

Research Article

Benefits of Post-COVID-19 Pulmonary Rehabilitation: A Systematic Review

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Abstract

To evaluate the benefits of pulmonary rehabilitation in individuals in the post-COVID period through various rehabilitation programs. This was a systematic review study that was conducted between March and May 2022. The following electronic databases were used in the search: Pubmed (National Library of Medicine National Institutes of Health) and Scielo (Scientific Electronic Library Online). This study followed the PRISMA checklist for systematic reviews and was registered in PROSPERO (CRD42022356794). The inclusion criteria were read in full by the reviewers. For risk of bias analysis, the Review Manager 5.4 program (RevMan) was used. In the twelve selected articles, it was observed that pulmonary rehabilitation favors physical-functional recovery, improves exercise tolerance, dyspnea, and quality of life, and prevents sequelae and limitations arising from the disease and its complications. This systematic review demonstrates that pulmonary rehabilitation is a beneficial process for patients affected by COVID-19.

Keywords: Benefits; Pulmonary rehabilitation; COVID-19; Pandemic

Introduction

The Coronavirus disease (COVID-19) pandemic has brought about a highly complex scenario in global health, involving different types and degrees of functional impairment in individuals who have recovered from the disease [1]. As for the clinical evolution, COVID-19 can be classified as mild, moderate, severe and critical. Among patients diagnosed with COVID-19, 81% evolve with the mild form and up to 14% with moderate to severe forms, requiring hospitalization and invasive and non-invasive supports, such as oxygen therapy, Non-Invasive Ventilation (NIV) and invasive. These more severe patients present symptoms such as dyspnea, oxygen saturation <93%, presence of bilateral pulmonary infiltrates and, around 5% of these patients, evolve with the severe or critical form, coursing with respiratory failure, septic shock and multiple organ dysfunction [2].

Due to the systemic impairment caused by COVID-19, often even in patients who develop the mildest forms of the disease, symptoms often persist for months after diagnosis. Among the most reported symptoms are dyspnea, fatigue, angina and low exercise tolerance [3]. These sequelae can be considered as persistent symptoms or development of sequelae three to four weeks after the onset of acute manifestations [4]. Individuals in this condition are indicated for pulmonary rehabilitation, which involves individualized treatment with exercises that promote respiratory performance. Although there is little support so far regarding post-hospital rehabilitation, it is known that it can improve function, vital capacity and quality of

life and should be adapted to the individual characteristics of each patient [5].

Rehabilitation should be initiated in the hospital environment, followed on an outpatient basis and, in many cases, at home, it is a safe and effective method, especially for patients with greater limitations, and can reduce the risk of reinfection [6]. Another option is telerehabilitation, a method that has been widespread since the beginning of the pandemic. Among the activities developed by the physiotherapist, aerobic training with progressive and gradual increase, muscle strength training of upper and lower limbs, balance training and specific breathing exercises [7]. NIV, especially in patients with pre-existing cardiopulmonary disease, is a method that can increase exercise tolerance [8,9].

Taking into account that COVID-19 can cause significant morbidity and mortality based on risk factors; these must be taken into account when establishing the rehabilitation program in order to individualize the process. Thus, the objective of this research was to evaluate the benefits of pulmonary rehabilitation in individuals in the post-COVID period through the various rehabilitation programs.

Materials and Methods

This systematic review study was conducted between March and May 2022. The following electronic databases were used in the research: Pubmed (National Library of Medicine National Institutes of Health) and Scielo (Scientific Electronic Library Online), starting with the selection of descriptors by consulting DeCS (Descriptors in Health Sciences) and MeSH (Medical Subject Headings), using the following descriptors in Portuguese and English respectively: “Benefits”, “Pulmonary Rehabilitation”, “COVID-19”, “Benefits”, “Pulmonary Rehabilitation”, “COVID-19”, using the logical operator “AND” to combine terms. This study followed the principles of the PRISMA checklist for systematic reviews and was registered in PROSPERO (CRD42022356794).

Articles without language limitations were included in the research, which analyzed adults, with a publication period from December 2019 to April 2022, studies whose main theme is on post-

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COVID-19 pulmonary rehabilitation in its most varied possibilities (in the hospital phase, outpatient, telerehabilitation and at home). The following were excluded: bibliographical reviews, works presented in conference proceedings, dissertations, theses, repeated studies and articles that deal with themes beyond mobilization.

All processes were carried out respecting the inclusion criteria, analyzed in full by the researchers, independently, and then compared for agreement between pairs. In case of disagreement regarding the inclusion of the study, a discussion was initiated and another researcher was consulted. The process of locating and selecting studies took place in three stages. First, they were selected by reading the titles, in the second step by reading the abstracts and in the third, the full text was analyzed. Finally, the articles belonging to the inclusion criteria were read in full by the evaluators.

The primary outcome evaluated in this research was tolerance to physical exercise and the secondary ones were lung function and quality of life. A meta-analysis was not performed due to the heterogeneity of the data obtained. To analyze the risk of bias, the Review Manager 5.4 program (RevMan) was used, classifying the risk of bias as high (high risk of bias), low (low risk of bias) and undetermined risk (unclear risk of bias).

Results

The database search identified 79 articles, 27 of which were selected for full text evaluation. Of these, 15 were excluded due to lack of information. Twelve studies were included in this review. These results were described in Flowchart 1.

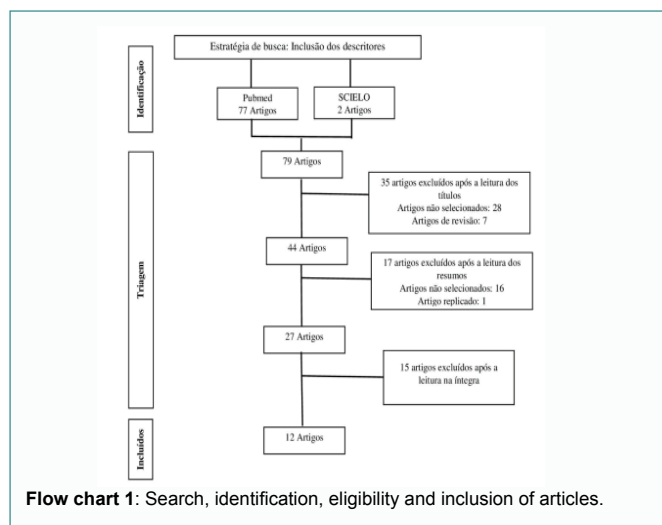


Table 1 presents the characteristics and results of the selected studies. In all, the articles were attached to journals evaluated in strata ranging from B1 to A1 by Capes.

Functionality and functional independence after cardiopulmonary rehabilitation

Hermann et al. [10] when analyzing patients undergoing cardiopulmonary rehabilitation, who were previously admitted to the ICU, found that 12 were mechanically ventilated and 16 underwent non-invasive methods. Functionality was measured in this study using the 6-Minute Walk Test (6-MWT). As for the main results, comparing admission to CR with discharge, including a multimodal program with aerobic training, strength training and psychosocial support, in a total of 25 to 30 sessions, verifying an average gain in

the 6MWT of +130 meters. At the end of the CR, all patients were independent in carrying out their activities of daily living.

Bernal-Utrera et al. [11] observed the benefits of CR *via* telerehabilitation in 25 patients, demonstrating patient self-reports of improvements in functional independence and ability to perform activities of daily living. The study proposed a program of aerobic and muscle strengthening exercises performed at home. Bertolucci et al. [12] verified, in patients after hospital discharge, the Barthel Index (BI) and Functional Ambulation Categories (FAC) as measures of physical disability. A care protocol was developed in CR with strengthening, aerobic and respiratory exercises. As a result, the average time spent in CR was 20 days, the BI showed a significant improvement in all evaluated points, demonstrating an improvement in functional independence; FAC was dependent on walking ability, with lower levels in patients with greater clinical severity.

Tozato et al. [13] evaluated, through the development of a PR protocol lasting 300 minutes per week for 3 months, physical fitness, peripheral muscle strength and double product at rest, demonstrating, through the 6MWT, an increase in the distance covered between 16% and 94%, gain in peripheral muscle strength by 20% up to six times of its initial value and reduction of the double product at rest between 8% and 42%.

Curci et al. [14] evaluated the BI, modified dyspnea scale, 6MWT and PaO₂/FiO₂ ratio, demonstrating a BI of 45.2 ± 27.6; only 14 patients were able to walk, being able to perform the 6MWT; in these, there was an average gain in the distance covered in a variable way, but, on average, 45.0 ± 100.6 meters. The worst functional indices were related to the greater need for the use of supplemental oxygen.

Gloeckl et al. [15] evaluated exercise performance through the 6MWT, verifying a reduced initial value, dividing them into groups: mild/moderate (median 509 meters) and severe (median: 344 meters); upon discharge from the CR program, there was improvement in all groups, with patients considered to have mild/moderate limitations with an average gain of 48 meters and severe ones, a gain of 124 meters.

Al Chikhaie et al. [16], when comparing patients with and without COVID-19 in the outpatient phase of cardiopulmonary rehabilitation with the 6MWT as a parameter, demonstrate that patients in the post-COVID-19 phase showed significant gains with a pulmonary rehabilitation program, with a mean of 205 ± 121 meters, and patients with respiratory failure due to another cause, a mean of 93 ± 66 meters.

The study by Spielmanns et al. [17], evaluating a group of severe post-COVID-19 patients (n=99) with other lung diseases (n=419) demonstrates that the 6MWT obtained a gain of 180 ± 101 meters in post-COVID-19 patients and 102 ± 89 meters in the others; the Functional Independence Measure (FIM) also showed significant results comparing before and after CR in both groups, demonstrating that CR is safe and effective for these patients, especially in post-COVID-19 conditions in its most critical form.

Fanshawe et al. [18] evaluated a patient who used corticosteroids and, in the post-COVID-19 period, underwent a personalized CR program with aerobic, strengthening and respiratory exercises; there was a significant gain in the 6MWT and also in the one-minute sit-to-stand test when compared with the initial values, with a direct association with the increase in the patient's functional independence.

Table 1: Characteristics of selected studies.

Author/year	Study title	Characterization of the study
Hermann et al., 2020.	Feasibility and efficacy of cardiopulmonary rehabilitation following COVID-19.	A retrospective analysis was performed in a Cardiopulmonary Rehabilitation (CR) clinic. The evaluated patients were referred from reference hospitals in COVID-19. Cohort composed of 28 patients - submitted or not to mechanical ventilation in the hospital phase -, with equal proportion between genders (female 50%, male 50%), mean age of 66 years and mean length of hospital stay of 19.3 ± 10.7 days before being sent to the RC. Of the total, 61% of the patients underwent treatment in the ICU. CR was considered effective and safe for all evaluated aspects.
Bernal-Utrera et al., 2021.	Perspectives and attitudes of patients with COVID-19 toward a telerehabilitation programme: a qualitative study.	The study evaluates telerehabilitation for 14 days in post-COVID-19 patients who had a history of ICU admission due to the disease. The study verified the feasibility and usefulness of telerehabilitation in these patients. Aspects related to the perception of clinical benefit, psychological aspects, exercise plan, motivation and applicability were verified. The telerehabilitation CR program was well received by patients and achieved improvements in patients' physical functions.
Bertolucci et al., 2021.	Comprehensive rehabilitation treatment for sub-acute COVID-19 patients: An observational study.	Observational study that reported the CR characteristics and results of 39 patients who presented severe COVID-19 in comprehensive rehabilitation settings. CR in this group proved to be effective in terms of physical aspects and functional independence.
Tozato et al., 2021.	Cardiopulmonary rehabilitation in post-COVID-19 patients: case series.	It reports four cases of different severities of patients in the post-COVID-19 outpatient phase undergoing a CR program. The CR program demonstrates a positive impact on the patients followed, with an improvement in functionality.
Curci et al., 2020.	Early rehabilitation in post-acute COVID-19 patients: data from an Italian COVID-19 Rehabilitation Unit and proposal of a treatment protocol.	A cross-sectional study that characterized aspects of lung function and disability status, proposing an early rehabilitation protocol in post-COVID-19 patients in a rehabilitation unit, including 32 patients.
Gloeckl et al., 2021.	Benefits of pulmonary rehabilitation in COVID-19: a prospective observational cohort study.	Prospective observational study that included 24 post-COVID-19 patients admitted to a CR program for three weeks, evaluating exercise performance, lung function and quality of life.
Al Chikhainie et al., 2021.	Effectiveness of pulmonary rehabilitation in COVID-19 respiratory failure patients post-ICU.	Retrospective analysis of 21 patients rehabilitated in an outpatient clinic after admission to the ICU due to COVID-19. CR performed early after discharge from the ICU represents an effective means of patient recovery.
Spielmanns et al., 2021.	Effects of a comprehensive pulmonary rehabilitation in severe post-COVID-19 patients.	A prospective analysis comparing post-COVID-19 patients with patients with other lung diseases undergoing CR, recommending this strategy in both groups.
Fanshawe et al., 2021.	Corticosteroids and pulmonary rehabilitation reducing long-term morbidity in a patient with post-COVID-19 pneumonitis: A case study.	A case study of a post-COVID-19 patient undergoing an eight-week personalized CR program.
Zampogna et al., 2021.	Pulmonary rehabilitation in patients recovering from COVID-19.	A retrospective analysis that evaluated the effectiveness of CR in post-COVID-19 patients, concluding that it is a safe and effective method in patients who had a severe/critical form of the disease, submitted to oxygen therapy and non-invasive ventilation during the hospital phase.
Shan et al., 2020.	Post acute inpatient rehabilitation for COVID-19.	Case report of an 80-year-old patient who presented the critical form of COVID-19, was admitted to the ICU and submitted to 14 days of mechanical ventilation. The study demonstrated that CR is essential for improving functional capacity and aerobic capacity.
Noop et al., 2022.	Outpatient pulmonary rehabilitation in patients with long covid improves exercise capacity, functional status, dyspnea, fatigue, and quality of life.	A prospective cohort of 58 patients in post-COVID-19 patients undergoing CR demonstrates that exercise capacity, functional status, fatigue and dyspnea, and quality of life were positively impacted.

CR: Cardiopulmonary Rehabilitation; ICU: Intensive Care Unit

Zampogna et al. [19] evaluating 140 post-COVID-19 patients with a history of ICU admission due to the disease, demonstrating that a CR program was able to improve the BI (from 55 to 95) and the distance covered in the 6MWT (298 ± 116.7 meters). Shan et al. [20] in a patient with less functional independence, starting to walk 150 steps on admission using a walker and, at the end of the CR, 250 steps without a walking aid, improving the increase in walking speed, heart rate and oxygen saturation. Noop et al. [21] demonstrated that after a CR program there was an improvement in the distance covered in the 6MWT (584.1 ± 95 meters) and in exercise tolerance.

Lung function measurements

Hermann et al. [10] observed the pulmonary function test before discharge, demonstrating a predominant restrictive ventilatory pattern in the sample and reduced diffusion capacity; FEV1 had a mean gain of 12 percentage points, the FEV1/FVC ratio 81% (+9), mean total lung capacity (TLC) of 62% (gain of +8). For Bertolucci et al. [12], a sample of 11 tracheostomized patients after CR demonstrates that, despite this, there was a significant improvement in gas exchanges, with gains in the $\text{PaO}_2/\text{FiO}_2$ ratio, considering an

effective recovery of lung function. Likewise, Curci et al. [14] verified dyspnea associated with the practice of exercises suggested by the CR program, demonstrating that, after CR, there was a significant reduction in the sensation of dyspnea. Gloeckl et al. [15] also verified the FVC in patients, reporting a gain of 7.7% in patients with mild limitations and 11.3% in severe/critical ones after the CR program.

Fanshawe et al. [18] verified a gain in the $\text{PaO}_2/\text{FiO}_2$ ratio and FEV1/FVC, directly reflecting on exercise tolerance, ensuring progression in strength exercises, exercise tolerance and the ability to progress in aerobic exercises in a patient submitted to an individualized CR program. Noop et al. [21] demonstrated a reduction in dyspnea and fatigue, diffusion capacity and inspiratory muscle pressure after the CR program.

Quality of life

Hermann et al. [10] evaluated Quality Of Life (QOL) using the Feeling-thermometer, an analysis of aspects related to physical performance within daily activities, demonstrating significant improvements, with an average increase of +40 points. Bertolucci et

al. [12] observe the change in aspects of quality of life through the self-report of patients, in a subjective way, concluding that, in general, this parameter was dependent on the improvement in functional independence. Curci et al. [14] associated quality of life with BI, concluding that greater inability to perform activities of daily living is more closely related to worsening general quality of life. Gloeckl et al. [15] used the SF-36 questionnaire to assess QoL, demonstrating a low mental health score before the beginning of CR and an improvement in the score of 5.6% in patients with mild/moderate impairment and 14.4% in severe/critical patients. Noop et al. [21] attribute improvement in QoL markers to muscle gains and exercise tolerance.

Risk of bias

As for the risk of bias, the results of the analysis demonstrate low methodological quality in the analyzed studies. The individualized description is characterized in Figure 1.

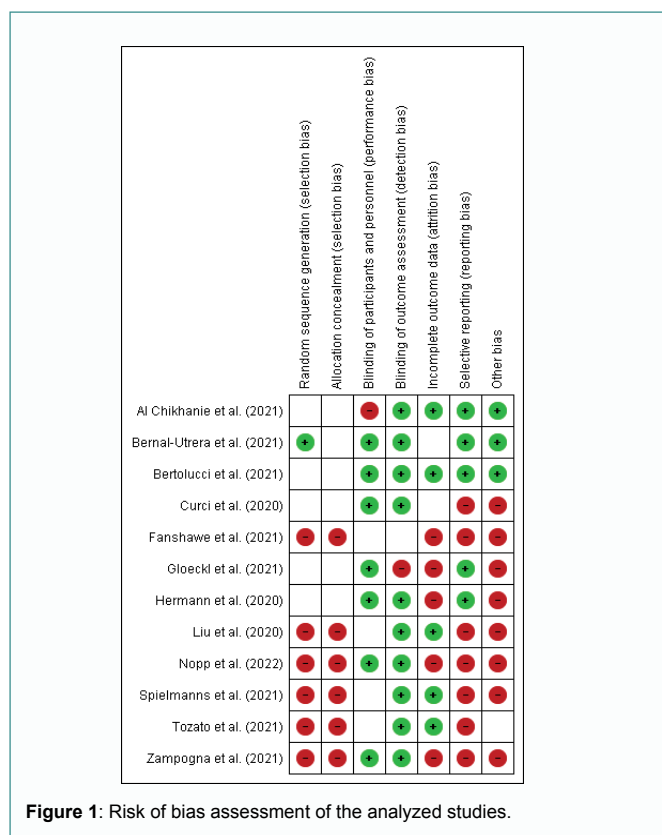


Figure 1: Risk of bias assessment of the analyzed studies.

Discussion

The aim of the present study was to analyze the benefits of pulmonary rehabilitation in individuals in the post-COVID-19 period through various cardiorespiratory rehabilitation programs. It was observed that pulmonary rehabilitation favors physical-functional recovery, improves exercise tolerance, dyspnea and quality of life, in addition to preventing sequelae and limitations resulting from the disease and its complications.

The Coronavirus most prominently affects the respiratory system. Clinical and imaging reports demonstrate that the inflammatory response in the respiratory tract is part of its pathophysiological process [21]. Some consequences caused by COVID-19 in the lungs can be regenerated, depending on the severity of the injury. The person in recovery should undergo frequent medical examinations,

especially in organs such as the kidneys, pancreas, in addition to analysis of lung and heart capacity [22].

Although post-COVID-19 sequelae are more common in the severe form of the disease, patients in the moderate form and without the need to be hospitalized may also have functional impairment [23]. In the post-COVID-19 period, it is necessary to seek physical-functional recovery and social reintegration of these patients through pulmonary rehabilitation [23]. In the present study, the findings suggest that pulmonary rehabilitation prevents secondary deficiencies [11,16], corroborating other studies [24], in which they indicate that it should be started during the hospitalization period and subsequently continued after discharge.

In addition, pulmonary rehabilitation favors physical-functional rehabilitation and provides a better quality of life after COVID-19 [9,10,12,14-16]. Other studies in the literature show that in the rehabilitation process, the physiotherapist aims to work on physical conditioning with exercises that stimulate the respiratory system, such as an ergometric bicycle and treadmill, as well as active exercises with muscle strengthening, repairing the musculoskeletal system [25,26].

With regard to the result of improved tolerance to exercise and dyspnea [13,15,18-20], a study carried out by Frankel et al. [27] demonstrated that pulmonary rehabilitation improves the 6-Meter Walk Test (6MWT) in patients when performed with a certain frequency and intensity.

Showing a significant increase in exercise tolerance, translated into an increase in walking distance in the 6MWT after pulmonary rehabilitation and an important improvement in dyspnea [28]. This can be explained by the improvement in cellular respiration of the musculoskeletal system, reduction in lactic acid production and, consequently, improvement in physiological parameters, found in the conditioning program [29].

Aiming to reduce difficulties and risks in the rehabilitation period of patients with COVID-19 sequelae, the telerehabilitation care model received more attention. In which, it used telecommunication resources to offer rehabilitation services remotely, whether in real time or not. The benefits are similar to face-to-face rehabilitation. Its authorization was corroborated with the teleconsultation, teleconsultation and telemonitoring services by the World Health Organization and was carried out, in Brazil, through resolution no.

Aware that pulmonary rehabilitation in post-COVID-19 patients provides functional benefits and quality of life, it is important that research with the aim of updating be carried out, aiming at establishing reliable results related to the advantages, barriers and contraindications of the procedure in patients, with the intention, in this way, of preventing future sequelae and reducing risks of aggravations.

Limitations

Due to the heterogeneity of the studies, it was not possible to develop a meta-analysis resulting from this systematic review. In addition, the scientific evidence on the subject in the literature is still considered low, which makes us suggest the development of intervention studies for clearer conclusions about the effects of cardiopulmonary rehabilitation in patients with COVID-19.

Conclusion

This systematic review demonstrates that pulmonary rehabilitation is a beneficial process for patients affected by COVID-19 and provides

physical and functional recovery, improves exercise tolerance and lung function, reduces dyspnea and gains in quality of life, in addition to preventing secondary disabilities.

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