Improving the function of vital lung capacity of post-COVID-19 patients through deep breathing exercises

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Abstract

Prolonged respiratory disorders in post-COVID-19 patients still exist after patients return to the hospital. Deep breathing exercises are recommended that can increase the vital capacity of the lungs. This study aimed to identify the effect of a deep breathing exercise on vital lung capacity in post-COVID-19 patients. The intervention group (20) received deep breathing exercises, and the control group (20) received standard care. The vital lung capacity was evaluated after two weeks. The findings show that there is increased functional capacity for both groups. There is increasing the functional capacity increased in L from a mean of 1.73 with SD 0.38 to 1.87 with SD 0.37 (p=0.000, CI 95%) in the intervention group, and in the control group, it increases from 1.63 with SD 0.21 to 1.73 with SD 0.21 (p=0.008, CI 95%). The finding of the t-test result showed a significant difference in the average value of the vital lung capacity before and after the intervention between the intervention and the control groups (p=0.008; 95% CI=0.02-0.07). A deep breathing exercise improves the vital lung capacity of post-COVID-19 patients.

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Introduction

Coronavirus Disease 2019 (COVID-19) is one of the infectious diseases caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2). It was first found in December in Wuhan, Hubei, China, and rapidly spread to other countries. The virulence of the virus is high, and the virus is easily spread through the air, droplets, and aerosols, making the COVID-19 cases increase vastly across countries. The World Health Organization (WHO) stated that COVID-19 is a pandemic case.

For over two years, WHO and countries worldwide have made tremendous efforts to minimize mortality and increase the recovery rate of COVID-19 patients. As of 8 September 2021, from 221 million cases globally, 198,005,136 patients had recovered. In Southeast Asian countries, out of a total of 10,662,530 cases, 9,476,685 patients recovered. Meanwhile, in Indonesia, 3,876,760 of 4,147,365 patients were revived. At DKI Jakarta, there were a total of 2,977 patients who recovered from COVID-19. Indonesia was ranked at fourteen based on a total of recovered cases. Globally, the recovery rate of COVID-19 cases was 69.97% as of 8 September 2021, and in Indonesia it was 79.19%. Although the recovery rate increased, it was reported that there were new problems that emerged post COVID-19.[1]

Based on a negative PCR swab result, recovered patients still had COVID-19 symptoms four to twelve weeks from the onset of COVID-19, which could be prolonged until six months in chronic conditions. This circumstance was called long COVID-19 or post-COVID-19 syndrome. [2] Reported that two to three weeks after the PCR test showed a negative result, 35% of the patients were not fully recovered, and 20% of the patients between the ages of 18 and 34 years old experienced more than two prolonged symptoms of COVID-19.[3]

In comparison to other symptoms, respiratory complaints such as dyspnea, cough, and shortness of breath were most commonly reported in post-COVID-19 patients.[1,3] This condition was caused by Angiotensin Converting Enzyme 2 (ACE2), as the receptor of SARS-CoV-2 was found 83% in the respiratory organ. Thus, respiratory problems dominantly occurred and were prolonged during post COVID-19. Although there was no definite mechanism that could explain post-COVID-19 syndrome,[4] it was believed that the condition was caused by the inflammation process when the virus infected and damaged the lungs, which led to a decrease in lung compliance resulting in lowering vital lung capacity.[5] The circumstance may lead to relapse, prolonged recovery, decreased quality of life, and triggered prolonged symptoms. The recommendation to perform immediate rehabilitation was based on similar cases due to a lack of research and data.[6]

One recommended intervention to overcome respiratory complaints is deep breathing exercises.[7,8] This exercise is one of the nursing care interventions that aim to increase the function of vital capacity by enhancing alveolus ventilation, preventing atelectasis, increasing effective cough, maintaining gas diffusion and decreasing stress.[9] Deep breathing exercise is simple and applicable to everyone. In fact, deep breathing exercise was recommended as rehabilitation self-management post COVID-19 for persistent respiratory problems.[7] However, this needs to be proven by conducting further research on whether this technique has an effect on improving vital lung capacity in patients with post-COVID-19 cases and the benefits of this technique in reducing persistent symptoms in post-COVID-19 patients. Therefore, this study aimed to examine the effectiveness of deep breathing exercises in improving the vital lung capacity of post COVID-19 patients.

Materials and Methods

Participants and sampling

Quasi-experimental pre- and post-test with a control group and consecutive sampling were used in this study. This design was chosen because researcher wanted to know whether there was an effect of an intervention on the research sample. This study was conducted between 10 February – 22 March 2022 at the outpatient clinic of a referral hospital for respiratory diseases. Based on the calculation of the formula, the minimum sample of this study is 30, with details of the intervention and control groups, each of which is 15 respondents. To avoid dropping out of the sample, an additional 10% of respondents were added so that there were 17 respondents in each group. The total number of respondents involved in this study was 34. In this study, the researchers increased. The sample to 40 respondents considering that the sample was more varied. A total of 40 respondents participated in this study, with a distribution of 20 respondents assigned to each control and intervention group (Figure 1).

Inclusion/exclusion criteria

Inclusion criteria for the respondents were as follows: compos mentis, age ≥18 years old, recovered COVID-19 patients based on a negative swab PCR result, Borg dyspnea scale (respiratory status) ≤4, SpO_2 ≥95%, Respiratory Rate (RR): ≥10-≤22 breaths/minute, and living around Jakarta and Bekasi, Indonesia. Meanwhile, the exclusion criteria included patients with exacerbated Chronic Obstructive Pulmonary Disease (COPD) and class IV congestive heart failure.

Study design

Quasi-experimental pre- and post-test with a control group and consecutive sampling were used in this study. Respondents in the intervention group received a deep breathing exercise for 45 minutes each session with a five minute break after ten minutes of practice three times a day (morning, afternoon, and evening) for two weeks. The steps included taking a deep breath (inspiration) from the nose for about four seconds. Then patients were asked to hold their breath for four seconds. Lastly, let go of the breath in six seconds through the mouth (expiration). At the same time, respondents in the control group received standard nursing care, including health education regarding daily oral medication, nutrition, fluid and electrolyte, comfort, personal hygiene, therapy compliance, activities, and circumstances where they need to go to the healthcare facilities.

Data collection

Data were collected by the first author (VE). During data collection, VE was assisted by three enumerators who had bachelor's degrees in nursing. The enumerator received information about the procedure of the study, including the intervention. The training session took 4-5 hours, with an interactive discussion session and role play for intervention. To maintain the same intervention for enumerators, the researcher conducted an Intraclass Correlation Coefficients (ICC) test with the Two-Way-Mix type Absolute Agreement model. The first ICC test was used to equalize perceptions regarding spirometry measurements between researchers and enumerators. The second ICC test is used to equalize perceptions about deep breathing exercises. The results of these two tests showed ICC results of 0.834 and 0.934, respectively. Based on the interpretation of CC results, including poor (<0.50), fair (≥0.50-0.75), good (0.75-0.90), and excellent (0.90-1.10), it can be concluded that enumerators can be involved in research and have the same perception with researchers.

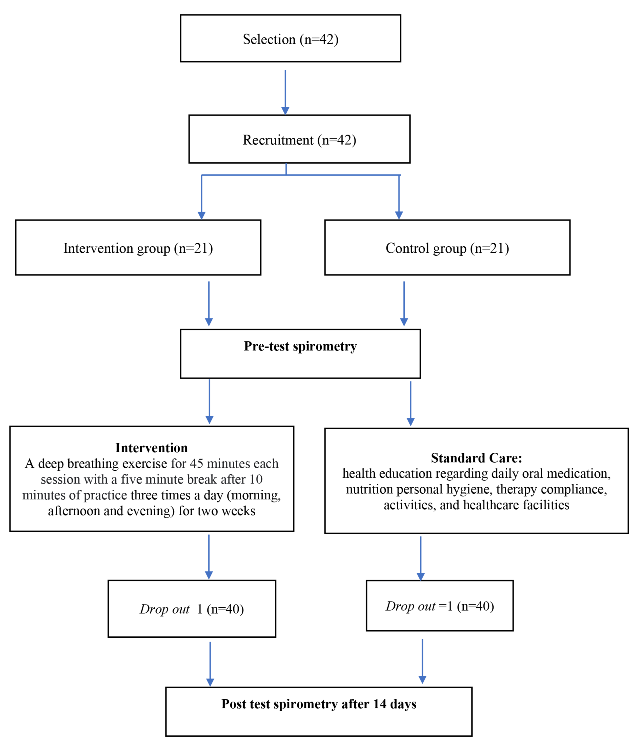

Figure 1. Study flowchart.

Instruments used in this study consisted of a questionnaire containing the respondents' characteristics (gender, age, past medical history, smoking history, and obesity) and the portable spirometry CONTEC SP70B. Spirometry was utilized to obtain data about vital lung capacity value. The value was measured before the intervention was given and two weeks after. The parameters that can be measured by spirometry include Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV_1), the ratio FEV_1/FVC, and Peak Expiratory Flow (PEF). In this study the authors used the FEV_1 parameter to see the patient's vital lung capacity with an interpretation of ≥4 litres/minute (80-100%) as normal, 2.5-<4 litres/minute (50-<80%) as less, and <2.5 litres/minute (<50%) as bad. This interpretation is based on references from the Thoracic Society Standardization of Spirometry 2019 update.[11] The spirometry was calibrated two times a week to maintain accuracy.

Data analysis

The data was analysed using SPSS version 25. Univariate analysis was used to determine the distribution of independent and dependent variables. The variable related to the average difference in the vital capacity before and after the intervention within each group was measured by using paired t-test. The average difference between the intervention and the control group was measured using an independent sample t-test.

Ethical considerations

The study was reviewed and approved, and ethical clearance was obtained from the Ethical Committee Review Faculty of Nursing, University of Indonesia (Number: ket-10/UN2.F12.D1.21/PPM.00.02/2022). This study also received ethical approval from the Comitte Ethic Board Persahatan Hospital Jakarta, Indonesia (Number: 13/KEPK-RSUPP/02/2022), and receive letter of research permission from Persahabatan Hospital (Number: DL.01.01/IX.2/2055/2022). All respondents in this study was informed about this study and gave their consent to participate in the study. Informed consent from respondents was obtained if they agreed to participate in the study. Participation was voluntarily, and the respondents could make a withdrawal from the study whenever they wanted without any consequences.

Results

The statistical analysis was performed using SPSS version 25. In the univariate analysis, age of respondents (numeric) were presented as mean ± SD. The gender, past medical history, smoking history and obesity (categoric variable) were presented in the form of a frequency distribution table. A bivariate analysis was used a paired-sample T test to examine differences in VLC values in the intervention group after administration of deep breathing exercise and differences in VLC among the patients in the control group, who received the standard therapy. Differences with p values <0.05 were considered significant. The data were tested for normal distribution using the Shapiro-Wilk normality test (<50 sample). The differences in the changes in VLC after treatment between the control and intervention groups were determined using an independent-sample T test. Differences with p values <0.05 were considered significant. In addition to the tests to determine the statistical variance between the control and intervention groups, Levine's test was used for numerical data, and a chi-square test was used for categorical data, where all data groups had the same variance (p>0.05).

Respondents' characteristics

Respondents in the intervention group are dominantly male (60 %), while the control group has a similar gender distribution (50% female and 50% male). Most of the respondents from the intervention and control groups do not have a past medical history (70% in Intervention and 75% in control group), are not obese (70% in Intervention and 80% in control group), and do not smoke (both group 60%). In Table 1, The average age of respondents in the intervention group was 42.25 years old (95% CI), while in the control group 41.15 years old (95% CI; Table 2).

Differences average of the VLC before and after the intervention within each group

Differences average of the VLC before and after the intervention within each group are presented in the following table (Table 3). The result of paired-T test showed both of interventions increased the VLC (p<0.05). The average value of the vital lung capacity in the intervention group before the deep breathing intervention was 1.73 (95% CI) and after the intervention was 1.87 (95%CI). In the control group, the average value before the stan-

Table 1. The distribution of respondents' age.

Group	Mean±SD	95% CI Lower-Upper
Intervention	42.25±9.16	37.9-46.5
Control	41.15±9.19	36.8-45.4

Table 2. The average value of the vital lung capacity before and after the intervention within each group.

Group	Variable	Measure	Mean	SD	Df	T	MD (95% CI)	Value
Intervention	Vital lung capacity	Before intervention	1.73	0.38	19	11.88	0.13(0.16;0.12)	0.000
		After intervention	1.86	0.37				
Control	Vital lung capacity	Before intervention	1.63	0.21	19	11.67	0.09(0.11;0.08)	0.000
		After intervention	1.73	0.21				

Table 3. The average value of the vital lung capacity before and after the intervention within each group.

Variable	Group	Mean	SD	Df	T	MD (95% CI)	Value
Vital lung capacity	Intervention	0.13	0.05	38	2.79	0.04(0.02;0.07)	0.008*

dard intervention was 1.63 (95% CI) and after the standard intervention was 1.73 (95% CI). his means even though both of intervention increased the VLC, but average value of the vital lung capacity in the intervention group was greater than in the control group.

Differences average of the VLC before and after the intervention between each group

The result of the statistical test independent t-test showed a significant difference in the average value of the vital lung capacity before and after the intervention between the intervention and the control groups (p=0.008; 95% CI=0.02-0.07) (Table 3). The results of spirometry both in the intervention and control group before the interventions were delivered were bad (<50% or <2.5 liters) and less (50%-<80%, or 2.5-0.4 liters). The deep breathing exercise and standard intervention significantly improved the vital lung capacity within each group. However, the Mean Difference (MD) showed a different result in the intervention group 0.13 (95% CI) meanwhile in the control group 0.09 (95% CI). This result means a significant difference between the intervention and control groups in the vital lung capacity (0.04).

Discussion

This study highlighted that both a deep breathing exercise and standard intervention have significantly improved the vital lung capacity of COVID-19 patients.[13] However, there was a significant difference between the two interventions based on the mean difference. The mean difference showed that a deep breathing exercise improves the vital lung capacity of the patients better than the control group with standard intervention.

A deep breathing exercise delivered to the intervention group is one of the recommended rehabilitation for COVID-19 patients. Regular exercise of deep breathing can improve respiratory organs and support the recovery process of the lung caused by the virus infection.[7,8] The deep breathing exercise can be delivered for patients who use their respiratory breathing inefficiently, have abnormal breathing patterns, and have increased work of breathing that leads to a decrease in the vital lung capacity.[14] The deep breathing exercise aims to achieve controlled ventilation conditions, thus decreasing the breathing workload and increasing the maximum alveolus capacity.[15] When performing the deep breathing exercise, the parasympathetic nervous system is stimulated which then controls the hemodynamics, thus achieving relaxation. This condition prevents the body from using respiratory accessories muscles and decreases oxygen consumption. Moreover, the diaphragm contracts to allow more room for the air to enter the lung. The more the diaphragm contracts, the more air enters the lung increasing alveolus ventilation and thus providing the oxygen needed.[16] The exercise trains the diaphragm to prevent the decrease of lung compliance because of infection to recover patients' vital lung capacity.[17]

The standard intervention in the form of education delivered in the control group is one of the nursing interventions. The intervention involves educating or giving information that aims to increase patients' ability to do daily living and care for themselves.[18,19] Health education can influence health status by changing behavior and improving patient awareness. According to Green (1980) in Pratiwi *et al.* (2018) behavior is one of the factors that can improve the recovery process and can be changed through health education. Similarly, Pratiwi et al reported a significant change in health status, behavior, and compliance in taking medicine before and after health education intervention (p=0.020). Health education creates self-awareness and improves the health status of patients in the recovery phase.[21,22]

The difference in average value between the intervention and control group may cause by the effects of deep breathing in the respiratory system, including the diaphragm and parasympathetic nervous system leads to controlled hemodynamics, relaxation, decreased cortisol hormone, and increased acetylcholine hormone. The acetylcholine hormone sends signals to the body to decrease the inflammation process.[14] Parasympathetic prevents the body from using respiratory accessories muscles resulting in decreasing oxygen need, dyspnea and increased lung compliance.[5,23] Individuals who regularly practice deep breathing and abdomen muscles were reported to increase lung compliance resulting in chest expansion.

In general, we speculate that this study, despite the limited sample size and the impossibility of a control group for ethical reasons, corroborates with several previous studies in the current literature, demonstrating the benefits of deep breathing exercises for a pulmonary and functional rehabilitation program for post-COVID-19 patients.

Our study adds to the literature that deep breathing exercise for post-COVID-19 patients has benefited the studied sample, and could be extrapolated to other patients affected by COVID-19, and can optimizing lung function patients post COVID. Deep breathing exercise can be used as a nursing advance intervention given early on to patients with COVID-19 to prevent or reduce the occurrence of prolonged symptoms after the patients is declared cured of COVID-19.

Conclusions

The deep breathing exercise three times a day for two weeks can improve the vital lung capacity of post Covid 19 patients. It was found that the average value of the vital lung capacity in patients who received a deep breathing exercise was higher than in patients who received standard intervention in the control group. Therefore, we recommend breathing exercises as an effective modality to increase the vital capacity of the lungs for post COVID.

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