






ORIGINAL ARTICLE

Effects of pulmonary rehabilitation in patients with acute post-COVID-19 syndrome: a quasi-experimental study*

HIGHLIGHTS

1. Rehabilitation had a significant impact on improving functional capacity.
2. There was a significant reduction in dyspnea, as evidenced by the mMRC scale.
3. Improved walking test distance after intervention.
4. The Barthel index indicated greater independence after rehabilitation.

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ABSTRACT

Objective: to verify the effects of a pulmonary rehabilitation program on dyspnea, functional capacity, and degree of functional independence in patients with acute post-COVID-19 syndrome. **Method:** This is a quasi-experimental study carried out from August 2020 to October 2022 in a hospital in Curitiba, Paraná, Brazil. A total of 49 participants were assessed before and after rehabilitation using the dyspnea scale, the six-minute walk test, and the Barthel Index. The moments were compared using non-parametric tests (Wilcoxon and Sign). **Results:** There were significant improvements in dyspnea, functional capacity, and independence, as shown by the instruments used ($p < 0.001$). **Conclusion:** The study highlighted the benefits of personalized pulmonary rehabilitation in patients with post-COVID-19 syndrome, underscoring the importance of integrating these programs into the continuum of care to reduce the burden on health systems. More research is needed to optimize the management of this condition and ensure adequate care for patients.

DESCRIPTORS: COVID-19; Acute Post-COVID-19 Syndrome; Rehabilitation; Physiotherapy; Functional Status.

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INTRODUCTION

The COVID-19 pandemic, unleashed by SARS-CoV-2 in December 2019, has had a major impact on global health, manifesting itself in high transmissibility and lethality. In addition to the immediate challenges of infection, many patients have experienced persistent symptoms after the acute phase, characterizing "Long COVID" or "post-COVID-19 syndrome."¹ This condition is marked by symptoms such as memory loss, dyspnea, cough, and fatigue, which can persist or appear weeks after the initial infection. The symptoms have significant effects on the functional capacity of individuals, resulting in a worsening quality of life²⁻³.

In addition, post-COVID-19 syndrome requires long-term follow-up and represents a challenge for health services, especially for the Unified Health System (UHS), which was already facing a considerable burden due to the growing demand for treatment.

In this context, rehabilitation has emerged as a fundamental approach in the management of patients who have recovered from the acute phase of the disease. Physiotherapy plays a crucial role in restoring functional capacity, quality of life, and lung function through programs that include aerobic, strength and endurance exercises, balance, and stretching⁴.

Some studies⁵⁻⁶ have shown that structured and personalized rehabilitation interventions can significantly improve clinical outcomes, functionality, and quality of life in post-COVID-19 patients. A rehabilitation program that uses validated assessment tools and addresses patients' needs in an integrated way can greatly benefit all aspects of their health.

Therefore, this study aimed to verify the effects of a pulmonary rehabilitation program on dyspnea, functional capacity, and degree of functional independence in patients with acute post-COVID-19 syndrome.

METHOD

This is a quasi-experimental study conducted with a convenience sample, which included adults diagnosed with acute post-COVID-19 syndrome referred for pulmonary rehabilitation at the outpatient clinic of a university hospital in Curitiba (PR), Brazil, which operates exclusively through the UHS. The data was collected between August 2020 and October 2022.

Patients hospitalized with a diagnosis of COVID-19 received outpatient medical follow-up after discharge. Those who had persistent functional, physical, and respiratory complaints after four weeks from the onset of the acute infection, without other probable causes, were referred to outpatient physiotherapy to participate in a pulmonary rehabilitation program. It is important to note that all referrals were made at least four weeks after the onset of infection, which characterizes the post-COVID-19 syndrome.

The inclusion criteria included individuals of both sexes over 18 years of age, regardless of race, who had been admitted to the hospital and tested positive for COVID-19, with a medical recommendation for physiotherapy after discharge. Patients with previous motor impairment, neurological and orthopedic alterations, severe cardiovascular involvement,

uncontrolled hypertension, and peripheral oxygen saturation lower than 80% at rest were excluded from the study.

Initially, the participants underwent a physiotherapeutic assessment and were given the following instruments: the Modified Medical Research Council (mMRC) dyspnea scale, the six-minute walk test, and the Barthel Index. The assessment was carried out using a form specifically designed for data collection, including epidemiological and sociodemographic information, data on hospitalization in the acute phase due to COVID-19, complaints, and comorbidities.

To grade dyspnea related to Activities of Daily Living (ADLs), the mMRC scale was used, based on the patient's subjective perception during daily activities. The scale has a categorization ranging from 0 to 4, where 0 refers to 'dyspnea only during vigorous physical exercise' and 4 indicates 'dyspnea on minimal exertion'⁷.

To assess functional capacity and exercise tolerance, the six-minute walk test was used, in which the patient had to walk the longest distance possible in a 30-meter corridor for six minutes. The test was conducted according to the guidelines of the American Thoracic Society (ATS)⁸.

The Barthel Index was used to analyze the degree of functional independence. The instrument, validated by Minosso (2010)⁹, consists of 10 domains: eating, bathing, dressing, personal hygiene, bowel elimination, bladder elimination, toilet use, chair-bed passage, walking, and stairs. By adding up the scores obtained, it is possible to classify the individual with total dependence (0-20 points), severe dependence (21-60 points), moderate dependence (61-90 points), mild dependence (91-99 points) or independent dependence (100 points) for their daily activities.

The treatment protocol was planned and customized to meet the individual needs of the participants. The prescription of low- to moderate-intensity exercises was fundamental to ensuring the safety of the individuals, considering the changes identified in the initial assessment.

It should be noted that during the assessment process, the application of the instruments and the intervention protocol were carried out by one of the physiotherapists on the research team, who had been previously trained for the study. Information about the hospital stay was taken from the patient's electronic medical record.

The intervention program included warm-up exercises followed by aerobic exercises of adequate duration to promote an improvement in cardiovascular and respiratory capacity. Muscle-strengthening exercises and stretches were included to regain strength and flexibility. In addition, functional training was an integral part of the program to improve ADL performance (Chart 1).

The protocol proposed by the team lasted eight weeks, with two or three sessions a week. After the intervention, the participants were reassessed using the same instruments used in the initial stage.

After collecting and tabulating the data, statistical analysis was carried out using Statistica (version 7) and SPSS (version 20) software. Initially, the data was summarized by calculating descriptive measures (quantitative variables) and constructing contingency tables (categorical variables).

Chart 1. Proposed rehabilitation program. Curitiba, PR, Brazil, 2024

Protocol	Exercises	Estimated time
Warm-up exercises	<ul style="list-style-type: none"> Active upper limb exercises. Static walking. 	5 minutes
Aerobic exercise	<ul style="list-style-type: none"> Treadmill or bicycle ergometer. 80% of the incremental test load. 	30 minutes
Muscle strengthening	<ul style="list-style-type: none"> Upper and lower limbs. 3 sets of 8 to 12 repetitions. 	5 minutes
Functional training	<ul style="list-style-type: none"> Balance and gait training. Functional exercises. 	5 minutes
Muscle stretching	<ul style="list-style-type: none"> Global. 	8 minutes
Breathing exercises	<ul style="list-style-type: none"> Ventilation patterns. Bronchial hygiene (if necessary). 	5 minutes
Guidance	<ul style="list-style-type: none"> Educational guidance on the disease and preventive measures. Home exercises. 	2 minutes
Oxygen supplementation	<ul style="list-style-type: none"> If $SpO_2 < 88\%$. 	Time needed to adjust SpO_2

Source: Elaborated by the authors (2024).

Non-parametric statistical tests were used to compare the pre- and post-rehabilitation periods, the choice of which was defined by the Shapiro-Wilk normality test. The Wilcoxon test was used for continuous quantitative variables, and the Sign test or McNemar test was used for ordinal qualitative variables.

The study was approved by the institution's Research Ethics Committee (Opinion 4.805.035).

RESULTS

Of the 87 patients who accessed the pulmonary rehabilitation service, 15 refused to take part in the study, and 14 were excluded (four due to severe cardiovascular disease, five due to previous motor/functional impairment, two pregnant women, two with contraindications to aerobic exercise, and one due to cognitive alterations). Of the 60 eligible patients, 11 were classified as sample losses (three for breaking the aerobic protocol and eight for interrupting the rehabilitation program), giving a final sample of 49 participants

Twenty-six participants (53.1%) were female, with a mean age of 56.1 years. There was a higher frequency of white people, with a total of 45 (91.8%), and obese

people, especially those with grade 1 obesity, totaling 22 (44.9%). As for lifestyle habits, 28 participants (57.1%) had a history of smoking. The other epidemiological and sociodemographic characteristics of the sample, data on hospital admissions for COVID-19, complaints, and comorbidities are summarized in Table 1.

The average hospital stay was 23.8 days, with 34 participants (69.4%) staying in the Intensive Care Unit (ICU) and all using oxygen therapy. The main persistent complaints reported were muscle fatigue and dyspnea in 32 (65.3%) and 31 participants (63.3%), respectively. The most frequent comorbidities were hypertension, present in 30 participants (61.2%), obesity in 15 (30.6%), and diabetes in 11 (22.4%) (Table 1).

Table 1. Epidemiological and sociodemographic profile, hospital data, complaints, and comorbidities of the participants. Curitiba, PR, Brazil, 2024

Variable		Total (n = 49)	
Epidemiological and sociodemographic profile			
Age (years) - Mean ± SD		56.1	10.1
		n	%
Sex	Female	26	53.1
	Male	23	46.9
Self-reported race / color	White	45	91.8
	Brown	3	6.1
	Indigenous	1	2.0
	Black	0	0.0
Obesity	Eutrophy	3	6.1
	Overweight	11	22.4
	Obesity grade 1	22	44.9
	Obesity grade 2	10	20.4
	Obesity grade 3	3	6.1
Smoking	Current	0	0
History of smoking	Yes	28	57.1
	No	21	42.9
HO data, complaints and comorbidities			
Days of HO - mean ± SD		23,8	16.2
		n	%
ICU admission	Yes	34	69.4
	No	15	30.6
Use of oxygen therapy	Yes	49	100.0
	No	0	0.0
Main complaints	Dyspnea	31	63.3
	Muscle fatigue	32	65.3
	Pain	18	36.7
	Memory loss	13	26.5
	Paresthesia	7	14.3
	Coughing	5	10.2
Comorbidities	SAH	30	61.2
	Obesity	15	30.6
	Diabetes	11	22.4
	Cardiovascular	5	10.2
	Pulmonary diseases	9	18.4
	No comorbidities reported	1	2.0

Caption: SD = Standard Deviation; HO = Hospitalization; ICU = Intensive Care Unit.

Source: Elaborated by the authors (2024).

As for dyspnea, as assessed by the mMRC scale, there was a significant reduction post-rehabilitation ($p < 0.001$ - Sign Test). Of the 49 participants assessed at both times, 44 (89.79%) scored better on the scale, while five (10.20%) maintained the degree of dyspnea after the rehabilitation program. Finally, concerning the participants who had grades 2, 3, and 4 at pre-rehabilitation, it was found that all of them reduced their degree of dyspnea after the intervention (Table 2).

Table 2. mMRC dyspnea scale: pre- and post-rehabilitation. Curitiba, PR, Brazil, 2024

Moment	Level of dyspnea				
	0	1	2	3	4
Pre-rehabilitation n (%)	1 (2.0)	12 (24.5)	16 (32.7)	17 (34.7)	3 (6.1)
Post-rehabilitation n (%)	23 (46.9)	19 (38.8)	6 (12.3)	1 (2.0)	0 (0.0)
p-value	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$

Caption: mMRC = Modified Medical Research Council dyspnea scale.

Source: Elaborated by the authors (2024).

Concerning functional capacity, assessed by the six-minute walk test, the study showed a significant increase post-rehabilitation, both in the average distance walked in meters and in the percentage of the predicted distance ($p < 0.001$ - Wilcoxon test) (Table 3).

About the degree of functional independence, assessed by the Barthel Index, there was a significant change post-rehabilitation, with an increase in the means when comparing the two periods ($p < 0.001$ - Wilcoxon test) (Table 3).

Table 3. Six-minute Walk test and total Barthel Index: Pre- and post-rehabilitation. Curitiba, PR, Brazil, 2024

Variable	n	Mean	Median	Min	Max	SD	p-value	Δ post-pre
6MWT - Distance covered								
Distance (m) - Pre	49	367.6	376.1	80.2	581.3	115.3	<0.001	67.1
Distance (m) - Post	49	434.7	428.8	127.5	669.0	106.3		
Distance (% predicted) - Pre	49	71.9	76.1	15.4	115.9	20.9	<0.001	12.7
Distance (% predicted) - Post	49	84.6	89.1	24.6	119.4	17.6		
Barthel Index - Total								
Barthel total - Pre	49	94.1	95.0	50.0	100.0	9.0	<0.001	4
Barthel total - Post	49	98.1	100.0	75.0	100.0	4.8		

Caption: Min = minimum; Max = maximum; SD = Standard Deviation; 6MWT = six-minute walk test; m = meters.

Source: Elaborated by the authors (2024).

Also with regard to the Barthel Index, the study showed a significant change in the level of dependence ($*p < 0.001$). Among the participants, 27 remained at the same level, and 22 decreased their level of functional dependence after rehabilitation (Sign Test). There was also a significant increase in the number of independent participants after the rehabilitation program, totaling 39 (79.59%) (Table 4).

Table 4. Barthel Index - level of dependence: pre and post rehabilitation. Curitiba, PR, Brazil, 2024

Moment	Barthel - Level of dependence			
	Severe	Moderate	Light	Independent
Pre-rehabilitation n (%)	1 (2.0)	10 (20.4)	18 (36.7)	20 (40.81)
Post-rehabilitation n (%)	0 (0.0)	5 (10.20)	5 (10.20)	39 (79.59)
p-value	p<0.001	p<0.001	p<0.001	p<0.001

Source: Elaborated by the authors (2024).

DISCUSSION

The results of this study indicated that pulmonary rehabilitation had a positive impact on the treatment of post-COVID-19 syndrome, with a statistically significant reduction in the degree of dyspnea after the intervention, as assessed by the mMRC Scale. This result was crucial since dyspnea is one of the main complaints associated with post-COVID-19 syndrome.

Similarly, another study of 58 patients reported a significant improvement in dyspnea after rehabilitation, as assessed by the mMRC scale. In addition, significant increases were observed in other outcomes, including fatigue, quality of life, lung function, and distance covered in the six-minute walk test, which registered an increase of 62.9 meters after the rehabilitation program¹⁰.

In a prospective observational study¹¹, in which patients were assessed using the mMRC, it was observed that after the early incorporation of a rehabilitation protocol, dyspnea showed a significant improvement of more than one point in 93.7% of patients.

This study also showed an improvement in the participants' functional capacity, as evidenced by the six-minute walk test. These findings are in line with previous studies, which have highlighted the effectiveness of the six-minute walk test in assessing and monitoring the progress of patients before and after rehabilitation.

A systematic review that evaluated the effects of physical activity programs on the recovery of post-COVID-19 patients showed health benefits regardless of the exercise modalities performed. In 97% of the studies included in this review, there was a significant increase in at least one functional capacity performance parameter, and 96% of the studies reported improvements in quality of life. Finally, all the studies in the review showed an improvement in the walk test¹².

In addition, three studies included in a systematic review and meta-analysis found that the pooled estimate of the effect of rehabilitation on the six-minute walk test showed an improvement in physical capacity for post-COVID patients¹³. The review also showed that rehabilitation improved dyspnea and quality of life.

Also, regarding the walking test, a quasi-experimental study¹⁴ carried out in India highlighted an improvement of 80 meters in the distance covered after early pulmonary rehabilitation post-COVID-19. Other studies reviewed confirmed that rehabilitation programs have a significant impact on functional status, as evidenced by the increase in distance in the walking test¹⁵.

The results of this study also showed an improvement in the Barthel Index concerning the participants' level of dependence, with the majority showing a reduction after the intervention. This result indicates the positive impact of the rehabilitation program on patients' autonomy. Furthermore, these findings are in line with other studies that have highlighted the importance of the Barthel Index in assessing functional dependence and demonstrated the benefits of post-COVID-19 rehabilitation¹⁶⁻¹⁷.

A cohort study¹⁸ that assessed the functional aspects and quality of life of post-COVID-19 patients undergoing rehabilitation also found a statistically significant improvement in the average Barthel Index.

Another quasi-experimental study¹⁹ showed significant improvements in functional parameters and quality of life after an individualized rehabilitation program for post-COVID-19 syndrome, using instruments similar to those in this study. A cross-sectional study²⁰ carried out in a back-up hospital in Brazil found that the average score on the Barthel scale of the 72 patients in the sample increased from 35.9% on admission to 89% after rehabilitation, indicating an improvement in functional dependence. Other observational studies corroborate the significant improvement in Barthel Index results after rehabilitation programs^{6,21}.

That said, the findings of this study establish connections with the existing literature, highlighting its relevance to clinical practice. However, it is important to point out that one limitation found in the study was the sample size, which was reduced due to the decrease in referrals after the introduction of vaccines.

Post-COVID-19 rehabilitation is relevant to society because the effects of the pandemic surpass the physical implications of the disease. Studying these effects allows us to understand how the disease has impacted individuals. In addition, research into pulmonary rehabilitation can contribute to the formulation of public policies, the identification of vulnerable groups, and the development of effective interventions, favoring the social reintegration and well-being of the population.

CONCLUSION

This study demonstrated the positive effects of personalized pulmonary rehabilitation for patients with post-COVID-19 syndrome, proven through the results of the tests carried out, which found a reduction in dyspnea, an increase in functional capacity, and an improvement in functional independence.

By contributing to an understanding of the importance of rehabilitation strategies in the post-COVID-19 period, the study provides valuable input for the field of public health, highlighting the need to integrate pulmonary rehabilitation programs as part of the continuum of care for patients recovering from the disease. Implementing these approaches can not only promote functional recovery but also ease the burden on health systems by reducing the demand for more complex treatments and providing more effective long-term follow-up.

In view of the global impact of COVID-19 and the prevalence of post-COVID-19 syndrome, it is essential that more research is carried out on the subject, with a view to better managing this health condition and ensuring adequate care for patients.

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Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work - **Tulio AIB, de Lira ADB, Bobato HRA, Gomes RHS, Motter AA**; Drafting the work or revising it critically for important intellectual content - **Tulio AIB, de Lira ADB, Bobato HRA, Gomes RHS, Motter AA**; Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved - **Tulio AIB, de Lira ADB, Bobato HRA, Gomes RHS, Motter AA**. All authors approved the final version of the text.

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