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REHABILITATION IN PERSISTENT EFFECTS OF COVID-19 INFECTION REVIEW: IMPORTANCE OF TELE-REHABILITATION, INTEGRATED MULTIDISCIPLINARY APPROACH

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ABSTRACT

Given the global prevalence of Post-COVID-19 Condition, marked by a varied spectrum of persistent symptoms, the imperative for efficacious rehabilitation strategies is evident. This systematic review consolidates existing evidence concerning rehabilitation interventions, specifically examining their effectiveness in enhancing functional outcomes and the quality of life among affected individuals. The findings consistently indicate that rehabilitation substantially contributes to ameliorating physiological impairments, bolstering physical capacity, and fostering improvements in respiratory function, psychological well-being, and overall quality of life. Traditional, in-person rehabilitation modalities provide considerable advantages, especially when delivered under supervision and tailored to individual needs. Notably, telerehabilitation and integrated, multidisciplinary approaches have emerged as particularly effective and forward-looking solutions. Telerehabilitation mitigates geographical and logistical impediments, offering accessible and frequently comparably effective care for enhancing functional capacity and alleviating symptoms. Hybrid models, integrating virtual and in-person components, further optimize comprehensive patient care. Although ongoing research is essential to refine optimal protocols and address existing limitations, the evidence robustly supports the superiority of rehabilitation over its omission. Furthermore, innovative, personalized, and technology-driven approaches demonstrate considerable potential for fostering long-term recovery in Post-COVID-19 Condition.

KEYWORDS

COVID-19, Post COVID-19 Condition, Rehabilitation, Quality of Life, Tele-Rehabilitation, Integrated Rehabilitation

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Introduction

The global SARS-CoV-2 pandemic has resulted in millions of fatalities and has also left a significant proportion of infected individuals with persistent symptoms, collectively termed Post-COVID-19 Condition or "long COVID."(Gloeckl et al., 2023) This debilitating condition, estimated to affect 145 million individuals worldwide, is characterized by a diverse array of persistent physical, medical, and subjective sequelae lasting at least 12 weeks post-infection, often irrespective of initial disease severity or hospitalization status(DeMars et al., 2022; Pietranis et al., 2024). These multifaceted symptoms can impact numerous organ systems and health domains, necessitating comprehensive rehabilitation strategies to mitigate their effects (Saunders et al., 2025). The World Health Organization has emphasized the critical need for rehabilitative interventions, advocating for integrated care models to manage the complex needs arising from these persistent conditions, which impose a substantial burden on individuals, healthcare systems, and economies globally (Gloeckl et al., 2023). Consequently, understanding the efficacy of various rehabilitation approaches is paramount for ameliorating the functional decline and diminished quality of life experienced by these patients(León-Herrera et al., 2023) (Sari & Wijaya, 2023). Despite increasing recognition of Post-COVID-19 Condition, its underlying pathological mechanisms and the variability in clinical manifestations largely remain enigmatic (Nopp et al., 2022). Current rehabilitation guidelines are predominantly based on expert opinions and observational data, highlighting an urgent need for evidence-based interventions to support patients with this condition (Pouliopoulou et al., 2023).

Given the persistent and diverse symptoms experienced by a significant percentage of adults with Post-COVID-19 Condition, including fatigue, dyspnea, and various other sequelae, there is a critical need to develop robust, evidence-based, and multidisciplinary rehabilitation protocols (Dillen et al., 2023; Pouliopoulou et al., 2023; Sakai et al., 2023). Individualized rehabilitation programs, encompassing physiotherapy, occupational therapy, and psychotherapy, are essential to address the complex and heterogeneous nature of long COVID (Araya-Quintanilla et al., 2023; Fugazzaro et al., 2022). These tailored strategies, moving beyond a one-size-

fits-all approach, must also incorporate innovative delivery methods such as telerehabilitation, which has emerged as an effective and accessible alternative for improving functional capacity and quality of life in Post-COVID-19 patients, particularly when in-person programs present challenges (Alsharidah et al., 2023; Bernal-Utrera et al., 2022; Cerfoglio et al., 2024; Elyazed et al., 2024; Huang et al., 2022; Nopp et al., 2022; Pescaru et al., 2023; Valverde-Martínez et al., 2023; Vian et al., 2024). Thus, comprehending the efficacy of diverse rehabilitation approaches, including these novel modalities, is crucial for mitigating the functional decline and diminished quality of life observed in these patients (León-Herrera et al., 2023; Sari & Wijaya, 2023).

This systematic review aims to synthesize the current evidence regarding the effectiveness of rehabilitation interventions, focusing on their impact on physical capacity and overall quality of life, to identify effective therapeutic strategies involving new methods such as telerehabilitation and integrated approaches.

2. Methodology

2.1. Search Strategy

A comprehensive and systematic literature search was conducted across multiple electronic databases, including PubMed, Embase, Cochrane Library, PsycArticles, MEDLINE, Web of Science, and EuropePMC. The search strategy was collaboratively developed by the research team and was based on a combination of Medical Subject Headings terms and free-text keywords related to COVID-19, its persistent conditions, and rehabilitation interventions. The search terms comprised "COVID-19," "SARS-CoV-2," "Long COVID," "Post-COVID-19 Condition," "rehabilitation," "pulmonary rehabilitation," "physical therapy," "exercise," and "tele-rehabilitation." To mitigate publication bias and ensure comprehensive coverage, existing COVID-19 literature repositories were systematically screened, and the reference lists of all included studies and relevant systematic reviews underwent manual examination. The search was restricted to publications between 2021 and 2025 to capture contemporary evidence on this evolving topic. Only studies published in English were deemed eligible for inclusion.

2.2. Eligibility Criteria

Study selection for this systematic review adhered to the Population, Intervention, Comparison, Outcome, and Study Design framework.

Population: Studies enrolling adult patients diagnosed with Post-COVID-19 Condition in the post-acute phase, characterized by clinical stability and persistent symptoms, were included. Conversely, studies focusing on patients in the acute phase of COVID-19 were excluded.

Intervention: Any rehabilitation intervention designed to enhance physical function, improve quality of life, or ameliorate persistent symptoms of Post-COVID-19 Condition was considered. This broadly encompassed conventional physiotherapeutic respiratory interventions, pulmonary rehabilitation programs, respiratory muscle training, exercise therapy, and telerehabilitation-delivered interventions.

Comparison: Studies comparing rehabilitation interventions against standard care, a no-intervention control, or alternative rehabilitation approaches were deemed eligible.

Outcomes: Primary outcomes of interest included measures of physical function and health-related quality of life. Secondary outcomes comprised symptom burden, psychological well-being, and the capacity for return to daily activities.

Study Design: Randomized controlled trials, non-randomized controlled trials, prospective and retrospective cohort studies, cross-sectional studies, and case series with a minimum of 10 patients were included. Additionally, information and conclusions drawn from systematic reviews and meta-analyses were considered.

2.3. Inclusion Procedure

Following the search, all identified studies were imported into a reference management program. The screening process comprised two independent stages, conducted by separate research team members. Initially, titles and abstracts were screened for relevance against the predefined eligibility criteria. Articles deemed potentially relevant then proceeded to the second stage, where their full texts were retrieved and independently reviewed by the research team. Any discrepancies arising during either screening stage were resolved through discussion and consensus.

2.4. Data Analysis

Data from the included studies were extracted by designated research team members. The extracted data included details such as author, year of publication, country, study design, population characteristics, intervention type, duration, and primary outcomes. A quality check of the extracted data was subsequently performed by a second reviewer from the team to ensure accuracy and completeness.

Literature Review

Given the expanding body of literature on Post-COVID-19 Condition, a thorough review of current rehabilitation strategies is essential to pinpoint effective interventions for enhancing physical capacity and quality of life (Pouliopoulou et al., 2023) (Sakai et al., 2023). The World Health Organization has critically emphasized the necessity for rehabilitative interventions and advocates for integrated care models to address the intricate requirements associated with these persistent conditions, which exert a considerable burden on individuals, healthcare systems, and global economies (Gloeckl et al., 2023). This urgency is further magnified by the high global prevalence of PCC symptoms, particularly among individuals with a history of hospitalization, and the concomitant economic strain stemming from diminished work capacity and income (Araya-Quintanilla et al., 2023) (Gloeckl et al., 2023). The inherent heterogeneity and multi-organ involvement characteristic of post-acute sequelae of SARS-CoV-2 infection mandate the development of individualized, multidisciplinary rehabilitation programs, potentially integrating physiotherapy, occupational therapy, and psychotherapy, to cater to the diverse needs of affected populations and transcend generic, uniform approaches.(Fugazzaro et al., 2022) (Araya-Quintanilla et al., 2023).

Rehabilitation interventions generally demonstrate a beneficial impact on post-COVID syndrome. While initial investigations were often preliminary and lacked randomized controlled trials, more recent systematic reviews underscore the potential efficacy of comprehensive rehabilitative strategies, particularly those integrating cardiorespiratory, neuromuscular, and psychological components (Chen et al., 2022) (Arienti et al., 2024) (Tamburlani et al., 2023).. Many individuals severely affected by COVID-19 experience persistent cardiopulmonary complications, necessitating targeted rehabilitation to optimize recovery and facilitate a return to daily activities(Dumitrescu et al., 2023) . Pulmonary rehabilitation, which encompasses aerobic, respiratory, and strength exercises, has proven effective in enhancing health status, well-being, and quality of life, alongside improving exercise capacity and reducing fatigue levels in post-acute COVID-19 patients (Tamburlani et al., 2023). For example, comprehensive cardiopulmonary rehabilitation has been shown to improve workload, respiratory function, and overall clinical status in individuals with post-COVID syndrome (Szarvas et al., 2023). This form of rehabilitation, similar to that employed for other chronic lung diseases, aims to mitigate symptoms, strengthen respiratory and accessory muscles, and improve exercise endurance (Szarvas et al., 2023). Furthermore, the principles of pulmonary rehabilitation, which have demonstrated advantages for individuals with chronic respiratory conditions, are hypothesized to similarly benefit PASC patients experiencing persistent symptoms such as fatigue and dyspnea (Rutkowski et al., 2023) (Pescaru et al., 2023). Indeed, several guidelines for COVID-19 rehabilitation, including those from the World Health Organization, the Chinese Medical Association of Rehabilitation, and the European Respiratory Society/American Thoracic Society, recommend pulmonary rehabilitation for managing the long-term effects of critical illness associated with COVID-19, often incorporating exercise training, education, and behavioral modifications (Ahmed et al., 2022). These rehabilitation programs are customized to address various symptoms, including dyspnea, anxiety, and kinesiophobia, while aiming to improve muscle strength, walking capacity, and overall quality of life (Fugazzaro et al., 2022). Preliminary studies have indicated that pulmonary rehabilitation can enhance exercise capacity, reduce fatigue, and improve pulmonary functions in patients with post-acute sequelae of COVID-19 (Nasrullah et al., 2023). Specifically, systematic reviews and meta-analyses have affirmed that pulmonary rehabilitation significantly improves physical capacity, lung function, and health-related quality of life, while also reducing dyspnea and fatigue in patients with long COVID-19 (Li et al., 2025) (Nopp et al., 2022). Additionally, early evidence from specialized COVID rehabilitation programs has corroborated the positive effects of pulmonary rehabilitation on exercise tolerance and respiratory symptoms(Daynes et al., 2023). These programs typically integrate aerobic endurance and resistance training, along with thoracic mobility exercises, to enhance overall physical function and lung expansion(Meléndez-Oliva et al., 2023). Moreover, pulmonary rehabilitation is a multidisciplinary approach that includes physical training, nutritional counseling, and psychological support, all directed at mitigating the debilitating effects of persistent COVID-19 symptoms and enhancing the patient's capacity for independent functioning (Nasrullah et al., 2023).

Research indicates that unsupervised home-based telerehabilitation programs, incorporating both breathing and aerobic exercises, have demonstrated efficacy in enhancing muscle strength, pulmonary function, and quality of life in individuals recovering from COVID-19 (Nasrullah et al., 2023). A recent systematic review and meta-analysis additionally affirmed the effectiveness of pulmonary rehabilitation in ameliorating symptoms and improving physical function in patients with long COVID-19, particularly highlighting the significance of delivery modality and duration(Li et al., 2025). Telerehabilitation, by integrating diverse training approaches such as breathing and aerobic exercises, has emerged as a viable and effective alternative, especially for improving pulmonary and muscular functions and overall quality of life (Tamburlani et al., 2023). The implementation of such programs, whether delivered in-person or remotely, typically involves a combination of respiratory physiotherapy, aerobic exercise, and strength training (Tamburlani et al., 2023). The incorporation of telerehabilitation within these stratified strategies presents a promising opportunity for broader accessibility and improved adherence, given its demonstrated benefits in augmenting functional capacity and pulmonary function(Mheiri et al., 2023). While various rehabilitation protocols exist, often emphasizing deep breathing, inspiratory muscle training, and physical exercises for strength and endurance, their efficacy is notably contingent upon the level of supervision provided (Pescaru et al., 2023).

However, despite these potential advantages, current rehabilitation guidelines for patients with Post-COVID-19 Condition are predominantly derived from expert opinions and observational data, underscoring a pressing need for evidence-based interventions(Pouliopoulou et al., 2023). This discrepancy highlights the necessity for rigorous research, particularly randomized controlled trials, to establish robust rehabilitation protocols(Pouliopoulou et al., 2023). Despite encouraging preliminary findings, the inherent heterogeneity of long COVID-19 symptoms and patient profiles mandates further investigation into individualized rehabilitation protocols to optimize therapeutic outcomes(Meléndez-Oliva et al., 2023) (Li et al., 2025). Ongoing research endeavors are exploring the efficacy of varied exercise regimens, including both aerobic and resistance training, to ascertain the most beneficial approaches for this diverse patient population(Meléndez-Oliva et al., 2023) (Besnier et al., 2022). Specifically, the effects of these rehabilitation interventions on cardiopulmonary fitness and ventilatory efficiency, as assessed by key components of cardiopulmonary exercise testing, remain largely underexplored(Besnier et al., 2025).

Nonetheless, existing evidence suggests that individualized rehabilitation programs, frequently comprising resistance training, strength training, and inspiratory muscle training, can lead to substantial improvements in fatigue and functional limitations experienced by patients(Ortiz-Ortigosa et al., 2024). Such comprehensive programs, often integrating breathing exercises and aerobic training, have been shown to ameliorate dyspnea and enhance physical function in individuals with subacute and long COVID-19(Meléndez-Oliva et al., 2023). However, the diverse symptomology and pathophysiological underpinnings of long COVID-19 subtypes imply that different rehabilitation approaches may be warranted for optimal patient outcomes(Besnier et al., 2025). Consequently, future research should concentrate on developing stratified rehabilitation strategies that align with distinct phenotypical presentations of PASC, ensuring interventions are precisely targeted to individual patient needs and underlying pathologies.(Nasrullah et al., 2023) This personalized approach to rehabilitation, which considers the broad spectrum of individual patient experiences and recovery trajectories, is critical for effective intervention(Dumitrescu et al., 2023). For instance, a structured pulmonary rehabilitation program that integrates aerobic and muscular strength exercises, alongside inspiratory muscle training, has been identified as highly effective, particularly when delivered under supervision(Ortiz-Ortigosa et al., 2024). This suggests that a comprehensive, personalized, and supervised pulmonary rehabilitation program, potentially combined with inspiratory muscle exercises, represents the most effective treatment approach for patients recovering from COVID-19(Ortiz-Ortigosa et al., 2024).

Furthermore, the integration of virtual reality into pulmonary rehabilitation programs offers an engaging and immersive medium that can divert patients' attention from discomfort during exercises, thereby potentially enhancing adherence and motivation (Rutkowski et al., 2023). This innovative approach could foster more sustainable engagement in rehabilitation protocols, ultimately facilitating improved long-term outcomes for individuals recovering from COVID-19. Further exploration is warranted to ascertain the specific benefits of virtual reality integration on physiological parameters and patient-reported outcomes across diverse long COVID-19 cohorts. Recognizing the multifaceted challenges posed by Post-Acute Sequelae of COVID-19, it is imperative to continue advancing rehabilitation methodologies to address the complex interplay of physiological and psychological impairments (Thomas et al., 2021). This encompasses not only optimizing physical recovery but also providing robust psychological support, given the significant mental health burden

frequently associated with prolonged illness and recovery(Fernández-Lázaro et al., 2022). The incorporation of mental health interventions alongside physical rehabilitation is therefore critical for holistic patient care, addressing prevalent symptoms such as anxiety, depression, and cognitive dysfunction in long COVID-19 patients(Pouliopoulou et al., 2023).

Moreover, the absence of specific pharmaceutical treatments for Long COVID-19 underscores the critical role of individualized, multidisciplinary rehabilitation programs in alleviating persistent symptoms and improving patient outcomes(Pietranis et al., 2024). These programs leverage a combination of physical exercises, respiratory physiotherapy, and psychological support to enhance recovery and mitigate the long-term impact of the virus (Li et al., 2024). Given that multidisciplinary rehabilitation is recognized as the most effective approach to managing long COVID-19, identifying key rehabilitation aspects is crucial for designing effective physiotherapy programs(Pietranis et al., 2024) (Ostrowska et al., 2023). Exploring interventions to enhance respiratory function could significantly elevate the quality of post-COVID-19 rehabilitation(Pietranis et al., 2024). To this end, an online multimodal rehabilitation program, facilitated by a multidisciplinary team, has shown promise in addressing the varied symptoms of long COVID-19, including arthralgia, fatigue, dyspnea, and cognitive impairment(Flannery et al., 2022; León-Herrera et al., 2024). Such holistic programs underscore the necessity of collaborative efforts among researchers, healthcare professionals, and policymakers to establish evidence-based guidelines for effective rehabilitation practices(Abdelwahab et al., 2023). This collaborative approach is particularly important given the current lack of consensus or a "gold standard" for treatment recommendations, despite numerous studies on rehabilitation(Frisk et al., 2023). Therefore, developing a consensus on effective rehabilitation strategies is paramount for optimizing recovery trajectories and mitigating the long-term societal and economic burdens associated with PASC(Formica et al., 2024). The absence of a standardized treatment protocol for long COVID further emphasizes the need for comprehensive research into the content, duration, and delivery methods of rehabilitation programs(León-Herrera et al., 2023). Specifically, an individualized, multidisciplinary approach that integrates physical, psychological, and psychiatric support is highly recommended to restore functioning, health, and well-being in patients with long COVID-19(Ostrowska et al., 2023). This patient-centered holistic approach, tailored to individual needs, should also incorporate educational components as a key element of rehabilitation(Ostrowska et al., 2023). This is crucial for equipping patients with the knowledge and skills necessary for self-management and sustained functional improvement, given the chronic nature of many post-COVID-19 symptoms(Sánchez-García et al., 2023). The rehabilitation regimen should be designed to alleviate dyspnea and psychological distress, while simultaneously enhancing participation in rehabilitation, improving physical function, and elevating the overall quality of life, with continuous patient review throughout the process(Ostrowska et al., 2023). Moreover, initial rehabilitation efforts within 30 days post-acute infection have been shown to maximize recovery impact, highlighting the importance of early intervention (Tamburlani et al., 2023). This necessitates systematic screening for rehabilitation needs throughout the recovery process to ensure timely and appropriate interventions are initiated (McCarthy et al., 2023).

Results

Following an extensive initial selection, a stringent screening methodology yielded 63 relevant studies for inclusion, comprising 53 centered on conventional respiratory rehabilitation and 10 on telerehabilitation.

Conventional Rehabilitation

The aggregated evidence from these investigations consistently revealed substantial improvements across several functional metrics, such as forced vital capacity, 6-minute walk distance, and health-related quality of life, which were attributed to pulmonary and physical rehabilitation interventions(Meléndez-Oliva et al., 2023; Sakai et al., 2023). This body of evidence highlights the effectiveness of structured rehabilitation protocols in ameliorating the enduring physiological sequelae linked to long COVID-19, thereby facilitating discernible advancements in patient recuperation and holistic welfare(Al-Mhanna et al., 2022; Meléndez-Oliva et al., 2023; Nasrullah et al., 2023). In particular, pulmonary rehabilitation has been demonstrated to augment respiratory capacity, psychological health, and physical capabilities, thereby addressing common issues such as dyspnea and peripheral muscle weakness frequently observed in COVID-19 patients, especially among the geriatric population(Al-Mhanna et al., 2022). Moreover, a comprehensive systematic review and meta-analysis substantiated that post-COVID-19 pulmonary rehabilitation could markedly improve exercise tolerance, quantifiable by the 6-minute walk test, in individuals presenting with mild to moderate pulmonary dysfunction. Nonetheless, the influence on lung function, dyspnea, and quality of life necessitates cautious interpretation

given the inconsistencies in data reported across various studies(Incorvaia et al., 2022; Meléndez-Oliva et al., 2023). Conversely, despite these documented advantages, multiple reviews indicated ambiguity concerning the exact effect of specific rehabilitation constituents, such as respiratory and resistance exercise regimens, on dyspnea and physical exercise capacity when contrasted with a no-treatment control in patients with non-severe COVID-19(Arienti et al., 2024). Furthermore, the incorporation of respiratory physiotherapy, aerobic conditioning, and strength training, coupled with neuropsychological assistance, has been evidenced to favorably influence exercise performance, pulmonary function, and attenuate symptoms such as dyspnea and fatigue in individuals recovering from COVID-19(Tamburlani et al., 2023). Virtual reality rehabilitation constitutes an innovative progression within this field, exhibiting comparable efficacy to conventional interventions in enhancing exercise capabilities and mitigating psychological stress among post-COVID-19 patients(Rutkowski et al., 2023). This methodology transcends mere physical rehabilitation, also targeting psychological factors and providing streamlined follow-up care, thereby alleviating the burden on healthcare facilities(Vallier et al., 2023).

Telerehabilitation

Telerehabilitation has proven to be a highly effective and feasible alternative, enhancing functional capacity and quality of life among post-COVID-19 patients, particularly in situations where conventional in-person programs are impractical(Vian et al., 2024). For example, studies have demonstrated that telerehabilitation interventions can significantly boost exercise capacity and health-related quality of life in young female patients recovering from COVID-19, particularly when contrasted with the absence of rehabilitation(Alsharidah et al., 2023). Furthermore, research suggests that home-based telerehabilitation programs substantially improve motor and respiratory function, evidenced by an 18.3% increase in walking distance for individuals with long COVID (Cerfoglio et al., 2024). These programs are also effective in mitigating symptoms like dyspnea and fatigue, leading to a marked enhancement in participants' overall quality of life(“45. Jahrestagung Der Österreichischen Gesellschaft Für Pneumologie5. Jahrestagung Der Österreichischen Gesellschaft Für Thoraxchirurgie,” 2021). The feasibility and efficacy of these programs in augmenting functional exercise capacity for COVID-19 patients have also been established, with structured interventions yielding improvements in both endurance and strength(Elyazed et al., 2024). Moreover, comprehensive telerehabilitation programs incorporating therapeutic education, physical exercise, and respiratory components, delivered synchronously, have shown considerable improvements in fatigue, aerobic capacity, and both limb and respiratory strength over a 12-week duration(Carpallo-Porcar et al., 2025). The positive impacts of telerehabilitation encompass advancements in physical health parameters, including reduced pain and increased exercise capacity, alongside enhanced mental health outcomes, highlighting its broad benefits for recovery following acute COVID-19(Pescaru et al., 2023).

Collectively, these findings indicate that while conventional rehabilitation yields substantial advantages, telerehabilitation represents a vital and often comparably effective pathway for widespread implementation, particularly in addressing the varied and extensive needs of COVID-19 survivors (Sakai et al., 2023). Additionally, studies have revealed that tele-supervised home-based exercise regimens, comprising breathing, chest expansion, aerobic, and lower limb strengthening exercises, markedly enhance 6-minute walk test performance, extremity muscle power, and quality of life in COVID-19 survivors(Elyazed et al., 2024). The integrated educational and psychosocial elements within telerehabilitation programs are crucial, as they not only shape patients' perceptions of their functional status and general health but also boost adherence, resulting in superior functional outcomes and a more rapid reintegration into work and social life(Tamburlani et al., 2023). This holistic approach, therefore, effectively addresses both the physical and psychological consequences of COVID-19, promoting a more comprehensive recovery(Bernal-Utrera et al., 2022; Valverde-Martínez et al., 2023).

Nonetheless, despite the growing body of evidence supporting telerehabilitation, further high-quality randomized controlled trials are necessary to unequivocally establish its efficacy, especially when compared to traditional face-to-face rehabilitation, and to fully delineate its impact on various clinical, physical, and psychological outcomes for patients with post-COVID-19 conditions(Huang et al., 2022; Yang et al., 2024). Telemedicine offers distinct advantages, such as reduced costs and convenient access to treatment, thereby minimizing travel requirements and infection risks. Furthermore, telerehabilitation provides the flexibility to deliver therapy at the patient's convenience, enabling therapists to prescribe diverse interventions and receive feedback through modern digital technology(Mheiri et al., 2023). Despite these benefits, challenges such as

low technological literacy among some patients, technical difficulties, and the absence of physical contact can impede its widespread adoption(Chuang et al., 2023).

A prospective surveillance model, integrating both face-to-face and telematic follow-up, has been proposed to optimize post-discharge care for COVID-19 patients requiring rehabilitation(Fernández-Lázaro et al., 2022). This hybrid approach leverages the strengths of both modalities, offering personalized care while surmounting geographical and logistical impediments(Pescaru et al., 2023). However, telerehabilitation may present limitations in offering the same degree of flexibility for real-time adjustments to exercise load, volume, and intensity compared to traditional in-person physiotherapy (Quintana et al., 2024). Despite these inherent challenges, the efficacy of telerehabilitation in infectious pulmonary diseases, such as COVID-19, has been demonstrated in randomized controlled trials, offering a viable alternative to traditional in-person care (Quintana et al., 2024). Its utility is further emphasized by the fact that many patients discharged after severe COVID-19 are significantly debilitated, making traditional in-person rehabilitation difficult or impossible(Quintana et al., 2024).

Nevertheless, hybrid models that integrate virtual and in-person rehabilitation components are emerging as a pragmatic solution to mitigate these challenges, ensuring comprehensive patient care and improved adherence to rehabilitation protocols(Incorvaia et al., 2022). This adaptability to diverse patient needs and preferences reinforces the value of telerehabilitation as a sustainable and accessible model for long-term recovery from post-COVID-19 conditions(Frutos et al., 2023; Pescaru et al., 2023). The increasing evidence supporting digitally delivered rehabilitation programs underscores their capacity to overcome access barriers inherent in traditional face-to-face programs, particularly in managing long-term conditions(Daynes et al., 2023). Moreover, telerehabilitation modalities, including video conferences, recorded sessions, and telephone assessments, have been instrumental in maintaining patient engagement and facilitating continuous care during periods of social distancing(Elyazed et al., 2024; León-Herrera et al., 2023). Telemedicine-driven pulmonary rehabilitation, for instance, has been shown to significantly improve physical and mental health, as well as quality of life, in post-acute COVID-19 patients, highlighting the potential for widespread implementation of such approaches (Pescaru et al., 2023). Specifically, systematic reviews confirm that telerehabilitation for post-acute COVID-19 patients leads to improvements in pulmonary function, exercise capacity, and overall quality of life(Pescaru et al., 2023). Indeed, measures such as the six-minute walking distance and scores for fatigue and pain have demonstrably improved in patients undergoing telemedicine-driven pulmonary rehabilitation(Pescaru et al., 2023). The effectiveness of telerehabilitation in improving functional capacity and symptoms, as well as enhancing quality of life, has been consistently observed across various studies. Furthermore, these interventions offer significant economic advantages and enhanced safety by reducing patient contact compared to center-based rehabilitation programs (Frutos et al., 2023; Tamburlani et al., 2023, Elyazed et al., 2024). This widespread applicability and demonstrated effectiveness across various modalities underscore telerehabilitation's critical role in addressing the long-term sequelae of COVID-19, particularly for those with persistent symptoms(Valverde-Martínez et al., 2023). Its ability to offer continuous care and support without the need for physical presence makes it an invaluable tool for patients experiencing prolonged recovery(Alsharidah et al., 2023; McGregor et al., 2024).

Personalized Rehabilitation Approaches

Achieving optimal outcomes in telerehabilitation hinges upon accurate diagnosis and comprehensive evaluation, thereby necessitating the customization of rehabilitation sessions to align with each patient's distinct requirements for superior therapeutic results(Quintana et al., 2024). The intricate physiological underpinnings of persistent dyspnea, frequently involving impaired lung function, inflammation, and concurrent cardiovascular and neurological impairments, can be favorably influenced by such structured rehabilitation programs(Szarvas et al., 2023). These programs typically integrate exercise training, educational components, and psychological support, all meticulously adapted to address the specific constellation of symptoms experienced by individuals with long COVID(Mheiri et al., 2023). Moreover, the strategic inclusion of remote patient monitoring within telerehabilitation facilitates continuous assessment and prompt intervention, thereby optimizing recovery trajectories and mitigating symptom exacerbations in patients experiencing persistent COVID-19 symptoms(Mheiri et al., 2023). This approach is particularly pertinent given that a substantial proportion of post-hospitalization patients continue to exhibit sleep disturbances, breathlessness, anxiety, and diminished exercise endurance, thereby underscoring the critical demand for accessible and effective rehabilitation strategies(Besnier et al., 2022). Such programs, emphasizing individualized and supervised exercise training, have consistently demonstrated improvements in symptoms,

cardiorespiratory fitness, and overall quality of life among patients with chronic pulmonary and cardiovascular diseases, offering a direct parallel for the management of long COVID(Besnier et al., 2022). Indeed, a considerable percentage of individuals post-COVID-19 hospitalization report enduring symptoms such as breathlessness, fatigue, and reduced exercise capacity, thereby highlighting the indispensable role of rehabilitation in ameliorating these long-term sequelae and preventing a "deconditioning spiral" (Besnier et al., 2022). These individualized rehabilitation plans are pivotal for enhancing functional exercise capacity, alleviating dyspnea and depressive symptoms, and improving the overall quality of life in patients afflicted by long COVID(Besnier et al., 2025). Empirical evidence indicates that structured rehabilitation can lead to significant improvements in exercise capacity, functional status, and quality of life for individuals with long COVID(Nopp et al., 2022). This comprehensive methodology ensures that patients receive continuous support, which is paramount for managing the multifaceted and often protracted recovery trajectory associated with persistent COVID-19 effects(Huang et al., 2022; Pescaru et al., 2023). Furthermore, long COVID syndrome, characterized by symptoms enduring beyond four weeks post-infection, frequently encompasses dyspnea, fatigue, and impaired lung function, rendering targeted rehabilitation indispensable for recovery(Alsharidah et al., 2023). Consequently, personalized cardiopulmonary rehabilitation programs are vital for mitigating these persistent symptoms and enhancing patients' overall quality of life(Szarvas et al., 2023).

Discussion

Pulmonary rehabilitation has emerged as a cornerstone in managing the persistent sequelae of COVID-19 infection, offering a multidisciplinary approach that effectively addresses the complex symptomatology of Long COVID(Nasrullah et al., 2023). Numerous investigations have demonstrated that structured pulmonary rehabilitation programs significantly enhance physical capacity, lung function, and health-related quality of life, concurrently reducing fatigue and dyspnea in affected individuals(Li et al., 2025) (Besnier et al., 2022). These programs frequently integrate exercise training, educational components, and psychosocial support to comprehensively meet the diverse needs of patients(Pescaru et al., 2023) (Besnier et al., 2022). Furthermore, recent systematic reviews and meta-analyses have substantiated the efficacy of pulmonary rehabilitation in improving functional outcomes and attenuating symptoms in patients with long COVID-19(Li et al., 2025) (Meléndez-Oliva et al., 2023). Specifically, pulmonary rehabilitation has been shown to elicit moderate to substantial effects on dyspnea, physical function, quality of life, and depressive symptoms when compared to standard care interventions(Meléndez-Oliva et al., 2023). This evidence underscores the importance of tailored pulmonary rehabilitation strategies in fostering recovery and improving the long-term prognosis for individuals contending with the sequelae of COVID-19(Li et al., 2025) (Besnier et al., 2022). Preliminary studies further suggest that pulmonary rehabilitation may also augment exercise capacity and mitigate fatigue, thereby enhancing pulmonary functions in patients experiencing post-acute sequelae of COVID-19(Nasrullah et al., 2023).

Standard Rehabilitation: Benefits and Limitations

Conventional, in-person rehabilitation approaches have demonstrated significant benefits across various domains. The pathological mechanisms underlying these persistent symptoms are multifactorial, encompassing direct viral effects, immune dysregulation, and organ damage, thereby necessitating a holistic rehabilitative approach that traditional programs are well-equipped to provide(Nasrullah et al., 2023). For instance, individualized rehabilitation programs incorporating resistance training, strength training, and inspiratory muscle training have been shown to significantly alleviate fatigue and functional limitations(Ortiz-Ortigosa et al., 2024). Moreover, cardiopulmonary rehabilitation specifically customized for post-COVID syndrome has demonstrated improvements in workload, respiratory function, and overall quality of life (Szarvas et al., 2023). These programs often entail a comprehensive assessment by a multidisciplinary team to formulate personalized interventions that address the unique constellation of symptoms and functional limitations experienced by each patient(Li et al., 2024). The benefits of such exercise-based rehabilitation programs extend to improving a range of biological systems, including pulmonary, cardiovascular, neuromuscular, and immune functions, ultimately enhancing exercise tolerance and ameliorating symptom burden(Daynes et al., 2023). The efficacy of these interventions is particularly evident in studies where patients participate in supervised exercise programs, emphasizing the importance of a structured approach to rehabilitation(Meléndez-Oliva et al., 2023). This structured approach contributes to addressing cardiopulmonary complications and enhancing overall quality of life, which are critical for individuals experiencing persistent effects of COVID-19(Dumitrescu et al., 2023). Supervised, tailored exercise interventions integrating both resistance and endurance training at low to moderate intensity have

demonstrated superior efficacy and safety compared to standard recommendations, leading to improved cardiovascular fitness, muscle strength, and reduced fatigue, depression, and enhanced quality of life in post-COVID-19 individuals(Jimeno-Almazán et al., 2022). Notably, even low-intensity exercise regimens can expedite recovery and enhance overall fitness, achieving levels comparable to high-intensity training if performed regularly for at least three months, while potentially being better tolerated by patients(Dumitrescu et al., 2023). This suggests that lower-intensity interventions might be more feasible and sustainable for a broader patient population recovering from severe COVID-19, particularly in managing persistent dyspnea and gradual restoration of pulmonary function and aerobic capacity(Dumitrescu et al., 2023).

Nevertheless, traditional, center-based rehabilitation also presents inherent limitations. Rehabilitation programs that are exclusively education-based and lack direct clinician supervision frequently exhibit diminished effectiveness compared to interventions guided by healthcare professionals, primarily attributable to factors such as incorrect equipment utilization and suboptimal patient adherence(Pouliopoulou et al., 2023). Consequently, effective rehabilitation strategies must prioritize supervised and individualized approaches, integrating both aerobic and muscle-strengthening exercises, to successfully counteract the deconditioning observed in post-COVID-19 patients and enhance their physical capacity and overall quality of life(Besnier et al., 2022).

Moreover, the prevalence of post-exertional malaise often constitutes a significant impediment to the implementation of physical exercise training in long COVID patients, thereby necessitating a nuanced approach to exercise prescription and progression (Gloeckl et al., 2024). Therefore, rehabilitation programs must meticulously consider the individual's symptom profile and calibrate activity levels to avert symptom exacerbation, particularly fatigue, while promoting gradual functional recovery(Jimeno-Almazán et al., 2022). This delicate balance underscores the imperative for personalized, symptom-guided rehabilitation strategies that prioritize patient safety and progressive adaptation(Besnier et al., 2022).

Telerehabilitation and Innovative, Integrated Approaches: The Future of Care

The evolution of rehabilitation for enduring post-COVID-19 conditions mandates the adoption and expansion of innovative and integrated strategies, particularly telerehabilitation and individualized, multidisciplinary programs. These approaches are crucial for effectively addressing the varied and intricate patient needs across diverse healthcare settings. Ongoing research continues to optimize rehabilitation protocols for individuals with long COVID, consistently emphasizing the utility of tailored, progressive exercise regimens (Meléndez-Oliva et al., 2023) (Besnier et al., 2022). For instance, customized exercise therapy, such as supervised low-intensity training or inspiratory muscle training, has demonstrated efficacy in ameliorating fatigue, enhancing muscle strength, and improving quality of life in post-COVID-19 patients(Chowdhury et al., 2023). This stands in contrast to conventional training programs, which sometimes exacerbate post-exertional malaise. Ideally, these bespoke interventions should incorporate both aerobic and strength exercises, administered for a minimum of 4 weeks with 2–5 sessions per week, to effectively alleviate symptoms and address exercise intolerance (Colas et al., 2023). Similarly, moderate-intensity tailored exercise regimens have been shown to positively influence muscular strength and endurance without adverse effects on fatigue or other post-COVID-19 symptoms, nor contributing to post-exertional malaise(Chowdhury et al., 2023).

Telerehabilitation holds substantial promise by circumventing geographical and logistical impediments, thus presenting a scalable solution to the persistent and widespread demand for rehabilitative services. Telemedicine, in particular, offers considerable benefits, including reduced costs and enhanced access to treatment, thereby minimizing the necessity for extensive travel and mitigating infection risks(Sakai et al., 2023). The inherent flexibility of telerehabilitation allows for therapy delivery at the patient's convenience, enabling therapists to prescribe diverse interventions and gather feedback through advanced digital technologies(Mheiri et al., 2023). Despite potential challenges, such as varying levels of technological literacy among patients and technical issues(Chuang et al., 2023), the effectiveness of telerehabilitation in managing infectious pulmonary diseases, including COVID-19, has been substantiated by randomized controlled trials, establishing it as a viable alternative to traditional in-person care(Quintana et al., 2024). Its importance is further amplified by the fact that many patients discharged following severe COVID-19 remain significantly debilitated, rendering conventional in-person rehabilitation difficult or impractical(Quintana et al., 2024). The growing body of evidence supporting digitally delivered rehabilitation programs highlights their capacity to surmount access barriers inherent in traditional face-to-face models, particularly for the management of chronic conditions(Daynes et al., 2023). Furthermore, various telerehabilitation modalities, including video conferencing, recorded sessions, and telephone-based assessments, have been pivotal in sustaining patient

engagement and ensuring continuous care during periods requiring social distancing(Elyazed et al., 2024) (León-Herrera et al., 2023). Telemedicine-guided pulmonary rehabilitation, for example, has demonstrated significant improvements in physical and mental health, as well as quality of life, among post-acute COVID-19 patients, underscoring its potential for broad implementation(Pescaru et al., 2023). Systematic reviews specifically confirm that telerehabilitation for post-acute COVID-19 patients leads to enhancements in pulmonary function, exercise capacity, and overall quality of life(Pescaru et al., 2023). Notably, objective measures such as the six-minute walking distance and subjective reports of fatigue and pain have shown demonstrable improvements in patients participating in telemedicine-driven pulmonary rehabilitation(Pescaru et al., 2023). The consistent effectiveness of telerehabilitation in boosting functional capacity, alleviating symptoms, and enhancing quality of life has been observed across numerous studies(Tamburlani et al., 2023) (Frutos et al., 2023). These interventions also yield significant economic advantages and improved safety by reducing direct patient contact compared to center-based rehabilitation programs(Elyazed et al., 2024). This extensive applicability and proven efficacy across diverse modalities underscore telerehabilitation's crucial role in addressing the long-term sequelae of COVID-19, especially for those experiencing persistent symptoms(Valverde-Martínez et al., 2023). Its capability to provide continuous care and support remotely positions it as an invaluable resource for individuals undergoing prolonged recovery(McGregor et al., 2024) (Alsharidah et al., 2023).

The intricate nature of post-acute sequelae of COVID-19 necessitates a comprehensive management strategy that integrates physical, cognitive, psychosocial, and vocational rehabilitation to address multisystem involvement and neurological or musculoskeletal complications(Sari & Wijaya, 2023). Such an integrated approach, combining various therapeutic modalities, has proven superior to standard care in improving functional aerobic capacity, lower limb strength, dyspnea, and overall quality of life among individuals with post-COVID-19 conditions (Pouliopoulou et al., 2023). This integrated model of care, which incorporates personalized rehabilitation plans, is essential for managing the persistent and varied symptoms experienced by individuals with long COVID(Nopp et al., 2022). The World Health Organization advocates for a person-centred, comprehensive, and multidisciplinary approach to rehabilitation for these patients, encompassing education, self-management strategies, and a carefully paced return to activities(Dillen et al., 2023). This strategy is vital for optimizing recovery and enabling patients to gradually and safely resume daily activities, thereby mitigating the long-term impact of the condition(Sari & Wijaya, 2023). These guidelines emphasize the importance of tailored interventions that account for the multisystemic character of COVID-19 and the diverse clinical presentations among patients(Fugazzaro et al., 2022) (DeMars et al., 2022). For example, the incorporation of pulmonary rehabilitation models, specifically adapted for COVID-19 survivors, has shown substantial potential in alleviating common post-COVID symptoms such as dyspnea and fatigue. (Thomas et al., 2021)Moreover, multidisciplinary teams, typically comprising specialists such as pulmonologists, physiotherapists, psychologists, and occupational therapists, collaborate to develop individualized treatment pathways(Ostrowska et al., 2023). This collaborative framework ensures a holistic assessment of patient needs and the implementation of a coherent, coordinated rehabilitation plan(Cheng et al., 2025; McCarthy et al., 2023; Ostrowska et al., 2023).

The American Academy of Physical Medicine and Rehabilitation, among other professional organizations, has advocated for consensus statements and integrated care models to guide the assessment and treatment of patients with Post-Acute Sequelae of SARS-CoV-2, particularly emphasizing the necessity of comprehensive, interdisciplinary collaboration(Barshikar et al., 2023). These frameworks highlight the importance of a coordinated clinical effort to address the diverse manifestations of Long COVID, moving beyond isolated symptom management towards integrated, patient-centered care (Cheng et al., 2025). Specifically, these guidelines promote individualized, multidisciplinary rehabilitation that addresses physical, psychological, and psychiatric dimensions to restore functionality, health, and overall well-being(Ostrowska et al., 2023). This holistic approach, encompassing exercise, nutritional guidance, education, and the management of specific symptoms such as breathlessness and neurocognitive impairments, is crucial for enhancing functional capacity and quality of life in survivors (Sari & Wijaya, 2023). For individuals experiencing debilitating symptoms, prompt referral to a multidisciplinary rehabilitation team is vital for a thorough needs assessment and management strategy(Chuang et al., 2023). Such teams frequently develop comprehensive resources for clinicians to effectively evaluate and manage adult patients with Long COVID symptoms, particularly in settings where subspecialty care is limited(Cheng et al., 2025). This integrated model acknowledges Long COVID as a multisystemic condition, necessitating comprehensive, continuous rehabilitation delivered by a diverse team including family physicians, physiotherapists, speech therapists,

psychologists, nutritionists, occupational therapists, and social workers (León-Herrera et al., 2024). The interdisciplinary nature of this collaboration is critical, pooling varied expertise to tackle the complex and heterogeneous presentations of Long COVID, as evidenced by frameworks that synthesize insights from over twenty-seven scientific and research disciplines.(Abdelwahab et al., 2023) These collaborative endeavors underscore a paradigm shift towards integrated care pathways that are responsive to the dynamic and evolving needs of individuals experiencing prolonged post-COVID-19 symptoms(Cheng et al., 2025). This extensive approach aims to mitigate episodic disability and enhance overall functional capacity through evidence-based interventions customized to individual patient profiles(O'Brien et al., 2024). Despite the absence of a universal "gold standard" for treatment recommendations and some studies suggesting minimal benefit from increased physical activity for a significant proportion of patients(Frisk et al., 2023), personalized rehabilitation programs incorporating aerobic exercises, muscle strengthening, and specific breathing techniques are increasingly advised to counter deconditioning and improve functional outcomes in individuals with persistent post-COVID-19 symptoms(Besnier et al., 2022). This patient-centered holistic approach prioritizes individual needs, with education playing a pivotal role in empowering patients to effectively manage their condition(Ostrowska et al., 2023). Such programs are specifically designed to address muscle deconditioning and the increased sedentary behavior often observed in individuals post-COVID-19, thereby enhancing physical capacity and quality of life(Besnier et al., 2022). Cardiopulmonary rehabilitation programs, specifically adapted for Long COVID-19 patients, have demonstrated promise in alleviating persistent breathlessness and fatigue through the integration of individualized training protocols(Besnier et al., 2022). Furthermore, physical therapy interventions, comprising tailored exercise regimens for strength, flexibility, and cardiovascular fitness, are fundamental in addressing common symptoms such as fatigue, myalgia, and dyspnea(Sánchez-García et al., 2023). Moreover, these interventions are critical for improving respiratory function, frequently compromised in Long COVID-19 patients, via targeted exercises that enhance lung capacity and diaphragmatic strength(Pietranis et al., 2024). Hybrid models integrating virtual and in-person rehabilitation components are emerging as a practical solution to overcome challenges, ensuring comprehensive patient care and improved adherence to rehabilitation protocols(Incorvaia et al., 2022). This adaptability to diverse patient needs and preferences reinforces the value of telerehabilitation as a sustainable and accessible model for long-term recovery from post-COVID-19 conditions(Frutos et al., 2023) (Pescaru et al., 2023). The incorporation of virtual reality into rehabilitation protocols offers an innovative avenue for engagement and customized exercise regimens, proving as effective as traditional approaches in improving exercise tolerance and mitigating stress responses (Rutkowski et al., 2023). This methodology extends beyond physical rehabilitation, addressing psychological variables and providing efficient follow-up care that reduces hospital burden(Vallier et al., 2023). The lack of a standardized treatment protocol for Long COVID further emphasizes the need for comprehensive research into the content, duration, and delivery methods of rehabilitation programs(León-Herrera et al., 2023). An individualized, multidisciplinary approach that integrates physical, psychological, and psychiatric support is highly recommended to restore functioning, health, and well-being in patients with Long COVID-19(Ostrowska et al., 2023). This patient-centered holistic approach, customized to individual needs, should also incorporate educational components as a key element of rehabilitation(Ostrowska et al., 2023). The rehabilitation regimen should be designed to alleviate dyspnea and psychological distress, while simultaneously enhancing participation in rehabilitation, improving physical function, and elevating the overall quality of life, with continuous patient review throughout the process(Ostrowska et al., 2023).

Conclusions

The evidence meticulously compiled throughout this review unequivocally demonstrates that rehabilitation interventions are not merely beneficial but significantly aid in managing the protracted consequences of COVID-19. They offer substantial improvements in patient functioning and quality of life. Indeed, rehabilitation is demonstrably superior to its absence in alleviating symptoms and enhancing the health status of individuals afflicted with post-COVID-19 syndrome.

Integrated rehabilitative approaches, encompassing both conventional programs and innovative methodologies, have proven highly effective. Pulmonary rehabilitation programs, aerobic exercises, strength training, and psychological support consistently contribute to improved physical capacity, respiratory function, reduced fatigue and dyspnea, and an elevated overall quality of life(Besnier et al., 2022; Li et al., 2025; Meléndez-Oliva et al., 2023; Nasrullah et al., 2023). Individualized and supervised approaches, which tailor

exercise intensity to the patient's subjective sensations, are particularly valuable, given the inherent variability of symptoms in post-COVID-19 syndrome(Besnier et al., 2025).

Telerehabilitation and approaches integrating various disciplines emerge as highly effective tools in combating post-COVID-19 syndrome, and they represent a definitive solution for the future. Telerehabilitation effectively surmounts geographical and logistical barriers, providing accessible care that enhances functional capacity, respiratory function, and overall quality of life(Alsharidah et al., 2023; Cerfoglio et al., 2024; Elyazed et al., 2024; Pescaru et al., 2023; Vian et al., 2024). Its capacity for continuous patient support and monitoring, without the necessity of physical presence, renders it an invaluable asset in the prolonged recovery process(Alsharidah et al., 2023; McGregor et al., 2024; Valverde-Martínez et al., 2023). Furthermore, hybrid models, which seamlessly combine virtual and in-person rehabilitation components, are proving to be pragmatic solutions, ensuring comprehensive care and improved adherence to rehabilitation protocols (Incorvaia et al., 2022).

While the long-term efficacy continues to be an area of active investigation, and the optimal parameters for rehabilitation programs are still being refined, the current body of evidence unequivocally underscores the pivotal role and immense potential of telerehabilitation and personalized, multidisciplinary interventions. Their inherent flexibility and adaptability to individual patient needs, coupled with the strategic integration of modern technologies, position them as an exceptionally promising direction for advancement in the treatment of post-COVID-19 syndrome. These innovative approaches are well-equipped to address complex health challenges and provide comprehensive, long-term care across diverse conditions and settings.

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