Literature Review

The Effectiveness of Pulmonary Rehabilitation in COVID-19 Patients

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ABSTRACT

Background: Patients with COVID-19 have experienced numerous symptoms prior to and after hospitalization, particularly in the respiratory system. The symptoms vary widely. Based on symptoms occurring through patients' airways, most patients who have recovered from COVID-19 still have enduring symptoms of breathlessness. Pulmonary rehabilitation can be an option of rehabilitation programs directed to the patients.

Aim: Explore the effectiveness of pulmonary rehabilitation specifically in COVID-19 patients. This literature review seeks to provide an agenda for further research related to adjusted treatment on pulmonary rehabilitation based on the patients' needs.

Material and Methods: The author synthesized, reviewed, and analyzed 10 literatures employing semi-systematic review technique.

Results: The short-term aim of pulmonary rehabilitation is to reduce dyspnea and anxiety as well as depression, meanwhile the long-term aim is to maintain patients' functional status to the maximum extent, improve quality of life and facilitate patients to return to performing daily activities. In addition, a 6-minute walking test and sit-to-stand test might be the alternative exercise to improve respiratory functions.

Conclusion: Pulmonary rehabilitation should be provided during the treatment process, including inpatients or outpatients phase to ensure returning patients' recovery of respiratory function. Moreover, exercise recommendations should be tailored based on patients' specific needs.

Keywords: *Breathing exercise, COVID-19, Dyspnea, Rehabilitation.*

Introduction

In December 2019, a new type of coronavirus emerged in Wuhan, China. It spread across the world and has been classified under a pandemic status by the World Health Organization (WHO). This new virus is known as *severe acute respiratory syndrome coronavirus 2* (SARS-CoV-2) which caused the coronavirus disease 2019 (COVID 2019).[1] The virus enters someone's system through a large amount of droplets from cough or sneeze. COVID-19 has been precipitating the increasing number of mortality, morbidity, and workload that has never been encountered by any country or population. COVID-19 tends to affect the elder population, those with multi-comorbidities, and people within the lower socioeconomic status.[2] The transmission has been rapid and infectious. It could infect someone for 2-10 days without signs of immediate symptoms. The symptoms may appear afterwards.[3]

Post-acute COVID-19 is a multi-system disease that sometimes shows mild symptoms. The symptoms vary widely. Mild symptoms are mostly cough, fever, and fatigue. These mild symptoms might relapse. In addition to the mild symptoms observed from the patients, other series of reported symptoms are breathlessness, chest pain, headache, neurocognitive problems, muscle pain and weakness, gastrointestinal pain, metabolic disorder, depression, and other mental health issues.[4]

To date, it remains unknown why the recovery process in some patients took a longer time. The amount of virus which remains in the patient's system depends on the degree of antibody response, relapse or reinfection, deconditioning, mental factors such as post-traumatic stress. Based on symptoms taking place within patients' airways, most patients who have recovered from COVID-19 still have enduring symptoms of breathlessness. On the other hand, lung disease that resulted in the form of fibrotic (interstitial lung disease) was barely found in some patients who have no symptoms of hypoxia, even though the long-term outcomes remain inconclusive.[4] It is still unclear if the disease would cause physical damage to patients' lungs permanently. The transformation of lung tissues such as ground- glass opacities, consolidation, vascular thickening, bronchiectasis, pleural effusion, crazy paving pattern, may be found in more than 80% of affected patients.[5]

Therefore, this review will discuss the effectiveness of pulmonary rehabilitation in reducing the short term and long term effects in post-COVID-19 patients. This review aims to add literature and reference regarding treatment towards COVID-19 patients sustainably, and not limited towards the patients who received in-patient treatment or encountered severe COVID-19 symptoms. The review of these 10 literatures will be discussed in the next section.

Material and Methods

The author synthesized, reviewed, and analyzed 10 literatures by employing a semi-systematic qualitative literature review.[6] Semi-systematic literature review would be purposeful to identify common issues on specific topics or study area.[6] This review is based on topical or content analysis related to the effectiveness of pulmonary rehabilitation and also COVID-19 patients' symptoms. The main topics covered particularly on:

i. The rehabilitation exercise program implemented during in-patient and out-patient treatment;
ii. Rehabilitation exercise program suited based on the severity of the symptoms;
iii. Short and long-term effects of the various types of planned rehabilitative programs.

Results

COVID-19 mainly affected the patients' respiratory functions. This is due to the cytokine storm as antibody response towards the virus leads to acute respiratory distress syndrome (ARDS). The COVID-19 symptoms related to respiratory impairments can be moderate or severe.[7] Some post-acute COVID-19 patients

reported they encountered fatigue to chronic fatigue syndrome. In response to this, breathing exercise or pulmonary rehabilitation can be an option of rehabilitation programs directed to the patients. For example, chest pain is mostly suffered by post-acute COVID-19 patients. From the clinical side, treatment towards chest pain as COVID-19 effect should be distinguished whether it was caused by musculoskeletal impairment or other nonspecific chest pain (e.g lung burn disease in lung cancer patients) as the result of a cardiovascular disease.[4]

In order to respond to the COVID-19 effects, patients who are recovered from COVID-19 would need health support to prepare an early assessment on the impact of the disease. Support has to be designed accordingly by professional teams (such as general practitioner, nurse, social worker, rehabilitation team, and occupational therapist if needed).[4] For instance, support may be given towards survivors who encountered limited respiratory function and gas exchange after being treated in ICU.[8] Specifically, the patients are likely to witness a higher propensity of weakened skeletal muscle.[8] Patients who have been treated in ICU are mostly in prolonged protective lung ventilation, sedation, and neuromuscular blocking agents. Therefore, those at high risk of developing ICU-acquired weakness would require early rehabilitation to respond to the post-acute respiratory distress. This will help ensure patients' functional recovery swiftly.[3] In addition, post-treatment patients must be prepared to have a consultation and early assessment based on the symptoms shown on the respiratory function. Finally, to better provide a comprehensive assessment of respiratory symptoms, follow-up and exercise in post-treatment patients must be organized earlier due to patients being often susceptible to suffer fatigue that is related to movement, similar to acute respiratory distress syndrome (ARDS).[5]

Research*	Findings	Discussion	Limitation
Gutenbrunner et al	Rehabilitation can minimize the consequences of the COVID-19 pandemic by: • shortening length of stay in all phases of healthcare • increasing the employment rate for COVID-19 survivors strengthening the health of healthcare workforce (and families of patients) • optimizing health outcomes	In this climate of shifting resources, rehabilitation services are made available in acute, post-acute, and long-term care for COVID-19 patients, accessible to vulnerable populations (older people, people with disabilities, and people living in poverty), delivered by rehabilitation services providers, and maintained in health systems.	• The impact has not yet been documented through research where this situation reduces chronic health conditions and people with disabilities • Rehabilitation services accessible to people recovering from COVID-19 are determined by the consequences of COVID-19 for persons with disabilities and other vulnerable groups and specific rehabilitation programs for people after COVID-19.
Thomas et al	• In terms of workforce planning and preparation, physiotherapists may take comprehensive management for COVID-19	N/A	• Evolving nature of clinical guidance • The study only extrapolated recommendations based on best evidence of critically ill patients and outcomes in critical illness patients. Thus, no patient was involved in the study. Recommendations provided are exclusively effective for the intervention in the acute-care setting.

Research*	Findings	Discussion	Limitation
	patients. Additional strategies covering the PPE, screening, early mobilisation, mobilisation and exercise prescription, mobility and exercise equipment need to be taken particularly for patients treated in ICU. • In terms of delivery of physiotherapy interventions, a wide range of respiratory interventions are recommended. • In regard to mobilisation, exercise, and rehabilitation interventions, physiotherapists need to be mindful to provide musculoskeletal, neurological, and cardiopulmonary rehabilitation tasks.		With this, long-term review may be needed
Greenhalgh et al	Patients enduring from different symptoms such as cough, breathlessness, pulmonary rehabilitation, fatigue, cardiopulmonary, chest pain, thromboembolism, neurological sequelae can be treated by variant of pulmonary management. Post-COVID-19 patients should be treated pragmatically and symptomatically emphasising on holistic treatment.	N/A	• With current limited evidence on revealing whether prolonged Covid-19 patients will recover without specialist treatment or would be more effectively treated through a community-facing rehabilitation, further study on this area can be conducted. • Systemic solution to address whether post-acute Covid-19 patients are worse for vulnerable communities are beyond the scope of the paper, which may need to be studied further.

Research*	Findings	Discussion	Limitation
Polastri et al	An initial assessment of symptoms, function, and exercise should be prepared before outpatient treatment. Based on this study, outpatient rehabilitation was carried out by general practitioners, physiotherapists, occupational therapists and nurses. Physical, cognitive, and psychosocial conditions must also be considered before providing rehabilitative activities.	Treatment for PICS is still in development, despite findings in non-COVID-19 ARDS patients. Post-ICU rehabilitation and exercise intervention to date have not shown a significant effect. According to a study by DENEHY and co-workers, patient characteristics were thought to have an impact on the outcome of functional exercise. These conditions must be achieved in a rehabilitation program, such as pulmonary rehabilitation, by meeting the specific needs of patients suffering from PICS.	This study has insufficient evidence to determine whether ICU follow-up services are effective in identifying and addressing the unmet health needs of ICU survivors.
Nugraha et al	Rehabilitation as a major role in managing COVID-19 health issues for admitted and discharged patients. The establishment of a special rehabilitation center and the development of a network of partners in the community are recommended. Telerehabilitation and teleconsultation are core elements for dealing with complex problems and the growing number of people requiring acute rehabilitation care and suffering for the long term.	Increasing rehabilitation capacity and financing related to rehabilitation services for COVID-19 patients is a recommendation at the health level as included in this study. To achieve optimal health outcomes, collaboration of rehabilitation professionals and telerehabilitation that is a complementary treatment for patients must be provided.	The problem is not about the lack of health workers but the number of health providers themselves. The uneven distribution of rehabilitation experts and rehabilitation providers in Indonesia is a problem that exacerbates this condition. This has been considered and refined by PBNU through several plans.
Spruit et al	The International Task Force recommended patients with COVID-19 should receive rehabilitation at/around the bedside and should be encouraged to do regular daily activities. Survivors	N/A	It is better to offer the option not to answer because the respondent feels that he is not qualified to answer the question. Experts say a combined question should be asked, and a question about the content of treatment with a time statement. Respondents do not understand the questions so that they feel they do not have the expertise to answer questions.

Research*	Findings	Discussion	Limitation
	with pre-existing/ongoing lung function impairment should receive a comprehensive rehabilitation program, compared to no rehabilitation program. Those with loss of lower limb muscle mass and function after hospital discharge should have a muscle strengthening program.		
Wang et al	An important role in the restoration of function and limitation of disability by the pandemic is performed by physical medicine, rehabilitation and rehabilitation physicians. Physical treatment, rehabilitation interventions, and pulmonary rehabilitation can be used as additional tools to against COVID-19.	N/A	The study was written and extrapolated from studies of COVID-19 patients, pulmonary rehabilitation patients without COVID-19, and SARS/MERS. With this, further review and adjustment sourced from multidisciplinary studies across specialties will be relevant to uncover novel challenges in this evolving pandemic.
Yang et al	Regardless of whether the patient is hospitalized or discharged, pulmonary rehabilitation must be provided throughout the diseases management process. Also, individualised condition should be incorporated to the rehabilitation treatment. Effective pulmonary rehabilitation will help in the long-term course recovery of patients.	N/A	According to the medical staff, pulmonary rehabilitation for recovered patients is currently a big challenge, where joint exploration and multidisciplinary collaboration are needed. So that high-quality support can be implemented.
Zhao et al	Mildly ill patients	Based on latest study,	N/A

Research*	Findings	Discussion	Limitation
	are prescribed to have an exercise in twice a day, duration 15 to 45 min/session. Meanwhile for moderately ill patients, semi-sitting position or leaning forward position is recommended in patients with shortness of breath. In critically ill patients, early mobilization should be paid attention during the entire activity to prevent tubing detachment. The total training duration for a single session is 30 minutes.	the timing for respiratory rehabilitation was added and targeted respiratory rehabilitation protocol was revised. This was done to support frontline clinical diagnosis and maintain physical function, as well as recovering psychological and remodelling activity.	
Zhu et al	N/A This systematic review serves as protocol information.	The uncertainty on to what extent the respiratory rehabilitation therapy could improve lung function in post-Covid-19 patients with severe pneumonia symptoms has been widely discussed.	Lack of RCTs in the methodology.

***** *Research reviewed on this study were sourced from literatures commissioned in 2020.*

Aims of Pulmonary Rehabilitation

Pulmonary rehabilitation is vital for patients with COVID-19. According to the American Thoracic Society/European Respiratory Society, pulmonary rehabilitation means a comprehensive intervention suited to patients' needs such as exercises, education, and the alteration of behavior, which is designed to enhance physical condition in patients with respiratory dysfunction.[9]

Furthermore, breathing exercise is recommended when the patients face symptoms such as shortness of breath, wheezing, and difficulty in these series of functions: (i) expectoration of mucus, (ii) body position management, (iii) adjustment of breathing, and (iv) traction of breathing muscle group.[10]

The aim of pulmonary rehabilitation in COVID-19 patients is to reduce dyspnea, relieve anxiety, maintain functional status, and improve quality of life.[9] Pulmonary rehabilitation has a main role in non-invasive treatment.[11] Not just enhancing physical and mental patient's condition, pulmonary rehabilitation can also help patients to return immediately in performing their daily activities and recommended that pulmonary rehabilitation can be a main standard management in COPD patients and any chronic lung disease.[10] The short-term aim of pulmonary rehabilitation is to reduce dyspnea and anxiety as well as depression, meanwhile the long-term aim is to maintain patients' functional status to the maximum extent, improve quality of life and facilitate patients to return to performing their daily activities. Pulmonary rehabilitation would also provide sustainable effects when the professional team assesses the patients'

condition comprehensively before starting the rehabilitation program.[10]

Pulmonary Rehabilitation Program Types

Pulmonary rehabilitation program is recommended for patients with mild symptoms such as fever, fatigue, cough, and one or more physical dysfunction.[12] For example, breathing exercise is vital for patients' recovery during the treatment and rehabilitation phase. This exercise would be safe and feasible for patients with acute exacerbation which effectively improves physical performance and quality of life.[11] Those exercises are airway clearance techniques, physical training, breathing exercise, and anxiety management. These exercises allow diaphragm breathing performed by patients to utilize the diaphragm muscle while minimizing the movement of accessory muscle. Inspiration through the nasal cavity is recommended along with diaphragm breathing to increase the humidity level inside the nasal. The contraction of the abdomen muscle is actively used at the end of expiration phase to increase the abdomen pressure and push the diaphragm upward.[9]

Pulmonary rehabilitation can be started from the acute phase or early post-acute and needs to be taken forward to the long-term rehabilitation phase. Screening should be conducted in patients who are discharged from the hospital during the first few weeks to determine the level of required oxygen supplementation.[8] In the acute phase, the exercise is focused on respiratory function and to prevent complications to occur (contracture, thrombosis, deconditioning). Prevention can be conducted through positioning management, breathing exercise, active and passive movement, and early mobilization. To maximize the result, respiration technique and mobilization would be vital. Rehabilitation during an acute phase should assess whether the patients' conditions can safely conduct the advised exercises. These conditions are, but are not limited to, patients' nutritional condition, airway, posture, clearance technique, oxygen supplementation, breathing exercise, stretching, manual therapy, and physical activities.[9]

In the early acute phase, training of lung function, early mobilization, and rehabilitation in affected body function and basic activities from daily-living activities are important. Other studies showed approximately around 10% of patients might present post-viral fatigue syndrome.[2] Some findings stated around 3%-5% of patients with moderate symptoms can transform into severe even critical after 7-14 days of getting infected. Therefore, the intensity of training cannot be too high and has to be objectively designed based on patients' condition to maintain patients' physical condition. Pulmonary rehabilitation can be stopped in certain conditions such as (1) dyspnea index: Borg score >3; (2) chest tightness, shortness of breath, headache, dizziness, blurred vision, hyperhidrosis, heart palpitations, balance disorder. For severely even critically ill patients with confirmed cases which are found around 15.7 %, exercise is not recommended if their conditions remain unstable or worsen progressively. The perfect time to start the intervention is when there is no contraindication and worsening.[12]

Pulmonary rehabilitation can be initiated at the right time hence decreasing delirium level significantly and use of a ventilator, along with increasing patients' functional status. Before starting the intervention in severely and critically ill patients, evaluation of systemic function comprehensively is required, especially cognitive function, respiration, cardiovascular, and musculoskeletal.[12]

Physical training is the main component of pulmonary rehabilitation and can be initiated with mobilization on the bed for deconditioned patients to walking in patients who can ambulate. Rehabilitation intervention should target SpO2 more than 90 % with titration from oxygen to reach target saturation. The application of airway clearance can reduce the need of using a ventilator significantly and the propensity of being hospitalized. The technique helps to clear the airway by moving the mucus to cephalad direction from peripheral to the upper airway which allows the elimination of mucus with coughing technique. Huffing can be also used to push mucus secretion. It

is performed by opening the glottis where it gives the same pressure in dynamic compression from the airway, increasing the velocity in expiration hence pushing secretion of mucus. Posture has a main role in respiratory function. Patients are recommended to hold their head up and neck during breathing exercises and every time if it is possible. Sitting and standing can also be chosen for the position in patients with no critical signs to maximize lung function including total capacity volume, compliance, lungs' recoil, and mediastinal structure.[9]

In addition, prone positioning has been proven efficient to catalyze the recovery of respiratory function.[3,9] For instance, adult patients with COVID-19 are suggested to have prone position ventilation for 12 to 16 hours per day. This procedure needs a professional team to ensure no complications occurred (e.g disturbed airway during the procedure).[10] Some evidence in hospitals are suggesting prone positioning during hospitalization in patients gives a good result.[9] Professional teams can also perform airway clearance techniques for COVID-19 patients with a lack of airway clearance. They can support patients with positioning in a prone position to enhance oxygenation.[3] Pronation has been used in ICU patients to increase the gas exchange in ARDS and increase Pa/FiO2 in patients with ventilators and decrease cardiovascular comorbidities.[9]

Acute exacerbation in patients with chronic lung disease, as the result of pulmonary rehabilitation, provides an effect on the quality of life which is related to health and training capacity. Pulmonary rehabilitation in post-acute patients cooperates with increasing the training capacity of patients.[9] Overall, pulmonary rehabilitation in acute patients tends to be safe and may effectively be able to decrease mortality, and can be implemented for COVID-19 patients.[9]

The Implications of Pulmonary Rehabilitation to COVID-19 Patients

Some clinical studies verified the benefits of pulmonary rehabilitation in inpatients, outpatients, and home care patients. The benefits are to improve the training tolerance in patients with chronic pulmonary disease, decrease the number of hospitalization and length of hospital stays, improve respiratory muscle function, skeletal muscle in the upper and lower limb, and reduce dyspnea, anxiety, depression.[10] Therefore, it is vital to discuss how pulmonary rehabilitation works specifically to improve lung function for COVID-19 patients.

To support lung function, the diaphragm has approximately 80% role in respiratory function. After an illness or deconditioning, the breathing pattern may be changing, with the reduction of diaphragm movement and mostly use of accessory muscle in the shoulder and neck. Some patients who were in the first 6-week recovery phase did not undergo the pulmonary rehabilitation program immediately post COVID-19.[4]

Pulmonary rehabilitation should be provided during the treatment process, including for inpatients and outpatients. Moreover, exercise recommendations should be tailored based on patients' specific needs. An effective combination of pulmonary rehabilitation with the treatment management and patients' routine, would therefore result in the long-term benefit for patients and their family.[10] Based on the International Task Force (ITF) suggestions and standards, Martin et al (2020) found that COVID-19 survivors are vigorously (70%) advised to receive comprehensive pulmonary rehabilitation 6-8 weeks following the post-hospitalization. This timing is due to three reasons. *First*, is the inconclusive data regarding the decay of infection. *Second*, the 8-week timing may have been followed by a physical recovery. *Finally,* if the rehabilitation is conducted less than 6 weeks after patients were discharged from the hospital (e.g 4-week), the rehabilitation team may face difficulties in recruiting patients to attend the post-exacerbation rehabilitation program.[8]

Additionally, some other exercises such as muscle strengthening programs in patients with loss of lower limb muscle mostly in patients with prolonged ventilators are also strongly recommended. Another required formal assessment during 6-8 weeks following the post-

hospitalization would be the patients' physical and emotional functioning assessment.[8]

In regards to the result of recommended pulmonary rehabilitation, Wang et al (2020) found that COVID-19 patients who have undergone pulmonary rehabilitation witnessed a significant improvement in respiratory function, quality of life, and were able to reduce anxiety, depression, particularly in elderly patients. The research also found that lung functions are getting recovered less than six weeks after the pulmonary rehabilitation program.[9] This was due to pulmonary rehabilitation would involve intercostal muscles, abdominal wall muscles, accessory muscles, and erector spinae muscles which have a vital role in helping patients to have their normal respiratory function returned from post-COVID-19 phase. The research also suggests a good impact on the physical and mental of COVID-19 patients. The research stated pulmonary rehabilitation can also improve the quality of life of patients with asthma, chronic obstructive pulmonary disease (COPD), and post-surgery cancer.[9]

Besides breathing exercises, several alternatives could be performed by the patients to recover their respiratory functions. *First,* a 6-minute walking test (6MWT) exercise can also be conducted when the patients' endurance has been improved after a 6-week pulmonary rehabilitation program.[9] *Second,* another type of exercise that is advised to evaluate hypoxia is a one-minute sit-to-stand test.[8] However, the exercise will succeed based on patients' tolerance which should be used to design the intensity, time, and training of pulmonary rehabilitation.

Conclusion

Pulmonary rehabilitation treatment is suggested immediately for patients with or post COVID-19. Pulmonary rehabilitation itself provides a good impact not only for patients with COVID-19 but also for other respiratory diseases. Short-term impact includes reducing dyspnea, anxiety, and depression. Meanwhile, long-term impacts are to improve patients' functional status in daily living and quality of life. Based on 10 literatures, they stated numerous benefits from pulmonary rehabilitation in patients with COVID-19, either during hospitalization or home care. However, it must be designed based on the comprehensive assessment and tolerance of patients to the training program. Furthermore, the timing of the program to be started would also be vital to be considered. Based on this journal, it would be benefitted from further research suggesting how long the side effects for post-COVID-19 patients would remain in the system. It would also require further study on the types of exercise for COVID-19 tailored based on specific needs of patients, as the pandemic remains ongoing.

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