

## Review

# Pulmonary Rehabilitation in Coronavirus Disease 2019 Patients

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## Abstract

Since coronavirus disease 2019 mainly affects the respiratory system, pulmonary rehabilitation has increased its importance during the novel coronavirus pandemic. Healthcare professionals must use appropriate personal protective equipment during rehabilitation of patients infected with severe acute respiratory syndrome coronavirus 2. Comorbidities of the patient should be taken into consideration while organizing the rehabilitation program. Clinical manifestations range from asymptomatic to acute respiratory distress syndrome. There is no need for pulmonary rehabilitation in asymptomatic patients. Pulmonary rehabilitation may be recommended in patients with mild-moderate disease. It is advised that patients be followed up during the rehabilitation period. Positioning and passive range of motion exercises are beneficial in preventing immobilization complications in patients with critical illness. Post-coronavirus disease 2019 rehabilitation program should be established according to the needs and functional levels of the patients.

**KEYWORDS:** Pulmonary rehabilitation, COVID-19, SARS-CoV-2

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## INTRODUCTION

Since the beginning of the pandemic, more than 96 million people worldwide have been infected with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), causing coronavirus disease 2019 (COVID-19). More than 2 million people have been recorded killed by the virus since the disease first emerged in China.<sup>1</sup>

Pulmonary rehabilitation (PR), as defined by the American Thoracic Society (ATS) and the European Respiratory Society (ERS), is an evidence-based, multidisciplinary, and comprehensive intervention for patients with chronic respiratory diseases who are symptomatic and often with limitation in activities of daily living. Individualized pulmonary rehabilitation programs provided to the patient in conjunction with medical treatment are designed to reduce symptoms, optimize functional status, increase participation, and reduce healthcare costs by stabilizing or reversing the systemic symptoms of the disease.<sup>2</sup> To minimize the negative effects of COVID-19, the World Health Organization also recommends rehabilitation practices in these patients.<sup>3</sup>

Post-COVID-19 rehabilitation programs can be diverse and comprehensive. Rehabilitation programs are organized to prevent immobilization complications and secondary musculoskeletal problems and to increase respiratory functions, patient independence, and quality of life, taking the patient's comorbidities into account. The purpose of PR after COVID-19 is to decrease dyspnea, relieve anxiety, reduce complications, minimize disability, preserve function, and improve quality of life.<sup>4</sup>

In this review, pulmonary rehabilitation practices and their efficacy after COVID-19 will be discussed with the current literature.

## CLINICAL AND RESEARCH CONSEQUENCES

### General Principles

Since transmission risk is high during the acute phase of COVID-19, PR applications should be performed with minimal contact. Telerehabilitation is a safe and cost-effective method mainly used in the treatment of disability caused by different neurological diseases such as stroke, spinal cord injury, and multiple sclerosis.<sup>5</sup> Also, it has been shown to be an effective and safe treatment method in the rehabilitation of different respiratory tract diseases such as chronic obstructive pulmonary disease (COPD), asthma, and cystic fibrosis.<sup>2,6</sup> In addition to treatment with telemedicine methods, functional status of the patients can also be evaluated. The Hull University-proposed pathway recommends that all COVID-19 survivors should be evaluated in terms of rehabilitation needs. Monitoring of symptoms and radiological follow-up, and evaluation by a multidisciplinary team 6-12 weeks after discharge were recommended.<sup>7</sup> In telerehabilitation applications, patients should be evaluated with a multidisciplinary team within the framework of the International Classification of Functioning, Disability, and Health.

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In a case series that implemented a telehealth COVID-19 rehabilitation model, it has been concluded that rehabilitation via telehealth for individuals recovering from COVID-19 was safe and feasible. With telemedicine and videoconference methods, it is possible to evaluate patients, prescribe individualized exercise methods, and monitor patients through appropriate equipment during exercise.<sup>8</sup> However, patients with limited cooperation, comorbidities, communication problems, and complex symptoms require detailed evaluation, thus telemedicine methods may not be suitable for these patients.

If the patient infected with SARS-CoV-2 is not suitable for telemedicine and the PR program needs to be implemented directly, it is critical that the healthcare professional use appropriate personal protective equipment (PPE). It is recommended that the rehabilitation professional use full PPE including gloves, masks, and isolation gowns for all person-to-person interactions. Also, a face shield and/or goggles are recommended if there is a risk of airborne transmission.<sup>9</sup> Recommendations for rehabilitation centers to prevent the spread of the disease are given in Table 1.

The main goals of PR are to prevent secretion accumulation with appropriate methods (such as positioning, mobilization, cough, and postural drainage) and to reduce respiratory tract resistance, ensure that respiratory muscles are in proper position and function, reduce energy consumption during breathing, increase chest mobility, correct postural deformities, reduce dyspnea, increase general exercise tolerance, decrease depression and anxiety, and to increase functionality and quality of life.<sup>10</sup>

The international task force coordinated by the ERS and ATS recommends bedside (critical care and/or ward-based) PR for hospitalized patients with COVID-19. It was also recommended that, similar to the case with other critical illnesses, at the onset of PR, the patient discharged from the hospital be evaluated in terms of compliance. However, it was stated that some specialists in the task force had some concerns about patient safety due to the possible impact of rehabilitative

#### MAIN POINTS

- Healthcare professionals are required to use appropriate personal protective equipment.
- Pulmonary rehabilitation (PR) programs can be presented with telerehabilitation methods in eligible patients.
- There is no need for PR in asymptomatic patients.
- Comorbidities and functional status of the patients should be taken into consideration while organizing the PR program.
- Pulmonary rehabilitation is recommended after patient evaluation in COVID-19 pneumonia.
- Individualized programs are recommended in PR.
- It is recommended to reduce the adverse effects of immobilization and secretion during acute respiratory distress syndrome.
- High-quality studies are needed for post-COVID-19 exercise recommendations.

**Table 1.** Recommendations for Rehabilitation Centers

- All healthcare workers should use appropriate PPE.
- Surgical mask, eye protection, gloves, and disposable gown should be worn during aerosol-generating procedures.
- Patients should use a surgical mask during rehabilitation practices.
- It is recommended to use negative pressure systems and HEPA filters in exercise rooms.
- There should be at least 30 minutes between patients to be evaluated in the exercise test room.
- Surfaces should be sanitized after each patient's rehabilitation session.
- The number of patients to be rehabilitated at the same time should be determined according to the size of the area.
- Patient appointments and waiting room should be arranged to provide social distance.

PPE, personal protective equipment; HEPA, high-efficiency particulate air.

interventions since the understanding of the pathophysiology is limited and it is still unknown if there is any threshold of disease severity.<sup>11</sup> There is not yet a core set for baseline assessment of patients.<sup>12</sup>

Differences in the duration of COVID-19 symptoms also create different opinions in the timing of PR. Around 35% of patients with polymerase chain reaction (PCR) (+) stated that they could not return to their normal health status even 3 weeks after diagnosis. In the evaluation made 14-21 days after the diagnosis of COVID-19, it was stated that 20% of patients aged 18-34 could not return to usual health. This rate was found to be 47% in patients older than 50 years.<sup>13</sup> In another study including 143 patients, only 12.6% of individuals who were followed up for an average of 60 days after the diagnosis of COVID-19 reported no symptoms, 32% had 1-2 symptoms, 55% had 3 or more symptoms, 44.1% reported worsening in quality of life, 53.1% reported fatigue, 43.4% reported shortness of breath, 27.3% reported joint pain, and 21.7% reported chest pain.<sup>14</sup> With this information, it can be said that SARS-CoV-2 can cause symptoms that may continue for a long time after the disease. This situation should not be forgotten while considering patient education and PR timing. In addition to the publications suggesting that patients should start PR early after COVID-19, there are also publications suggesting that patients should be evaluated 6-8 weeks after discharge.<sup>15</sup> There is currently no generally accepted recommendation regarding the timing of PR.

Patient education plays an important role in achieving rehabilitation success. Patient education can be applied via video conferencing, information booklets, telephone calls, and video calls. Patients should be educated about the clinical course of COVID-19 and their own comorbidities, if any.<sup>16</sup> Recommendations for the management of additional conditions such as smoking, overweight, inadequate fluid intake, and poor sleep hygiene should be offered to patients infected with SARS-CoV-2.<sup>10</sup> It is recommended to advise and educate patients on fatigue, dyspnea, mood disorders, and social isolation in the early period after discharge.<sup>15</sup>

Emotional state of the patients is an important factor in the success of rehabilitation in many diseases that cause disabilities, including COVID-19. Cognitive impairment, post-traumatic stress disorder, anxiety disorder, chronic pain, sleep disturbance, fatigue, and fibromyalgia have been shown in patients after COVID-19. It is stated that these emotional changes may be caused by a prolonged stay in an intensive care unit (ICU), immobilization, social isolation, disruption of the sleep-wake cycle, as well as general inflammation or neurotropism of SARS-CoV-2.<sup>17</sup> Therefore, patients should be evaluated in terms of emotional functionality within 6-8 weeks after discharge in order to determine their rehabilitation needs.

### **Pulmonary Rehabilitation Recommendations According to the Stage of the Disease**

a report of 72 314 cases from the Chinese center for disease control and prevention, 81% of the patients were classified as mild (without or with mild pneumonia), 14% as severe (dyspnea, blood oxygen saturation <93%, partial pressure of arterial oxygen to fraction of inspired oxygen ratio <300, or lung infiltrates >50% within 24-48 hours), and 5% as critical disease (acute respiratory distress syndrome (ARDS), septic shock, or multiple organ dysfunction).<sup>18</sup>

The recommendations made by Zhao et al<sup>4</sup> for PR after COVID-19 are as follows: (1) PR can be used to reduce dyspnea, anxiety, and depression, and improve physical function and quality of life; (2) early respiratory rehabilitation is not recommended for severely/critically ill patients; (3) PR programs for patients should be implemented through training videos, informational documents, or telerehabilitation; (4) patients should be evaluated and monitored during PR; and (5) in case of face-to-face contact, appropriate PPE should be used.

#### **1. Acute Phase Management**

##### **a. Asymptomatic Disease Management**

There is no need for PR application in asymptomatic patients. Low-to-medium intensity stepping and range of motion exercises can be recommended to protect patients from the negative effects of immobilization during the quarantine period.<sup>10</sup>

##### **b. Mild Disease Management**

No signs of pneumonia on imaging and mild symptoms are considered to be mild illness in COVID-19. In mild disease, PR can be applied in an outpatient setting using the telehealth technique.<sup>19</sup> Pulmonary rehabilitation program in mild disease includes patient education, activity guidance, breathing exercises, airway clearance techniques, anxiety management, and physical exercise.<sup>4</sup> A home-based rehabilitation program can be recommended for patients with mild illness and no additional risk factors. The main goal of rehabilitation in this patient group is to avoid inactivity complications.<sup>19</sup> The criteria for patient stabilization after COVID-19 infection include decreased fever, decreased dyspnea, respiratory rate <30 breaths/min, and SpO<sub>2</sub> >90%. In the period when virulence decreases, individualized PR program can be performed for suitable patients. In patients with mild pneumonia, range of motion exercises (active-assisted or active), mobilization exercises, general muscle strengthening exercises, and bronchial hygiene techniques (use of incentive spirometry or

triflow, controlled cough, and huffing maneuver) can be given in the PR program. It is not necessary to use airway cleaning techniques in patients having dry cough and no sputum.<sup>10</sup>

Patients who do not have additional risk factors after mild COVID-19 should have warm-up, exercise, and cool-down periods. During warm-up and cool-down, there should be at least 5-10 minutes of low-intensity endurance exercises. Aerobic exercises and resistance training can be recommended in the exercise program. Aerobic exercises should be done >5 days a week, 30-60 minutes per session, and targeting 40-59% of heart rate reserve. Resistance exercises should aim at strengthening large muscles such as biceps, triceps, deltoid, pectoralis major, gluteus, iliopsoas, quadriceps, hamstring, anterior tibialis, and calf muscles. Strengthening exercises can be recommended 2-3 days a week (with appropriate rest intervals) using weight 60-70% of the 1 repetition maximum, 2-3 sets, and each set with 8-12 repetitions. For endurance training, the number of sets can be decreased (1-2 sets) and the number of repetitions can be increased (15-25 repetitions). Exercise recommendations for mild COVID-19 patients with comorbidities should be disease-specific. In patients with hypertension, blood pressure should be monitored during exercise, sufficient cooling exercise should be recommended for heart rate and blood pressure to return to normal, and movements such as the Valsalva maneuver that increase blood pressure should be avoided. Exercise should be stopped if patients with cardiovascular disease have symptoms of exercise intolerance such as shortness of breath, palpitations, chest pain, and dizziness. Because of the QT prolonging effect of drugs used in the treatment of COVID-19, a cardiology consultation may be requested for exercise safety. In patients with diabetes mellitus, blood glucose should be controlled before and after exercise. Patients should be followed closely for signs of hypoglycemia (tremor, abnormal sweating, confusion, visual impairment, etc.).<sup>19</sup>

Breathing exercises can be performed in COVID-19 patients with mild involvement. The purpose of diaphragmatic breathing is for the patient to learn how to use the diaphragm, which is the main muscle of inspiration while breathing, and thus to minimize the movement of the auxiliary respiratory muscles. In diaphragmatic breathing, the first breathing is through the nose and the abdomen is inflated, and then the mouth is opened and the breath is exhaled. In a randomized controlled trial (RCT) investigating the effectiveness of PR after COVID-19 in elderly patients, respiratory muscle training, coughing, diaphragmatic breathing, and stretching exercises were applied 2 days a week for 6 weeks. Significant increases were detected in the respiratory functions, functional capacity, and quality of life of the patients in the intervention group at the end of 6 weeks.<sup>20</sup> The practices used in respiratory physiotherapy including incentive spirometry, respiratory muscle training, diaphragmatic breathing, pursed-lip breathing, and bronchial hygiene techniques are not recommended in patients with COVID-19 during the acute phase in order not to cause an additional burden on the work of breathing.<sup>21</sup>

##### **c. Moderate/Severe Disease Management**

Symptomatic patients with respiratory distress, respiratory rate >30/min, resting oxygen saturation <93%, or PaO<sub>2</sub>/FiO<sub>2</sub>

<300 mmHg are considered as having moderate/severe illness. Hospitalization and monitoring of these patients are recommended.<sup>4</sup> Although there is insufficient evidence for PR applications in the acute phase of COVID-19, the efficacy and safety of PR in COPD exacerbations have been studied previously. It has been reported that PR programs increased the exercise capacity and health-related quality of life of patients with COPD exacerbations, and no significant side effects were observed.<sup>22</sup> In addition, there are studies indicating that early rehabilitation programs after interstitial pneumonia reduce mortality.<sup>23</sup> In early PR and mobilization practices, besides evaluation of patients, it is important to evaluate the hospital conditions and the safety of healthcare workers. During PR and mobilization, SARS-CoV-2 aerosols may spread into the environment, so proper PPE use is essential for the protection of healthcare workers and other patients.<sup>24</sup>

Due to the risk of disease progression and serious disease development in a short time after being infected with SARS-CoV-2,<sup>25</sup> the exercise intensity should be carefully evaluated in the PR program and appropriate patients should be monitored. The criteria for the patients not to be included in the PR program during the acute disease period are as follows: (1) body temperature >38.0°C; (2) if the time to first diagnosis or onset of symptoms is >3 days; (3) if the time interval between disease onset and dyspnea is ≤3 days; (4) chest image showing >50% progression within 24-48 hours; (5) SpO<sub>2</sub> <90%; (6) blood pressure <90/60 mmHg or >180/90 mmHg; (7) respiratory rate >40/min; (8) heart rate <40/min or >120/min; (9) the presence of new-onset arrhythmia and myocardial ischemia; and (10) altered level of consciousness.<sup>4,26</sup>

Physical exercise is the main point of the PR program, but in immobile patients, the PR program can be started with passive or active in-bed exercises.<sup>2</sup> During PR, saturation should be maintained at >90%. In order to achieve this goal, oxygen support should be used if necessary. Exercise should be interrupted if the saturation value falls below 90% or if the modified Borg dyspnea scale score is >3.<sup>26</sup> Exercise practices should also be stopped in the presence of palpitations, chest pain, and dizziness.<sup>2</sup>

#### **d. Critical Disease**

Critical illness includes ARDS, sepsis, and septic shock. Radiological and clinical worsening is seen in patients with ARDS. The patient's symptoms cannot be explained by cardiac functions and fluid overload. Although there are publications reporting that lung volumes and spirometric measurements were normal by 6 months after ARDS,<sup>27</sup> there are also publications reporting obstructive involvement in 6-43% of patients and restrictive effects in 15-58% of patients on pulmonary function test performed within the first year after ARDS.<sup>28</sup> There is insufficient evidence on the effect of early mobilization of critically ill patients in ICU on physical function, muscle strength, performance, adverse events, and health-related quality of life.<sup>29</sup>

Evidence of septic shock hypotension (systolic blood pressure <90 mmHg, diastolic blood pressure <60 mmHg, or vasopressor requirement), clinically significant acute renal,

hepatic, or neurological dysfunction have been reported in COVID-19-infected patients.<sup>30</sup> Pulmonary rehabilitation application is not recommended during these periods when the patient is not stable. Patients who survive severe disease should be evaluated individually and a PR program should be organized after their viral load decreases. Pulmonary rehabilitation application should be stopped in case of progression of the disease, presence of respiratory rate >30 breaths/min, increased respiratory workload and dyspnea, SpO<sub>2</sub> <90% under oxygen therapy or more than 4% decrease from baseline value, fever, chest pain, dizziness, severe headache, symptoms such as visual impairment, imbalance, tinnitus, palpitations, excessive sweating, and radiological lesion progressing more than 50% within 24-48 hours. Positioning, passive range of motion (ROM) exercises, and procedures for secretion management can be applied to the patient in the ARDS period. In positioning, the patient should stay in the prone position for 12-16 hours a day. The position of catheters should be checked during transitions between the supine and prone positions and the safety of the patient should be ensured. Immobile patients should be checked regularly for pressure ulcers. In order to prevent joint contracture, the patient should be applied a joint ROM exercises (passive/active-assisted/active depending on the patient's condition) at least once a day for 15 repetitions.<sup>10</sup>

#### **2. Post-Acute Phase Management**

In the staging of COVID-19, in the early infection stage (stage 1), symptoms such as fever, diarrhea, and cough are seen; dyspnea, hypoxia, and pulmonary involvement are observed in the pulmonary phase (stage 2); and in the hyper inflammation phase (stage 3), ARDS, shock, multiple organ failure, and death are the undesired outcomes.<sup>31</sup> Since the long-term effects of the disease are not fully known, post-COVID-19 PR recommendations are generally based on studies in other respiratory diseases and expert opinion.

After the acute phase of the disease, during the recovery period, early rehabilitation applications are recommended. According to the needs of the patient, neuromotor rehabilitation may be done in a rehabilitation center or at home. Patients and healthcare professionals should use appropriate PPE at all treatment stages. The oxygen level of the patients should be monitored closely and at least 90% peripheral oxygen saturation should be provided. Adequate support should be provided in terms of psychological advice and counseling in the post-COVID-19 period. The intervention should be stopped in the presence of symptoms such as high fever, increased shortness of breath, tachypnea (>30 breaths per minute), decreased peripheral oxygen saturation during exercise (>4%), and respiratory distress. Posture changes and management, including prone, sitting, or semi-orthopneic positions, can be done to increase systemic oxygenation in COVID-19 patients with FiO<sub>2</sub> ≥40 and <60%. In the post-acute period, ROM exercises, stretching exercises, and ankle pumping exercises can be applied to immobile patients. Thrombosis after COVID-19 is common; performing these exercises is important for preventing conditions such as deep vein thrombosis and pulmonary embolism. The following can be applied to patients in the PR program: controlled breathing, chest-abdominal coordination exercises, and clearance techniques.<sup>32</sup>

While the oxygen requirements of patients generally decrease, the oxygen need of some patients continues after discharge.<sup>33</sup> Some patients may experience dyspnea and oxygen desaturation during exercise that are not observed at rest. For this reason, it is recommended to evaluate the oxygen requirement of patients at rest and during effort before discharge.<sup>11</sup> As the lung pathology improves, the oxygen need of the patients may decrease, so follow-up planning should be done to evaluate the oxygen need after discharge. Patients with low oxygen needs ( $\text{FiO}_2 \geq 21$  and  $< 40$ ) have better functional capacity, and active ROM exercises and muscle strengthening exercises can be given to these patients as a part of the PR program. It is important to improve mobilization and balance in the post-acute period. Fatigue and dyspnea levels should be monitored and exercises should be started at low intensity. Walking training should be initiated in patients who can stand and have appropriate muscle strength. Thoracic expansion training, forced inspiration/expiration, intensive spirometry, and positive expiratory pressure can be used to improve pulmonary function in COVID-19 patients with  $\text{FiO}_2 \geq 21\%$  and  $< 40\%$ .<sup>32</sup>

In a study where an individualized cardiopulmonary rehabilitation program (aerobic exercise and strengthening exercises) was applied to patients after COVID-19, significant increases were found in the 6-minute walking test in both mechanically ventilated and not ventilated groups.<sup>34</sup> There is insufficient evidence for the use of aerobic exercises such as treadmills and cycle ergometers after COVID-19.

Some of the patients have difficulty during daily activities after COVID-19. Patients with long-term hospitalization, serious illness, comorbidities, and persistent symptoms may have difficulty during daily activities.<sup>11</sup> It has been shown that most of the patients who developed acute respiratory failure due to different diseases had significant increases in their physical functions in the second month after discharge. Advanced age, prolonged sedation time, and longer length of stay at ICU are factors that negatively affect functional recovery.<sup>35</sup> It is important to encourage patients to do daily activities within 6-8 weeks after discharge in order to increase their physical functions. However, patient's oxygen saturation, perceived difficulty, and dyspnea should be evaluated regularly.<sup>11</sup>

Prescribing exercise after COVID-19 is a delicate issue. Oxygen desaturation may occur with exercise due to the ongoing inflammatory process and persistent symptoms in discharged patients. It is stated that moderate-intensity exercises are safe and feasible in critical illness survivors.<sup>36</sup> In an RCT evaluating the effectiveness of exercise after SARS, patients in the exercise group had significant improvement in pulmonary function, muscle strength, and 6-minute walk distance.<sup>37</sup>

There are no detailed studies on the effects and prescription of exercise after COVID-19. Some clinicians suggest that there is no need for exercise restriction in asymptomatic patients following mild illness.<sup>38</sup> During the mild illness period, a low-medium intensity exercise program can be given in accordance with the patient's symptoms, comorbidities, and physical capacity. Some clinicians also want to be more

cautious about prescribing exercise due to the possibility of long-term disease, especially cardiovascular complications.<sup>39</sup>

Although it has been shown that regular exercise has positive effects and is a safe method in chronic fatigue syndrome,<sup>40</sup> it is not clear whether exercise has an effect on fatigue after COVID-19. It is known that peripheral muscle dysfunction develops in patients with ARDS and those requiring prolonged ICU stay. Peripheral muscle weakness is associated with immobilization, inflammation, myopathy, neuropathy, and medication. Peripheral muscle strengthening is an important part of PR in suitable patients with chronic respiratory disease. Although there is insufficient evidence for the benefits of lower extremity muscle strengthening after COVID-19, it is recommended that patients with lower extremity weakness or dysfunction begin a strengthening program 6-8 weeks after discharge.<sup>2</sup> The muscle strengthening program should be appropriate for the functional level of the patient, applicable, and progressive.

Proper protein and calorie intake is required for the patient to gain functional muscle mass or to minimize muscle loss. Coronavirus disease 2019 patients may experience appetite problems, loss of taste and smell, and swallowing disorders.<sup>41</sup> Appropriate nutritional supplements and moderate-intensity physical exercises at home are recommended for COVID-19 survivors after discharge.<sup>11</sup>

It should be kept in mind that COVID-19 survivors may be at different functional levels; hence, individualized rehabilitation programs should be created. It is recommended to perform re-evaluation every 3 months for 1 year after severe illness. Follow-up after critical/serious illness should be performed by a multidisciplinary team, taking extrapulmonary involvement into consideration.<sup>12</sup>

Physical examination, laboratory tests, and imaging methods can be used in the clinical evaluation of COVID-19 survivors. To evaluate respiratory functions, respiratory muscle strength assessment and respiratory function test can be done. A manual muscle test, UK Medical Research Council Scale or isokinetic muscle test, and goniometric ROM measurement can be used to evaluate exercise capacity. Berg balance scale to evaluate balance functions; 6-minute walking test and cardiopulmonary exercise test to evaluate aerobic exercise capacity; Physical Activity Scale for Elderly and International Physical Activity Questionnaire for physical activity assessment; and the Barthel index to evaluate activities of daily living can be administered.<sup>4</sup> However, respiratory function test and cardiopulmonary exercise test are not recommended in the acute phase of the disease due to the risk of contamination.<sup>42</sup> Although exercise capacity can be evaluated remotely and practically with sit-to-stand and timed up-and-go tests, exercises should not be prescribed to patients based on these tests.<sup>43</sup>

In addition, scores of symptom scales, infectious disease/immunological status, hematological data, imaging results, cardiorespiratory function, nutritional status, and comorbidities should be evaluated regularly. It is necessary to monitor the gas exchange during the PR process. Although arterial blood gas measurement ( $\text{PaO}_2/\text{FiO}_2$ ) is the gold standard for evaluation, it is recommended that all patients use pulse

oximetry during exercise at home. Evaluation of frailty is important to predict the course and effectiveness of PR. In frailty measurements, patients should be evaluated for exercise capacity, muscle strength, balance, coordination, nutrition, and psychosocial status multidimensionally.<sup>12</sup>

### 3. Chronic Phase/Complications Management

Comorbidities detected in COVID-19 patients are as follows: hypertension (55%), coronary artery disease and stroke (32%), diabetes mellitus (31%), COPD (7%), malignancy (6%), chronic renal failure (4%), gastrointestinal diseases (3%), and immunodeficiency (1%).<sup>44</sup> In the rehabilitation program to be implemented after COVID-19, additional diseases and functional status of the patient should be considered.

Critical disease polyneuropathy (CIP) is a sensorimotor neuropathy with axonal degeneration. It can be seen in up to 46% of patients hospitalized in the ICU with a diagnosis of ARDS. Clinical signs of CIP are atrophy, distal sensory loss, symmetrical weakness (respiration may be negatively affected by diaphragm involvement), and decrease or absence of deep tendon reflexes. As a result of CIP, ROM limitation, pain, incontinence, gait disturbance, loss of balance, and dysphagia can be observed.<sup>45</sup> There is no precise data on the prevalence of CIP after COVID-19.

Critical disease myopathy (CIM) is present in 48-96% of patients hospitalized in the ICU with a diagnosis of ARDS. Myopathy may be associated with corticosteroids, inflammation, and paralysis. Weakness, decreased endurance, decreased quality of life, and loss of function can be seen in patients with CIM.<sup>46</sup> As with CIP, there is no scientific evidence yet for CIM prevalence among COVID-19 survivors.

It has been shown that 20% of COVID-19 patients have a cardiac injury. The incidence of mechanical ventilation need and death has been reported to be higher in patients with cardiac injury. It has also been stated that ARDS, acute kidney damage, electrolyte disturbance, and coagulation disorders were more common in patients with cardiac injury. Persistent tachycardia or new-onset or worsening hypertension may occur in patients with cardiac damage after COVID-19. The mechanism of COVID-19 cardiac injury is unclear. According to the hypothesis, the high affinity of the spike protein of SARS-CoV-2 to the angiotensin-converting enzyme-2 receptor may be associated with cardiac injury. It has been reported that cardiac involvement of SARS-CoV-2 may cause acute myocarditis, myocardial edema, and acute myocardial damage.<sup>47</sup>

Neurological involvement has also been reported in patients with COVID-19. Encephalitis, aortic ischemic stroke, cerebral edema, and headache are some of the neurological involvements. In addition, lymphocyte and monocyte infiltration in the vessel wall, ischemic changes of neurons, and demyelination of nerve fiber have also been reported. It has been stated that there may be an increased risk of stroke after infection as a result of hypoxia and vascular changes.<sup>48</sup>

Heterotopic ossification, adhesive capsulitis, decubitus ulcer, contracture, and osteoporosis can be seen as immobilization

complications in COVID-19 patients requiring mechanical ventilation. Brachial plexus injury and peripheral nerve entrapment may be observed due to positioning and muscle imbalance.<sup>49</sup>

In a study evaluating the impact of COVID-19 on cognitive functions, it was found that patients with severe respiratory symptoms and long-term hospital stay were negatively affected. Decrease in cognitive functions may have a negative effect on rehabilitation success.<sup>50</sup>

### CONCLUSION

The COVID-19 pandemic continues to affect the whole world. With the increase in scientific data and a better understanding of the disease, post-COVID-19 rehabilitation practices have also gained importance. Further randomized controlled studies are needed to evaluate the effectiveness of post-COVID-19 rehabilitation programs. With telerehabilitation applications, it is possible to reach a wide audience and make a great impact.

Physical medicine and rehabilitation physicians can play an important role in increasing patients' functionality and reducing disability during the SARS-CoV-2 outbreak. Although scientific evidence is not sufficient for PR after COVID-19, recommendations can be made considering the effectiveness of PR programs in different lung diseases.

Proper patient selection and protection of healthcare professionals are priorities in a PR program. Physical medicine and rehabilitation doctors can provide guidance about nutrition, airway clearance techniques, posture, breathing exercises, stretching, strengthening, and physical activity for patients recovering from COVID-19.

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