

Effectiveness of pulmonary rehabilitation on improving quality of life in post-COVID-19 patients

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Abstract

Background: Coronavirus disease 2019 (COVID-19) frequently results in persistent respiratory, physical and psychological sequelae after the acute infection resolves. Many survivors report reduced exercise capacity, dyspnea, fatigue and decreased health-related quality of life (HRQoL). Pulmonary rehabilitation (PR) — a structured programme of breathing retraining, aerobic and strengthening exercises, and education — has been proposed to mitigate these long-term consequences. This study aimed to evaluate the effectiveness of a 5-week pulmonary rehabilitation programme on exercise capacity and HRQoL in post-COVID-19 patients. **Methods:** A pre-post experimental design was used. Thirty participants who recovered from COVID-19 within the previous year (age 20–55 years) were recruited and allocated into two equal groups (n=15 per group): an experimental group receiving a combined PR programme (diaphragmatic breathing plus aerobic training, ROM and strengthening exercises) and a control group receiving diaphragmatic breathing alone. Interventions were delivered 5 days/week for 5 weeks; each session lasted 30 minutes for the experimental group and 10 minutes for the control group. Outcome measures were the Six-Minute Walk Test (6MWT) for exercise capacity and the SF-36 questionnaire for HRQoL, both administered pre and post-intervention. Data were analysed using paired t-tests for within-group comparisons and independent t-tests for between-group comparisons; significance was set at $p < 0.05$. **Results:** Both groups demonstrated statistically significant improvements within groups for 6MWT distance, SF-36 Physical Component Summary (PCS) and Mental Component Summary (MCS) after the intervention period. The experimental group showed a larger mean increase in 6MWT distance (mean change ≈ 38 m, $p < 0.001$) compared with the control group (mean change ≈ 9 m, $p < 0.05$). Post-intervention between-group comparisons revealed significantly greater gains in the experimental group for 6MWT distance (mean difference ≈ 41 m, $p < 0.05$), PCS (mean difference ≈ 18 points, $p < 0.001$), and MCS (mean difference ≈ 14 points, $p < 0.001$). These findings indicate that a combined pulmonary rehabilitation programme produced clinically and statistically significant improvements in both exercise capacity and HRQoL in post-COVID-19 patients over a 5-week period. **Conclusions:** A short, structured pulmonary rehabilitation programme that couples diaphragmatic breathing with aerobic and strengthening exercises significantly improves exercise capacity and health-related quality of life in post-COVID-19 patients compared with diaphragmatic breathing alone. These results support the incorporation of multi-component PR into post-COVID care pathways to address persistent functional limitations and psychosocial sequelae. Further large-scale and longer-term studies are recommended to confirm durability of benefits and to optimize programme parameters.

Keywords: Respiratory rehabilitation; COVID-19; walk test; health survey; aerobic exercise; breathing exercises.

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BACKGROUND

Coronavirus disease 2019 (COVID-19), caused by the severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), has resulted in unprecedented global morbidity and mortality. Although the acute phase of infection has been the primary focus of early clinical management, accumulating evidence indicates that a substantial proportion of individuals experience persistent symptoms weeks to months after recovery from the acute illness. This condition, variously termed post-acute COVID-19 syndrome, long COVID, or post-COVID-19 condition, is characterized by ongoing respiratory, cardiovascular, neuromuscular, and psychosocial impairments^{1,2}. These persistent sequelae have significant implications for functional independence, quality of life, and healthcare utilization.

Respiratory symptoms such as dyspnea, cough, reduced exercise tolerance, and fatigue are among the most frequently reported complaints in post-COVID patients^{3,4}. Pathophysiological mechanisms proposed include residual pulmonary parenchymal damage, impaired gas exchange, respiratory muscle weakness, cardiovascular deconditioning, systemic inflammation, and prolonged physical inactivity during hospitalization or home isolation^{5,6}. Functional limitations are often evident even in patients who experienced mild to moderate acute illness, highlighting the need for comprehensive rehabilitation strategies beyond pharmacological management⁷.

Pulmonary rehabilitation (PR) is an evidence-based, multidisciplinary intervention traditionally used in chronic respiratory diseases such as chronic obstructive pulmonary disease (COPD), interstitial lung disease, and post-thoracic surgery recovery. PR typically incorporates aerobic training, breathing exercises, muscle strengthening, flexibility training, and patient education to improve physical capacity and health-related quality of life (HRQoL)⁸. Given the overlap between post-COVID impairments and those seen in chronic respiratory conditions, PR has been increasingly advocated as a core component of post-COVID care^{9,10}.

Recent studies have demonstrated that PR and structured exercise programmes are feasible and safe in post-COVID populations, with reported improvements in exercise capacity, dyspnea scores, fatigue levels, and HRQoL¹¹⁻¹³. Systematic reviews and meta-analyses further support these findings, although they emphasize heterogeneity in programme duration, intensity, and outcome measures, as well as a predominance of small-scale or observational studies^{14,15}. Consequently, there remains a need for methodologically sound clinical studies that evaluate pragmatic PR interventions suitable for routine clinical practice.

In addition to intervention effectiveness, the selection of appropriate participants through well-defined inclusion and exclusion criteria is critical to ensure safety, internal validity, and clinical relevance. Current guidelines and expert consensus documents recommend that post-COVID rehabilitation programmes carefully screen patients for cardiopulmonary stability, functional capacity, and the presence of comorbidities that may contraindicate exercise^{9,16}. Clear justification of eligibility criteria, grounded in contemporary evidence, strengthens the methodological rigor of rehabilitation research and enhances comparability across studies.

Therefore, this study aimed to evaluate the effectiveness of a structured pulmonary rehabilitation programme on exercise capacity and HRQoL in post-COVID-19 patients, while explicitly grounding its inclusion and exclusion criteria and methodological approach in recent evidence from the last seven years. By doing so, the study seeks to contribute clinically relevant data to the growing body of literature supporting rehabilitation-based management of post-COVID-19 condition.

METHODS

Study design

A pre-post experimental study design was adopted to evaluate the short-term effectiveness of a pulmonary rehabilitation intervention in post-COVID-19 patients. Pre-post designs are commonly employed in rehabilitation research where ethical and logistical considerations may limit randomization, particularly in emerging clinical conditions such as post-COVID syndrome^{11,17}. This design allows for assessment of within-group changes over time and between-group differences following intervention.

Study setting

The study was conducted in the physiotherapy department of a tertiary care hospital with facilities for supervised exercise training and standardized functional assessment. Conducting the study in a controlled clinical environment ensured participant safety, adherence to intervention protocols, and accurate outcome measurement, consistent with recommendations for post-COVID rehabilitation research^{9,18}.

Sampling method and sample size

Convenience sampling was used to recruit participants, reflecting pragmatic constraints commonly encountered during and after the COVID-19 pandemic, such as limited patient availability and infection-control measures¹⁹. Although probability sampling enhances generalizability, convenience sampling has been widely accepted in early-phase rehabilitation studies provided baseline comparability between groups is demonstrated²⁰. A total of 30 participants were enrolled and equally allocated into experimental and control groups.

Inclusion criteria

Adults aged 20–55 years. This age range was selected to minimize the confounding effects of advanced age-related comorbidities and frailty on exercise capacity and rehabilitation outcomes, as supported by recent post-COVID exercise studies^{12,21}. Confirmed history of COVID-19 infection diagnosed by RT-PCR or rapid antigen testing. Laboratory confirmation is recommended to ensure diagnostic accuracy in post-COVID research²⁹. Completion of the acute phase of illness with at least four weeks elapsed since diagnosis. This criterion aligns with definitions of post-acute COVID-19 condition and ensures medical stability prior to exercise participation^{1,16}.

Presence of persistent symptoms such as dyspnea, fatigue, or reduced functional capacity. These symptoms constitute primary indications for pulmonary rehabilitation in post-COVID populations^{3,14}.

Ability to ambulate independently and perform functional tests such as the Six-Minute Walk Test (6MWT). Functional ambulation is essential for valid assessment of

exercise capacity and participation in aerobic training²². Willingness to participate and provision of informed consent.

Exclusion criteria

Unstable cardiovascular disease, including uncontrolled hypertension, recent myocardial infarction, or severe arrhythmias. Exercise training in such conditions may pose significant risk and is contraindicated without cardiology clearance²³. Severe chronic respiratory disease unrelated to COVID-19, such as advanced COPD or idiopathic pulmonary fibrosis, which could independently affect exercise tolerance and HRQoL^{8,24}. Recent thoracic or abdominal surgery, as postoperative pain and restrictions may limit effective participation in exercise training²⁵.

Neurological or musculoskeletal disorders impairing gait or exercise performance, which could bias functional outcome measures²⁰. Cognitive impairment or severe psychiatric illness that could interfere with comprehension of instructions or completion of questionnaires²⁶. Pregnancy, due to altered physiological responses to exercise and ethical considerations in intervention research²⁷. These eligibility criteria are consistent with those employed in recent post-COVID pulmonary rehabilitation studies and guidelines, supporting both safety and methodological validity^{9,11,14}.

Methodology

Participants in the control group received diaphragmatic breathing exercises alone. Diaphragmatic breathing is a fundamental respiratory physiotherapy technique shown to improve ventilation distribution, reduce dyspnea, and promote relaxation in post-COVID patients^{3,28}. Sessions were conducted for approximately 10 minutes per day, five days per week for five weeks, following standardized respiratory physiotherapy recommendations¹⁸.

The experimental group underwent a comprehensive pulmonary rehabilitation programme comprising diaphragmatic breathing, aerobic training, range-of-motion exercises, and muscle strengthening. Multicomponent PR programmes are strongly recommended in recent post-COVID rehabilitation guidelines due to their superior impact on functional outcomes and quality of life^{9,14,29}.

Aerobic training was delivered using a walking-based protocol at moderate intensity (60–80% of predicted maximum heart rate), consistent with exercise prescription principles for post-COVID recovery^{21,30}. Each session lasted approximately 30 minutes and was conducted five days per week for five weeks.



SF-36 questionnaire evaluation



Aerobic training

Outcome measure: Exercise capacity was assessed using the Six-Minute Walk Test (6MWT), a validated and reliable measure widely used in pulmonary rehabilitation and post-COVID research^{22,31}. Health-related quality of life was assessed using the SF-36 questionnaire, which evaluates physical and mental health domains and has demonstrated sensitivity to change following rehabilitation interventions^{32,33}.

Statistical analysis and results

Data were analyzed using paired t-tests for within-group comparisons and independent t-tests for between-group comparisons. These statistical methods are appropriate for normally distributed continuous data and are commonly applied in rehabilitation trials with small sample sizes^{20,34}. Statistical significance was set at $p < 0.05$.

Participant flow and baseline characteristics, Thirty participants were enrolled and completed the study ($n=15$ experimental, $n=15$ control). Groups were comparable at baseline for age, sex distribution and baseline 6MWT and SF 36 scores, confirming homogeneity prior to intervention.

Experimental participants displayed a significant increase in 6MWT distance (mean changes pre 490.26 ± 40.68 to post 528.33 ± 39.71 ; mean change is 38.06; $p < 0.001$). SF 36 PCS improved markedly (mean change is 17.06 points; $p < 0.001$) and MCS showed a significant increase (mean change is 10.80 points; $p < 0.001$) following the combined PR programme.

Table 1: Comparison within group (Paired t-test)

Outcome Variable	Group	Pre-test Mean $\pm$ SD	Post-test Mean $\pm$ SD	Mean	t value	p value
Exercise Capacity	Experimental	490.26 ± 40.68	528.33 ± 39.71	38.06	12.57	$P < 0.001$
	Control	478.46 ± 30.24	487.26 ± 29.97	8.80	7.08	$P < 0.05$
PCS Score	Experimental	64.73 ± 11.40	81.80 ± 4.72	17.06	7.55	$P < 0.001$
	Control	62.40 ± 11.27	63.73 ± 10.67	1.33	6.32	$P < 0.05$
MCS Score	Experimental	69.33 ± 9.22	80.13 ± 6.52	10.80	9.41	$P < 0.001$
	Control	63.66 ± 10.12	65.86 ± 9.60	2.20	6.20	$P < 0.05$

Participants in control group receiving diaphragmatic breathing alone also improved but to a lesser extent: 6MWT increased modestly (mean change is 8.80 m; $p < 0.05$), PCS increased slightly (mean change is 1.33 points; $p < 0.05$) and MCS improved modestly (mean change is 2.20 points; $p < 0.05$).

Table 2: Comparison between groups (Independent / Unpaired t-test)

Outcome Variable	Test	Experimental Mean $\pm$ SD	Control Mean $\pm$ SD	Mean Difference	t value	p value
Exercise Capacity	Pre-test	490.26 ± 40.68	478.46 ± 30.24	11.80	0.90	0.375
	Post-test	528.33 ± 39.71	487.26 ± 29.97	41.06	3.19	$P < 0.05$
PCS Score	Pre-test	64.73 ± 11.40	62.40 ± 11.27	2.33	0.56	0.57
	Post-test	81.80 ± 4.72	63.73 ± 10.67	18.06	5.99	$P < 0.001$
MCS Score	Pre-test	69.33 ± 9.22	63.66 ± 10.12	5.66	1.60	0.12
	Post-test	80.13 ± 6.52	65.86 ± 9.60	14.27	4.75	$P < 0.001$

Post intervention comparisons favoured the experimental group: 6MWT distance was significantly higher (mean difference is 41.06 m; $p < 0.05$), PCS was substantially greater (mean difference is 18.06; $p < 0.001$) and MCS benefited more in the experimental group (mean difference is 14.27 points; $p < 0.001$). These differences suggest clinically meaningful advantage for multi component PR vs breathing alone.

DISCUSSION

The present study demonstrates that a structured pulmonary rehabilitation programme grounded in evidence-based inclusion and exclusion criteria leads to significant improvements in exercise capacity and health-related quality of life among post-COVID-19 patients. These findings align with the growing body of literature supporting rehabilitation as a cornerstone of post-COVID management¹¹⁻¹⁵.

The observed improvements in the experimental group can be attributed to the multicomponent nature of the intervention. Aerobic training enhances cardiovascular and peripheral muscle conditioning, counteracting deconditioning caused by prolonged inactivity during illness and recovery^{21,30}. Breathing exercises improve respiratory muscle efficiency and ventilatory mechanics, thereby reducing dyspnea and perceived exertion^{28,31}. Strengthening and range-of-motion exercises address musculoskeletal weakness and joint stiffness, which are frequently reported in post-COVID patients^{6,29}.

Comparison with existing literature reveals consistency in outcome trends. Several recent studies report clinically meaningful improvements in 6MWT distance and HRQoL following PR programmes of similar duration and intensity^{12, 13, 31}. Systematic reviews further corroborate these benefits while highlighting variability in programme design and participant selection^{14, 15}. By explicitly grounding eligibility criteria in recent guidelines and empirical evidence, the present study enhances methodological transparency and comparability with existing research.

The careful selection of inclusion and exclusion criteria also contributed to participant safety and adherence. No major adverse events were observed, supporting prior reports that appropriately screened post-COVID patients can safely engage in moderate-intensity exercise^{9, 18}. This underscores the importance of evidence-based screening in rehabilitation research and clinical practice.

Despite these strengths, limitations must be acknowledged. The use of convenience sampling and a relatively small sample size limits generalizability. The short-term follow-up precludes conclusions regarding long-term sustainability of benefits. Additionally, objective pulmonary function tests were not included, which could have provided further insight into physiological adaptations^{15, 24}. Future studies should employ randomized controlled designs, larger samples, and extended follow-up periods to strengthen the evidence base.

Overall, the findings support the integration of structured pulmonary rehabilitation into post-COVID care pathways and highlight the importance of clearly justified inclusion and exclusion criteria in ensuring safe and effective rehabilitation outcomes.

CONCLUSION

A 5-week pulmonary rehabilitation programme combining diaphragmatic breathing with aerobic and strengthening exercises significantly improved exercise capacity and health-related quality of life in post COVID-19 patients compared with diaphragmatic breathing alone. These results support the inclusion of multi-component PR in post-COVID rehabilitation pathways. Future research should test optimized protocols, assess long-term outcomes and evaluate implementation across diverse clinical settings.

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