



# Successful Pulmonary Rehabilitation in COPD During COVID-19 Pandemic Era: A Case Report

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## Abstract

**Background:** Chronic obstructive pulmonary disease (COPD) patients are at high risk for COVID-19 infection and severe pulmonary complications. Exercise-based pulmonary rehabilitation (PR) in outpatient settings is essential for COVID-19 survivors with COPD comorbidities, providing the most critical patient benefits, but it is challenging during the pandemic.

**Case:** A sixty-four-year-old man with COPD since 2 years ago, a history of COVID-19 one month ago, and Pulmonary Tuberculosis since 1 year ago presented with chief complaints of tiredness, cough, and breathlessness after walking for more than 100 meters. We performed PR, including breathing retraining exercise, chest mobility exercise, active cycle breathing technique (ACBT), posture correction, and aerobic exercise with static ergo-cycle for 8 weeks.

**Discussion:** After 8 weeks of PR, there was a 3% increase in the O<sub>2</sub> saturation level from 94-95% room air to 98%, an increase of single breath counting test (SBCT) from 20 to 38 counts, improvement of peak cough flow from 100-110-100 to 420-435-425 L/minute, and peak flow meter from 140-150-145 to 380-400-400 L/minute. Before PR the patient could not perform the sit-to-stand test (STS) and a 6-minute walking test (6MWT), but after 8 weeks of PR, STS was 5 times in 30 seconds, and 6MWT maximum distance was 248 meters. COPD assessment test (CAT) score improved from 23 to 9, and the Modified Medical Research Council (mMRC) dyspnea scale improved from 3 to 2.

**Conclusion:** Eight weeks of pulmonary rehabilitation showed benefits for the patient in reducing dyspnea and improving exercise tolerance and quality of life, especially in hospital-based settings.

**Keywords:** chronic obstructive pulmonary disease, COVID-19, exercise tolerance pulmonary rehabilitation, hospital based-rehabilitation

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## INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) is a systemic disease that causes progressive obstruction of the respiratory tract, significantly reduces exercise tolerance, and induces mental illness, resulting in disability and decreasing quality of life.<sup>1-3</sup> Based on the National Health Research (RISKESDAS) in 2013, the prevalence of COPD in Indonesia was 3.7%.<sup>4,5</sup> This number is still increasing due to the rising population of active smokers at young and productive ages.<sup>6-8</sup>

According to the Global Initiative for Obstructive Lung Disease (GOLD), patients with a history of COPD are now at an elevated risk for COVID-19 infection and severe pulmonary complications in the survivor. The severity and

mortality rates are higher in COPD patients. Therefore, a new therapeutic approach is required for this population.<sup>7-11</sup>

Pulmonary rehabilitation (PR) and pharmacological treatment for COPD patients may be implemented concomitantly in treating COPD to achieve a successful therapy in improving patient lives.<sup>11-14</sup> Pulmonary rehabilitation has been proven as the most effective non-pharmacological treatment in enhancing a patient's health and has become a standard care in COPD patients.<sup>11,12</sup>

Pulmonary rehabilitation is a multidisciplinary team intervention comprising patient assessment, exercise training, education, nutritional intervention, and psychosocial support.<sup>8,13</sup> Exercise-based PR plays an essential role in the recovery phase of

COVID-19 survivors with a history of COPD. The PR aims to restore optimal physical, physiological, and social functions. Fatigue is one of the most common complaints of COVID-19 survivors.<sup>9–11</sup> This complaint also often limits the patient from exercising; therefore, educating the patient about energy-conserving techniques to improve compliance in the PR program is essential.<sup>13</sup>

Systematic review and meta-analysis have shown the benefits of PR in COPD patients in terms of increasing exercise capacity and quality of life, reducing dyspnoea, and reducing the cost of hospitalization.<sup>8,11,14</sup> Despite the proven benefits, PR has not been widely applied, especially in developing countries.<sup>15</sup>

Pulmonary rehabilitation can be performed in inpatient, hospital-based outpatient, community-based outpatient, or home-based settings. Studies have shown that the best PR benefit was achieved in hospital-based outpatient settings. The British Thoracic Society recommends that the PR program should be followed up for a minimum of 6 weeks with a frequency of 2 times a week under supervision. The gold standard of the therapy is supervised PR, yet this has become a challenge during the COVID-19 pandemic.<sup>14–16</sup>

Supervised PR requires supporting facilities and staff in the COVID-19 pandemic era. Prevention of COVID-19 transmission and patient safety have become top priorities. All of the patients are required to wear the appropriate mask.<sup>1,9,15,17</sup> Mask can only be removed during exercise and must be worn during rest. In addition, supporting facilities such as rooms with negative pressure and limiting the number of patients and staff in 1 room should also be provided. Medical staff must use personal protective equipment according to the hospital policy.<sup>14</sup>

## CASE

A 64-year-old man, a retired private employee with a sedentary lifestyle, has had COPD in the last 2 years, and history of mild COVID-19 in March 2022, a history of smoking one pack per day for 30 years before and ceased the habit 2 years ago (Brinkman

Index of 600 (heavy smoker)). He denied any history of diabetes mellitus or cardiovascular, and cerebrovascular disease. He had uncontrolled hypertension, osteoarthritis of both knees KL III-IV, and pulmonary tuberculosis with treatment for 1 year and had been declared cured by the beginning of September 2022. Since then, the patient has started routinely undergoing a pulmonary rehabilitation program at the hospital three times a week since September 5<sup>th</sup>, 2022.

Before starting the rehabilitation program, the patient experienced fatigue quickly, with coughs and shortness of breath after walking for more than 100 meters. The patient had to pause every few steps when walking. The patient also reported pain on a pain rating of 5 in both knees, especially while shifting from sitting to standing. Blood pressure was 142/78 mmHg, heart rate was 104 times/minute, respiratory rate was 22 times/minute, and O<sub>2</sub> saturation was 94–95% on room air.



Figure 1. Chest expansion

The Borg scale is a tool used to assess the Rating of Perceived Exertion (RPE) during physical activity. Patients rate their exertion on a scale of 6 to 20 by combining all physical stress and fatigue

sensations.<sup>18</sup> Additionally, the Borg scale is used to evaluate shortness of breath and limb fatigue using a Category Ratio (CR) of 1 to 10, referred to as the Borg CR10, as seen in Table 1.<sup>18</sup> The patient's Borg scale score was 13-3-1, indicating a level of exertion that was somewhat hard, moderate dyspnea, and very slight limb fatigue.

Table 1. Borg RPE and Borg CR10 scale

Borg RPE		Borg CR10	
Score	Level of Exertion	Score	Level of Exertion
6	No exertion	0	No exertion
7		0.5	Very, very slight
7.5	Extremely light	1	Very slight
8		2	Slight
9	Very light	3	Moderate
10		4	Somewhat severe
11	Light	5	Severe
12		6	
13	Somewhat hard	7	Very severe
14		8	
15	Hard (heavy)	9	Very, very severe
16		10	Maximal exertion
17	Very hard		
18			
19	Extremely hard		
20	Maximal exertion		

The COPD Assessment Test (CAT) score was 23. The stratification of dyspnoea based on the Modified Medical Research Council (mMRC) Dyspnoea Scale was 3, meaning the patient has to stop to catch a breath after walking about 100 meters. Chest expansion was measured by calculating the difference in thoracic circumference, in centimeters, at three levels: the upper chest (axilla), mid-chest (nipple), and lower chest (last rib), as seen in Figure 1.

The patient showed a decrease in chest expansion of 2 cm in the upper chest, 4 cm in the middle chest, and 4 cm in the lower chest. The single breath counting test (SBCT) was 20. The patient also experienced weak cough ability (PCF=100-110-100 L/m) and a low peak flow rate (140-150-145 L/m). The patient could not perform a sit-to-stand or 6-minute walking test.

Spirometry, chest X-ray, thorax computed tomography scan, and echocardiography were performed before PR started as baseline data. Chest X-ray (Figure 2) showed pulmonary fibrosis, and a

thorax computed tomography scan on June 29<sup>th</sup>, 2022 revealed reduced consolidated segment 6 in the right lung without peripheral consolidation of the upper lobe in the left lung (Figure 3). Spirometry results from September 1<sup>st</sup>, 2022 showed vital capacity was 2540 ml (81% prediction), forced vital capacity (FVC) was 2460 mL (76% prediction), forced expiratory volume 1 (%FEV<sub>1</sub>) was 1170 mL (51%), and %FEV<sub>1</sub>/FVC 48%. Echocardiography on September 1<sup>st</sup>, 2022 showed good left ventricle function with 68% ejection fraction, diastolic dysfunction grade I, good valve function, and global normokinetic.



Figure 2. Chest X-ray  
(a) June 18<sup>th</sup>, 2022, (b) November 17<sup>th</sup>, 2022



Figure 3. Thorax computed tomography scan on June 29<sup>th</sup>, 2022

The patient routinely took drugs to control COPD, including a long-acting bronchodilator (Tiotropium bromide) inhaler of 5 mcg once daily, N-Acetyl-cysteine 200 mg three times a day, and short-acting bronchodilator only if shortness of breath occurs. The pulmonary Rehabilitation program included breathing retraining exercises, chest mobility exercises (CM), infrared for chest wall, pursed lip breathing, and a diaphragm breathing exercise by a physiotherapist thrice weekly.

Active cycle breathing technique (ACBT) was taught to be used when he coughs, and postural correction exercise (PC) by a physiotherapist three times a week. The patient received transcutaneous electrical nerve stimulation (TENS) and six sessions of high-intensity intraarticular light amplification by stimulated emission of radiation (laser) for the knee pain. The patient also received static bicycle aerobic exercise 3 times per week, starting with a 20-watt load for 5 minutes, increasing gradually until 30 minutes.

After eight weeks of follow-up, on October 31<sup>st</sup>, 2022, the patient rarely experienced cough and shortness of breath during exercise. The patient felt better and could walk for 200 meters with occasional stops. The patient exhibited neither chest pain nor shortness of breath during the exercise and could perform static bicycle aerobic exercise with a 20-watt load for 30 minutes. Blood pressure was 122/78 mmHg, heart rate was 76 times/minute, O<sub>2</sub> saturation

was 98% on room air, with Borg scale was 9-0-0 during rest.

The CAT score in the follow-up period improved to 9, and the mMRC dyspnea scale improved to 2. Chest expansion was increased to 3-4-4 cm, and SBCT was 38. The peak cough flow was 420-435-425 L/minute, and the peak flow meter was 380-400-400 L/minute. The result of the sit-to-stand test was 5 times in 30 seconds. The 6-minute walking test (6MWT) distance was 248 meters. The spirometry result on October 27<sup>th</sup>, 2022 showed vital capacity was 2790 ml (89% prediction), forced vital capacity (FVC) was 2550 ml (82% prediction), forced expiratory volume 1 (%FEV<sub>1</sub>) was 1380 ml (60%), %FEV<sub>1</sub>/FVC 54%, and post-bronchodilator 54%.

## DISCUSSION

In our case, the PR performed in 8 weeks (from September 5<sup>th</sup>, 2022 to October 31<sup>st</sup>, 2022) reduced shortness of breath symptoms and increased exercise tolerance. A recent meta-analysis reported that the longer duration of therapy (at least six weeks) and more exercise sessions (more than 28) showed improvement in the maximum testing distance reached by the 6-minute walking test.<sup>2</sup>

Pulmonary rehabilitation in a hospital-based setting uses multimodalities that are inapplicable at home. Patient was able to perform circuit training for PR consisting of pre-rehabilitation (such as heating and other physical modalities), guided exercise with a trainer, an adjustable dose of training, with equipment such as cycle, treadmill, pulley exercise, and theraband exercise, combined with breathing techniques and energy conservation techniques in daily activities.<sup>1,15,19</sup>

Several challenges may be encountered during hospital-based rehabilitation, particularly in the elderly population, such as COPD exacerbation, transportation problems, and comorbidities that limit patient training compliance.<sup>1,15,19</sup> Research conducted in Korea reported a high dropout rate during PR research due to knee pain which limits patient activities.<sup>1,20</sup>



Before starting the pulmonary rehabilitation program, patients should perform exercise to measure the training capacity of each patient.<sup>21-23</sup> However, we could either assess the sit-to-stand test or 6MWT due to complaints of shortness of breath and pain in both knees. In addition to the pulmonary rehabilitation program, our patient also received therapy for both knees, a TENS modality lasting 30 minutes on both knees for 6 sessions. However, there was no improvement in both knees. Then the patient underwent intraarticular knee high-intensity laser treatment for 6 sessions and showed improvement so that the patient could perform the 6MWT.

PR as a non-pharmacological intervention provides substantial evidence regarding its effectiveness in enhancing the dyspnoea-related quality of life and exercise capacity.<sup>9,11-13</sup> In our case, dyspnoea symptoms improved after PR from mMRC 3 to 2. This result was similar to a study conducted by Kim et al, in which PR was conducted in 8 weeks with 2 sessions of hospital-based exercise, improved exercise capacity and quality of life.<sup>1</sup>

The patient experienced an improvement in dyspnoea symptoms based on the mMRC scale, and its impact on quality of life was measured using the CAT score. A similar result was observed in a study conducted by Monica et al where there was a significant association between the degree of shortness of breath in COPD patients with the quality of life ( $r = -0,531$ ).<sup>6</sup> The association between the mMRC scale and SGRQ was also found significant in the study of Ekici et al.<sup>16</sup>

We observed a reduction in CAT score by 14 points after pulmonary rehabilitation. Several indicators notably affected were shortness of breath, cough, and energy. In Houben-Wilke et al study, pulmonary rehabilitation significantly affected shortness of breath and energy indicators.<sup>17</sup>

Energy was the most affected in CAT because PR aims to increase cardiorespiratory fitness by increasing exercise capacity and reducing shortness of breath and fatigue symptoms. Individualized PR program shows an improvement in the daily activities of COPD patients through energy conservation

techniques.<sup>9-12</sup> Although all indicators in the CAT score were significantly improved, PR responses vary greatly in each individual, so PR should be tailored for each patient.<sup>12,19,20</sup>

Hansen et al reported that the reduction of CAT score was statistically significant in supervised pulmonary rehabilitation, though it did not exceed the minimal important difference (MID).<sup>16</sup> The MID for the CAT score is a reduction of 2 points.<sup>9,10,12</sup> In our case, a significant improvement was observed due to breathing exercises, including breathing retraining, chest mobility exercise, and supervised provision of infrared modalities for the chest wall so the patient could properly perform it.

Changes in mechanic pulmonary during exercise are related to the cardiovascular response towards exercise.<sup>6,24-26</sup> During exercise, dynamic hyperinflation increases intrathoracic pressure and decreases cardiac preload by decreasing venous return and left ventricular volume.<sup>2,27</sup> While in COPD patients, there is an improvement in ventilation related to an increase in volume during exercise, which resulted in exercise tolerance improvement in patients undergoing PR, as in our case.

Our patient received static bicycle aerobic exercise, starting with a load of 20-watt with a duration of 5 minutes. In post-COVID-19 patients, exercise should not be started with moderate intensity because of shortness of breath symptoms and restrictive lung disease.<sup>1,2</sup> Before being infected with COVID-19, our patient had COPD and a pulmonary TB history. These comorbidities also limit the patient from performing exercises. Besides, the age factor plays an important role, which in our case is in geriatric age, so the exercise principle is to start low and slow.

In COPD patient, exercise may reduce type IIB muscle fibers and increase type I muscle fibers that require lower oxygen, resulting in more efficient oxygen usage and increase elimination of carbon dioxide after the PR program.<sup>2,25-27</sup> Aerobic exercise results in reduced shortness of breath and increased tolerance during exercise and activity in patients.

COPD is a systemic disease with chronic inflammation.<sup>28,29</sup>

Exercise has an anti-inflammatory effect and improves the immune system by regulating C-reactive protein (CRP) levels and immunoglobulin function.<sup>2</sup> Aerobic exercise in COPD patients results in improved immunity and respiratory system in a short period.<sup>20,26</sup> According to the PR guidelines, the program is delivered at a frequency of 2 to 5 times per week for 6 to 12 weeks.<sup>3</sup>

### LIMITATIONS

Implementing hospital-based setting PR during the pandemic era increases costs for staff personal protective equipment, and also limited number of staff on duty due to infected with COVID-19. This study did not include specific nutritional interventions. The patient's 6MWT evaluation results after the 8-week program may not be significant because the patient has bilateral knee osteoarthritis KL Grade III-IV which limits the patient's walking. Lack of pulmonary rehabilitation resources in hospital-based settings during the pandemic era since most of the programs have shifted to home-based settings.

### CONCLUSION

Pulmonary rehabilitation when performed in hospital-based settings allows comprehensive assessment and tailored interventions addressing various aspects of patient's health. Eight weeks of pulmonary rehabilitation proved beneficial effect for the patient in reducing dyspnoea and improving exercise tolerance and quality of life.

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### CONFLICT OF INTEREST

None.

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