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Rehabilitation Management to Improve Respiratory Function in Severe and Critical COVID-19 Survivors: A Literature Review

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Abstract

Post-acute COVID-19 symptoms impact the quality of life, and pulmonary rehabilitation is recommended. This study explored the implementation, outcomes, and barriers of such programs for severe and critical COVID-19 survivors, focusing on improving respiratory function. Articles search was conducted from October to November 2021 through Google Scholar and PubMed databases. Pulmonary rehabilitation programs in severe and critical cases of COVID-19 survivors have a similar purpose in other respiratory cases. Pulmonary rehabilitation programs, including breathing, resistance, stretching, cardiorespiratory endurance exercises, respiratory physiotherapy, relaxation techniques, and education, significantly improved lung function and reduced symptoms. No studies exploring barriers to pulmonary rehabilitation were found. In conclusion, pulmonary rehabilitation programs for COVID-19 survivors with severe and critical cases have improved respiratory functions.

Keywords: breathing, exercise, physiotherapy, pulmonary rehabilitation, quality of life

Introduction

Coronavirus disease 2019 (COVID-19) is a global health issue with clinical manifestations that can develop into severe, critical, or even death, especially for older individuals and those with comorbidities.[1,2] COVID-19 survivors often experience post-acute COVID-19, which can be classified into subacute (symptoms persisting for 4-12 weeks) and chronic (persisting for more than 12 weeks).[3,4] Common symptoms include shortness of breath and fatigue, affecting various organ systems.[4,5]

Post-acute COVID-19 is attributed to multiple factors, including the invasion of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), leading to pulmonary fibrosis and reduced lung function.[4,6-8] Microvascular thrombosis, the immune system-induced tissue damage, inflammation, and cytokine storm contribute to organ dysfunction and complications.[4,6,7,9]

Pulmonary rehabilitation (PR) is recommended for severe and critical COVID-19 survivors to improve respiratory function and quality of life (QoL). The PR programs with exercise as one of the core components are administered to relieve symptoms, restore functional abilities, and reduce disability in order to improve overall QoL.[4,10] This was the first review to specifically explore pulmonary rehabilitation in managing respiratory function disorders in severe and critical COVID-19 cases. The potential benefits of PR in improving respiratory function and QoL for severe and critical COVID-19 survivors were highlighted. This study explored PR implementation, outcomes, and barriers, providing insights for health professionals and policymakers in managing long-term COVID-19 effects and emphasizing comprehensive care for post-acute patients.

Method

Articles were searched using the Google Scholar and PubMed databases with the following keywords: (1) ("COVID-19" or "COVID-19" or "2019-nCoV") and ("Rehabilitation"), (2) ("COVID-19" or "COVID 19" or "2019-nCoV") and ("Rehabilitation") and ("Barrier" or "Challenge"). The article type was an original research article and case reports published from October to November 2021. Inclusion criteria were proofread or published articles written in English and accessible in pdf

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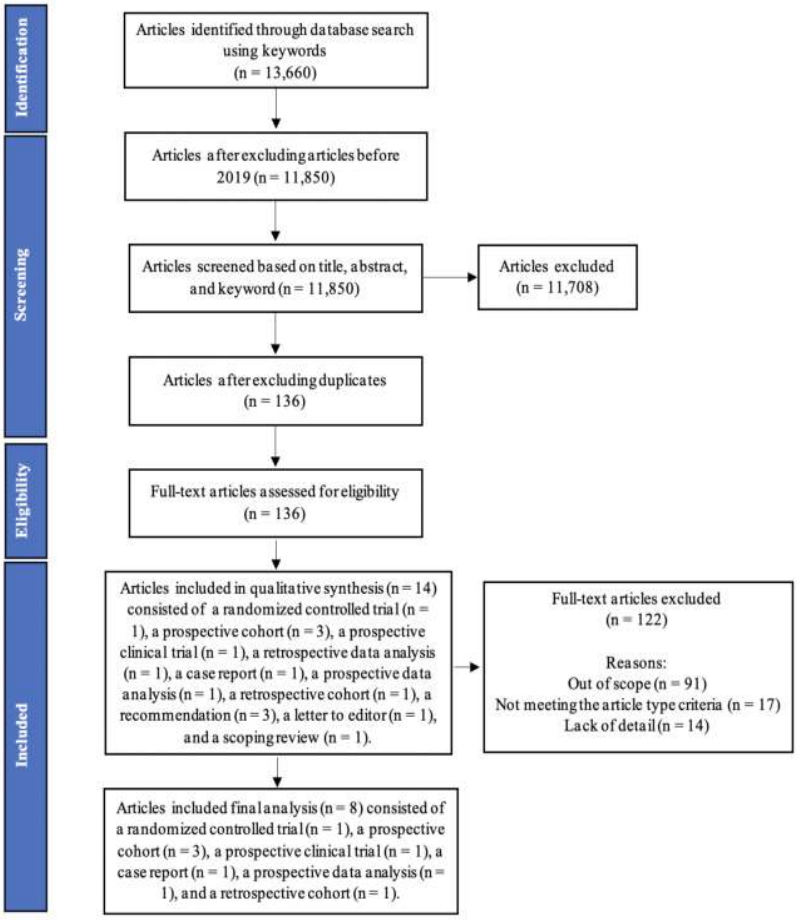

Figure 1. PRISMA Flowchart for the Literature Review

or HTML format. The articles were initially selected based on their titles, abstracts, and keywords. After reading the whole text, data were displayed as text and table.

Results

Eight articles discussing the implementation and outcomes of PR were found and no articles discussing barriers. The literature search flow based on preferred reporting items for systematic reviews and meta-analyses is shown in Figure 1, and the summary of PR interventions and outcomes is shown in Table 1.

Discussion

Implementation of Pulmonary Rehabilitation

COVID-19 survivors often experience residual symptoms even though they have been cured.[3,4] The PR program can be prescribed for COVID-19 survivors, especially in severe and critical cases, to relieve symptoms, improve quality of life, improve respiratory muscle function, and relieve symptoms of anxiety and depression.[13] The PR program for COVID-19 survivors includes breathing exercises, strength and stretching exercises, cardiorespiratory endurance exercises, respiratory physiotherapy, and relaxation technique.[11-18] Other interventions are psychological support, psychotherapy, nutritional counseling, occupational therapy, and activity of daily living exercises in calisthenics, speech therapy, and swallowing.[12,13,16-18] One article recommends mobilization, such as free and paced walking, balance, and aerobic exercise.[15]

Breathing exercises need to be carried out for COVID-19 survivors, especially in severe and critical cases, because lung function decreases in response to a cytokine storm in the acute phase. Decreased lung function is caused by impaired lung expansion due to alveolar damage to pulmonary fibrosis.[7,8] The intensive care unit care is involved in critical cases that cause the patient to experience muscle weakness related to mechanical ventilation, which significantly accelerates

Table 1. Summary of Articles Regarding Rehablitation Intervention and Outcomes in Managing Respiratory Function Disorders in Severe and Critical Cases of COVID-19 Survivors

Author (s)	Year	Study Design	Rehabilitation Management	Outcome
Liu, *et al.*[11]	2020	Randomized controlled trial	PR consisted of respiratory muscle, cough, diaphragm, stretching, and home exercises.	Significant improvement in lung function (FEV1, FVC, FEV1/FVC, and DLCO) in the intervention group.
Gloeckl, *et al.*[12]	2021	A prospective, observational cohort study	Comprehensive PR, including medical diagnostics and treatment, resistance training, strength training, patient education, respiratory physiotherapy, activity of daily living exercises, relaxation techniques, occupational therapy, psychological support, and nutritional counseling, is carried out for three weeks.	1. Significant lung function improvement in a group of mild/moderate COVID-19 and severe or critical. 2. Dyspnea, fatigue, and cough persist after completing PR in severe/critical COVID-19.
Sun, *et al.*[13]	2021	Before-after self-control prospective clinical trial	Breathing method exercises, respiratory muscle training, stretching exercises, and psychotherapy.	Dyspnea decreased, oxygen intake decreased, and oxygen saturation increased after 2- and 3-week PR.
Shan, *et al.*[14]	2020	Case report	PR focusing on increasing activity tolerance and endurance was performed for 10 days.	Improvement in oxygen saturation during excercise tests and incentive spirometer volume after PR.
Spielmanns, *et al.*[15]	2021	Prospective data analysis	PR includes endurance training, gymnastics, walking exercises, strength training, inspiratory muscle training, relaxation, and respiratory physiotherapy.	1. Oxygen supply was needed in 53% and 25% of patient before PR and after PR, respectively. 2. About 18 (26%), 12 (17%), 28 (41%), and 11 (41%) patients had no mild, moderate, or severe ventilation restrictions at the end of PR, respectively. 3. Diffusion capacities were normal, mild-, moderate-, and severe-limited in 9 (13%), 14 (20%), 28 (41%), and 18 (26%) patients, respectively.
Büsching, *et al.*[16]	2021	Retrospective cohort study	PR includes cardiopulmonary exercise, strength training, oxygen supply when needed, breathing exercises, relaxation techniques, and, if indicated, psychological counseling, speech therapy, nutrition, occupational therapy, and social services can be provided.	1. Significant CRQ in the COVID-19 and common pneumonia patient groups. 2. COVID-19 patients had similar outcomes in CRQ after PR compared to common pneumonia.
Hayden, *et al.*[17]	2021	Prospective observational study	PR program includes: 1. Physical exercise includes endurance, strength, whole-body vibration, and inspirational muscle training. 2. Respiratory physiotherapy 3. General physiotherapy 4. Education about COVID-19 5. Routine medical diagnosis 6. Close medical supervision 7. Psychosocial support 8. Nutrition counseling 9. Occupational therapy	1. Exertional dyspnea • Moderate to large changes in exertional dyspnea between pre-and post-PR. • A clinically relevant improvement of dyspnea in 66.1% of patients. • No correlations between the improvement in exertional dyspnea and lung function parameters such as VC, TLC, FEV1, PImax, and PaO2. 2. MMRC scores • Moderate changes between pre- and post-PR. • A clinically relevant improvement in more than 50% patients. 3. Dyspnea at rest: small to moderate changes in the intensity of dyspnea at rest.
Puchner, *et al.*[18]	2021	Observational cohort study	PR includes respiratory therapy, respiratory muscle training, endurance and strength training, speech therapy and swallowing evaluation, occupational therapy, psychological therapy, nutritional counseling, and passive therapy sessions.	1. A significant improvement in respiratory muscle strength after PR. 2. A significant improvement in lung functional parameters including FEV1, FVC, TLC, and DLCO during PR. 3. Lung function was still impaired in 57% of all patients. 4. A reduction of the DLCO at the end of PR in 83% of patients.

Notes: COVID-19 = coronavirus disease of 2019, CRQ = Chronic Respiratory Questionnaire, DLCO = Diffusing Lung Capacity for Carbon Monoxide, FEV1 = Forced Expiratory Volume in 1 Second, FVC = Forced Vital Capacity, MMRC = Modified Medical Research Council, PaO2 = Partial Pressure of Oxygen, PImax = Maximal Inspiratory Pressure, PR = Pulmonary Rehabilitation, TLC = Total Lung Capacity, VC = Vital Capacity.

and exacerbates respiratory muscle dysfunction.[4]

Sun, *et al.*,[13] applied the breathing method as the core of PR by adopting the 3-5-6 breathing method, three seconds of deep inspiration, then holding breath for three

to five seconds and slowly exhaling for six seconds. This exercise can be performed in a lying or standing position and is performed for three to four breath cycles per set with 30-60 seconds of rest, depending on the symptoms of shortness of breath.[13] Zhao, *et al.,* mentioned that breathing exercises include posture management, breathing rhythm adjustment, thoracic expansion exercises, respiratory muscle mobilization, etc.[19]

Several articles also recommend respiratory muscle training as a component of PR.[11,13,17,18,20] Respiratory muscle exercises, especially inspiratory muscles, can be performed in patients with inspiratory muscle weakness and can be performed with a frequency of up to two times a day.[13,17] Respiratory muscle exercises are carried out by inhalation and exhalation slowly to make the thorax expand, using diaphragmatic breathing and mobilization of the respiratory muscles for 15 minutes each in the right and left lateral decubitus positions alternately and followed by a supination position with a bridge exercise, alternating straight leg, air pedal, and ankle pump.[13,20]

These exercises can also be performed using a commercial hand-held resistance device with ten breaths per set and performed in three sets using a positive expiratory pressure device if necessary.[11,20] Liu, *et al.,* stated that diaphragmatic exercises are performed with 30 maximal voluntary contractions of the diaphragm plus a 1-3 kg load on the anterior abdominal wall.[11] Based on the articles that discussed respiratory muscle training in COVID-19 survivors, no standard exercise has been found.[11,13,16-20]

Almost all the literature found includes strength training or limb resistance exercise as a PR component.[12,15-21] Strength training is performed using a strength training machine for approximately 30-60 minutes per session and five days a week. The resistance training includes butterfly forward/backward, rowing, back extension, abdominal trainer, weight training using machines, free weights, elastic resistance bands, latissimus pull, cable pull, and robotic arm training.[12,17,18,20,21] Neuromuscular electrical stimulation can be used to help strengthen muscles.[21] Patients undergo one to three sets of each exercise with 8-12 repetitions per set and two minutes of rest between sets with increasing intensity.[12,17,19]

Spielmanns, *et al.,* declared that gymnastics can improve strength, endurance, coordination, range of motion, and balance.[15] Leg muscle strength training in COVID-19 survivors is carried out because of the cytokine storm in the acute phase of COVID-19, which causes damage to various organs, such as the dysfunction of skeletal muscles in the extremities,[7] which can worsen secondary to inactivity and immobilization.[4] The symptoms of fatigue and shortness of breath in COVID-19 survivors can cause survivors to limit their activities.[4,5]

Stretching exercises are also recommended in PR, which consist of exercises in the upper and lower extremities that aim to improve muscle function, especially joint flexibility, the lack of which can prevent activities. Stretching exercises can also be combined with strength training in upper and lower extremity functional activities, including upward lift, lateral lift, abduction, chest enlargement and grasping, lifting, kicking, tiptoeing, and stepping.[11,13]

Fatigue and shortness of breath are the most common complaints found in COVID-19 survivors.[4,5] These symptoms are caused by damage to various organs that lead to a decrease in cardiorespiratory fitness.[22] Based on this review, it was found that cardiorespiratory endurance exercises are a major PR component. Endurance training can be done by cycling at varying times, ranging from 10 to 60 minutes per session, and performed five to six times weekly.[12,15,17,18]

Gloeckl, *et al.*, discuss that exercise occurs at 60-70% of the peak work rate.[12] While, Puchner, *et al.*, stated that endurance training is performed based on the cardiopulmonary exercise test at 50% of the highest pressure sustained for one second.[18] The intensity of each exercise can change depending on oxygen saturation and pulse rate. Oxygen administration may be performed if indicated.[17]

Respiratory physiotherapy may vary from individual to individual. Physiotherapy is done twice to four times weekly for 30 minutes each session.[12] The techniques used in this physiotherapy include coughing techniques, mucus clearing, connective tissue massage, energy conservation techniques, learning about breathing (pursed lip breathing, secretion mobilization, and diaphragmatic breathing), mucolytic inhalation therapy, etc.[12,15,17] Liu, *et al.*, applied three sets of coughing exercises with 10 active coughs per set which can be done at home.[11]

Many psychiatric changes occur in COVID-19 survivors, such as post-traumatic stress disorder, depression, and anxiety.[23] Relaxation techniques can be included as a component of rehabilitation to reduce anxiety levels in COVID-19 survivors.[24] Gloeckl, *et al.*,[12] Spielmanns, *et al.*,[15] and Büsching, *et al.*,[16] also included relaxation techniques as part of PR. The relaxation technique is carried out by progressive muscle relaxation (Jacobson's technique) twice per week for 30 minutes.[12,15,16] Education as part of PR includes explanations about COVID-19 and general topics such as physical activity, oxygen therapy, and smoking cessation.[12] There was also an explanation about PR's importance in increasing patient compliance in undergoing rehabilitation.[16]This education can be done by direct exposure or using booklets and videos.[12,17,19]

Outcomes of Pulmonary Rehabilitation

The PR has been shown to improve lung function and symptoms of dyspnea in severe and critical COVID-19 survivors.[11-18] Liu, *et al.*, showed significant improvement in lung function, including FEV1, FVC, FEV1/FVC, and DLCO in the intervention group.[11] These results were consistent with Hayden, *et al.*, and Puchner, *et al.*, which showed a significant increase in vital capacity, FVC, TLC, FEV1, DLCO, and PImax after PR.[17,18] PR has also improved the partial pressure of oxygen, incentive spirometry volume, and decreased the need for oxygen support.[14,15,17] However, the persistence of dyspnea and fatigue after they underwent PR was found in many survivors.[12]

In addition, some symptoms, including exertional dyspnea, cough, fatigue, and phlegm production, also decreased.[13,17] Respiratory muscle exercise has increased diaphragmatic strength and endurance in COVID-19 survivors due to increased PImax.[17] Strength and endurance of the diaphragm and other respiratory muscles are associated with increased lung function.[11] Breathing exercises can also improve lung compliance and volume, which increases ventilation and gas exchange and further causes an increase in tidal volume, diaphragm capacity, and lung compliance.[13] Controlled breathing patterns and holding breath for a certain time decreased hypoxemia and local atelectasis.[13]

Improvement in symptoms is also caused by increased exercise capacity, exercise tolerance, and local muscle endurance as a result of a comprehensive PR program, as well as aerobic and resistance exercise.[11] Gloeckl, *et al.*,[12] discussing resistance exercise as part of PR showed a significant improvement in lung function (FEV1 and FVC) in severe and critical post-acute COVID-19 patients.

Barrier to Pulmonary Rehabilitation

No studies exploring barriers to pulmonary rehabilitation in COVID-19 survivors were found. Only one review by Wasilewski, *et al.*,[25] discussed barriers to PR, including COVID-19 infectivity, the varied health status of patients, lack of literature, insufficient PPE, problems related to rehabilitation staff, and health system issues. The varying degrees of severity of COVID-19 patients can be challenging in prescribing and initiating rehabilitation. Disability and the unstable condition of the patient can also become obstacles.[25] Korupolu, *et al.*, showed that the patient's ability to care for themselves and the caregiver's availability were inhibiting factors for rehabilitation in the outpatient unit.[21]

The high number of COVID-19 cases and limited PPE and staff are also obstacles to rehabilitation.[21,25] Wasilewski, *et al.*,[25] also mentioned that the problems of the rehabilitation staff, such as high workloads, declining staff health, and fear of being infected with COVID-19, could prove obstacles. The infectivity of COVID-19 is also one of the considerations in the implementation of the rehabilitation program.[21,25] Limited access to rehabilitation due to isolation procedures and the closure of rehabilitation centers has also occurred due to the increase in COVID-19, so the treatment focuses on the respiratory management of COVID-19 only.[25,26] Conversely, it is also difficult to implement the rehabilitation program to implement physical distancing. Families should also not be involved in the care of COVID-19 patients.[25]

The health system issue is a challenge for implementing the rehabilitation program. Lack of coordination at all health system levels limits rehabilitation implementation's effectiveness. Lack of funding to support telerehabilitation and other infrastructure, as well as very strict billing procedures that reduce the time and quality of patient care, also hinder the rehabilitation program implementation.[25]

This review specifically discussed the implementation, outcomes, and barriers of PR, even though the collected data were limited. This review can be used as a reference to explore more about this topic. However, there were some limitations, such as a limited database (only PubMed and Google Scholar), only written in English, and a short search period, so there are possible different outcomes if the review was done using more databases, not limited to English, and longer searching period. Future studies can be done by correcting these.

Conclusion

The PR program in severe and critical cases of COVID-19 survivors aims to improve the QoL by alleviating symptoms, restoring functional abilities, and reducing disability. The PR program includes breathing, strength, stretching, cardiorespiratory endurance exercises, respiratory physiotherapy, relaxation techniques, and education. Some articles stated that PR significantly improves lung function and reduces the symptoms.

Abbreviations

COVID-19: coronavirus disease 2019; PR: Pulmonary Rehabilitation; QoL: Health-Related Quality of Life; PPE: Personal Protective equipment; FEV1: Forced Expiratory Volume in 1 Second; FVC: Forced Vital Capacity; DLCO: Diffusing Lung Capacity for Carbon Monoxide; TLC: Total Lung Capacity; PImax: Maximal Inspiratory Pressure.

Ethics Approval and Consent to Participate

Not applicable.

Competing Interest

The authors declares that there are no significant competing financial, professional, or personal interests that might have affected the perform-

ance or presentation of the work described in this manuscript.

Availability of Data and Materials

The data used in this study were publicly available in the Google Scholar and PubMed databases.

Authors' Contribution

AN contributed to the conception and design of the study. AN, RN, and SAW drafted the article or revised it critically for important intellectual content and final approval of the version to be submitted.

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