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The effect of a pulmonary rehabilitation exercise program on patients after COVID-19: A report of three cases

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Abstract

Purpose: This study aimed to investigate the effect of a pulmonary rehabilitation exercise program on post-COVID-19 patients. **Method**: Three patients (two women and one man) with different severities, from moderate to severe, were selected. Blood pressure, heart rate, blood oxygen, and body function were measured at the beginning and end of the exercises, which included 12 sessions of arm and leg cycle ergometer and treadmill with adjustable resistance levels. Patients' functionality was assessed using the Barthel index, and their quality of life was assessed using the SF-36 questionnaire. **Results:** Regarding the first patient, oxygen saturation increased from 85 to 95, the 6-minute walk test (6MWT) result increased from 0 to 420 meters, and the Barthel index increased from 35 to 85. For the second patient, arterial oxygen saturation increased from 82 to 92, the 6-minute walk test (6MWT) result increased from 0 to 390 meters, and the Barthel index increased from 30 to 90. For the third patient, arterial oxygen saturation increased from 87 to 96, the 6-minute walk test (6MWT) result increased from 320 to 510 meters, and the Barthel index increased from 60 to 85. All the patients showed improvements in their physical functions, such as walking, personal affairs, and quality of life. This functional improvement was higher in more severe levels of the disease. **Conclusion:** Based on the results, it seems that pulmonary rehabilitation exercises for post-COVID-19 patients can contribute to the improvement of their status, arterial oxygen level, quality of life, and pulmonary functionality.

Keywords: COVID-19, pulmonary rehabilitation, arterial oxygen, quality of life, Barthel index

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INTRODUCTION

Despite the efforts made by the medical system to prevent and treat COVID-19, it has affected a large percentage of the population as an infectious disease with high transmissibility and various complications, manifestations, and clinical signs (Kumar, 2020). All age groups are exposed to coronavirus; however, the elderly and those with underlying diseases are more predisposed to diseases such as acute pneumonia and respiratory failure (Zhu et al, 2021). Furthermore, various studies have confirmed the association between COVID-19 and underlying diseases; one such study is that conducted by Mostafaei et al. (2021) on the association between contracting COVID-19 and underlying diseases such as high blood pressure, cardiovascular diseases, diabetes, asthma, and chronic obstructive pulmonary disease (Mostafaei et al, 2021). This virus affects several organs, such as the lungs, kidneys, and liver, and may also lead to intravascular coagulation and disorders in the central nervous system (Ghazanfari et al, 2021). Of the patients with severe conditions, 20% experience critical levels of the disease, especially in the pulmonary system, which leads to chronic pulmonary disorders in many cases (Zampogna et al, 2021). The lungs, especially cardio-respiratory fitness, experience the most significant harm caused by COVID-19, and patients may have persistent respiratory disorders after discharge (Torres-Castro et al, 2020). In severe cases of respiratory diseases, movement disorder might occur in addition to cardio-pulmonary outcomes, which calls for special care and rehabilitation (Piquet et al, 2021).

No certain antiviral medication and vaccines are available for COVID-19 patients (Alizadeh et al, 2021); therefore, we need to look for other effective methods to be used alongside treatments using medications. Based on the cardio-pulmonary rehabilitation guidelines and considering the few studies around the world, it seems that pulmonary rehabilitation can be considered a therapeutic intervention for these patients to improve their exercise tolerance (Vitacca et al, 2021). Recent studies have confirmed the positive effect of rehabilitation exercises on patients' respiratory capacity. For instance, one study reported the effects of 5-9-day rehabilitation exercise on movement, respiratory, and functional improvement in COVID-19 patients (Piquet et al, 2021). It has been suggested that rehabilitation exercises can be safe and available auxiliary options regardless of the severity of the disease (Gloeckl et al, 2021).

However, the effects of various rehabilitation protocols (enhancing respiratory muscles, improving lung volume, and complementary aerobic exercises) on respiratory function and recovery, especially in COVID-19 patients at different ages, are unknown (Liu et al, 2020). The present study aimed to optimize different exercises modified to improve patients' cardio-respiratory capacity. Accordingly, this study aimed to assess the effects of a pulmonary rehabilitation exercise program on post-COVID-19 patients' cardio-respiratory capacity.

METHOD

This study reports the effects of rehabilitation exercises on three post-COVID-19 patients with various levels of disease severity. All the patients signed the consent form to participate in this program and completed the quality of life and Barthel index questionnaires before and after the rehabilitation sessions. An expert in this field supervised the sessions. The rehabilitation program consisted of 12 sessions with different intensities in accordance with each patient's cardio-respiratory capacity. The exercise protocol was based on the cardiopulmonary rehabilitation (CPR) guidelines, including training and counseling, warm-up exercises, respiratory exercises, aerobic and muscular endurance exercises, and cool-down exercises. Three sessions a week were held under direct supervision, and two sessions included counseling and instructions for other necessary home-based exercises. The exercises included 5 minutes of warm-up exercises, 15 minutes of respiratory exercises such as deep breathing, diaphragmatic breathing, intermittent breathing, controlled deep breathing, breathing while stretching, and other breathing and aerobic exercises, including working with an arm and leg cycle ergometer and treadmill, which were done at different intensities and inclines according to each patient's conditions. Endurance exercises such as specialized breathing exercises (aiming to enhance respiratory muscles and increase lung volume) with increased pressure using pilates bands and weights, breathing exercises such as deep breathing and nose breathing, and upper-body stretching exercises were also included. The duration of the exercises started from 27 minutes and reached 60 minutes in the final sessions. (Figure1)

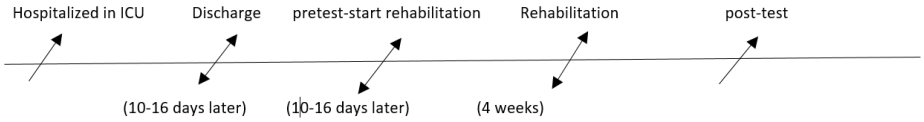

fig 1. Timeline of the study

RESULTS

Case reports:

Patient 1:

A 45-year-old woman with symptoms similar to those of Influenza, SPO2 = 85%, HR = 93, and temperature of 36 degrees, presented to the doctor on September 12, 2021. Her PCR was positive, and the CTA results revealed fibrotic lesions in the middle lobe of the lung and 98% lung involvement. She was hospitalized on the same day in the ICU for 21 days due to the severity of her condition and acute dyspnea. During her hospitalization, she was given prednisolone 5, pirfenidone, colchicine, and pregabalin 50. After being discharged, she was referred to rehabilitation. At the beginning of rehabilitation, the patient was using a wheelchair and was dependent on oxygen due to her physical and functional weakness. With a Barthel score of 35, she was even unable to do her personal affairs.

In the first session, her SPO2 was 92. She received training and counseling from the first to the fifth session and had respiratory exercises using an arm cycle ergometer. The device's workload is presented in Graph 2. After the fifth session, the leg cycle ergometer was added to the patient's program too. During these exercises, deep diaphragmatic breathing was done every one or two minutes according to her condition. Moreover, the patient was completely dependent on oxygen when exercising and in normal conditions. In the tenth session, the resistances of the arm and leg cycle ergometers reached 28 and 23, respectively, and the patient was no longer dependent on oxygen. She received supplemental oxygen only after her exercises. In the 12th session, the patient’s dependence on oxygen, even during her exercises, was completely gone. Her physical functionality had improved to the extent that she came to the center independently and without need for a

wheelchair or help. In the 12th session, the arm and leg ergometers' resistances increased to 30 and 35, respectively, and SPO2 was 97. Due to the patient's physical conditions and the doctor's discretion, a treadmill was not used for this patient. In the first reexamination after the 12 rehabilitation sessions on October 12, 2021, the blood tests were normal, and chest radiography showed some improvements in the fibrotic lesions. Also, SPO2 was 95, HR was 104, her temperature was 35.9, and prednisolone was discontinued.

Patient 2:

A 59-year-old woman with a history of diabetes and hypertension presented to the doctor on November 17, 2020, with symptoms similar to those of influenza. The results of CTA showed fibrotic lesions and 85% lung involvement; her PCR was positive, and she was hospitalized on the same day due to the severity of her condition. However, she was transferred to the ICU several times due to hypoxemia and returned to the general ward after having improved. She was hospitalized for 30 days in the ICU and 15 days in the general ward. On December 26, primidone, xalerban, and colchicine were prescribed for the patient. Three days later, the patient was treated with NovoRapid insulin due to a rise in blood sugar. In the next examination on January 9, CTA showed a reduction of fibrotic lesions, and the patient was given pirfenidone and prednisolone 50. The patient had a resting heart rate of 105-115 and was in the compensatory fatigue phase; therefore, she was referred to the rehabilitation center.

In the beginning, the patient was using a wheelchair, was dependent on oxygen, and her SPO2 was 82. She was completely dependent on others for her personal affairs, and her Barthel score was 30. From the first to the fourth session, she only exercised with the arm cycle ergometer with the minimum workload, and the device's resistance was set at zero in the first session. After the fourth session, a leg cycle ergometer was added to her exercise program, and the resistances of the arm and leg cycle ergometers were 15 and 20 watts, respectively. Up to the eighth session, the patient was entirely dependent on oxygen in exercising and under normal conditions. In the ninth session, the resistances of the arm and leg cycle ergometers had increased to 23, and the patient did not need oxygen and received oxygen in the final minutes of the exercises and after them

based on her blood oxygen levels. In the 12th session, the patient's dependence on oxygen, even while exercising, was completely gone, and her physical functionality had improved to the extent that she came to the center without a wheelchair. In the 12th session, the arm and leg ergometer resistances were increased to 31, and SPO2 was 92; moreover, based on the patient's physical condition and the doctor's discretion, a treadmill was not used for this patient.

Patient 3:

An 84-year-old man with a history of CPD, cardiac problems, and smoking presented to the doctor on June 1, 2021, with symptoms similar to those of influenza and dyspnea. The CTA results revealed fibrotic lesions at the base of the lungs and 50% lung involvement. The patient's CPR was positive, HR was 79, SPO2 was 87, and her temperature was 35.7 degrees centigrade. Six days later, the patient was hospitalized for seven days due to hypoxia and polycythemia. Two days later, according to the CTA, his lungs were normal, and examination revealed cardiac arrhythmia, which was treated, and 10 days later, the patient was referred to the rehabilitation center.

In the first session, the patient worked with arm and leg cycle ergometers with 13 and 18 watts resistance, respectively. His SPO2 was 82, and he was supported by supplemental oxygen while exercising. In the second session, exercise on a treadmill with a speed of 2 km/h and a 2.5% incline was added to his exercise program. In the sixth session, the resistances of the arm and leg cycle ergometers were increased to 23, and 41 watts, the speed of the treadmill was increased to 3.5 km/h, and its incline was increased to 3.5, and the patient did not need any supplemental oxygen. In the 12th session, the patient's respiratory and functional status had improved significantly to the extent that the resistances of the arm and leg cycle ergometers were 35 and 54, respectively, the speed of the treadmill was 5 km/h, its incline was 5, and the SPO2 was 96.

The patients' physical functionality and quality of life information are presented in Table 1. All the patients showed marked improvements in functionality based on the Barthel and quality of life score measured using the SF-36 questionnaire.

Table1: The patients' physical function and quality of life before and after the pulmonary rehabilitation course

			Case 1	Case 2	Case 3
Functional factors	**6MWT**	**Before**	0	0	320
		after	420	390	510
	Bartel	**Before**	35	30	60
		after	85	90	85
Quality of life	**PF (Physical function)**	**Before**	40	80	40
		after	100	80	60
	RP (Role physical)	**Before**	25	75	50
		after	75	100	75
	RE (Role emotional)	**Before**	33/33	66/66	33/33
		after	66/66	66/66	33/33
	EF (Fatigue effect)	**Before**	50	50	75
		after	75	100	100
	EW (Emotional welfare)	**Before**	60	60	60
		after	100	80	80
	SF (Social function)	Before	50	50	0
		after	50	50	50
	P (pain)	Before	100	100	50
		after	100	100	50
	GH (General health)	Before	60	40	40
		after	80	100	60

All the patients reported shortness of breath and respiratory failure in the initial sessions. Moreover, the results, the functional improvement trend, the ability to do physical activities using stationary bikes, and blood oxygen levels are presented in Figures 2 and 3. For the first patient, oxygen saturation increased from 85 to 95, 6MWT increased from 0 to 420 meters, and the Barthel index increased from 35 to 85. For the second

patient, arterial oxygen saturation increased from 82 to 92, 6MWT increased from 0 to 390 meters, and the Barthel index increased from 30 to 90. For the third patient, arterial oxygen saturation increased from 87 to 96, 6MWT increased from 320 to 510 meters, and the Barthel index increased from 60 to 85. All the patients showed improvements in their heart rate, arterial oxygen, physical functions, such as walking and doing personal affairs, and their quality of life after 12 sessions of rehabilitation exercises.

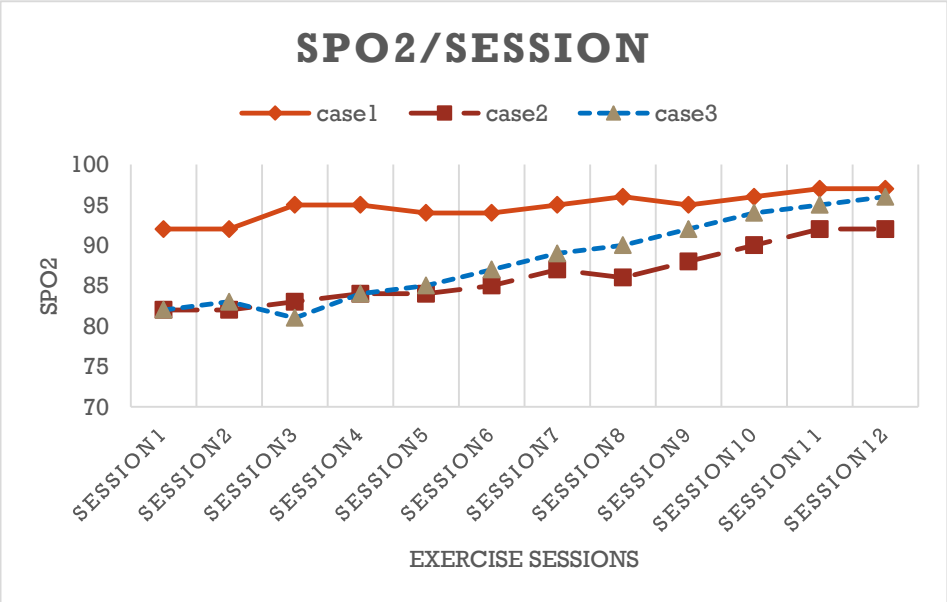

Fig 2. Changes in the oxygen level (SPO2) during the 12 sessions of pulmonary rehabilitation in the three cases.

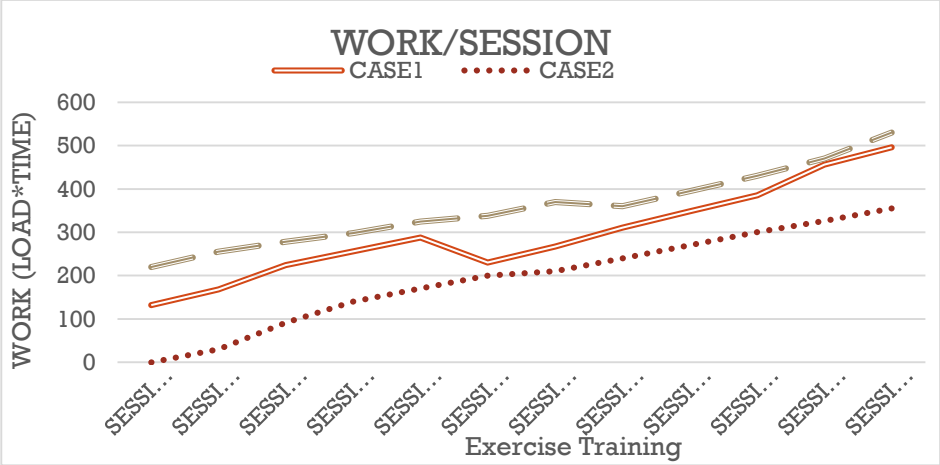

Figure 3. Ability and changes in physical activities workload during the 12 pulmonary rehabilitation sessions in the three cases.

DISCUSSION

This study reported three cases with different severities and outcomes of COVID-19. The rehabilitation program was based on cardiopulmonary rehabilitation guidelines emphasizing the possible pulmonary outcomes such as a decrease in SPO2 and dyspnea. The results showed that pulmonary rehabilitation programs for post-COVID-19 patients after the inflammatory and severe phases of the disease are beneficial in terms of psychology, quality of life, physiology, and functionality. All three patients showed improvements in heart rate, arterial oxygen, daily physical functions, such as walking and doing personal affairs, and quality of life score after the 12 rehabilitation exercise sessions. An increase in functional capacity and an improvement in heart rate were ostensible after the rehabilitation program.

Rehabilitation exercises and workload were selected based on the homeostasis challenge/adaptation according to the patient's endurance. The results regarding functionality and cardio-respiratory capacity indicated that pulmonary rehabilitation programs could return the patients who have experienced the severe phase, have been hospitalized, have problems in doing daily activities, and have experienced a decline in quality of life for a long period to their everyday life and improve their functional ability. Results similar to those of the present study can be seen in a few studies. For instance, improvements were reported in the functional capacity of a 62-year-old man (Lee et al, 2022). the arterial oxygen of a 51-year-old man (Pancera et al, 2020), and muscular strength and Barthel index (Saeki et al, 2020). In another similar study, Tozato et al. (2021) reported decreases in the heart rate and Borg rating of perceived exertion index and increases in arterial oxygen in 3 post-COVID-19 patients after aerobic and endurance exercises with a cycle ergometer (Tozato et al, 2021).

In some studies, rehabilitation exercises began when the patient was hospitalized; however, few studies have analyzed patients' inactivity, deconditioning after dependence on oxygen, and atrophic changes in the muscles and in cardiac, respiratory, and metabolic systems. However, these were considered in the present study. These conditions lead to a decline in patients' physical functionality and disorders in doing personal affairs; moreover, spending a long time in quarantine can lead to mental disorders in people (Cao et al, 2020). The results of the present study indicated a significant increase in the functionality of patients who had experienced these conditions after pulmonary rehabilitation exercises, even those with cardiac arrhythmia resulting from COVID-19. A crucial point in rehabilitation programs is that the type and intensity of the exercises should be determined based on each patient's condition and endurance, which was carried out every session.

Sterilized environment, the distance between the equipment, reducing the number of patients in each session, local hygiene, and using appropriate health equipment were heeded by the doctor and nurses in all the sessions. However, since this disease is rather new, more studies on treating these patients with more rehabilitation exercises in more extended periods of time are needed.

CONCLUSIONS

Respiratory rehabilitation exercises stressing the significance of pulmonary ventilation and aerobic exercises supported by supplemental oxygen according to patients' conditions can positively affect their functional capacity, quality of life, and oxygenation. However, there is a need for more studies on a larger number of patients with a greater variety of conditions.

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