Pulmonary rehabilitation in patients with prior COVID-19 infections

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ABSTRACT

Background: *Patients with prior COVID-19 infections can develop persistent dyspnea and physical limitation. This may reflect chronic lung disease, chronic heart disease, or neuromuscular disease. Treatment approaches include pulmonary rehabilitation. This study analyzed the benefits of conventional pulmonary rehabilitation in patients with chronic symptoms following COVID-19 infections.*

Methods: *Twenty-eight patients completed pulmonary rehabilitation at University Medical Center in Lubbock, Texas. The primary outcome was the time spent on four different types of exercise equipment during aerobic exercise sessions.*

Results: *This study included 15 women and 13 men, with a mean age of 54.4 years. The racial distribution included 12 White patients, 10 Hispanic patients, and 6 Black patients. Ten patients had a smoking history, 19 patients used supplemental oxygen, 14 patients had hypertension, and 11 patients had diabetes. The median COPD Assessment Test (CAT) score was 21.5 (Q1, Q3: 17.5, 29), the median Patient Health Questionnaire-9 (PHQ-9) score was 8 (Q1, Q3: 4.5, 15.5), and the median Medical Research Council (MRC) score was 2. Twenty-six patients had the abnormal chest x-rays within 3 months of starting the rehabilitation program; these included 5 patients with focal interstitial infiltrates, 9 patients with diffuse interstitial infiltrates, 6 patients with focal opacities, and 6 patients with bilateral opacities. These patients completed 22.9 (Q1, Q3: 6.8, 36) exercise sessions. There were statistically significant increases in all machine times on all 4 machines.*

Conclusion: *This study indicates pulmonary rehabilitation can significantly increase aerobic activity levels in patients with prior COVID-19 infections. This improvement occurred in patients with important comorbidity, abnormal chest x-rays, and chronic oxygen supplementation requirements. Patients with prior COVID-19 infections and persistent respiratory symptoms should be referred to pulmonary rehabilitation.*

Keywords: COVID-19, long COVID, rehabilitation

INTRODUCTION

COVID-19 infections can cause long-term effects in some patients; Long COVID or post-COVID conditions (PCC) can include several symptoms that can last weeks, months, or years.[1] Symptoms of PCC include constitutional symptoms (e.g., tiredness, fatigue, post-exertional malaise), respiratory and cardiac symptoms (e.g., shortness of breath, cough, chest pain, palpitations), neurological symptoms (e.g., difficulty concentrating, headache, sleep problems, lightheadedness, changes in smell or taste, depression or anxiety), digestive symptoms (diarrhea), and other symptoms such as joint/muscle pain, rash, and changes in the menstrual cycle. These complications occur more frequently in patients who had severe COVID-19 illness; however, anyone infected with COVID-19 can develop these syndromes.

The benefits of pulmonary rehabilitation are well established in various chronic lung diseases. It can

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improve exercise capacity, self-efficacy, and health-related quality of life.[2,3]

Nopp et al. found that after 6 weeks of personalized interdisciplinary pulmonary rehabilitation, patients with long COVID had improved exercise capacity, functional status, dyspnea, fatigue, and quality of life.[4]

In this study we analyzed the benefits of conventional pulmonary rehabilitation in patients with post-COVID conditions in our hospital's pulmonary rehabilitation center.

Methods

This is a retrospective study of 28 post-COVID pulmonary rehabilitation patients from 2020 to 2022 at the University Medical Center in Lubbock, Texas. Each patient chart was reviewed to record the time spent on four different types of aerobic exercises, liters of oxygen used during exercise, age, race, chest x-rays within 3 months of starting the rehabilitation program, initial and final 6-minute walk test (6-MWT), initial and final PHQ-9 survey scores, initial and final CAT scores, initial and final MRC values, initial and final amounts of time on the early and final session, smoking history, comorbidities, and a total number of sessions completed by the patient. The types of exercises included treadmill, NuStep, arm ergometer, and bike. In order to see the patients' progress throughout the rehabilitation, data from an early session and last session were recorded. The patients' first two sessions were considered an adjustment period; thus, data from the third session were recorded as the patients' initial starting points. The time spent on each of the four exercises was used as the primary outcome. This was compared with the time spent in the patient's last session. The amount of oxygen used in these early and final sessions was also recorded. Comorbidities recorded in this study included hypertension, diabetes mellitus, obstructive sleep apnea, chronic kidney disease, congestive heart failure, chronic obstructive pulmonary disease. This study was approved by the Institutional Review Board (Legacy L23-151) at Texas Tech University Health Sciences Center in Lubbock, Texas.

After recording these data points, Microsoft Excel was used to obtain percentage values, averages, and paired t-test results. A percentage value was obtained for gender distribution, race (White, Hispanic, or Black), number of smokers, and number of oxygen users. A mean was obtained for age. Median and interquartile values were obtained for initial CAT scores, PHQ-9 scores, and MRC values. An average was found for total time per session and total amount of sessions. For each of the four exercises and the 6-minute walk, paired t-tests were performed, and p-values were obtained.

Results

This study included 15 women and 13 men with a mean age of 54.4 years. The racial distribution included 12 White patients, 10 Hispanic patients, and 6 Black patients. Ten patients had a smoking history, 19 patients used supplemental oxygen, 14 patients had hypertension, and 11 patients had diabetes. The median CAT score was 21.5 (Q1, Q3: 17.5, 29), the median PHQ-9 score was 8 (Q1, Q3: 4.5, 15.5), and the median MRC score was 2. Twenty-six patients had the abnormal chest x-rays within 3 months of starting the rehabilitation program; these included 5 patients with focal interstitial infiltrates, 9 patients with diffuse interstitial infiltrates, 6 patients with focal opacities, and 6 patients with bilateral opacities. These patients completed 22.9 (Q1, Q3: 6.8, 36) exercise sessions. Table 1 reports the changes in machine times from baseline to the last session of rehabilitation. There were statistically significant increases in all machine times on all 4 machines.

Discussion

The COVID-19 pandemic has challenged all aspects of healthcare systems. Post-COVID conditions

Table 1. Machine Times During Rehabilitation Sessions

Machine	Baseline, Minutes	Post-rehabilitation, Minutes	Paired t Test
Treadmill	9.6	14.4	<0.01
NuStep	10.2	14.8	<0.01
Arm ergometer	7.7	11.4	<0.01
Bike	8.0	12.2	<0.01

adversely affect patients' quality of life chronically and have affected approximately 23 million Americans since the beginning of the pandemic. Experts have referred to PCC as 'the next public health disaster' and may have a $3.7 trillion impact on the US economy.[5]

Davis et al. published a review of long COVID in 2023 that considered major clinical presentations, possible underlying mechanisms, and recommendations.[6] They estimate that the incidence is 10% of all infected people and that that incidence increases to 50 to 70% in hospitalized cases. Symptom presentation can involve multiple organs and several pathophysiologic processes. The most debilitating presentations include myalgic encephalomyelitis/chronic fatigue syndrome-like presentations and dysautonomia, especially postural orthostatic tachycardia syndrome. Patients with pulmonary symptoms usually have cough and dyspnea and may have abnormal chest x-rays and abnormal gas exchange. There is no definitive treatment for this condition. These authors suggest that exercise is harmful in patients who have post-exertional malaise. Patients with respiratory symptoms often have obvious abnormalities on chest x-ray and pulmonary function testing, and these patients potentially benefit from pulmonary rehabilitation.

Achkar et al. have reviewed post-COVID lung disease. They note that many patients hospitalized with COVID-19 infections have posthospitalization fatigue and dyspnea.[7] During hospitalizations, especially during Intensive Care Unit (ICU) care, these patients may develop post-COVID acute respiratory syndrome with fibrosis, post viral infection organizing pneumonia, ventilator-induced lung injury, thromboembolism, cardiac dysfunction secondary to myocarditis, and deconditioning.[7] Pulmonary function testing frequently reveals a restrictive ventilatory defect with a reduced forced vital capacity and total lung capacity, in addition, the diffusion capacity is often reduced.[7] These patients can have a low peak oxygen consumption on cardiopulmonary exercise testing. They recommend a comprehensive rehabilitation program that includes formal assessment, low intensity aerobic exercises, strengthening exercises, psychological support, and occupational therapy, if needed. Some aspects of these programs can be carried out using home-based programs and telemedicine.[7]

Hama Amin et al. published a meta-analysis to determine the prevalence of post-COVID pulmonary fibrosis and the potential risk factors for development of this post viral complication.[8] Thirteen articles including 2018 patients were analyzed in their study. The prevalence of post-COVID pulmonary fibrosis was 44.9%.[8] Chronic obstructive pulmonary disease was the most frequent comorbidity associated with the development of this condition. These patients often had persistent symptoms, including dyspnea, cough, fatigue, and myalgia. Factors associated with the development of fibrosis included ICU admission, invasive and noninvasive mechanical ventilation, longer hospitalizations, and corticosteroid treatment. Chest x-rays frequently revealed parenchymal bands, ground glass opacities, interlobar septal thickening, and solid consolidation. Consequently, this study suggests that post-COVID pulmonary fibrosis is relatively frequent in patients who have required hospitalization, especially ICU care. These patients need follow-up to determine the presence and severity of any fibrotic lung disease following this infection.[8]

The benefits of pulmonary rehabilitation in various chronic lung diseases are well established.[2] A retrospective pre-post study demonstrated that patients with chronic lung diseases (chronic obstructive lung disease, asthma, bronchiectasis, interstitial lung diseases, and lung cancers) who participated in pulmonary rehabilitation had clinically significant improvements in exercise capacity, self-efficacy, and health-related quality of life. Several studies have reported the benefits and outcomes in patients with post-COVID respiratory symptoms who have undergone pulmonary rehabilitation.

Nopp et al. reported a prospective cohort observational study with 58 patients with long COVID; these patients started the rehabilitation program approximately 4 months following COVID-19 infection.[4] Exercise capacity based on 6-minute walk test, functional status, dyspnea, fatigue, and quality of life improved after 6 weeks of personalized interdisciplinary pulmonary rehabilitation. In addition,

pulmonary function test including FEV1, diffusion capacity, and inspiratory muscle strength significantly increased during rehabilitation. Chen et al. reported a meta-analysis in 2022 based on three studies with 233 patients after COVID-19 infection and reported that pulmonary rehabilitation could improve exercise capacity measured by 6-MWT in patients with mild to moderate lung impairment after COVID-19 infection and improved dyspnea scores and quality of life.[9] However, there were inconsistent effects on the pulmonary function test. Another meta-analysis published in 2023 reviewing thirty-four studies that included 1970 patients with subacute and long COVID reported moderate to large improvements in dyspnea, physical function, quality of life, and depressive symptoms compared to usual care intervention.[10] These studies did not find any effect on fatigue levels or anxiety after pulmonary rehabilitation.

Sanchez-Garcia et al. published a systematic review of studies of physical therapy in patients with long COVID.[11] They define prolonged COVID as a persistent condition characterized by fatigue, muscle pain, sleep disturbances, brain fog, and symptoms involving the cardiovascular, respiratory, digestive, neurologic systems. Their literature search eventually recovered 6 articles that were included in the review. In general, the results indicated that physical therapy has definite effects in these patients. Physical therapy should last at least 6 weeks and possibly should include inspiratory muscle training exercises. Three of these studies involved online or telemedicine at home training. Most of the studies reported significant improvement in symptoms, including fatigue, dyspnea, and depression. One study involving 26 patients reported an increased peak VO_2 in patients. The authors suggest that physical activity should be incorporated into daily routines rather than as a separate activity and that this might increase participation since this involves their daily routine. The studies were undertaken by physiotherapists to provide a comprehensive approach to the rehabilitation of patients. These approaches included development of tailored exercise programs to improve muscle strength, flexibility, and cardiovascular performance. In addition, physiotherapists provide help with psychological problems and provide education on pacing strategies and energy conservation.

Pouliopoulou et al. published a systematic review and meta-analysis of rehabilitation interventions in patients with post-COVID conditions.[12] Their literature search identified 14 trials with 1244 patients with a median age of 50 years. These trials demonstrated that there were improvements in functional capacity based on the 6-MWT, improvement in dyspnea, and improvement in quality of life. Patients in the intervention groups increased their 6-minute walk distance by 35.84 meters. No trials reported significant numbers of adverse events during rehabilitation.

Benzarti et al. studied the outcome of a pulmonary rehabilitation program in 14 patients with moderate to severe post-COVID symptoms.[13] They used questionnaires for health-related quality of life, depression, anxiety, and physical activity. The rehabilitation program involved three sessions per week for four weeks. Each session lasted 70 minutes and included aerobic exercise, strength, training, and education. There was significant improvement in all questionnaires following rehabilitation. These authors conclude that pulmonary rehabilitation can improve the symptom profile in patients with moderate to severe COVID-19 infections, who live in low-income countries.

Our study demonstrates a significant clinical benefit with pulmonary rehabilitation in in patients with post-COVID respiratory symptoms, abnormal chest x-rays, and abnormal pulmonary function tests. This rehabilitation significantly increased aerobic activity levels in these patients with prior COVID-19 infections.

Conclusion

The benefits of pulmonary rehabilitation in post-COVID conditions have been demonstrated in several studies. Pulmonary rehabilitation programs for PCC should be used widely. However, better organization and systems of funding should be established to allow more efficient and effective use of limited resources. This will benefit all patients and the overall health care system. Experts need to develop guidelines for PCC evaluation and management. An at-home

rehabilitation program directed by rehabilitation specialists may be useful.

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