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Physiotherapy strategies in Post-COVID-19 pulmonary recovery: A narrative review

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Abstract

The COVID-19 pandemic has left a substantial proportion of survivors with persistent respiratory complications, notably reduced lung function, dyspnea, fatigue, and decreased exercise tolerance. Physiotherapy, particularly pulmonary rehabilitation, plays a critical role in restoring respiratory function, physical performance, and overall quality of life in post-COVID-19 patients. This narrative review synthesizes current evidence on physiotherapeutic strategies aimed at improving pulmonary outcomes in post-acute and long COVID syndromes. It explores breathing retraining, aerobic reconditioning, airway clearance techniques, and tele-rehabilitation approaches tailored for COVID-19 survivors. The paper also discusses adaptations in rehabilitation protocols based on symptom severity, comorbidities, and healthcare access. Key challenges such as patient adherence, safety monitoring, and long-term outcomes are examined. A conceptual framework is presented to guide rehabilitation teams in implementing individualized, evidence-based strategies. Future research priorities include longitudinal studies, digital rehabilitation tools, and integrated multidisciplinary models.

Keywords: Post-COVID-19, COVID, integrated multidisciplinary, pulmonary recovery,

Introduction

COVID-19, caused by the SARS-CoV-2 virus, has fundamentally altered healthcare systems worldwide, not only during the acute infection phase but also through its long-term sequelae. As millions of individuals recover from the initial infection, an increasing number are experiencing persistent symptoms lasting weeks or even months a phenomenon widely referred to as "long COVID" or "post-acute sequelae of COVID-19 (PASC)." Among the most prominent and debilitating of these lingering effects are pulmonary complications, including chronic dyspnea, reduced lung volumes, impaired gas exchange, and decreased physical endurance. These symptoms often lead to a decline in quality of life, prolonged dependency on oxygen therapy, and increased psychological stress due to activity limitations.

Physiotherapy, particularly pulmonary rehabilitation, has emerged as a cornerstone in the multidisciplinary management of post-COVID-19 patients. Grounded in evidence from the treatment of chronic respiratory diseases such as chronic obstructive pulmonary disease (COPD) and interstitial lung diseases, pulmonary physiotherapy targets improved ventilation, enhanced physical conditioning, and functional independence. Unlike traditional rehabilitation, post-COVID rehabilitation must be tailored to a diverse range of patients from those who experienced severe illness and mechanical ventilation to individuals with mild infections who develop late-onset respiratory symptoms.

Recent studies have identified physiotherapy as beneficial not only in physical recovery but also in psychological and cognitive rehabilitation. Interventions such as breathing retraining, diaphragmatic strengthening, airway clearance techniques, and progressive aerobic training have demonstrated efficacy in addressing the multifactorial nature of post-COVID respiratory dysfunction. Furthermore, the COVID-19 crisis has propelled the adoption of tele-rehabilitation services, enabling patients to engage in guided physiotherapy from the safety of their homes, which is particularly valuable in minimizing the risk of reinfection and alleviating healthcare burdens.

This narrative review aims to consolidate current evidence and clinical experiences related to physiotherapeutic strategies for post-COVID-19 pulmonary recovery.

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By exploring the pathophysiological underpinnings, identifying effective interventions, and examining practical implementation frameworks, this paper seeks to offer a comprehensive guide for physiotherapists, clinicians, and rehabilitation specialists involved in managing the growing cohort of COVID-19 survivors.

Pathophysiology of Post-COVID-19 pulmonary impairments

SARS-CoV-2, the causative agent of COVID-19, primarily targets the respiratory system, with the lungs serving as the main site of viral replication and immune-mediated damage. During the acute phase of infection, viral entry into alveolar epithelial cells via ACE2 receptors triggers an inflammatory cascade that can lead to alveolar damage, capillary leakage, and the formation of hyaline membranes hallmarks of acute respiratory distress syndrome (ARDS). While many patients recover from the acute phase, a subset experiences persistent structural and functional pulmonary abnormalities long after viral clearance.

Post-COVID pulmonary impairments encompass a spectrum of pathologies, including interstitial fibrosis, small airway dysfunction, pulmonary vascular remodeling, and neuromuscular deconditioning. Radiological evidence frequently reveals ground-glass opacities, fibrotic bands, and bronchiectasis even months after recovery. Pulmonary function tests (PFTs) in post-COVID patients often demonstrate reduced diffusing capacity for carbon monoxide (DLCO), restrictive ventilatory patterns, and diminished peak expiratory flow. These impairments correlate with clinical symptoms such as exertional dyspnea, dry cough, chest tightness, and fatigue.

One of the most significant contributors to persistent symptoms is the prolonged inflammatory state, often referred to as a cytokine storm. Elevated levels of interleukins (IL-6, IL-1 β), tumor necrosis factor-alpha (TNF- α), and transforming growth factor-beta (TGF- β) are implicated in the development of post-inflammatory pulmonary fibrosis. The fibrotic remodeling of alveolar spaces reduces lung compliance and impairs gas exchange, resulting in chronic hypoxemia and increased work of breathing. In mechanically ventilated patients, additional complications such as ventilator-induced lung injury (VILI), diaphragmatic weakness, and critical illness polyneuropathy further compound respiratory dysfunction.

Beyond structural changes, deconditioning due to prolonged bed rest and immobility plays a substantial role in pulmonary recovery delay. Muscle wasting, especially involving the respiratory and postural muscles, contributes to inefficient ventilation, reduced inspiratory muscle strength, and diminished aerobic capacity. Moreover, psychological factors such as post-traumatic stress disorder (PTSD), anxiety, and depression, commonly reported among COVID-19 survivors, indirectly affect respiratory performance by exacerbating perceived dyspnea and reducing participation in rehabilitative efforts.

Given the multifactorial nature of post-COVID respiratory impairment, a comprehensive physiotherapy approach must address not only the mechanical aspects of breathing but also the metabolic, neuromuscular, and psychosocial contributors. Understanding these underlying pathophysiological changes is crucial for designing targeted interventions that promote optimal lung recovery, restore functional independence, and prevent long-term disability.

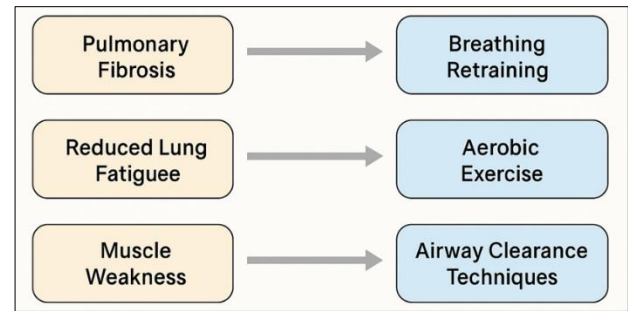


Fig 1: Cycle of post-COVID pulmonary complications and corresponding physiotherapy targets

Role of Physiotherapy in Pulmonary Rehabilitation

Pulmonary rehabilitation (PR) is a multidisciplinary intervention based on a thorough patient assessment followed by tailored therapies to improve the physical and psychological condition of individuals with chronic respiratory diseases. In the context of post-COVID-19 recovery, physiotherapy assumes a central role within PR due to the high prevalence of respiratory and musculoskeletal deconditioning, even in previously healthy individuals. As outlined by leading respiratory societies such as the American Thoracic Society (ATS) and the European Respiratory Society (ERS), core components of pulmonary rehabilitation—namely, exercise training, education, and behavior change—are directly applicable and highly beneficial to COVID-19 survivors. The primary goal of physiotherapy in pulmonary rehabilitation is to reduce the impact of respiratory symptoms such as dyspnea and fatigue, improve functional exercise capacity, and enhance quality of life. Post-COVID patients frequently experience symptoms of breathlessness during minimal exertion, which is often disproportionate to structural lung damage. Physiotherapy addresses this by retraining the breathing pattern, enhancing respiratory muscle efficiency, and gradually exposing patients to structured aerobic activity. Techniques such as diaphragmatic breathing and pursed-lip breathing not only improve oxygenation but also reduce anxiety and respiratory rate, particularly in patients with dysfunctional breathing patterns. Exercise tolerance is markedly reduced in post-COVID individuals, often as a result of muscle atrophy and systemic inflammation. Physiotherapy-led aerobic and resistance training have proven effective in reversing this trend. According to a study published in the *Journal of Rehabilitation Medicine* (2021), COVID-19 survivors enrolled in physiotherapy-supervised exercise programs showed significant improvements in six-minute walk test (6MWT) distances, maximal oxygen uptake (VO₂ max), and reported better overall well-being. Importantly, these benefits were observed even in patients who had not required ICU admission, indicating the broad applicability of these interventions. Beyond respiratory and musculoskeletal improvements, physiotherapy also contributes to neuromotor recovery. Prolonged hospitalization and immobility frequently result in impairments in balance, coordination, and postural control. Vestibular and proprioceptive training delivered through physiotherapy can reduce fall risk and improve confidence in movement, especially in older adults recovering from severe COVID-19. Gait training, often incorporated through parallel bars, treadmill walking, or over ground mobility tasks, is a core part of rehabilitation and helps patients transition from

dependency to independence. Education is another essential component facilitated by physiotherapists. Patients are taught to recognize early signs of respiratory distress, self-monitor oxygen saturation levels, and manage energy expenditure through pacing strategies. These educational efforts empower patients to actively participate in their recovery and reduce the risk of readmission. In many post-COVID rehabilitation programs, physiotherapists collaborate with dietitians, psychologists, and occupational therapists to provide a holistic, patient-centered approach. Additionally, physiotherapists play a vital role in respiratory secretion management. Techniques such as active cycle of breathing technique (ACBT), autogenic drainage, and use of oscillatory positive expiratory pressure (PEP) devices aid in airway clearance, reduce infection risk, and alleviate cough. These are particularly beneficial for patients with persistent mucus hypersecretion or coexisting bronchiectasis. The adaptability of physiotherapy is another key strength in post-COVID care. Home-based rehabilitation programs and telerehabilitation platforms have enabled patients with limited mobility or living in remote regions to access structured exercise plans and professional monitoring. The use of wearable technology and mobile apps to track physical activity, heart rate, and respiratory patterns has enhanced engagement and allowed for real-time feedback and progression adjustments. These remote strategies have proven effective and safe, especially for individuals at higher risk for reinfection or those with immunosuppressive comorbidities. In essence, physiotherapy serves as the foundation of post-COVID pulmonary rehabilitation, bridging the gap between acute medical care and full functional recovery. It not only restores lung function and physical endurance but also re-integrates patients into their daily routines with increased autonomy and confidence. The continued evolution and refinement of physiotherapeutic strategies will remain vital as new variants and long-COVID syndromes continue to challenge global healthcare systems.

Evidence-based physiotherapy strategies for post-COVID Pulmonary Recovery

The development and application of physiotherapeutic interventions in post-COVID-19 care are grounded in decades of pulmonary rehabilitation research, yet adapted to the unique pathophysiological features of SARS-CoV-2 infection. Several strategies have emerged as particularly effective across varying levels of illness severity, from mild residual symptoms in non-hospitalized patients to complex multisystem impairments in those recovering from intensive care. One of the most foundational techniques is breathing retraining, particularly diaphragmatic and pursed-lip breathing. These exercises aim to normalize breathing patterns, reduce accessory muscle use, and improve oxygenation efficiency. Diaphragmatic breathing enhances tidal volume and reduces respiratory rate, while pursed-lip breathing creates back-pressure in the airways, preventing alveolar collapse. These techniques are especially useful in patients with persistent dyspnea, dysfunctional breathing, or anxiety-induced hyperventilation. Airway clearance techniques are crucial for patients with mucus retention, which can be exacerbated by immobility, infection, or pre-existing pulmonary pathology. The Active Cycle of Breathing Technique (ACBT), postural drainage, manual percussion, and oscillatory PEP devices help loosen and expel secretions, thereby reducing the risk of secondary

infections. These strategies are personalized based on sputum characteristics, patient tolerance, and contraindications such as hemoptysis or severe bronchospasm. Inspiratory muscle training (IMT), utilizing threshold loading devices, has gained popularity in post-COVID rehabilitation. It strengthens the diaphragm and accessory respiratory muscles, improving inspiratory capacity and reducing the perception of breathlessness. Studies show that a structured IMT program, conducted 5-6 days per week for 6-8 weeks, leads to measurable improvements in maximal inspiratory pressure (MIP), functional performance, and fatigue scores. Aerobic exercise training is the cornerstone of functional recovery. Low to moderate-intensity aerobic training, such as walking, stationary cycling, or aquatic therapy, is initiated early and progressed gradually based on patient tolerance. The American College of Sports Medicine (ACSM) guidelines adapted for post-COVID patients recommend starting at 40-60% of VO_2 max, with sessions lasting 20-30 minutes, three to five times per week. Heart rate, oxygen saturation, Borg scale of perceived exertion, and symptom monitoring guide the progression. Resistance training complements aerobic activity by restoring muscle mass lost during hospitalization or inactivity. Targeted exercises focusing on major muscle groups, particularly the lower limbs, help improve mobility and reduce fall risk. Using elastic bands, light dumbbells, or bodyweight exercises, resistance training is typically introduced in short sets (e.g., 1-2 sets of 10-15 reps) and increased as tolerated. Balance and functional training are essential, particularly for elderly or critically ill patients. These programs include sit-to-stand drills, step-ups, tandem walking, and proprioceptive training on unstable surfaces. The goal is to enhance postural control, reduce the risk of falls, and restore independence in daily activities such as stair climbing or bathing. Tele-rehabilitation and home exercise programs have become indispensable in the pandemic era. Platforms offering guided video sessions, real-time monitoring via wearable sensors, and mobile-based feedback have proven effective for delivering safe, accessible care. Cottrell *et al.* (2021) found no significant difference in functional outcomes between in-person and tele-rehab delivery in post-viral pulmonary recovery, validating its use in COVID-19 patients.

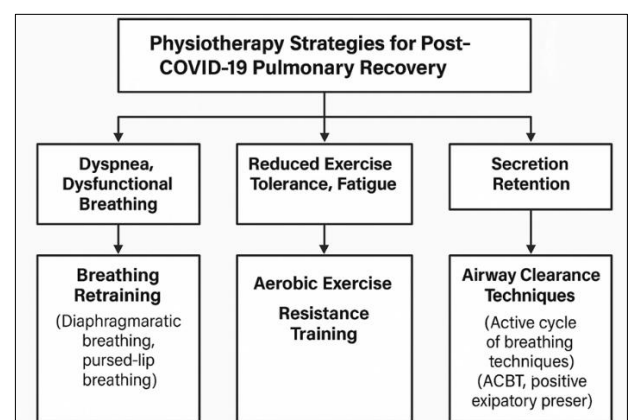


Fig 2: Physiotherapy strategies tailored to address key post-COVID-19 symptoms

Special Considerations in Post-COVID Recovery

Rehabilitation in post-COVID-19 patients requires a tailored approach that accounts for the wide spectrum of residual

impairments, comorbid conditions, and sociodemographic factors. Unlike traditional rehabilitation models focused on well-defined pulmonary pathologies such as COPD, post-COVID rehabilitation presents with variable and often unpredictable clinical courses. The physiotherapy strategy must therefore be patient-centered, flexible, and guided by continuous assessment.

One critical consideration is the diversity of clinical presentations. Some individuals recover rapidly and fully, while others, despite having had mild acute infections, develop prolonged respiratory symptoms or post-exertional malaise. Conversely, patients discharged after intensive care may struggle with a complex interplay of respiratory insufficiency, critical illness polyneuropathy, joint stiffness, and psychological trauma. Physiotherapists must evaluate not only pulmonary function but also endurance, musculoskeletal integrity, balance, cognitive status, and emotional wellbeing.

Comorbidities such as diabetes, obesity, cardiovascular disease, and chronic respiratory disorders significantly influence recovery trajectories. These conditions not only predispose individuals to severe COVID-19 outcomes but also complicate the rehabilitation process. For instance, patients with poorly controlled diabetes may experience delayed tissue healing and reduced exercise tolerance, while those with pre-existing COPD may require more aggressive airway clearance techniques and pharmacological support. In such cases, physiotherapy must be coordinated with other specialties including pulmonology, endocrinology, and cardiology to ensure integrated care.

Psychological symptoms are also highly prevalent in post-COVID recovery. Anxiety, depression, sleep disturbances, and post-traumatic stress symptoms affect both participation in physiotherapy and long-term outcomes. Studies report that nearly 30-40% of COVID-19 survivors exhibit clinically significant psychological distress. Physiotherapists must therefore be skilled in motivational interviewing, stress-reducing breathing techniques, and must collaborate closely with psychologists or mental health counselors. For some patients, re-engagement in physical activity can serve as a therapeutic outlet, helping to reduce anxiety and restore a sense of control over their health.

Fatigue, particularly when chronic and unrelated to exertion, is one of the most disabling symptoms in long COVID. This phenomenon may be linked to mitochondrial dysfunction, autonomic dysregulation, or persistent inflammatory responses. Importantly, in such cases, traditional graded exercise therapy may worsen symptoms a condition known as post-exertional symptom exacerbation (PESE). Physiotherapists must be alert to signs of this and modify the rehabilitation strategy to prioritize pacing, energy conservation, and frequent rest intervals. Tools like the Borg Rating of Perceived Exertion (RPE) scale and fatigue diaries can help guide intensity.

Age and frailty status also affect rehabilitation outcomes. Older adults often present with sarcopenia, balance deficits, and fear of falling. Rehabilitation in this group must include low-impact resistance exercises, balance retraining, and cognitive reinforcement. Additionally, older adults are more likely to experience social isolation and grief, which may hinder motivation and adherence. Tele-rehabilitation platforms, while useful, may not be accessible or user-friendly for all elderly patients, necessitating creative

solutions such as family-supported sessions or hybrid models combining home visits and digital support.

Cultural and socioeconomic factors further shape physiotherapy implementation. In low- and middle-income settings, barriers such as transportation costs, lack of specialized centers, and limited awareness may restrict access to structured rehabilitation. Community-based physiotherapy, delivered through mobile health units or local clinics, becomes crucial in such contexts. Similarly, language barriers, health literacy, and mistrust in healthcare systems must be navigated sensitively to foster engagement and continuity of care.

Finally, vaccination status and reinfection risk must be factored into rehabilitation planning. While vaccination significantly reduces the risk of severe disease and transmission, physiotherapy sessions especially group-based or in-person formats should still follow appropriate infection control protocols, including ventilation, masking, and symptom screening.

In conclusion, the success of post-COVID pulmonary rehabilitation depends not only on the technical quality of physiotherapy interventions but also on their alignment with the patient's physiological, psychological, and social context. An individualized, multidisciplinary, and culturally competent approach remains key to optimizing recovery and preventing long-term disability in this diverse and growing patient population.

Future Directions and Research Gaps

While current physiotherapy interventions have shown promising results in post-COVID-19 pulmonary recovery, numerous gaps remain in the understanding, application, and optimization of these strategies. Given the global burden of long COVID and its unpredictable evolution, future research must be expansive, multidisciplinary, and inclusive of diverse patient populations.

One of the primary needs is the establishment of standardized rehabilitation protocols. Presently, most physiotherapy regimens are adapted from models used for other respiratory diseases such as COPD or post-ARDS syndromes. However, COVID-19 presents unique pathophysiological challenges including microvascular injury, immune dysregulation, and fluctuating symptom patterns that may not be fully addressed by existing protocols. Developing COVID-specific physiotherapy frameworks validated through multicenter clinical trials is critical for ensuring effective and reproducible outcomes.

Another priority area is the long-term follow-up and outcome tracking of post-COVID rehabilitation participants. Most current studies have short timelines (4-8 weeks) and limited sample sizes, which restrict our understanding of sustained benefits, relapse rates, and long-term pulmonary function. Prospective cohort studies and randomized controlled trials (RCTs) with follow-ups extending beyond 6-12 months are necessary to evaluate durability, safety, and late-onset sequelae of physiotherapy interventions.

The integration of biomarkers and imaging tools into rehabilitation planning could also enhance personalization. For example, markers of inflammation (CRP, IL-6), lung function parameters (DLCO, FEV1), or chest CT severity scores might help stratify patients by severity and guide progression of therapy. Future research could explore predictive models using artificial intelligence to tailor exercise prescription based on clinical and biological data.

Digital health technologies such as mobile applications, wearable sensors, and AI-assisted monitoring platforms hold immense potential for scaling physiotherapy services. These tools can facilitate real-time tracking of symptoms, vital signs, and exercise adherence. However, more evidence is needed regarding their usability, accuracy, and effectiveness in rural or low-resource settings. Additionally, digital inequity particularly among the elderly, economically disadvantaged, or digitally illiterate populations must be addressed to prevent widening of healthcare gaps.

The psychological and cognitive aspects of post-COVID recovery remain under-researched in the context of physiotherapy. While it is known that fatigue, brain fog, and anxiety can impede physical rehabilitation, few studies have evaluated the bidirectional impact between physical recovery and mental health. Integrating cognitive-behavioral therapies and mindfulness-based exercises within physiotherapy protocols could enhance holistic outcomes and warrants systematic evaluation.

Another emerging topic is rehabilitation in pediatric post-COVID cases. Although children generally exhibit milder acute symptoms, reports of post-viral fatigue, myalgia, and reduced activity levels in pediatric populations are increasing. Tailored physiotherapy models for children and adolescents, including school-based or play-integrated formats, need to be developed and studied.

Interdisciplinary collaboration is essential for advancing the field. Physiotherapists should be actively involved in joint research initiatives with pulmonologists, infectious disease specialists, psychologists, and public health professionals. Developing consensus statements, clinical practice guidelines, and international rehabilitation registries can help standardize care and improve benchmarking across countries and health systems.

Lastly, health policy and funding mechanisms will play a pivotal role in sustaining rehabilitation services. Many healthcare systems, especially in low- and middle-income countries, do not reimburse physiotherapy or prioritize it in pandemic response plans. Advocacy for insurance coverage, inclusion in COVID recovery packages, and investment in rehabilitation infrastructure will be crucial for translating clinical advances into widespread public health benefits.

In summary, the future of post-COVID-19 physiotherapy must be dynamic, evidence-based, and responsive to the evolving understanding of the virus's long-term effects. Prioritizing research in protocol development, outcome tracking, technology integration, and equitable access will ensure that physiotherapy remains a cornerstone of recovery for millions affected worldwide.

Conclusion

The COVID-19 pandemic has redefined global healthcare challenges, not only through its acute morbidity but also via the long-term sequelae affecting respiratory, neuromuscular, and psychological domains. Among these, post-COVID-19 pulmonary complications have emerged as a major barrier to functional recovery and quality of life in a significant subset of survivors. Physiotherapy, embedded within comprehensive pulmonary rehabilitation frameworks, plays a pivotal role in addressing these challenges by restoring respiratory function, improving physical endurance, and promoting holistic well-being.

This narrative review has highlighted the multifaceted nature of post-COVID impairments and the corresponding

evidence-based physiotherapeutic strategies designed to mitigate them. Techniques such as breathing retraining, inspiratory muscle training, aerobic conditioning, airway clearance, and functional mobility exercises have proven effective in improving key clinical outcomes including dyspnea, oxygen saturation, fatigue, and exercise tolerance. Importantly, the flexibility of physiotherapy delivery whether in-person, home-based, or via tele-rehabilitation ensures its accessibility even in resource-limited or high-risk settings.

However, successful implementation of these strategies requires careful consideration of individual patient needs, comorbidities, psychological states, and socio-environmental factors. The diversity in post-COVID presentations ranging from mild functional decline to complex multisystem disabilities necessitates a patient-centered and multidisciplinary approach. Moreover, sustained patient education, motivation, and support remain essential for adherence and long-term benefit.

While the current evidence base is growing, significant gaps remain in terms of long-term outcomes, pediatric rehabilitation, digital health applications, and health system integration. As we move toward the post-pandemic era, the future of physiotherapy in COVID-19 recovery must focus on standardization, personalization, innovation, and equity. Collaborative research, policy advocacy, and capacity building will be instrumental in embedding physiotherapy as a fundamental pillar of pandemic recovery efforts.

In essence, physiotherapy is not merely a supportive therapy but a transformative intervention capable of bridging the gap between survival and complete recovery in post-COVID-19 care. Its strategic deployment will continue to shape the recovery trajectories of millions worldwide—helping patients breathe easier, move better, and live fuller lives.

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