. All these steps were repeated three times. So, the subject’s peak expiratory flow was the highest of the three numbers.

\subsection*{Statistical Analysis}

The Shapiro-Wilk test was used to test the normal data distribution. The paired t-test
RESULTS

**Participant characteristics**
A total of 20 COVID-19 survivors participated in this study, and no participant dropped out. The experimental group included ten survivors (80% men, mean age 44.30 ± 6.79 years), and the control group had ten survivors (50% men, mean age 48.10 ± 9.81 years). The sociodemographic characteristics of both groups were similar (Table 1). We observed no significant differences in mean and SD of baseline age, body weight, body height, body mass index (BMI), length of stay, and pre-PEF value between the experimental and control groups (p>0.05) (Table 1).

**Peak Expiratory Flow**
Table 2 represents the differences in the mean of peak expiratory flow (PEF) values before and after four weeks of treatment, both in the experimental and control groups. The PEF value in the experimental group increased significantly (p=0.000) with a mean of 394.00 ± 130.29 L/min before incentive spirometry exercise and 556.00 ± 152.25 L/min after exercise. In the control group, the PEF value increased significantly (p=0.001) after diaphragmatic breathing, with a mean of 450.50 ± 120.47 L/min before exercise and 562.50 ± 130.06 L/min after exercise. However, the comparison of differences in peak expiratory flow (ΔPEF) values between the experimental and control group showed no significant difference (p=0.198) (Table 3). While the calculations of the effect size of Cohen’s D showed a strong effect (d = 1.14) in incentive spirometry exercise and a moderate effect in diaphragmatic breathing (d = 0.89).

**DISCUSSION**
COVID-19, caused by SARS-CoV-2, can involve sequelae and other medical complications that last for weeks or even months after recovery; this condition is known as Long COVID.1–3 The symptoms of Long COVID include fatigue, dyspnea, cough, anxiety, cardiac abnormalities, cognitive impairment, sleep disturbances, post-traumatic stress disorder, myalgia, and headache.2,20,21 COVID-19 is principally a respiratory illness; those who overcome the acute infection may develop long-term abnormalities caused by pulmonary inflammation that affects survivors’ pulmonary function.18,22,23

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### Table 1. Basic characteristics of participants.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Experimental group (n = 10)</th>
<th>Control group (n = 10)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (year)</td>
<td>44.30 ± 6.79</td>
<td>48.10 ± 9.81</td>
<td>0.199</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>75.10 ± 9.40</td>
<td>71.20 ± 12.48</td>
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<tr>
<td>Body height (cm)</td>
<td>165.60 ± 7.76</td>
<td>164 ± 6.66</td>
<td>0.608</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>27.90 ± 4.83</td>
<td>27.29 ± 4.53</td>
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</tr>
<tr>
<td>Length of stay (day)</td>
<td>20.80 ± 10.17</td>
<td>25.00 ±11.83</td>
<td>0.257</td>
</tr>
<tr>
<td>Baseline PEF (L/min)</td>
<td>450.50 ± 120.47</td>
<td>394.00 ± 130.29</td>
<td>0.920</td>
</tr>
<tr>
<td>Sex</td>
<td>Male</td>
<td>Female</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8 (80)</td>
<td>2 (20)</td>
<td></td>
</tr>
<tr>
<td>Education Level</td>
<td>Middle school</td>
<td>High school</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>6 (60)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 (20)</td>
<td>2 (20)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>University</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4 (40)</td>
<td>6 (60)</td>
<td></td>
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<tr>
<td>Severity of COVID-19</td>
<td>Mild</td>
<td>Moderate</td>
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<tr>
<td></td>
<td>0</td>
<td>3 (30)</td>
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<tr>
<td></td>
<td>Moderate</td>
<td>Severe</td>
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<td></td>
<td>2 (20)</td>
<td>7 (70)</td>
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<tr>
<td>Comorbid</td>
<td>Hypertension</td>
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<tr>
<td></td>
<td>1 (5)</td>
<td>1 (5)</td>
<td>1 (8)</td>
</tr>
<tr>
<td></td>
<td>Dyslipidemia</td>
<td>Obesity</td>
<td>8 (43)</td>
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<tr>
<td></td>
<td>7 (58)</td>
<td>2 (20)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Autoimmune</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9 (47)</td>
<td>2 (17)</td>
<td></td>
</tr>
<tr>
<td>Post-COVID-19 Symptoms</td>
<td>Dyspnea</td>
<td>Cough</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>3 (25)</td>
<td>1 (8)</td>
<td>1 (6)</td>
</tr>
<tr>
<td></td>
<td>Headache</td>
<td></td>
<td>8 (67)</td>
</tr>
<tr>
<td></td>
<td>4 (27)</td>
<td>3 (20)</td>
<td>7 (47)</td>
</tr>
</tbody>
</table>

*Values are presented as mean ± standard deviation or number (%)*

BMI, body mass index; PEF, peak expiratory flow

### Table 2. Comparison of peak expiratory flow (PEF) before and after treatment in experimental group and control group.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Experimental Group</th>
<th>Control Group</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEF (L/min)</td>
<td>Pre (n = 10)</td>
<td>394.00 ± 130.29</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Post (n = 10)</td>
<td>556.00 ± 152.25</td>
<td></td>
</tr>
</tbody>
</table>

*Notes: significant if p < 0.05.*

*Abbreviations: PEF, peak expiratory flow*
Table 3. Comparison of differences of peak expiratory flow (Δ PEF) value between experimental group and control group.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Experimental group (n = 10)</th>
<th>Control group (n = 10)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Δ PEF (L/min)</td>
<td>162.00 ± 94.34</td>
<td>112.00 ± 71.18</td>
<td>0.198</td>
</tr>
</tbody>
</table>

Notes: significant if p < 0.05.
Abbreviations: PEF, peak expiratory flow.

Pulmonary function impairment is the most common disorder in COVID-19 patients. Liao et al. reported 6.40% of COVID-19 survivors still presented pulmonary function abnormalities three months after discharge. Pulmonary rehabilitation is recommended to improve pulmonary function, exercise tolerance, and reduce fatigue during physical activity in post-COVID-19 patients, especially after hospitalization. The principle of pulmonary rehabilitation is to provide an exercise that is simple, safe, easy, and can be done anywhere, including at home. Breathing exercise aims to maintain lung expansion and energy conservation while doing the activity and maintaining exercise tolerance during this COVID-19 pandemic.

Using a peak flow meter, this study measured pulmonary function with peak expiratory flow (PEF). Peak expiratory flow is a simple measurement of the maximal flow rate that can be achieved during forceful expiration following full inspiration. Measurement of pulmonary function using spirometry is the gold standard. Still, PEF correlates well with the predicted percentage of forced expiratory volume over 1 second (FEV1) and provides an objective measure of airflow limitation when spirometry is not available. In this COVID-19 pandemic, pulmonary function testing should be conducted safely with general infection prevention to minimize the risks of healthcare infections, prevent potential exposure to patients, and prevent the spread of SARS-CoV-2. The value of PEF can be measured using a peak flow meter, a portable meters, which are personal use, affordable and relatively simple to handle.

The variability of peak expiratory flow values depends on airway diameter, age, sex, body weight, body height, BMI, level of physical activity, and race. PEF values decreased by age due to degenerative changes in the musculoskeletal system, which caused a decrease in respiratory muscle strength. PEF values were also reduced in the group with high BMI, as increased adipose tissue in the thoracolumbar region limits muscle movement in this area, resulting in impaired lung mobility and reduced ventilation. Kaur et al. reported a significant relationship between PEF and body height due to the greater chest volume in taller subjects, as well as airway growth and expiratory muscle effort also increasing with increasing body height. PEF values in males are significantly higher than in females; this could be due to the greater size of the lungs and the increased muscularity in males compared to females with reduced muscle mass due to increased fat deposition.

This study showed a significant improvement in pulmonary function (PEF) after performing incentive spirometry exercises for four weeks (p=0.000). Incentive spirometry is a breathing exercise technique to help patients obtain maximum inspiration by using a device that gives visual feedback regarding flow and volume. The flow-incentive spirometry (TriFlo) is a device that consists of a mouthpiece connected to three chambers with one plastic ball in each chamber. The patient inhales through the mouthpiece, creating a negative pressure within the tubes, which causes the balls to rise. The number of balls and the level to which they rise depends on the magnitude of the flow achieved. The patient is instructed to hold the device upright, exhale normally, and then place the lips tightly around the mouthpiece. The next step is a slow inhalation to raise the balls to the target. The next step is a slow inhalation to raise the ball in the chamber to the set target. At maximum inhalation, the patients hold their breath for 3-5 seconds before removing the mouthpiece, followed by a normal exhalation. An incentive spirometry is used to help patients improve their respiration function; it is easy to use, safe, and affordable. It can be done at home, yet the precaution is hyperventilation, hypoxemia secondary, fatigue, and pain that may occur while exercising.

Incentive spirometry exercise showed an improvement in inspiratory muscle strength and lung volume, indicated by an increase in expiration flow which was seen by a significant rise in PEF values. Aliaaghpour et al. indicated that using incentive spirometry for two months improved pulmonary function (FEV1, FVC) in hemodialysis patients. Another study states that using incentive spirometry reduced pulmonary complications and improved pulmonary function in patients with rib fractures. However, there was no significant difference in pulmonary function (Δ PEF) between the experimental and control groups in this study. This result is similar to Aydin et al., that investigated the effect of flow-incentive spirometry on pulmonary functions in COVID-19 patients during a follow-up period of 1 month, resulted in no difference between absolute PEF values and percentages, as seen between the control and study groups. The result could be due to the short-term training in this study, so the long-term effects of incentive spirometry exercise could not be recognized.

Most studies concluded the effectiveness of incentive spirometry in pulmonary function is beneficial. Previous studies investigated the effect of incentive spirometry on patients with stroke and post-abdomen laparoscopy, resulting in a significant improvement in pulmonary function compared to the control group. This is aligned with the effect size of incentive spirometry exercise in this study which exhibited a strong effect (d = 1.14) on the improvement of pulmonary function compared to diaphragmatic breathing, which demonstrated a moderate effect (d = 0.89). Seyller et al. suggested that incentive spirometry should be considered part of treatment protocols for mild-to-moderate COVID-19 patients due to its theoretical benefits and limited risk.

This study applied the hybrid telerehabilitation method to prevent the spread of COVID-19 infection and telerehabilitation method to prevent the spread of COVID-19 infection and the spread of COVID-19 infection and...
commit social distancing. In the initial, via offline meeting, baseline data were collected, subjects conducted a physical examination, received information about the treatment, understood how to perform it, and had an explanation about safety protocols during exercise at home. Meanwhile, for the online training at home, subjects in the experimental and control groups performed the treatment daily, five times a day, ten repetitions each, for four weeks. The lead of telerehabilitation in this pandemic condition is to reduce physical contact, time efficiency, and flexibility to exercise, increasing compliance and reducing drop-out. There was no side effect or unwanted events during the study; thus, incentive spirometry exercise could be a safe and effective treatment for COVID-19 survivors at home.

This study may have several limitations and biases; the subjects’ physical activity outside the exercise program could not be controlled; the patient’s exercise compliance was carried out by filling an exercise diary and supervision by a family member at home and researchers by video conference. Also, this study has limitations in ensuring compliance, and the long-term effects of exercise were not measured in this study. Further research is necessary to observe the long-term effects of incentive spirometry on pulmonary function in COVID-19 survivors with better control of variables.

CONCLUSION
Incentive spirometry exercise significantly increases peak expiratory flow value in COVID-19 survivors, so it could be an alternative therapy to improve pulmonary function. Incentive spirometry is a safe medical device that provides visual feedback that could motivate and increase exercise compliance. However, considering the limited studies available, further research is required in this area.

ETHICAL CONSIDERATION
This study was approved by The Research Ethics Committee of Dr. Soetomo General Academic Hospital (Ref No. 0277/KEPK/X/2021). Prior to the study, written informed consent was obtained from all participants.

FUNDING
This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

CONFLICT OF INTEREST
The author reports no conflicts of interest in this work.

AUTHOR CONTRIBUTION
All authors have contributed equally from the conceptual framework, data acquisition, and data analysis until the study results are reported through publication.

ACKNOWLEDGMENTS
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