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Case Report

Long COVID may persist beyond three years: Cardiopulmonary rehabilitation remains effective

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ABSTRACT

A previously healthy 38-year-old female patient experienced persistent dyspnea and fatigue for over 36 months following severe COVID-19 (coronavirus disease 2019). Despite normal cardiopulmonary evaluations, the patient was diagnosed with long COVID and completed a 30-session cardiopulmonary rehabilitation program, including aerobic, resistance, and inspiratory muscle training. Marked improvements were observed in peak VO_2 (maximal aerobic capacity), metabolic equivalents, oxygen uptake efficiency, heart rate recovery, handgrip strength, and quality of life, without adverse events. To our knowledge, this represents the longest documented duration of long COVID successfully treated with cardiopulmonary rehabilitation, highlighting the potential benefits of rehabilitation even after prolonged symptom persistence.

Keywords: Cardiopulmonary exercise test, exercise therapy, post-acute COVID-19 syndrome, rehabilitation.

Most patients with COVID-19 (coronavirus disease 2019) return to their baseline health after acute infection with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2); but a proportion continue to experience persistent symptoms. Symptoms that last for at least two months and are present three months after the initial infection, without an alternative explanation, are referred to as long COVID (or post-COVID-19 condition).[1] Following acute SARS-CoV-2 infection, reports indicate that approximately 10 to 30% of patients develop long COVID.[2] The most commonly reported symptoms in previous studies include fatigue and dyspnea.[3] Female sex and a history of admission to the intensive care unit (ICU) during acute infection have been found to be associated with the development of long COVID.[4] In the posthospitalization period, Li et al.[5] reported that 64% of patients continued to experience sleep disturbances, 61% had reduced exercise tolerance, 58% suffered from shortness of breath, 62% experienced anxiety, and 84% sought advice on rehabilitation. In addition, individuals with long-term COVID complaints were found to exhibit a 4.9 mL/kg/min reduction in maximal aerobic capacity three months after infection compared to those without ongoing complaints.[6]

Currently, no specific therapeutic intervention exists for long COVID; however, cardiopulmonary rehabilitation (CPR) has demonstrated efficacy in enhancing exercise tolerance, mitigating dyspnea, and promoting health-related quality of life among affected individuals with long COVID.[7-9] Notably, in previous studies, the longest duration of COVID-19 symptoms among rehabilitated patients was reported to be 28.4 months.[7] The efficacy of rehabilitation in cases with longer symptom duration remains unknown. Herein, we presented a patient with COVID-19 symptoms persisting for more than 36 months and the patient's response to a CPR program.

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CASE REPORT

A 38-year-old female patient with no known comorbidities was admitted to the ICU in April 2021 due to COVID-19 pneumonia, where she received oxygen support for one month. Prior to the illness, the patient led an active lifestyle, regularly engaging in mountain biking for 100 km twice a week. Following hospital discharge, the patient continued to experience persistent dyspnea and fatigue, with significant limitations in daily activities. Due to dyspnea, the patient was only able to take less than 500 steps per day.

In 2023, coronary angiography was performed due to ongoing chest pain and dyspnea; however, no significant pathology was detected in the coronary arteries, and no intervention was deemed necessary. The only medication she regularly used was metoprolol 25 mg, prescribed for palpitations. Echocardiography revealed a pulmonary artery pressure of 42 mmHg and a left ventricular ejection fraction of 60%. Pulmonary function tests showed an FEV1 (forced expiratory volume in 1 sec) of 87%, FVC (forced vital capacity) of 89%, and an FEV1/FVC ratio of 84%. The most recent thoracic computed tomography scan demonstrated no significant pathology.

The patient was diagnosed with long COVID based on her previously active lifestyle, the absence of known comorbidities or alternative explanations for her symptoms, and risk factors associated with long COVID, including female sex and a history of intensive care admission due to COVID-19. The patient had not participated in any respiratory physiotherapy or CPR program prior to this study.

The patient underwent a total of 30 sessions of a CPR program, with three sessions per week. Each session included 30 min of aerobic interval training on a treadmill, 15 min of arm ergometry, and 30 min of light stretching exercises combined with progressive strengthening exercises for the upper and lower extremity muscles. The intensity of aerobic intervals was prescribed according to 70 to 85% and 40 to 60% of peak VO_2 (maximal aerobic capacity). The patient was monitorized with continuous electrocardiography and pulse oximetry. No adverse effects or desaturation events were observed during exercise sessions. Exercise intensity was gradually increased according to the patient's symptom tolerance.

TABLE 1
Change in outcome variables through rehabilitation

Parameter	Before rehabilitation	After rehabilitation	Change
Peak VO_2 (mL/kg/min)	9.9	20	+100%
Peak METs	2.8	5.7	+100%
VE/VCO_2 slope	81.9	41.4	-49%
OUES (mL/min/log L/min)	825	2349	+185%
1-minute heart rate recovery (bpm)	1	20	+ 19
Dominant handgrip strength (kg)	26.6	30.3	+3.7
S-index (cmH_2O)	70	84	+20%
Body mass index (kg/m^2)	37.3	37	-0.8%
Resting heart rate (bpm)	84	86	+2
Peak heart rate (bpm)	110	139	+29
RER peak (VCO_2/ VO_2)	0,88	0,93	+5%
SF-36 Physical functioning score (%)	10	50	+400
SF-36 General health score (%)	20	40	+100
SF-36 Vitality/energy/fatigue (%)	45	50	+11
Sf-36 Role limitations due to physical health (%)	10	30	+200
Sf-36 General mental health (%)	56	72	+28
Sf-36 Social functioning (%)	25	38	+52
SF-36 Bodily pain (%)	23	45	+95

VO_2: Oxygen consumption; MET: Metabolic equivalent of task; VE/VCO_2: Minute ventilation/carbon dioxide production; OUES: Oxygen uptake efficiency slope; RER: Respiratory exchange ratio; S-Index: Strength index; SF-36: The 36-Item Short-Form Health Survey.

In addition, inspiratory muscle training was performed using the Powerbreathe K5 device (POWERbreathe International Ltd., Southam, UK), with 30 repetitions per session. Training was conducted at 30 to 40% of the pressure value, measured weekly using the S-index.

Outcome measures, including a cardiopulmonary exercise test using the modified Bruce protocol on a treadmill, the 36-item Short-Form Health Survey (SF-36), S-index measurement via the Powerbreathe K5 device (POWERbreathe International Ltd., Southam, UK), and dominant handgrip strength measured using a calibrated Jamar Hand Dynamometer (Sammons Preston, Inc., Bolingbrook, IL, USA), were assessed before and after the rehabilitation program. Peak VO_2, peak metabolic equivalents of task (METs), minute ventilation/carbon dioxide production (VE/VCO_2) slope, 1-min hearth rate recovery (HRR), and oxygen uptake efficiency slope were analyzed.

Table 1 summarizes the changes in the outcome measures. Following the CPR program, the patient showed significant improvements in functional capacity, exercise tolerance, and quality of life. Notable enhancements were observed in aerobic capacity, ventilatory efficiency, inspiratory muscle strength, and physical functioning score. Additionally, considerable improvements were noted in 1-min HRR and handgrip strength. The patient tolerated the rehabilitation program well, with no adverse events or episodes of desaturation reported during the sessions. Written informed consent was obtained from the patient for the publication of this case report.

DISCUSSION

We presented a previously active, 38-year-old female patient who experienced persistent dyspnea and fatigue for over three years following COVID-19 pneumonia requiring ICU admission. To our knowledge, this is the longest documented case of long COVID in the literature. Despite the unprecedented duration of symptoms, the patient showed substantial improvements in cardiopulmonary capacity, autonomic function, and quality of life following a structured CPR program.

Previous studies have indicated that persistent symptoms after SARS-CoV-2 infection may be associated with physical deconditioning, cardiac dysautonomia, and dysfunctional breathing, even in patients without obvious cardiopulmonary pathology.[10] In this case, the patient's reduced peak VO_2 and METs were consistent with impaired aerobic capacity attributable to long COVID, particularly given her high pre-COVID-19 functional status.

Following 30 CPR sessions, objective improvements were observed in cardiopulmonary exercise test parameters, including peak VO_2, peak METs, oxygen uptake efficiency slope, 1-min HRR, and VE/VCO_2 slope. Heart rate recovery, an indicator of autonomic function and cardiovascular risk, was initially impaired, likely due to COVID-19-related dysautonomia, and showed marked improvement after rehabilitation.[11] Similarly, the elevated VE/VCO_2 slope, often associated with hyperventilation or increased dead space ventilation, decreased significantly, suggesting improved ventilatory efficiency.

While the pathophysiology of long COVID remains incompletely understood, its clinical course is known to be heterogeneous and prolonged. In a large cohort study, Servier et al.[12] identified that 4% of individuals with long COVID experienced persistent, high symptom burden up to two years after infection. Another report found that 22.9% of patients continued to experience at least one long COVID symptom at two years, most commonly fatigue.[13]

Cardiopulmonary rehabilitation has previously been shown to improve symptoms and functional capacity in long COVID, with the longest documented symptom duration in such studies being 28.4 months.[7] Our case extends this timeframe to over 36 months, demonstrating that even in patients with very prolonged symptom duration, rehabilitation can lead to clinically meaningful recovery.

Current evidence suggests that while exercise-based rehabilitation may offer benefits in long COVID, standardized protocols are lacking. Both the Cochrane review[14] and Gloeckl et al.[15] highlight the need for individualized, symptom-guided programs, particularly considering the presence of postexertional malaise.

In conclusion, this case demonstrates that structured CPR can lead to significant improvements in functional capacity, autonomic function, and

ventilatory efficiency in patients with long COVID symptoms persisting for over three years. Even after prolonged symptom duration, rehabilitation remains an effective and valuable intervention, underscoring the importance of individualized therapeutic strategies in long COVID management.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Idea/concept, data collection and/or processing, literature review, writing the article: Ç.G., L.K.; Design, analysis and/or interpretation: Ç.G., N.D.; Control/supervision: L.K., N.D.; Critical review: Ç.G., L.K., N.D.; References and fundings: Ç.G., L.K., N.D.; Materials: N.D.

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