

## Review Paper

## Exercise-based Rehabilitation to Improve Exercise Tolerance of Severe COVID-19 Survivors: A Review Paper



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**ABSTRACT**

**Objectives:** This review aimed to determine the form, results, and barriers to exercise-based rehabilitation programs for severe COVID-19 survivors.

**Methods:** Searching for the article was carried out from August to October 2021. We used the PubMed database as a search media with the keywords ([‘COVID-19’ OR ‘COVID 19’ OR ‘SARS CoV-2’ OR ‘post COVID-19’] AND [‘rehabilitation’]). Original articles and case reports published in the last 2 years (July 2019-2022), written in English, available in full text, and accessible in PDF or HTML format were included. Articles were excluded if they did not fit the research topic after reading the full text.

**Results:** There were a total of 7461 articles found at the initial screening using keywords. In the next screening using the inclusion and exclusion criteria and after reading the whole article, we found 9 articles that matched the topic. Of these, 7 articles were original articles and 2 case reports. All of the articles explained the forms and outcomes of exercise-based rehabilitation in severe cases of COVID-19 survivors. However, no article explained the barriers to rehabilitation.

**Discussion:** Exercise was generally given to increase exercise tolerance in severe COVID-19 survivors in both inpatient and outpatient cardiopulmonary rehabilitation programs. The form of exercise was aerobic, strength, or endurance training, and other forms of exercise such as balance training as well as breathing exercises. The type and intensity of exercises given were tailored to the patient’s needs. Research showed that exercise-based rehabilitation programs resulted in a positive impact on increasing the survivor’s quality of life, functional capability, and exercise tolerance. A previous study explained that barriers to rehabilitation in COVID-19 were related to the patient’s health condition, COVID-19 infectivity, and issues related to health services.

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## Highlights

- COVID-19 survivors may experience long-term complications following the recovery of the acute phase, resulting in a decrease in exercise tolerance.
- Exercise-based rehabilitation programs could improve the quality of life, functional capability, and exercise tolerance of survivors.

## Plain Language Summary

We reviewed the articles on forms, outcomes, and barriers of exercise-based rehabilitation programs for COVID-19 severe case survivors. The previous research found that many COVID-19 survivors experience long-term health problems and decreased quality of life. Exercise in a rehabilitation program was given in the form of aerobics, strength, and other exercises needed for the patients. These exercises could improve the ability of the survivors to do activities and exercises. There was an obstacle to rehabilitation stemming from an issue related to the COVID-19 pandemic, patient conditions, and problems related to health services.

## Introduction

**M**uscle weakness after acute phase recovery from COVID-19 is a real problem that could be experienced by survivors. As many as 10%-20% of COVID-19 patients experience persistent symptoms weeks to months after the acute phase of COVID-19 [1]. Research shows that survivors of severe COVID-19 can have various functional complications as a “follow-up”, such as persistent shortness of breath and post-intensive care syndrome which is characterized by muscle weakness, joint stiffness, deconditioning, cognitive dysfunction, psychiatric illness, and quadriplegia that persist after resolution of the acute illness [2-4].

COVID-19 survivors may experience a decrease in long-term exercise tolerance [5]. Research showed that COVID-19 survivors can experience a decrease in exercise capacity ( $VO_2$  max).  $VO_2$  max decreased by more than 10% compared to before infection [6]. Other studies showed that survivors of COVID-19 could have a  $VO_2$  max <80% of the predicted value after 3 months of being discharged from the hospital. The distance of the six-minute walk test (6-MWT) was decreased and a minimum  $SpO_2$  value in the 6-MWT was <96% 6 months after discharge from the hospital [7, 8]. The decrease in the functional capacity of COVID-19 survivors is not only caused by pulmonary organ dysfunction and decreased gas exchange but also by extrapulmonary factors such as cardiac dysfunction and muscle weakness associated with long-term hospitalization and immobilization after recovery from the acute phase of COVID-19 [9, 10]. Survivors of severe COVID-19 could have a sig-

nificantly greater decrease in exercise tolerance than survivors of mild COVID-19 [11-13]. Decreased exercise tolerance in COVID-19 survivors can result in increased morbidity and mortality, decreased quality of life, and a continuous increase in the burden on the health system [10, 14].

Rehabilitation is a multidisciplinary intervention that reduces morbidity, increases functional independence, and improves the ability to carry out daily activities. Based on the characteristics and complications caused by COVID-19, exercise-based multidisciplinary rehabilitation has the opportunity to increase functional capacity, provide a better prognosis, prevent long-term disability, and improve the quality of life of COVID-19 survivors [11, 15-17].

The magnitude of the negative physical impact on the survivors of COVID-19 and the absence of standardized guidelines in the implementation of rehabilitation were the reasons to conduct this review. In addition, the presence of potential barriers is important to know to determine the strategy to overcome the rehabilitation problems. This review aimed to determine the form, results, and barriers to exercise-based rehabilitation programs for severe COVID-19 survivors.

## Materials and Methods

This study uses an article review method by collecting and synthesizing data from the article related to exercise-based rehabilitation in severe COVID-19 survivors. Searching for the article was carried out from August to October 2021. We used the PubMed database

as a search media with the keywords ([‘COVID-19’ OR ‘COVID-19’ OR ‘SARS CoV-2’ OR ‘post COVID-19’] AND [‘rehabilitation’]). The type of articles used were original articles and case reports published in the last 2 years (2019-2021), available in English, and accessible in PDF or HTML format. Articles were excluded if they did not fit the research topic and were not available in full text. The article search flow is described in Figure 1.

## Results

There were a total of 4691 articles found at the initial screening using keywords. In the next screening using the inclusion and exclusion criteria and after reading the whole articles, we found 9 articles that matched the topic. Of these, 7 articles were original articles and 2 case reports (Figure 1). Nine articles discussed the forms and outcomes

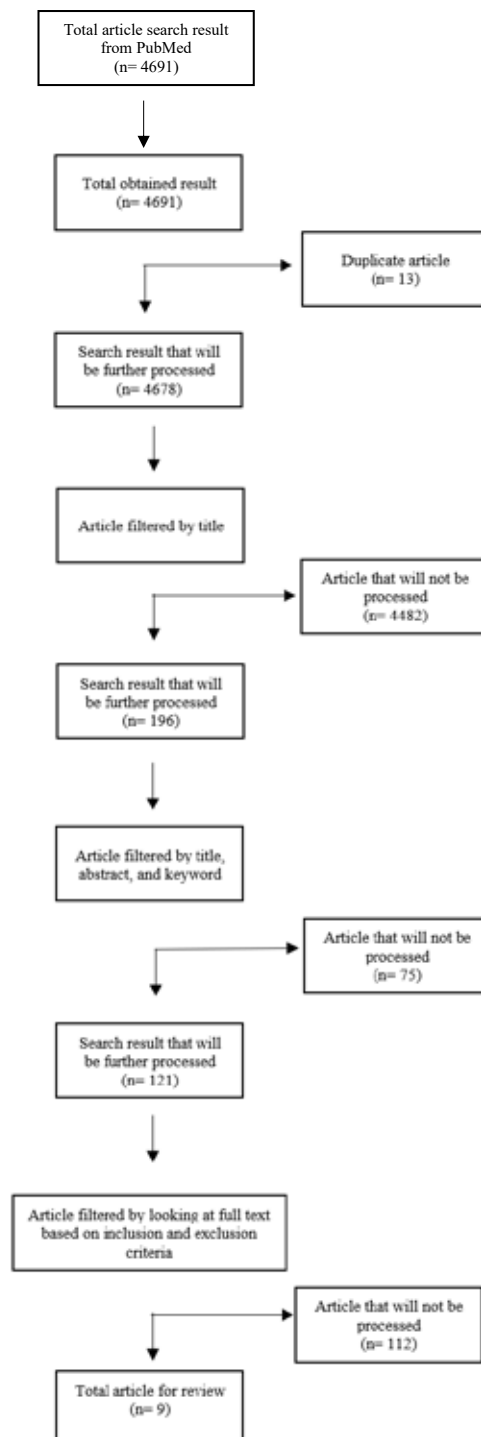


Figure 1. Article search flow

of exercise-based rehabilitation and no article discussed the barriers to rehabilitation. Nine articles outlined cardiopulmonary rehabilitation as a rehabilitation effort for COVID-19 survivors which consisted of a combination of various exercises such as aerobic exercise, resistance training, strength training, activities of daily living (ADL) training, and breathing exercises. A total of 9 articles explained an increase in functional ability and quality of life of COVID-19 survivors in severe cases (Table 1) [2,15,18-24].

## Discussion

Rehabilitation of COVID-19 survivors focuses on treating ongoing disorders including impaired mobility, respiratory function, nutrition, and communication to promote independence in performing ADL. The rehabilitation program provided is an ongoing treatment that is specific in nature according to the needs and abilities of the patient [12, 25].

### Exercise-based rehabilitation for severe COVID-19 survivors

Based on the articles reviewed, it was found that the exercise to increase exercise tolerance in survivors of severe COVID-19 cases was generally given in the form of physical exercise which was included in the cardiopulmonary rehabilitation program [15, 18, 23, 24]. The physical exercise program consisted of aerobic exercise, muscle strength training (weight training), resistance training, breathing exercises, and ROM exercises. The exercise program was given since the patient was hospitalized until the outpatient phase [18–20]. These forms of exercise are also supported by several previous studies discussing rehabilitation in COVID-19 survivors.

Gentil et al. (2021) recommended resistance training for COVID-19 survivors. The form of resistance training was resistance exercise with a low-volume and multi-joint. In addition, low external load resistance training can also be carried out by the patient and can provide the same results as high external load resistance training which is carried out with greater effort. As an alternative, high-velocity resistance training can be given if the patient cannot perform low/high external load training. [26].

A review article conducted by Agostini et al. (2021) mentioned the recommendation of aerobic exercise starting with low to moderate-intensity exercise which was increased gradually according to individual abilities [27]. Another review article study was conducted by Calabrese et al. (2021) recommended interval aerobic train-

ing with moderate to high intensity performed 3-5 times a week, for COVID-19 survivors [17].

Individually prescribed exercises according to the ability of the patient could also be given [18, 28]. The rehabilitation program can be provided for a minimum of 3 weeks in the inpatient phase and for 3 weeks during the outpatient phase [2]. Home-based exercise with telerehabilitation can also be given as a substitution for face-to-face rehabilitation programs [17]. There is no standard protocol for physical exercise for COVID-19 survivors with severe cases yet, either in the inpatient or outpatient phase.

### Result of exercise-based rehabilitation for COVID-19 survivors

The exercise-based cardiopulmonary rehabilitation program given to severe COVID-19 survivors could improve exercise tolerance, functional independence in ADL, as well as general health status which has a positive impact on the quality of life of survivors [2, 15, 18–20, 22–24]. A cohort study conducted by Olezene et al. (2021) showed that the multimodal rehabilitation program given to survivors of severe COVID-19 cases increased exercise tolerance as measured by an increase in the 6-MWT distance of 557.9 meters compared to before rehabilitation. This study also mentions an increase in 10-MWT speed of 0.61 meters/second and functional independence as measured by the ability for independence transfer and ambulation [2].

Another review reported similar results in an increase in 6-MWT distance and functional independence as measured by functional independence measure (FIM) after being given a combination of aerobic, endurance, strength, and breathing exercises [19, 20, 22, 24]. A rehabilitation program consisting of the series of these exercises which was increased gradually in intensity could also improve muscle strength and function as measured by an increase in bilateral hand muscle strength by 5 kg, peak quadriceps muscle strength by 21.2% of predicted value, and sit to stand speed by 3 seconds [15].

Articles reviewed in this study also described similar results with several previous studies. Agostini, et al. (2021) found that comprehensive cardiopulmonary rehabilitation improved mobilization and ADL functions as well as neuropsychological status [15, 21, 27]. A previous article review conducted by Gentil et al. (2021) found that resistance exercise could also improve cardiovascular function, physical ability, and functional capacity in addition to increased muscle mass strength [26].

Table 1. Exercise-based rehabilitation for severe COVID-19 survivors

Author(s)	Title	Research Type	Population/No. (%) / Mean±SD	COVID-19 Severity	Form of Rehabilitation Program	Result of the Rehabilitation Program	
Olezeze et al. (2021) [2]	Functional outcomes in the inpatient rehabilitation setting following severe COVID-19 infection	Cohort study	Population	29	Severe (required intubation in an acute phase)	Standard of inpatient rehabilitation carried out by a physical therapist with a duration and frequency of at least 3 hours/day, 5x/week	Improvement of functional ability and independence
			Male	20(70)			
			Caucasian	17(58.6)			
			Median (Range) of age (y)	60 (50.5–67.5)			
			Most frequent comorbidities (hypertension)	22(75.9)			
			Obesity	18(62.1)			
			Dyslipidemia	16(55.2)			
			Mean duration of	32.2(9.3)			
Gloeckl et al. (2021) [15]	Effectiveness of pulmonary rehabilitation in severe and critically ill COVID-19 patients: A controlled study	Cohort study	Population	26	Severe (based on WHO classification of COVID-19 severity)	The inpatient pulmonary rehabilitation program consists of medical diagnostics and treatment, resistance training, strength training, patient education, respiratory physiotherapy, and ADL exercises	Improved exercise performance, and increased lung capacity, muscle strength, as well as quality of life
			Male	18(69)			
			Median (range) of age (y)	66 (60–71)			
			Median (range) of BMI (kg/m <sup>2</sup> )	26.9 (24.2–29.2)			
			Median (range) of acute care duration (d)	37(18–60)			
			Mean ICU care Duration (d)	22±85			
Hermann et al. (2020) [18]	Feasibility and efficacy of cardiopulmonary rehabilitation after COVID-1	Cohort study	Population	28	Severe	Multimodal inpatient cardiopulmonary rehabilitation of individualized exercises consisting of aerobic exercise and strength training	Significant increase in functional capacity and health status as measured by 6-MWT and FT results
			Male	14(50)			
			Mean age (y)	66.04±9.3			
			Mean BMI (kg/m <sup>2</sup> )	27.6±4.9			
			Group with ventilation	12			
			Group without ventilation	16			
			Mean duration of acute care (d)	19.3±10.7			
			Mean duration of ICU care (d)	13.9±7.3			
			Most frequent comorbidities (hypertension)	14(50)			
Type 2 diabetes	14(50)						
Dyslipidemia	6(21.4)						
Ramalingam et al. (2020) [19]	Rehabilitation of a post-intensive care unit patient after severe COVID-19 pneumonia	Case report	<ul style="list-style-type: none"> <li>▪ Age (y)</li> <li>▪ The patient experiencing fatigue and weakness without symptoms of nervous system deficit, 2 days later experiencing respiratory failure due to ARDS</li> <li>▪ The patient received ICU treatment for 12 days and then after 7 days out, he was returned to the ICU unit for 15 days before undergoing rehabilitation</li> </ul>	64	Severe (respiratory failure due to ARDS that requires ICU treatment)	Post-hospital discharged rehabilitation program independently at home which includes: 1) Gymnastics, walking, and climbing stairs; 2) ROM exercises; 3) Leg strength training; 4) Energy conservation; 5) Diaphragmatic breathing exercises; 6) Walking aids; 7) Emergency contact	Insignificant increase in FIM Improved 6-MWT distance Improved bilateral hand-grip strength

Author(s)	Title	Research Type	Population/No. (%) / Mean ± SD	COVID-19 Severity	Form of Rehabilitation Program	Result of the Rehabilitation Program	
Spielmanns et al. 92021) [20]	Effects of comprehensive pulmonary rehabilitation in severe post-COVID-19 patients	Prospective cohort study	Population	99	Severe	An inpatient pulmonary rehabilitation program with a duration of 3 weeks consists of 25-30 sessions over 5-6 working days/week with endurance training, gymnastics, outdoor walking, strength training, relaxation, and respiratory therapy	An inpatient pulmonary rehabilitation program with a duration of 3 weeks consists of 25-30 sessions over 5-6 working days/week with endurance training, gymnastics, outdoor walking, strength training, relaxation, and respiratory therapy
			Male	67(68)			
			Median age (y)	67.72±10.23			
			Mean BMI (kg/m <sup>2</sup> )	28.21±6.11			
			Mean duration of acute care (d)	25.9±8.81			
			Mean duration of ICU care (d)	11.3±12.5			
			Required oxygen therapy	54(54)			
			Most frequent comorbidities (hypertension)	27(27)			
			Smoker	25(25)			
Puchner et al. (2021) [21]	Beneficial effects of multidisciplinary rehabilitation in post-acute COVID-19: An observational cohort study	Cohort study	Population	23			
			Male	16(70)			
			Mean age (y)	57±1			
			Mean BMI (kg/m <sup>2</sup> )	27±4			
			Mean acute care duration (d)	32±16			
			Mean ICU care duration (d)	19±14			
			Required mechanical ventilation	19(83)			
			Most frequent comorbidities (cardiovascular disease)	11(48)			
			Endocrine disorder	11(48)			
Type 2 diabetes	6(26)						
Solon et al. (2021) [22]	Rehabilitation outcomes for patients with severe presentation of COVID-19: A case series	Case report of 2 Caucasian male patients	Age	Patient 1: 82 and patient 2: 89	Severe	Rehabilitation consisted of: 1) Inpatient rehabilitation program; 2) Gait training; 3) Therapeutic exercises consisting of ROM training, aerobics, and endurance exercise.	Improved functional ability and ADL and aerobic capacity based on increased 6-MWD.
			BMI (kg/m <sup>2</sup> )	Patient 1: 32.7 and patient 2: 26.5			
			Comorbidities	Patient 1: Hypertension, chronic back pain, osteoarthritis, history of chronic smoking, and testicular cancer Patient 2: Hypertension, cardiac disorder, type 2 diabetes, hyperlipidemia, and smoking history Patient 1: 18 Patient 2: 19			

Author(s)	Title	Research Type	Population/No. (%) / Mean±SD	COVID-19 Severity	Form of Rehabilitation Program	Result of the Rehabilitation Program	
Betschart et al. (2021) [23]	Feasibility of an outpatient training program after COVID-19	Case report	Population	12 (severe and critical cases n=3)	Mild-critical (based on WHO classification of COVID-19 severity)	Outpatient pulmonary rehabilitation that combines aerobic exercise (bicycle training) and resistance training	Increased 6-MWD result after rehabilitation
			Male	8(67)			
			Median (range) of acute care (d)	11 (3–24)			
			Most frequent comorbidities (cardiovascular disease)	6(50)			
			Chronic kidney disease	5(42)			
			Arterial hypertension	3(25)			
			Cancer	3(25)			
Büsching et al. (2021) [24]	Effectiveness of pulmonary rehabilitation in severe and critically ill COVID-19 patients: A controlled study	Cohort study	Population	51	Severe and critical	Pulmonary rehabilitation consists of cardio-respiratory exercise, strength training, relaxation techniques, and other adjunctive-therapy if needed	Increased FIM and 6-MWD results after rehabilitation
			Male	38.75			
			Mean age (y)	65.8±11.7			
			Mean BMI (kg/m <sup>2</sup> )	27.3±4.9			
			Patients admitted to ICU	30(59)			
			Patient required intubation	27(53)			
			Mean duration of intubation (d)	13.2±7.1			

Abbreviations: 6-MWD: 6-Minute walking distance; 6-MWT: 6-minute walking test; ADL: Activity of daily life; BMI: Body mass index; WHO: World health organization; FT: Feeling thermometer; FIM: Functional independent measure; ICU: Intensive care unit; ROM: Range of motion.

A cohort study conducted by Puchner et al. (2021) also found an increase in lung capacity in COVID-19 survivors after multidisciplinary rehabilitation with a duration of 3 weeks [21]. In addition, cardiovascular rehabilitation consisting of aerobic and interval training had a positive impact on improving cardiovascular function, decreasing blood pressure after exercise, and respiratory function [17].

### The barrier of exercise-based rehabilitation for COVID-19 survivors

There was no article found that discussed barriers to the rehabilitation of COVID-19 survivors. The scoping review by Wasilewski et al. (2021) [25] described barriers to COVID-19 rehabilitation which were divided as follows: 1) COVID-19 infectivity (causing limitation of patients' access to rehabilitation facilities, prohibition to mobilize to public areas, prohibition to the involvement of the families in patients' care, and closure of healthcare facilities); 2) Patient health status (diversity in the severity of COVID-19, disability, and instability of the patient's condition); 3) Lack

of guidance in the rehabilitation management; 4) Problems related to the availability of personal protective equipment; 5) Problems related to healthcare staff (decreased health status of medical personnel, high workload, and fear of being infected with COVID -19); and 6) Problems in the health system (lack of communication between levels, lack of costs, and unpreparedness of health services to provide rehabilitation services) [25]. Barriers to the rehabilitation of COVID-19 survivors can occur in all phases of care [29].

To our knowledge, this study is the first to specifically discuss exercises to increase exercise tolerance in COVID patients and this study explores exercises to increase exercise tolerance from inpatient care to outpatient care. So, the results of this study can be used as a basis for efforts to prevent lowering exercise tolerance in COVID patients by providing exercise as early as possible after the patient is admitted. The weakness of this study is searching only 1 search engine so there is the possibility of other similar studies that are not explored.

## Conclusion

Research on the rehabilitation of COVID-19 survivors is still limited in number, especially regarding the rehabilitation of severe cases survivors. Based on the reviewed articles, we found that the rehabilitation program was generally provided in both inpatient and outpatient cardiopulmonary rehabilitation programs. Exercises given were aerobic exercise, resistance, and strength training, as well as ADL, range of motion (ROM), breathing, and other exercises. The exercise program was given as needed and tailored to the patient's needs. Exercise-based rehabilitation of severe COVID-19 survivors improved exercise tolerance, functional ability, and quality of life. Exercise could also improve organ function affected in the acute phase of COVID-19. There were several barriers encountered in the implementation of exercise-based rehabilitation such as the patient's condition, COVID-19 infectivity, lack of guidelines, and issues related to the provision of health services.

## Ethical Considerations

### Compliance with ethical guidelines

This systematic review is regarded exclusively on published literature.

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This research did not receive any grant from funding agencies in the public, commercial, or non-profit sectors

### Authors' contributions

Conceptualization: Arnengsih Nazir; Supervision: Arnengsih Nazir and Badai Bhatara Tiksnadi; Methodology, investigation, writing, funding acquisition and resources: All authors.

### Conflict of interest

The authors declared no conflict of interest

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