Effects of An Individualized Pulmonary Rehabilitation Program in Post-COVID Fibrosis: A Case Report

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Abstract: Long COVID-19 Syndrome, in addition to symptoms such as chronic cough, exertional dyspnea and fatigue, pulmonary fibrosis is presented as specific respiratory system problems. Post-COVID fibrosis is characterized by radiographic abnormalities consistent with pulmonary fibrosis. Patients with post-COVID fibrosis may benefit from pulmonary rehabilitation programs. This case report aimed to investigate the effects of an individualized pulmonary rehabilitation (PR) program on selected clinical parameters in a 46-year-old male who was diagnosed with post-COVID fibrosis. Spirometry and diffusion tests were investigated. Six-minute walk–and shuttle walk tests for exercise capacity, hand-held dynamometer for quadriceps muscle strength, mMrc dyspnea scale for dyspnea, Fatigue Severity Scale for fatigue and London Chest Activity of Daily Living for activities of daily living were evaluated. An individualized PR program included breathing exercises, single-leg cycle training (for the right leg, 10 to 30 min) and bilateral neuromuscular electrical stimulation for quadriceps muscles (30 min) was prescribed 3 days a week for 8 weeks. Small but promising improvements were observed in FEV1, FVC, FEV1/FVC, DLCO, 6MWD, shuttle walk tests walking distance and time, quadriceps muscle strength, mMRC and FSS scores. PR program combined with antifibrotic therapy has the potential to improve respiratory functions, exercise capacity, muscle strength, dyspnea, fatigue, and participation in ADL in patient with post-COVID fibrosis.

Keywords: COVID-19, Post-COVID fibrosis, Rehabilitation, Case report.

INTRODUCTION

Coronavirus Disease (COVID-19) is a contagious respiratory disease caused by severe acute respiratory syndrome virus 2 (SARS-CoV-2). Although most patients can be recovered from the COVID-19 infection, it has been reported that more than 70% of them have an involvement in body systems 4 months after diagnosis [1]. This situation is called “Long COVID-19 Syndrome” [2]. Symptoms such as chronic cough, chest tightness, and shortness of breath, cognitive dysfunction and extreme fatigue have been reported in Long COVID-19 Syndrome [3]. Pulmonary fibrosis is one of the pulmonary problems caused by the Long COVID-19 Syndrome [2]. Post-COVID fibrosis may be a follow-up to chronic inflammation or an idiopathic, genetically influenced, and age-related fibroproliferative process. Risk factors for the development of Post-COVID fibrosis are advanced age, worse disease severity including comorbidities such as hypertension and diabetes, prolonged length of stay in intensive care and mechanical ventilation, smoking and excessive alcohol consumption [4]. There is currently no fully documented therapeutic method in the treatment of post-COVID fibrosis. However, some pharmacological therapies may be considered. In addition, the importance of being included in the rehabilitation program was emphasized, especially for patients who developed lung fibrosis [5,6]. Pulmonary rehabilitation (PR) provides improvements in exercise capacity, quality of life, cardiovascular functions, respiratory functions, dyspnea, fatigue, anxiety and depression levels and inspiratory muscle strength in patients with idiopathic pulmonary fibrosis [7]. There is only one case study available in the literature which reported that 10 sessions of exercise-based PR program (including aerobic, strengthening and stretching exercises) had beneficial effects on supplemented oxygen need during exercise in a post-COVID fibrosis patient [8]. It has been reported that single- leg cycle training and neuromuscular electrical stimulation may have positive effects in patients with

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chronic respiratory conditions with increased level of dyspnea [9, 10]. This case study aimed to show the effects of an individualized PR program including single- leg cycle training and neuromuscular electrical stimulation on selected clinical parameters in a patient diagnosed with post-COVID fibrosis.

CASE REPORT

A 46-year-old male patient was admitted to a PR unit 168 days after the (+) PCR test. The patient was diagnosed with post-COVID fibrosis by chest computed tomography one month ago and antifibrotic treatment (Pirfenidone) was administrated. The main complaints of the patient were fatigue and exertional dyspnea when climbing stairs/hills and walking fast. The patient did never smoke and had no previous respiratory complaints or diagnosis.

At the beginning of the rehabilitation program, spirometry and diffusion tests were performed. Exercise capacity was assessed with different field tests. Six-minute walk test (6MWT) was used to assess the exercise capacity in accordance with the ATS/ERS guideline [11]. Blood pressures (Beurer GmbH, Germany), heart rate and oxygen saturation (MaProlinx GmbH, Germany) were measured, and dyspnea and fatigue levels were questioned before and after test. Walking distance were calculated. The incremental shuttle walk test (ISWT) was used to evaluate the maximal exercise capacity and the endurance shuttle walk test (ESWT) was used to observe endurance capacity [12, 13]. Quadriceps muscle strength was evaluated using a hand-held dynamometer (J-Tech Commander, TM Manuel Muscle Tester, JTech Medical, USA) for both lower extremities. Modified Medical Research Council (mMRC) dyspnea scale, Fatigue Severity Scale (FSS) and London Chest Activity of Daily Living (LCADL) were questioned [14-16].

The patient was asked to participate in an individualized outpatient PR program for 3 days a week for 8 weeks. The subject has previously been diagnosed with left knee chondromalacia and suffered from knee pain during activity. Increased fatigue was observed after incremental and endurance shuttle walk tests. Therefore, the PR program was prescribed with the aim of improving knee muscle strength and endurance by not aggravating the pain. The individualized PR program consisted of breathing exercises, aerobic exercises and neuromuscular electrical stimulation (NMES). Aerobic exercise applied as supervised single- right leg cycle training, at the intensity of %50-65 maximal heart rate (HR_{max}) for 10-30 minutes. During the single-leg cycle training, the perceived exertion level was in the range of 4-6 according to the modified Borg Scale. Oxygen saturation and heart rate were monitored throughout the session. Bilateral NMES (Cefar-COMPEX Rehab400, Swiss) with bilateral electrode placement on the quadriceps femoris under 35-60 Hz, symmetrical biphasic square wave current wave, phase transition time 8 seconds, active rest time at 15 seconds for 30 minutes was approached [17]. The patient did not receive O_2 support during the PR sessions. The patient was also encouraged to walk at least 10 minutes twice a day except for PR days. The adherence to the walking program was followed via an exercise diary. All assessments were repeated after 8 weeks of the PR program.

The patient attended 16 sessions in total and adherence to the walking program was good according to the exercise diary. No adverse event was observed related to the intervention or assessments. The pre and post-rehabilitation evaluations and changes of the patient are given in Table **1**. Small but promising improvements were observed after 8 weeks of the PR program in FEV1 %pred, FVC %pred, FEV1/FVC %pred, DLCO, 6MWD, ISWT walking distance, ESWT walking time, left and right quadriceps muscle strength, mMRC Dyspnea scale score and FSS score. The patient was given a home program to be followed at 3-month intervals. The patient reported his satisfaction level as 5 on a 1-5 Likert scale.

DISCUSSION

Symptoms such as shortness of breath, dry cough, and exertional dyspnea are the reported manifestations of the so-called Long COVID-19 Syndrome [2]. It is generally accepted that pulmonary fibrosis is a complication of Long COVID-19 Syndrome. Many pharmacological treatments including high-dose prednisone and N-acetyl-cysteine and antifibrotics have been questioned for post-COVID fibrosis with limited evidence [6, 18]. Therefore, rehabilitation becomes even more important.

Rehabilitation plays a crucial role in managing COVID-19 patients, with a focus on respiration and functionality, and therefore the importance of establishing treatment strategies to ensure optimal recovery of these patients has been emphasized. Rehabilitation improved respiratory functions, exercise

Table 1: Pre- and Post-PR Assessments of the Patient with Post-COVID Fibrosis

	Pre PR	Post PR	Δ (%)
Spirometry and DLCO	FEV1 % pred: 70.1% FVC % pred: 64.7% FEV1/FVC% pred: 112.2% DLCO: 49%	FEV1 % pred: 84.3% FVC % pred: 91.2% FEV1/FVC % pred: 112% DLCO: 58%	FEV1 % pred: 20.25% ↑ FVC % pred: 40.95% ↑ FEV1/FVC % pred: 0.17%↑ DLCO: 18.36% ↑
6MWT	437 m	470 m	7.55% ↑
Δ Heart rate (beat per minute)	16	13	18.7%↑
Δ SpO2 (%)	-1	0	100%↑
Δ Dyspnea (mBORG 0-10)	4	4	-
Δ Leg fatigue (mBORG 0-10)	3	3	-
Incremental shuttle walk distance	480 m	600 m	25% ↑
Endurance shuttle walk time	10 min 15 sec	11 min 14 sec	9.59%↑
Quadriceps muscle strength	Right: 90.2 N Left: 85.8 N	Right: 134.6 N Left: 136 N	Right: 49.22% ↑ Left: 58.51% ↑
mMRC Dyspnea Scale	1	0	100% ↓
FSS (total score)	32	29	9.38% ↓
LCADLS (total score)	11	8	27.27% ↓
VAS (during activity)	5	3	40% ↓

Δ: Difference between pre and post-PR assessments, FEV1: Forced Expiratory Volume in 1 sec, FVC: Forced Vital Capacity, DLCO: Diffusing Capacity of the Lung for Carbon Monoxide, 6MWT: Six minutes Walking Test, mMRC: Modified Medical Research Council, FSS: Fatigue Severity Scale, LCADLS: London Chest Activities of Daily Living Scale, VAS: Visual Analogue Scale.

endurance, self-care and psychological support in activities of daily living in patients with COVID-19 in the acute and post-acute periods [19]. It has been reported that physical activity recommendations should be clarified for managing symptoms associated with prolonged COVID-19 Syndrome and for continuing activities of daily living [20]. It has been stated that after COVID-19 pneumonia, it is necessary to evaluate the patient's physical functions long-term follow-up and establish rehabilitation programs [21]. The importance of being included in the rehabilitation program was emphasized, especially for patients with post-COVID fibrosis [5]. There is only one case study available in the literature which reported an exercise-based PR for a post-COVID fibrosis patient [8]. In the case study of Choi *et al*. 10 sessions of PR program which includes aerobic, strengthening and stretching exercises. It has been reported that the patient cut off the oxygen supplementation and complete the one-hour exercise without oxygen on the 8th day and was discharged after completing the 10-session program without any activity limitations. The duration and intensity of the PR were closed with our PR program. The strength training was applied using electrical stimulation and aerobic training was maintained as a single-leg cycle because of the limitations in the lower extremities. In the current case study, PR program consisted of breathing exercises, single-leg cycling and NMES. Although we also aimed to increase exercise capacity and muscle strength, our program was containing different methods. We observed that an individualized PR program combined with antifibrotic therapy has the potential to improve respiratory functions, exercise capacity, muscle strength, dyspnea severity, fatigue level, and participation in ADL in a patient with post-COVID fibrosis. It is possible that the increase in exercise capacity and respiratory functions that occurred in the present study resulted in an improvement in the mMRC dyspnea scale and less dyspnea in activities of daily living.

In a case study of 68-years-old patient affected by SARS-Cov-2 infection complicated by pulmonary fibrosis treated with a combined high dose of prednisone and N-acetyl-cysteine for one month [18]. It was reported that FEV1 % pred increased up to 75% of the predicted value (Δ=~ 17 % ↑) whereas FVC increased from 2.8 to 3.5 l (Δ= ~25 % ↑). In our study, we observed higher changes in FEV1 %pred and FVC % pred with 8 weeks of combined antifibrotic therapy and an individualized PR program. We think that the effects of combined PR and medical treatment in post-

COVID fibrosis should be comprehensively investigated in the future. Quadriceps muscle strength was lower in our case due to the left knee chondromalacia. After the individual PR program, there was a greater increase in left quadriceps muscle strength. With bilateral NMES, both quadriceps muscles were loaded equally and the weak left quadriceps muscle was strengthened more than the right quadriceps muscle. Since the load required to increase the maximum strength in weak muscles is lower, this result in our study is compatible with the literature [22].

It is not clear by which mechanisms COVID-19 infection causes pulmonary fibrosis, and it is not known what will happen to patients who develop post-COVID fibrosis in the future. Considering the patient's gains with the individualized PR, we think that this case report will be a guide for other prospective rehabilitation studies. Patients with post-COVID fibrosis should be included in comprehensive PR programs and should be followed for the long term. We think that this case study will be a guide for further prospective studies.

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