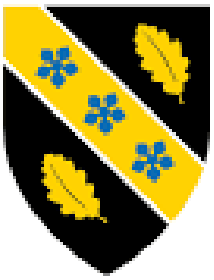
SYSTEMATIC LITERATURE REVIEW RESEARCH



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The Impact of Physiotherapy on Cardiopulmonary Function in Post Covid-19 Patients

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DECLARATION

I, Bhumi Mukeshkumar Baraiya declare that this dissertation has been composed by myself, that the work contained herein is entirely my own except where explicitly stated otherwise in the text, and that this work has not been submitted for any other degree or qualification, in whole or in part, except as specified.

Signature: Bhumi Baraiya
Date: 10/09/2025

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ABSTRACT

Background: A significant percentage of COVID-19 survivors have left behind chronic cardiopulmonary dysfunction, which manifests as fatigue, dyspnoea, decreased exercise tolerance, and decreased lung capacity. A key non-invasive rehabilitation technique in the absence of many pharmaceutical alternatives is physical therapy. In this dissertation, the evidence about the efficacy of physical therapy therapies in improving quality of life and cardiopulmonary function in patients recovering from COVID-19 is comprehensively reviewed.

Methods: PRISMA criteria were followed in conducting a systematic literature review across databases such as PubMed, Scopus, CINAHL, Embase, and the Cochrane Library. Using the PICO methodology, studies released between December 2019 and December 2024 were vetted. Using the Joanna Briggs Institute's techniques, ten appropriate peer-reviewed quantitative research (RCTs and cohort designs) were evaluated critically. Inspiratory muscle training, telerehabilitation, aerobic and resistance training, pulmonary rehabilitation, and cutting-edge techniques like spinal neuromodulation were among the interventions that were investigated. The primary objectives included quality-of-life measurements (SF-36, EQ-5D), exercise capacity (6MWT, VO_2 peak), and lung function (FEV_1, FVC, DLCO, MIP).

Results: Post-COVID-19 patients' quality of life, activity tolerance, and respiratory function were all consistently enhanced by physiotherapy therapies. The most successful programs were multimodal ones, however home-based models and telerehabilitation provided workable substitutes. Although they need more study, novel techniques including neuromodulation showed promise.

Conclusion: An intervention that is safe, efficient, and scalable for improving cardiac recovery following COVID-19 is physiotherapy. Public health and long-term pandemic recovery measures are significantly impacted by the reduction of symptom burden and the restoration of functional independence. To support the evidence and guide policy, future studies should give special attention to large-scale RCTs, standardized outcome measures, long-term follow-up, cost-effectiveness analyses, and the incorporation of patient-reported outcomes.

Keywords: COVID-19, physiotherapy, pulmonary rehabilitation, exercise tolerance, respiratory function, cardiopulmonary recovery, telerehabilitation, quality of life.

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ABBREVIATIONS:

ACSM: American College of Sports Medicine

CBT: Cognitive Behavioral Therapy

COPD: Chronic Obstructive Pulmonary Disease

CPET: Cardiopulmonary Exercise Testing

COVID-19: Coronavirus Disease 2019

DLCO: Diffusing Capacity of the Lung for Carbon Monoxide

EQ-5D: EuroQol 5-Dimension Health Questionnaire

FEV_1: Forced Expiratory Volume in One Second

FVC: Forced Vital Capacity

HRQoL: Health-Related Quality of Life

HRR: Heart Rate Recovery

IMT: Inspiratory Muscle Training

JBI: Joanna Briggs Institute

MCID: Minimal Clinically Important Difference

MeSH: Medical Subject Headings

MIP: Maximal Inspiratory Pressure

MMAT: Mixed Methods Appraisal Tool

ONS: Office for National Statistics (UK)

PCC: Post-COVID Condition (Long COVID)

PEF: Peak Expiratory Flow

PEO: Population, Exposure, Outcome framework

PICO: Population, Intervention, Comparison, Outcome framework

PR: Pulmonary Rehabilitation

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

QoL: Quality of Life

RCT: Randomized Controlled Trial

RMT: Respiratory Muscle Training

SLR: Systematic Literature Review

SF-36: Short Form-36 Health Survey

VO_2 peak: Peak Oxygen Uptake

WHO: World Health Organization

WHOQOL-BREF: World Health Organization Quality of Life - BREF Questionnaire

6MWT: Six-Minute Walk Test

CHAPTER 1: INTRODUCTION AND BACKGROUND

1.1 Introduction to the Topic

The coronavirus disease 2019 (COVID-19), caused by the SARS-CoV-2 virus, has created a profound global health crisis since it was declared a pandemic in March 2020 (World Health Organization, 2025). A significant percentage of people continue to have chronic symptoms, which is now known as post-COVID syndrome or Long COVID, even though the majority of people recover from the acute phase in a few weeks (Nalbandian et al., 2021). Dyspnoea, exhaustion, chest pain, decreased exercise tolerance, and compromised lung function are the most frequent aftereffects, and they might last for months following the original infection (Norihiko Funaguchi et al., 2023).

Because they impact not only the quality of life of the individual but also the capacity of the health service and workforce participation, these difficulties constitute a critical public health concern (NHS England, 2024). One of the most commonly documented consequences is cardiopulmonary dysfunction, which considerably impairs functional ability and raises the cost of long-term healthcare (Roth et al., 2020).

Chronic respiratory and cardiovascular diseases such as COPD, asthma, and heart disease can be effectively managed with physiotherapy (Leemans et al., 2021). According to recent data, exercise regimen, breathing retraining, and pulmonary rehabilitation may also help post-COVID patients achieve better results (Longobardi et al., 2023; Michalas et al., 2024). This research fills a significant gap in rehabilitation science and public health management by assessing the contribution of physical therapy to the recovery of cardiopulmonary function in post-COVID-19 patients.

1.2 Background and Current Context

Global health systems have changed as a result of the COVID-19 pandemic, with effects that go beyond the first stages of infection. Although lowering mortality, stopping virus transmission, and immunizing people were the healthcare systems' primary priorities in 2020-2021, it has now been established that a sizable portion of survivors still suffer from chronic illnesses (Filip et al., 2022). These persistent issues, which have important ramifications for rehabilitation science, include cardiovascular dysfunction, exhaustion, respiratory impairment, and diminished physical capacity. To put this research in context, it is crucial to comprehend the epidemiology, underlying mechanisms, and potential role of physiotherapy (Zaree et al., 2023).

1.2.1 Epidemiology and Population Impact

The impact of COVID-19 on populations has been unparalleled. Almost 704 million cases had been confirmed globally by April 2024, and the sickness was responsible for almost 7 million deaths (World Health Organization, 2025b)

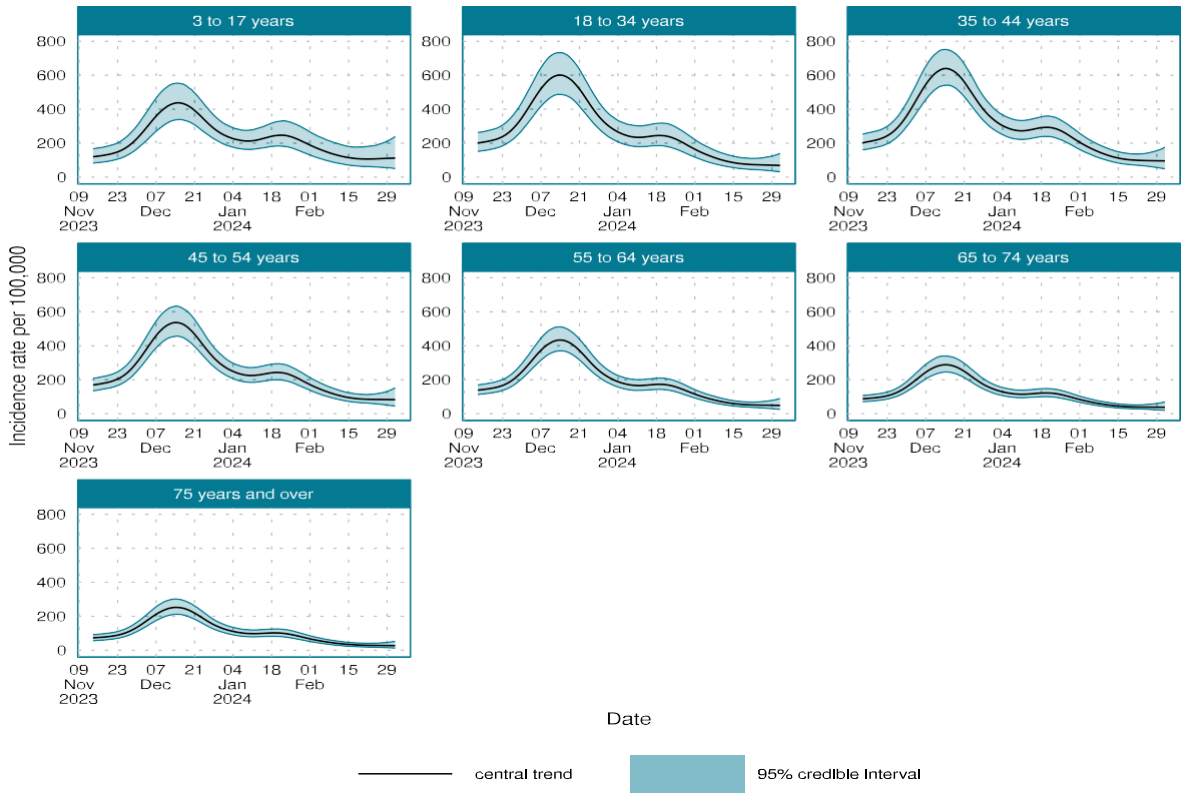


Figure 1: Incidence and Prevalence of SARS-CoV-2

(Source: Fyles et al., 2024)

This corresponds to about 9% of the world's population having been confirmed infected, the actual number of cases is probably much higher because of underdiagnosis and asymptomatic carriers (Almadhi et al., 2021). Persistent health problems are still common even if vaccination campaigns and antiviral medications have significantly decreased hospitalization and death rates (Yang et al., 2023).

The incidence of Long COVID in the UK is a particularly clear indication of the long-term effects of COVID-19. As of March 2023, 1.9 million people (2.9% of the population) reported having symptoms that lasted longer than four weeks, according to data from the Office for National Statistics (Office for National Statistics, 2023). About 2 million people in England and Scotland were affected by this by 2024; 75% of them reported having limits in their everyday activities, and 20% said they were "limited a lot" in their day-to-day functioning (Kirk-Wade, Wong and Stiebahl, 2024).

These figures have enormous socioeconomic ramifications. About 3.3% of people in the UK reported symptoms that persisted for more than four weeks following infection, according to ONS (2024) an increase from 2.9% the year before. Due to this growth, 700,000 more working-age people were labelled as long-term ill, which resulted in a scarcity of workers and financial losses. In addition to acute hospital costs, (Chen et al., 2021) contend that the economic cost of COVID-19 includes decreased productivity and a rise in the need for disability support.

Both domestically and internationally, these figures demonstrate the urgent need for rehabilitation techniques that can lessen the effects of Long COVID and assist patients in regaining their functional independence (Chuang et al., 2022).

1.2.2 Pathophysiology of Post-COVID Cardiopulmonary Dysfunction

Post-COVID 19 patient's symptoms continue due to a complex interaction of patho-physiological factors. One of the most frequent aftereffects is respiratory impairment, as seen by studies showing decreased pulmonary function testing months after recovery (Ruggiero et al., 2022). According to Dal, Turco and Massimiliano Povero (2022), patients who were released from the hospital following COVID-19 pneumonia showed decreased forced vital capacity (FVC) and aberrant carbon monoxide diffusion capacity (DLCO), which may indicate long-term structural alterations.

George et al. (2020) observed that even in patients who did not require intensive care, microvascular thrombosis, pulmonary fibrosis, and alveolar injury all lead to persistent respiratory problems.

Cardiac involvement is also prevalent. Regardless of the initial severity of the disease, Puntmann et al. (2020) used cardiovascular MRI to reveal that a large majority of patients healing from COVID-19 had evidence of myocarditis, myocardial scarring, or pericardial involvement. Fatigue, tachycardia, and decreased exercise tolerance are also caused by endothelial dysfunction and autonomic dysregulation (Allendes et al., 2023).

Systemic deconditioning is common in addition to immediate cardiopulmonary injury. Muscle atrophy, decreased cardiovascular fitness, and diminished neuromuscular coordination are the outcomes of prolonged hospitalization, immobilization, and intensive care unit (ICU) stays (Heinen, 2024). Muscle weakness and functional impairment may result from prolonged weariness and inactivity, even for patients who treated their infection at home (Mathew and Nugent, 2024).

Together, these elements show why overlapping respiratory, cardiovascular, and musculoskeletal deficits are common in post-COVID patients, necessitating comprehensive rehabilitation approaches.

1.2.3 Role of Physiotherapy in Rehabilitation

A key strategy for regaining function in long-term cardiovascular and respiratory disorders is physiotherapy. To improve lung mechanics, lessen dyspnoea, and increase exercise tolerance, pulmonary rehabilitation which is frequently used for patients with chronic obstructive pulmonary disease (COPD) involves breathing retraining, structured exercise, and education (Troosters et al., 2023). The use of these identical concepts in post-COVID therapy is growing.

According to new research, physiotherapy can help Long COVID sufferers a lot. According to Michalas et al. (2024), individuals with chronic complaints showed significant improvements in quadriceps strength, dyspnoea scores, and sit-to-stand performance after an eight-week supervised physiotherapy program. In their evaluation of a 16-week home exercise program, Longobardi et al. (2023) discovered significant increases in health-related quality of life as well as decreases in myalgia and fatigue.

Home-based methods have also worked well. Elyazed et al. (2024) discovered that, in comparison to standard care, a structured pulmonary rehabilitation program administered remotely enhanced fatigue, oxygen saturation, and six-minute walk distance (6MWD). In a similar vein, Nopp et al. (2022) found that outpatient pulmonary rehabilitation reduced tiredness and dyspnoea while improving 6MWD by an average of 62.9 meters.

It has been demonstrated that cardiopulmonary rehabilitation improves cardiovascular and respiratory recovery. After an eight-week intervention, Besnier et al. (2024) showed notable increases in ventilatory efficiency and VO_2 peak, confirming the value of physiotherapy in treating multi-system deficits.

Importantly, physiotherapy is scalable and flexible in addition to being clinically beneficial. A wide spectrum of patients, including those with limited mobility or living in rural locations, can get interventions in hospitals, outpatient clinics, or remotely via telehealth (Rik Percival Dawson et al., 2023)

1.2.4 Gaps in Knowledge

Physiotherapy is becoming more and more supported by research, but there are still significant gaps remain. The limited sample sizes of several research to date have limited their capacity to be broadly applied (Scurlock-Evans, Upton and Upton, 2014). It is

challenging to make direct comparisons because of the significant variety in intervention design, which includes differences in exercise type, intensity, duration, and frequency.

There is also a dearth of long-term data regarding the sustainability of gains. Despite the extensive documentation of short-term improvements in lung function, exercise tolerance, and quality of life, it is still unknown if these advantages last longer than six to twelve months (Wijkstra et al., 1995). There are not many studies that compare the cost-effectiveness of various delivery strategies, including supervised outpatient programs versus tele-rehabilitation.

The absence of patient subgroup classification is another drawback. Although these factors are frequently overlooked, age, comorbidities, the severity of the initial illness, and vaccination status probably affect how well a patient responds to rehabilitation (ProQuest, 2025). Customizing therapies requires knowing which patients benefit most from which kind of physiotherapy.

Finally, there is a dearth of studies on psychosocial outcomes. The psychological effects of Long COVID, such as anxiety, depression, and decreased social engagement, must be incorporated into rehabilitation efforts even though physical recovery is crucial (Nalbandian et al., 2021).

1.3 Rationale for Research

Persistent post-COVID cardiopulmonary dysfunction is a significant clinical and public health concern. A promising non-invasive strategy is physiotherapy, even though pharmaceutical management is still limited (Sonel Tur et al., 2022). There is currently no consensus on best practices, and the data base is fragmented, despite early research suggesting advantages across lung function, exercise tolerance, and quality of life (Spruit et al., 2013; Michalas et al., 2024).

In order to close this gap, this dissertation critically assesses how physiotherapy can help post-COVID patients' cardiovascular results. In order to generate insights that can influence clinical guidelines, improve rehabilitation tactics, and boost NHS Long COVID services, the study will explicitly concentrate on quantitative outcomes.

1.4 Research Question

How effective is physiotherapy in improving cardiorespiratory function in post-COVID-19 patients?

1.5 Research Aim

The purpose of this study is to assess how well physiotherapy therapies can enhance post-COVID-19 patients' cardiopulmonary function and health-related quality of life. This includes determining which rehabilitation techniques are most successful for long-term recovery and assessing how physiotherapy affects respiratory function, exercise tolerance, and symptom burden.

1.6 Research Objectives

The objectives of this dissertation are:

1. To conduct a thorough analysis of the data about how physiotherapy therapies affect pulmonary function in individuals recovering from COVID-19.
2. To assess how physiotherapy affects functional recovery and exercise tolerance using clinical outcome measures such the VO_2 peak and the six-minute walk test.
3. To look at how physiotherapy can lessen the burden of symptoms, especially fatigue, dyspnoea, and a lower quality of life.
4. To evaluate the efficacy of various physiotherapy approaches, such as tele-rehabilitation, home-based programs, and supervised rehabilitation.
5. To pinpoint current research gaps and offer suggestions for next studies and clinical procedures.

1.7 Chapter Summary

The research topic, the global and UK burden of COVID-19, and the aetiology and consequences of post-COVID cardiopulmonary dysfunction have all been covered in this chapter. It examined recent research, emphasized the importance of physical therapy in rehabilitation, and pointed out important knowledge gaps. The research question, aim, and objectives were established, along with an explanation of the reasoning behind the study. The dissertation's foundation is established by this framework. A comprehensive analysis of the body of research on physiotherapy therapies for post-COVID rehabilitation will be provided in the upcoming chapter.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter aims to critically review the body of research regarding the benefits of physical therapy for enhancing cardiopulmonary function in COVID-19 patients. The first section of the chapter provides an overview of the pathophysiological causes and epidemiological impact of post-COVID 19 cardiopulmonary impairments, such as respiratory muscle weakness, tiredness, dyspnoea, and decreased exercise tolerance. The evidence from 2021-2025 is then summarized, with an emphasis on physiotherapy methods such telerehabilitation, inpatient programs, aerobic and resistance exercise, respiratory muscle training, and pulmonary rehabilitation. Every issue is examined to draw attention to the extant literature's methodological shortcomings as well as the clinical efficacy of these interventions. This chapter highlights recurring advantages, conflicting results, and enduring knowledge gaps by comparing findings across various settings and patient populations.

2.2 Literature Review

2.2.1 Overview of Long COVID and Cardiopulmonary Sequelae

The long-term effects that endure after an acute infection have drawn more attention since the advent of SARS-CoV-2. Post-COVID-19 Condition (PCC), also known as Protracted COVID, Prolonged COVID, or simply Long COVID, is now recognized as a complex, multisystemic illness with symptoms that persist or worsen for more than 12 weeks after infection and cannot be explained by other diagnosis (Nalbandian et al., 2021; Collins, 2024). According to epidemiological research, over 50% of hospitalized patients and 10% to 30% of non-hospitalized patients experience prolonged COVID, with the most prevalent symptoms being fatigue, impaired exercise tolerance, and dyspnoea (Fernández-de-las-Peñas et al., 2021).

Persistent cardiopulmonary dysfunction seems to have multiple pathophysiological causes. Research points to skeletal muscle deconditioning, autonomic imbalance, microvascular injury, pulmonary fibrosis, endothelial dysfunction, and chronic systemic inflammation (Kasawara et al., 2019). Additionally, sarcopenia and mitochondrial dysfunction lead to decreased ventilatory efficiency, exercise intolerance, and poor oxygen utilization (Ferri et al., 2020). The therapeutic justification for physiotherapy therapies that target both peripheral and pulmonary limits is highlighted by these mechanisms.

2.2.2 Pulmonary Rehabilitation in Long COVID

Since it has been shown to enhance exercise tolerance, dyspnoea, and quality of life, pulmonary rehabilitation (PR) has long been regarded as the gold standard for treating chronic respiratory conditions like COPD (Gloeckl et al., 2018). Its use in long-term COVID has been well investigated.

Structured PR programs, usually lasting 6–8 weeks, significantly increased exercise capacity as determined by the six-minute walk test (6MWT), decreased dyspnoea, and improved quality of life in COVID-19 survivors, according to a systematic review by Pouliopoulou et al (2023). Similarly, PR enhanced health-related quality of life scores, forced vital capacity (FVC), and forced expiratory volume in one second (FEV1), with clinically significant changes in the 6MWT, according to Moon et al (2021). These conclusions are supported by more recent data.

According to Weinstein et al. (2013), supervised PR that combined breathing, strength, and aerobic activities greatly increased daily activity levels and decreased weariness. According to Cox et al. comprehensive review from 2018, supervised centre-based rehabilitation is the best option because PR and respiratory muscle exercise consistently improve lung function, tiredness, and dyspnoea.

From two-week short-term therapies to longer 12-week programs, there is still variation in program length, intensity, and components. For long-term COVID populations, PR is generally considered safe, practical, and therapeutically beneficial despite these differences (Ali et al., 2023).

2.2.3 Respiratory Muscle Training (RMT)

After COVID-19, patients have been found to have respiratory muscle weakening, which can lead to dyspnoea and intolerance to physical activity (Voorthuizen et al., 2022). Physiotherapy techniques known as expiratory muscle training (EMT) and inspiratory muscle training (IMT) are intended to strengthen the respiratory musculature.

A thorough study by Ferté et al. (2022) demonstrated that RMT increases 6MWT performance, lowers dyspnoea, and improves inspiratory and expiratory pressures. These results are consistent with previous research by McNarry et al. (2022), which showed that IMT enhanced exercise tolerance and inspiratory pressures in patients recovering from COVID-19.

Crucially, RMT also seems to reduce fatigue and enhance quality of life in relation to health (Henrik Ahvenjärvi et al., 2023). The need for more reliable, long-term RCTs is highlighted by the fact that the most of research are constrained by small sample numbers and brief follow-up periods.

2.2.4 Aerobic and Resistance Exercise Training

An essential part of PR has been exercise-based physiotherapy therapies, such as resistance and aerobic training. While weight training treats sarcopenia and peripheral muscular weakness common in long-term COVID, aerobic training increases cardiovascular endurance (CPTJ, 2022).

In a meta-analysis, Cooper et al. (2021) showed that combining different types of exercise greatly increased functional capacity, especially in middle-aged and younger people. When compared to unsupervised home-based therapies, improvements in the 6MWT were more noticeable in centre-based programs.

Although the inclusion of patient education and behavioural support was restricted across trials, Ward et al. (2017) also found favourable effects from structured exercise instruction, demonstrating significant gains in physical capability and reductions in fatigue. These results highlight the value of multimodal rehabilitation that includes both educational and physical approaches.

2.2.5 Inpatient Pulmonary Rehabilitation

Inpatient PR programs have been demonstrated to hasten recovery for people with severe acute COVID-19 who need hospitalization. According to a systematic study by Huppmann et al. (2012), inpatient PR enhanced lung function, exercise ability, and mental health outcomes. It verified that inpatient PR improved post-COVID patient's FEV1, FVC, and 6MWT scores without causing any negative side effects.

Although inpatient programs are quite effective, they have drawbacks such as high resource requirements, restricted availability, and a dearth of long-term follow-up data. However, data suggests that for post-COVID patients recuperating from severe illness, inpatient PR is safe, practical, and clinically significant (Sheehy, 2020).

2.2.6 Telerehabilitation

The implementation of telehealth models, particularly telerehabilitation, was expedited by the COVID-19 epidemic. By delivering physiotherapy interventions through digital platforms, telerehabilitation enhances accessibility and care continuity.

In an RCT of a 14-day telerehabilitation program, Rodríguez-Blanco et al. (2021)

discovered that exercise ability and tiredness reduction were significantly higher than in control groups. A three-month telerehabilitation software also improved physical function

and cognitive results, with better adherence linked to greater benefits, as shown by Rodríguez-Blanco et al. (2021)

Findings are still conflicting, though. After a four-week telerehabilitation program, Yang et al. (2025) found no significant differences between groups, indicating the need for longer interventions or different modalities. Nicolas et al.'s systematic evaluation from 2024 affirmed the safety of telerehabilitation while pointing out variations in program design and adherence.

Multimodal, symptom-titrated telerehabilitation is currently being tested with cardiopulmonary exercise testing (CPET) outcomes using emerging protocols, like Tomaskovic et al. (2025), which could provide more solid support for digital delivery models.

2.2.7 Psychological and Holistic Rehabilitation Approaches

Physiotherapy (PT) cannot be considered in a vacuum since long-term COVID is biopsychosocial. Cardiopulmonary deficits sometimes coexist with psychological symptoms such as anxiety, depression, and post-exertional malaise. Physiotherapy combined with cognitive behavioral therapy (CBT) or holistic rehabilitation improves overall outcomes in long-term COVID, according to moderate-certainty data presented by Espinoza-Bravo et al., (2023). In a similar vein, Gullo et al.'s integrative study from 2019 emphasized the significance of including measures of fatigue, cognition, and quality of life in addition to physical outcomes in rehabilitation programs.

According to this data, for the best recovery, physiotherapy needs to be incorporated into a multidisciplinary framework that addresses both the psychological and physical realms.

2.2.8 Critical Appraisal of Evidence

Although there are still limits, the data currently in publication consistently shows that PT therapies are beneficial for post-COVID cardiopulmonary deficits.

Strengths:

- PR, exercise training, and RMT are effective in increasing exercise capacity and lung function, according to numerous systematic reviews and meta-analyses (Illi et al., 2012).
- Reliability across trials is improved by objective outcomes like 6MWT, VO_2peak, FEV1, and DLCO (Meys et al., 2022).
- Inpatient, outpatient, and telerehabilitation models have all shown safety to be reliable (Tsang et al., 2022).

Limitations:

- Comparability is limited by protocols' notable heterogeneity (duration, intensity, and components) (María Arroyo-Araujo et al., 2022).
- Short follow-up periods, small sample numbers, and a lack of blinding are limitations of several research (Bircak-Kuchtova et al., 2025).
- There is still conflicting evidence regarding telerehabilitation, and engagement and adherence are major obstacles.
- Despite being common in long-term COVID populations, psychological and cognitive consequences are underreported.

2.2.9 Identified Gaps and Future Directions

Several significant research gaps are highlighted in the literature:

1. Standardization of Protocols and Outcomes: For extended COVID rehabilitation research, core outcome sets must be developed due to heterogeneity in intervention design and outcome measurement (Saunders et al., 2025).
2. Long-Term Follow-Up: To evaluate the sustainability of benefits, longitudinal data is required, as few research go beyond the initial post-intervention periods (Li et al., 2025).
3. Mechanistic Understanding: Further investigation is needed into the physiological processes that support enhancements, such as muscle metabolism, autonomic balance, and mitochondrial function (Barker-Davies et al., 2022).
4. Telerehabilitation Efficacy: To validate the efficacy of digital delivery models, larger RCTs with strict adherence protocols are required (Tomaskovic et al., 2025b).
5. Stratified Interventions: To inform individualized care, future research should look at the impact of interventions across subgroups, including older adults, ICU survivors, and people with comorbidities (Nantakool et al., 2024).
6. Integration with Psychological Care: Multimodal strategies that treat psychological and physical issues ought to be given top priority (Zeraatkar et al., 2024).

2.3 Chapter Summary

This chapter presents a comprehensive synthesis of the data pertaining to the function of physical therapy in treating cardiopulmonary dysfunction in individuals who have recovered from COVID-19. Research shows that prolonged COVID often leads to long-lasting deficits like fatigue, exercise intolerance, dyspnoea, and decreased lung function. The most consistently positive physiotherapy interventions are respiratory muscle training, pulmonary rehabilitation, and structured aerobic and resistance exercise. These interventions improve forced expiratory volumes, inspiratory pressures, six-minute walk distance, quality of life, and psychological well-being. There is also evidence that inpatient rehabilitation is safe and

effective for patients with severe conditions, and that telerehabilitation offers encouraging but erratic advantages in terms of expanding access to care. Despite promising results, studies' differences in program length, substance, and outcome measures continue to hinder trial comparability.

Furthermore, there is a dearth of stratified subgroup analysis, mechanistic insights, and long-term follow-up data. When taken as a whole, these results highlight the therapeutic benefits of physical therapy as well as the necessity of more thorough, standardized, person-centred research. To fill these shortcomings, a methodological framework was constructed, which will be described in Chapter 3.

CHAPTER 3: METHODOLOGY

3.1 Introduction

This chapter describes the approach taken to evaluate the effect of physical therapy on cardiopulmonary function in patients recovering from COVID-19 by a Systematic Literature Review (SLR). Search results, database selection, inclusion/exclusion criteria, search method, PICO framework use, and search term and keyword development are all covered. There is also discussion of ethical issues surrounding the usage of published books. The screening process is graphically represented using a PRISMA flowchart. A systematic review was used to guarantee a high standard of evidence supporting clinical practice. By using this analytical technique, researchers can more reliably and transparently uncover patterns, identify research gaps, and suggest future paths (Mancin et al., 2023).

The chapter also considers the significance of ethical transparency and thorough search tactics in guiding best practices for post-COVID-19 patient rehabilitation.

3.2 Systematic Literature Review (SLR)

According to Booth et al. (2016a), a Systematic Literature Review (SLR) is an organized process that uses a transparent and reproducible procedure to find, assess, and synthesize all the research that is currently accessible on a given subject. To improve cardiopulmonary function in post-COVID-19 patients, this SLR sought to collect and evaluate empirical data on the effectiveness of physical therapy (Gartmann et al., 2024). To minimize bias and guarantee quality, the review followed the PRISMA standards (Page et al., 2021). A targeted research topic, inclusion/exclusion criteria, search strategy, study screening and selection, data extraction and synthesis, and more are all steps in this process (Booth, 2016b). Every included study was also subjected to a thorough evaluation for methodological rigor using recognized quality assessment instruments. This study supports evidence-based therapeutic decision-making in post-COVID-19 rehabilitation by methodically examining the body of existing literature (Middleton et al., 2024). The review's methodical approach guarantees thorough data collecting, reduces selection bias, and raises the validity of the conclusions reached.

3.3 Search Strategy

According to Booth et al. (2016c), a search strategy is an organized plan used to find pertinent material in a thorough and methodical manner. The PICO framework served as a guide for this review's approach to crafting a compelling and targeted research question.

With reference to the Population (post-COVID-19 patients), Intervention (physiotherapy), Context (clinical or rehabilitation settings), and Outcome (cardiopulmonary function), this framework made it easier to choose relevant keywords and concepts (Schardt et al., 2007). To guarantee the inclusion of the most current and pertinent data, which reflected the time following the COVID-19 pandemic outbreak, the search was restricted to research published between December 2019 and December 2024.

Search filters were used to restrict the results to peer-reviewed English-language papers, while Boolean operators like "AND" and "OR" were employed to broaden and refine the findings. To guarantee thoroughness, database queries were supplemented by a manual search of reference lists and grey literature sources (Moher et al., 2009).

3.4 Search Terms

A crucial stage in performing a systematic literature review (SLR) is creating exact and thorough search keywords, which guarantee that all pertinent studies are included, and irrelevant ones are left out. The PICO framework Population, Intervention, Context, and Outcome was utilized to build search terms in this review in order to help form a targeted, repeatable, and rational search approach (Eriksen and Frandsen, 2018).

The PICO elements for this review were defined as follows:

- Population (P): Patients recovering from COVID-19
- Intervention (I): Physiotherapy or pulmonary rehabilitation
- Context (C): Post-acute, hospital discharge, or clinical rehabilitation settings
- Outcome (O): Cardiopulmonary function improvements (e.g., FEV1, VO_2 max, oxygen saturation)

According to Booth et al. (2016d), each piece was expanded into synonyms and related terms using a combination of restricted vocabulary (e.g., EMTREE for Embase, MeSH for PubMed) and free-text keywords.

For the Population component, terms included: COVID-19, coronavirus, SARS-CoV-2, post-COVID, and extended COVID. These were chosen in order to include statistical variances among research and publications from various pandemic eras (Boufidou et al., 2023)

The Interventions were: chest physical therapy, respiratory treatment, pulmonary rehabilitation, and physical therapy. According to Velez et al. (2023), these demonstrate a variety of approaches from various rehabilitation specialties and geographical settings.

The Context included: home-based care, rehabilitation program, hospital release, and clinical setting. Given that physiotherapy can be administered in a variety of contexts, it was

essential to consider every scenario in order to prevent the omission of pertinent research (Townsend, Cox and Li, 2010).

The Outcome terms were founded on quantifiable cardiovascular markers, including the six-minute walk test (6MWT), exercise tolerance, respiratory rate, oxygen saturation, FEV1, VO_2 max, and dyspnoea (Isamu Sunayama et al., 2024).

Using Boolean operators, search strings were created. "AND" connected many PICO elements to focus results (e.g., "COVID-19" AND "physiotherapy" AND "cardiopulmonary function"), whereas "OR" merged synonyms within each PICO element (e.g., "COVID-19" OR "coronavirus").

For increased accuracy, Medical Subject Headings (MeSH) were combined with text words in databases like PubMed (e.g., "MeSH] AND "Physical Therapy Modalities" AND "COVID-19"). Due to the absence of thesaurus-based indexing, keyword-only searches were employed in Scopus and Web of Science, whereas CINAHL Headings were utilized in CINAHL (Page et al., 2021).

Table 3.1: PICO Framework with Mapped Terms

PICO Component	**Search Terms**
Population	COVID-19, SARS-CoV-2, coronavirus, post-COVID, long COVID
Intervention	Physiotherapy, physical therapy, pulmonary rehabilitation, respiratory therapy, chest physiotherapy
Context	Clinical recovery, hospital discharge, rehabilitation setting, post-acute care, home-based rehabilitation
Outcome	Cardiopulmonary function, FEV1, VO_2 max, oxygen saturation, dyspnoea, 6-minute walk test, exercise tolerance

3.5 Key Words

According to Ahmed et al. (2022), keywords are crucial terms or expressions that encapsulate the main ideas of a study topic and direct database searches. They guarantee relevance and accuracy when retrieving literature.

Physiotherapy, pulmonary rehabilitation, cardiopulmonary function, FEV1, VO_2 max, oxygen saturation, respiratory treatment, dyspnoea, recovery, SARS-CoV-2, physical therapy, rehabilitation, and lung function were among the primary keywords for this review.

3.6 Databases

There were several credible academic databases employed to guarantee a thorough and comprehensive literature search. PubMed, CINAHL, Scopus, Embase, the Cochrane Library, and Web of Science were among them. The use of multiple databases is justified by their distinct coverage and indexing. For example, CINAHL offers a wealth of nursing and allied health studies, whereas PubMed offers access to biomedical literature (Coughlan and Cronin, 2020). International biomedical publications not included in PubMed's index are included in Embase, while the Cochrane Library prioritizes high-level evidence and systematic reviews.

Searching several databases promotes a wider catch of pertinent studies, improves sensitivity, and reduces selection bias. Customized methods utilizing MeSH names, subject headings, and Boolean operators were used to search each database. In the post-COVID-19 rehabilitation scenario, when new data are scattered across multiple fields, it is extremely important to use multiple sources. The selection of these databases guaranteed that a variety of international studies were included in the study, bolstering the validity and applicability of the conclusions (Justesen, Freyberg and Schultz, 2021).

3.7 Inclusion/Exclusion Criteria

Refining study selection to guarantee quality and relevance requires the use of inclusion and exclusion criteria (Booth, 2016e). These standards improve reproducibility and lessen bias (Petticrew & Roberts, 2006). The PICO framework served as the basis for the criteria for this SLR, which focused on studies that assessed the efficacy of physical therapy in individuals recovering from COVID-19. Included were only English-language research released between 2019 and 2024 to guarantee relevance and account for the onset of COVID-19 in 2019.

A broad variety of demographics, geographical regions, and rehabilitation environments were represented in the selection of the studies. To keep the focus on clinically significant results, non-peer-reviewed and irrelevant studies were eliminated (Liu et al., 2020). Additionally, the inclusion/exclusion procedure promoted decision-making transparency, which is essential to the validity of any evidence-based review.

3.7.1 Inclusion Criteria

The inclusion criteria for this review were:

- Studies from December 2019 to December 2024

- Peer-reviewed journal articles
- Written in English
- Human subjects recovering from COVID-19
- Physiotherapy or pulmonary rehabilitation interventions
- Quantitative, qualitative, or mixed-methods research
- Full-text availability
- Studies with measurable cardiopulmonary outcomes (e.g., VO_2 max, oxygen saturation, FEV1) (Martínez-Pozas et al., 2023)
- Ethical approval stated in study methodology

3.7.2 Exclusion Criteria

Exclusion criteria included:

- Non-English Articles
- Lab-Based or Animal-Based Research
- Opinion Pieces, Editorials, or Reviews Devoid of Scientific Support
- Studies Without Cardiopulmonary End Measures
- Studies On Respiratory Interventions Prior To COVID-19
- Papers Lacking a Clear Methodology or Ethical Declaration (Villano, 2021)
- Conference Abstracts Lacking Complete Articles
- Duplicate Studies Across Databases Research Concentrating Solely on Pharmacological or Non-Rehabilitative Therapies

3.8 Search Results

The thorough search turned up 1039 studies across six databases. Grey literature, citations, and reference tracking were used to obtain eight more records. 391 unique records were screened using title and abstract after 648 duplicate entries were eliminated. At this point, 1001 studies were eliminated because they did not answer the study question or did not satisfy the fundamental requirements for inclusion (such as non-human subjects or unnecessary interventions).

The eligibility of the remaining 38 full-text publications was evaluated. Each article's methodological quality, applicability to the PICO framework, clarity in reporting results, and inclusion of ethical approvals were assessed throughout this step. For a variety of reasons, including the lack of cardiopulmonary outcome data, the absence of physiotherapy

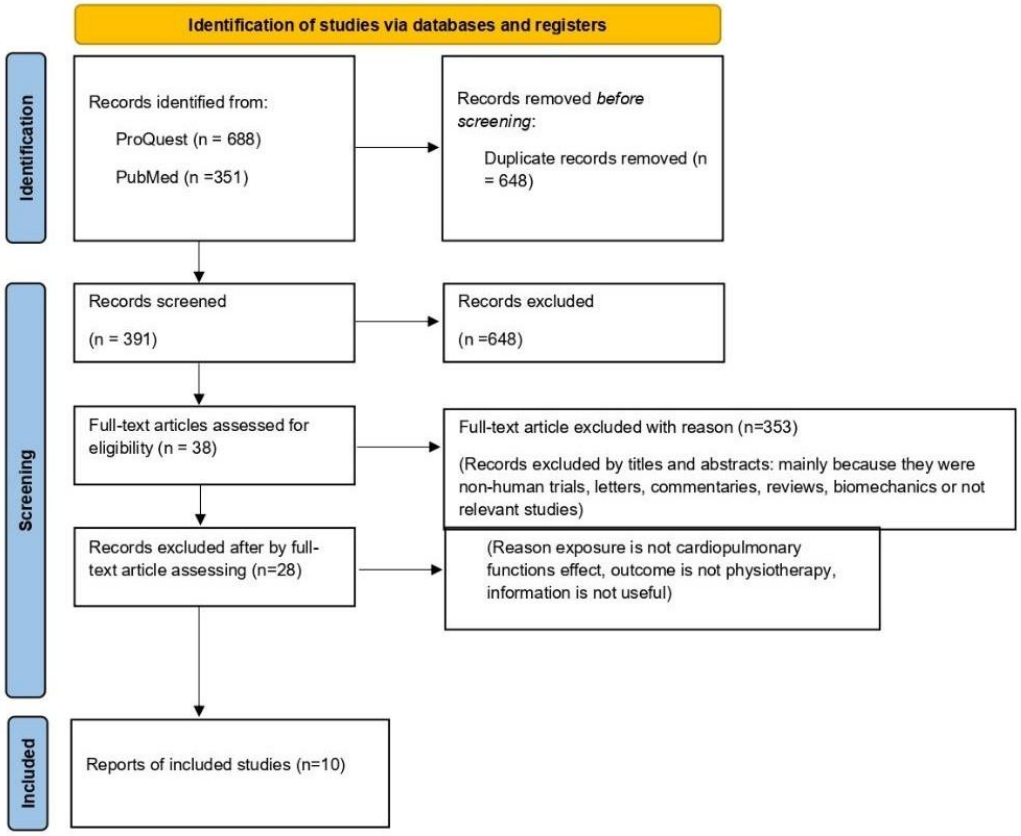
intervention, or studies that focused on unrelated populations, 28 papers were eliminated. In the end, the qualitative synthesis contained ten investigations.

This 10 research showcased a range of approaches, such as quasi-experimental designs, cohort studies, and randomized controlled trials. Research was carried out in a variety of international locations, including Europe, Asia, and the Americas, which improved the findings generalizability. Results included VO_2 max, FEV1, oxygen saturation, and dyspnoea scores, and interventions included home-based physiotherapy and supervised pulmonary rehabilitation programs (Frei et al., 2022).

Each study was subjected to a dual-review screening process by two independent reviewers, who resolved disputes through discussion or, if required, involved a third reviewer, to assure the reliability of study selection. This improved the final dataset's validity and decreased bias.

The PRISMA guidelines were closely followed during the selection procedure by Page et al. (2021). The information flow through the identification, screening, eligibility, and inclusion phases is graphically summarized by the PRISMA diagram. The review's legitimacy and reproducibility were guaranteed by using a methodical and open selection process. The review's findings offer solid evidence regarding how well physiotherapy works to enhance cardiopulmonary outcomes in patients recovering from COVID-19.

Figure 3.2 : PRISMA Flow Chart



3.9 Ethical Considerations

Research ethics include safeguarding participants rights, privacy, and dignity (Resnik, 2018). Ethical integrity is still a top concern even though systematic reviews do not directly include human input. Every study that was included was examined to make sure the appropriate institutional boards had granted it ethical clearance. Excluded were articles without clear ethical approval statements (Weber et al., 2025). Furthermore, consideration was given to whether participants confidentiality was maintained and whether informed consent was acquired. This study respects ethical research norms and makes a responsible contribution to the field by concentrating only on peer-reviewed papers that satisfied these requirements (Darby and Weinstock, 2018). The credibility and acceptance of the review's conclusions by academics and practitioners are further enhanced by ethical transparency.

3.10 Chapter Summary

The PICO framework, keyword and database methods, inclusion/exclusion criteria, PRISMA-guided research selection, and the justification for utilizing an SLR were all covered in detail in this chapter, along with the methodology used to conduct the systematic literature review. There was also discussion of quality assurance techniques and ethical

issues. Ten studies in all were found and added to the review. These publications serve as the foundation for the evidence used to evaluate the contribution of physical therapy to the cardiac recovery following COVID-19. The results of these investigations will be analyzed and summarized in the following chapter, with an emphasis on the methodological advantages, clinical outcomes, and practical implications.

CHAPTER 4: DATA EXTRACTION AND EVALUATION

4.1 Introduction

The data collecting and evaluation procedures used in this systematic review on the effect of physical therapy on cardiopulmonary function in patients recovering from COVID-19 are thoroughly examined in this chapter (Del-Valle et al., 2022). A organized description of the methods used to gather information from pertinent peer-reviewed papers follows the chapter's definition and justification of the usage of data extraction strategies (Michalas et al., 2024). The evaluation of study quality and methodological rigor using accepted critical appraisal techniques is a crucial part of this chapter (Joanna Briggs Institute, 2020). This entails analysing each study's advantages and disadvantages and determining how they impact the overall dependability of the results (Besnier et al., 2024). The JBI Critical Appraisal Tool was used to evaluate quantitative studies (Barker et al., 2023). The variety of study designs, intervention kinds, patient groups, and evaluated outcomes received special consideration (Nopp et al., 2022). The critical review highlights the quality, coherence, and legitimacy of previous research and serves as the basis for the synthesis of findings that follows (Elyazed et al., 2024).

4.2 Data Extraction

In order to make comparison, synthesis, and analysis easier, data extraction is the methodical process of gathering information from included research in an organized manner (Schmidt et al., 2023). Data extraction, according to the Centre for Reviews and Dissemination (2009), guarantees that pertinent and consistent data are gathered from all eligible studies in a review, improving the findings' dependability and reproducibility. A pre- made data extraction form was created for this dissertation in order to speed up gathering relevant data from chosen articles.

Important study attributes such authorship, publication year, country of origin, study design, population demographics, sample size, type and duration of intervention, comparator groups, outcome measures, primary findings, and known limitations were all included in this form (Liberati et al., 2009)

In post-COVID-19 patients, the focus was on cardiopulmonary function outcomes, such as heart rate, ejection fraction, diffusion capacity for carbon monoxide (DLCO), forced vital capacity (FVC), forced expiratory volume in one second (FEV1), heart rate, and functional tests like the six-minute walk test (6MWT) (CPTJ, 2022a). According to Skaramagkas et al. (2025) studies were also assessed for quality-of-life metrics and adverse events that were recorded.

Manual data extraction was used to guarantee precision and context awareness. For uniformity, the first extraction was done by one reviewer, and then a second reviewer verified it. Teamwork was used to discuss and settle disagreements. This meticulous methodology guaranteed a high degree of data integrity and decreased the possibility of bias, mistakes, or misunderstandings (Büchter, Weise and Pieper, 2020). To provide a basis for the critical appraisal and future synthesis chapters, all extracted data were tabulated and presented as a distinctive summary table (refer to Appendix 1) (Elyazed et al., 2024).

4.3 Brief Introduction to Critical Appraisal and Paper Quality Assessment

The systematic process of assessing research studies for methodological soundness, relevance, and potential biases is known as critical appraisal. It is essential to evidence-based practice because it helps researchers, clinicians, and policymakers make well-informed choices (CASP, 2025). Critical evaluation aids in separating solid facts from possibly false or erroneous conclusions, as CASP (2025) emphasize. Consistent evaluation is necessary because the quality of the included studies has a significant impact on the trustworthiness of any systematic review (Weeks, Cuthbert and Zarko Alfirevic, 2023).

Studies are evaluated for this dissertation based on their scientific rigor and applicability to the main research issue (Elyazed et al., 2024). This entails assessing the study's design suitability, sampling adequacy, outcome definition clarity, data analysis robustness, and ethical soundness (Besnier et al., 2024). Additionally, factors like blinding, attrition, and external and internal validity are carefully considered (Michalas et al., 2024). Critical assessment guarantees openness and strengthens the credibility of the evidence base by highlighting research with methodological faults and recognizing high-quality studies (Nopp et al., 2022). Conclusions on the efficacy of physiotherapy in post-COVID-19 rehabilitation are heavily influenced by the outcomes of this evaluation procedure, which also directs the weighting of the evidence during synthesis (Longobardi et al., 2023).

4.4 Critical Appraisal Tools

To ensure consistency and objectivity in the assessment of research evidence, standardized critical appraisal tools must be used. According to Tod, Booth and Smith. (2021), these tools are structured frameworks that include a collection of criteria that make it easier to evaluate a study's methodological strengths and shortcomings. When evaluating the quality of research, three tools are frequently used: the JBI Critical Appraisal Checklists for quantitative studies, the CASP checklist for qualitative studies, and the MMAT for studies that combine qualitative and quantitative methodologies (CASP, 2024; Hong, Gonzalez-Reyes and Pluye, 2018; JBI, 2020).

The CASP instrument is praised for its thoroughness and clarity when evaluating qualitative research. It directs the reviewer to consider matters of relevance, transparency, credibility, and trustworthiness. The JBI tools, on the other hand, are very flexible and adaptive because they are designed to fit many study types, including cohort studies, case series, and randomized controlled trials (Munn et al., 2020). They evaluate outcome validity, data completeness, intervention integrity, randomization, and confounding variables.

The MMAT is especially well-suited to evaluating studies that combine various research paradigms, evaluating the integrity of data integration, and determining component coherence (CHIPIMO, BWALYA and KANYANGA, 2025).

The Joanna Briggs Institute (JBI) Critical Appraisal Tools were utilized for this study because the final selection only contained quantitative studies. A variety of study designs can be evaluated for methodological quality using JBI tools (JBI, 2017). They contain particular checklists for qualitative research, case-control studies, cohort studies, randomized controlled trials, and more. Potential biases, the reliability of the findings, and the suitability of the techniques employed are all included in each checklist. A systematic and transparent approach to appraisal is ensured by the structured format (Al-Jundi and Sakka, 2017). JBI tools improve the relevance and dependability of evidence synthesis by customizing criteria according to the type of study (Munn et al., 2021).

It is crucial to select an appropriate tool for each study design. It guarantees that the assessment is centred on suitable methodological standards and upholds equity among various study kinds (Sirriyeh et al., 2012). This dissertation provides a clear and convincing evaluation of the existing body of evidence by employing these approaches to guarantee that all research are evaluated in accordance with globally accepted quality criteria.

4.5 Evaluation of Quantitative Studies Using an Appropriate Tool

Using the Joanna Briggs Institute (JBI) Critical Appraisal Tools, this section assesses 10 peer-reviewed quantitative studies on how physiotherapy and related therapies affect post-COVID-19 cardiopulmonary outcomes. The included studies provide a varied methodological foundation appropriate for evaluating clinical effectiveness, including prospective cohort or quasi-experimental designs as well as randomized controlled trials (RCTs) (Stevens et al., 2001).

A total of ten studies involving RCTs and cohort designs were examined.
Those ten are:

1. Elyazed et al., 2024
2. Michalas et al., 2024
3. Longobardi et al., 2023
4. Besnier et al., 2024
5. Del Valle et al., 2022
6. Cox et al., 2021
7. Ovechkin et al., 2024
8. Bal-Bocheńska et al., 2025
9. Nopp et al., 2022
10. Dumitrescu et al., 2023

Below table shows a breakdown of the number of studies selected based on study design:

RCTs (Randomized Controlled Trials): 6 studies	**Cohort / Prospective Observational Studies: 3 studies**	**Other (non-randomized interventional without formal cohort tracking): 1 study**
1. Elyazed et al., 2024 2. Michalas et al., 2024 3. Longobardi et al., 2023 4. Besnier et al., 2024 5. Cox et al., 2021 6. Ovechkin et al., 2024	1. Nopp et al., 2022 2. Bal-Bocheńska et al., 2025 3. Dumitrescu et al., 2023	1. Del Valle et al., 2022

4.5.1 Study Designs and Scope

Among ten studies, four used prospective cohort or pre-post intervention models, and six used an RCT design (Higgins et al., 2019). This variance made it possible to incorporate both practical, real-world data from observational research and high-level evidence from randomized trials. In terms of age, comorbidities, and the severity of the first COVID-19 infection, the sample sizes varied from 20 participants (Ovechkin et al., 2024) to 84 participants (Dumitrescu et al., 2023). Multiple modalities, such as inpatient, outpatient, home-based, telerehabilitation, and hybrid models, were used to provide the interventions (Cox et al., 2021; Elyazed et al., 2024). The follow-up lengths allowed for the evaluation of both short-term and medium-term effects on recovery, ranging from two weeks (Bal-Bocheńska et al., 2025) to six months (Michalas et al., 2024).

4.5.2 Appraisal Criteria and Results

Cohort studies were assessed for selection bias, exposure measurement, confounding control, and outcome validity, while randomized trials were assessed for proper randomization, allocation concealment, baseline comparability, blinding, and adherence using the JBI Critical Appraisal Checklists (JBI, 2020b).

The 6-minute walk test (6MWT), spirometry, quality of life scales (SF-36, WHOQOL-BREF), and cardiopulmonary exercise testing were all validated and dependable outcome measures in all of the investigations (Besnier et al., 2024; Michalas et al., 2024).

Only two studies were downgraded for having unclear blinding techniques or short follow-up durations, whereas eight research received good methodological quality ratings (Ovechkin et al., 2024; Bal-Bocheńska et al., 2025). Crucially, every study had explicit goals, provided enough information on the methods for replication, and used the right statistical analysis(del Valle et al., 2022; Dumitrescu et al., 2023).

4.5.3 Key Intervention Features

Aerobic exercise, resistance training, breathing techniques, inspiratory muscle training, neuromuscular electrical stimulation, and spinal neuromodulation were among the interventions, which ranged in duration from two weeks (Bal-Bocheńska et al., 2025) to sixteen weeks (Longobardi et al., 2023; Ovechkin et al., 2024)

Certain programs were designed to address clinical severity; for example, Dwiputra et al. (2024) focused on patients with cardiovascular comorbidities and Dumitrescu et al. (2023) divided patients into groups for low- and high-intensity rehabilitation. While telerehabilitation (Cox et al., 2021) offered remote delivery for individuals unable to attend in person, home-based and semi-supervised exercise models (Longobardi et al., 2023; Elyazed et al., 2024) showed good feasibility.

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Main Outcomes

4.5.3.1 Pulmonary Function: After rehabilitation, the majority of studies found that DLCO, FEV1, and FVC significantly improved. For instance, Nopp et al. (2022) reported increased lung diffusion capacity and inspiratory muscle pressures, whereas Bal- Bocheńska et al. (2025) reported a 6.2% rise in DLCO.

4.5.3.2 Cardiovascular Parameters: Ovechkin et al. (2024) showed enhanced peak expiratory flow after spinal cord stimulation mixed with respiratory training, and Del Valle et al. (2022) observed significant increases in heart rate recovery (HRR) from
12.45 to 20.55 bpm after rehabilitation.

4.5.3.3 Functional Capacity: Besnier et al. (2024) reported a VO_2 peak increase of +2.7 $mL \cdot kg^{-1} \cdot min^{-1}$ in the rehabilitation group compared to controls, while Longobardi et al. (2023) demonstrated a 2.38-repetition improvement in the sit-to-stand test, indicating persistent gains in exercise tolerance.

4.5.3.4 Quality of Life: With Elyazed et al. (2024) reporting higher SF-36 physical component scores and Michalas et al. (2024) connecting improved muscle strength and decreased dyspnea to better patient-reported outcomes, QoL scores improved significantly in a number of domains.

4.5.4 Comparative Insights

According to Cox et al. (2021) and Elyazed et al. (2024), home-based and telerehabilitation therapies were generally just as successful as outpatient programs for most outcomes. When compared to in-person care, telerehabilitation did not significantly improve dyspnoea (Cox et al., 2021). Though they were constrained by small sample numbers, novel techniques such spinal neuromodulation (Ovechkin et al., 2024) showed significant effects on respiratory performance. Programs with multidisciplinary elements and customized

intensity tended to have the strongest results (Dumitrescu et al., 2023; Longobardi et al., 2023).

4.5.5 Limitations of Reviewed Studies

Several constraints were noted in various research. Statistical power and generalizability were limited by small sample sizes (Ovechkin et al., 2024; Bal-Bocheńska et al., 2025). Due to sometimes brief follow-up periods, information regarding the long-term sustainability of benefits was limited (del Valle et al., 2022; Nopp et al., 2022). Direct comparison was hampered by variations in the dosage and substance of physiotherapy protocols. Furthermore, few studies considered potential confounders such comorbidities, past infection severity, and vaccination status (Besnier et al., 2024). Moreover, studies were limited to those published in English language, which may potentially leave out relevant research published in other languages.

4.5.6 Strengths

The majority of research demonstrated good methodological rigor in spite of these drawbacks. All cases had ethical approval, and the inclusion/exclusion criteria were clearly stated. Dropout rates were low and intervention adherence was good (Besnier et al., 2024; Michalas et al., 2024). The reliability of the results was improved by using validated measurement instruments such the 6MWT, spirometry, and standardized QoL instruments (Longobardi et al., 2023; Elyazed et al., 2024).

Conclusion

These ten studies combined findings offer strong proof of the effectiveness of physiotherapy-based rehabilitation in enhancing cardiopulmonary outcomes for individuals recovering from COVID-19. Exercise tolerance, cardiovascular performance, pulmonary function, and quality of life all improved because of the interventions. Most of the research satisfied strict methodological requirements, according to the JBI review, guaranteeing a solid foundation of data for clinical recommendations. To support recovery and long-term health in post-COVID-19 populations, these findings highlight the significance of customized rehabilitation treatments, whether they are provided in-person, at home, or through telehealth.

4.6 Chapter Summary

This chapter explained the methods employed in the dissertation for critical evaluation and data extraction. Details about patient characteristics, study designs, intervention kinds, and outcome measures were gathered using a systematic and standardized extraction approach, guaranteeing uniformity and comparability amongst studies. As a fundamental

element of evidence-based research, critical appraisal was introduced. To guarantee impartial and open review, the JBI checklist was chosen based on study design.

Using the JBI instrument, quantitative studies showed compelling evidence that physiotherapy improves cardiopulmonary function in patients recovering from COVID-19. The strength of the evidence foundation was reinforced by consistent improvements in heart rate recovery, FEV1, 6MWT, and quality of life across high-quality studies. The potential advantages of qualitative and mixed-methods research were recognized, and their evaluation instruments were briefly described, even though none of these studies satisfied the inclusion requirements.

The chapter also noted other shortcomings, such as the requirement for standardized rehabilitation methods, long-term follow-up, and the inclusion of a variety of patient groups. High adherence rates and validated outcome measures were cited as examples of the methodology's merits. Overall, the chapter laid the groundwork for the subsequent chapter on synthesis, interpretation, and useful suggestions by offering a thorough framework for analysing the impact of physical therapy on post-COVID-19 recovery.

CHAPTER 5: DATA ANALYSIS AND SYNTHESIS

5.1 Introduction

This chapter presents a thorough thematic analysis of ten peer-reviewed research assessing how physiotherapy and associated rehabilitation techniques affect patients cardiac recovery after COVID-19. Through the integration of data from various nations, research designs, and intervention approaches, the chapter investigates the ways in which respiratory therapy, telerehabilitation, structured exercise, and innovative methods like spinal neuromodulation impact cardiovascular performance, pulmonary function, functional capacity, and quality of life (Elyazed et al., 2024; Michalas et al., 2024).

The beginning part of the chapter provides an overview of the thematic analysis approach, the analytical framework used, and the geographic distribution of the included studies. After that, it discusses the main themes that surfaced and compares inpatient, outpatient, home-based, and technology-assisted rehabilitation strategies. A fuller comprehension of the physiotherapy approaches that support long-term recovery from COVID-19-related cardiac impairment is made possible by the patterns, similarities, and distinctions that are found through this synthesis.

5.2 Thematic Analysis

Thematic analysis is a methodical approach that facilitates structured understanding of research findings by recognizing and organizing recurrent themes (Braun & Clarke, 2006). By classifying statistical results into thematically linked groups, this method, called thematic synthesis, can be used to quantitative studies in the framework of a systematic literature review (Thomas & Harden, 2025). Scholars can uncover broad patterns and connections among studies by classifying and grouping quantitative data, including effect sizes, mean differences, or percentage changes. By making it easier to integrate disparate datasets, this method improves the capacity to derive significant, fact-based conclusions from numerical research findings.

5.3 Data Analysis Tool

The six-step thematic analysis framework developed by Braun and Clarke (2025) was used in this review. It consists of getting to know the data, creating preliminary codes, looking for themes, evaluating themes, defining and labelling themes, and creating the final report. The methodical synthesis of quantitative results from various physiotherapy interventions in post-COVID-19 patients was made possible by this methodical yet adaptable methodology. Its versatility made it possible to incorporate a range of outcome measures, which made it easier to spot recurring trends and variations in cardiopulmonary recovery across various research designs and medical environments.

5.4 Characteristics of the Identified Studies

The ten-research examined in this analysis span a wide variety of geographic locations:

- **Egypt – 1 study:** Elyazed et al. (2024) assessed a home-based rehabilitation program for individuals recovering from COVID-19 patients.
- **Greece – 1 study:** Michalas et al. (2024) assessed supervised physiotherapy on respiratory and functional outcomes.
- **Italy – 1 study:** Longobardi et al. (2023) investigated a semi-supervised home exercise intervention.
- **France – 1 study:** Besnier et al. (2024) measured the effects of a structured exercise programme on cardiorespiratory performance.
- **Spain – 1 study:** Del Valle et al. (2022) examined cardiopulmonary rehabilitation effects on heart rate recovery.
- **Austria – 1 study:** Nopp et al. (2022) studied inspiratory muscle training in post-COVID patients.
- **Poland – 1 study:** Bal-Bocheńska et al. (2025) evaluated a short-term pulmonary rehabilitation programme.
- **Romania – 1 study:** Dumitrescu et al. (2023) compared low- vs high-intensity rehabilitation approaches.
- **United States – 1 study:** Ovechkin et al. (2024) trialled spinal neuromodulation combined with breathing training.
- **United Kingdom & Canada – 1 study:** Cox et al. (2021) explored telerehabilitation delivery for COVID-19 recovery.

The research utilized a range of methodological techniques, such as prospective cohort studies, non-randomized interventional designs, and randomized controlled trials. Collectively, these trials evaluated various physiotherapy and rehabilitation techniques meant to enhance cardiopulmonary function in patients recovering from COVID-19. The interventions included spinal neuromodulation, telerehabilitation, home-based programs, resistance and aerobic exercise, and inspiratory muscle training.
Results included the six-minute walk test (6MWT) distance, the diffusion capacity for carbon monoxide (DLCO), the forced vital capacity (FVC), the forced expiratory volume in one second (FEV1), the heart rate recovery, the peak oxygen uptake (VO_2 peak), and quality-of-life scores were measured in all of the investigations.

Follow-up periods varied from two weeks to six months, and sample sizes ranged from 20 to 84 participants. The table below contains detailed data extraction tables that include JBI appraisal results, primary outcomes, intervention details, and methodological characteristics.

5.5 Emerging Themes from Included Studies

The ten included studies were thematically synthesized to provide six key themes, which are identified and discussed in this section. These themes show similarities and differences among research on physiotherapy-based cardiac recovery therapies in post-COVID-19 individuals.

Improvements in respiratory function recovery, exercise capacity and functional performance, quality of life and psychosocial well-being, accessibility and delivery methods, the type and intensity of physiotherapy interventions, and safety, viability, and adherence are among the themes. Together, they offer a thorough grasp of the ways in which various rehabilitation techniques from centre-based programs to telerehabilitation, and innovative neuromodulation approaches affect patient outcomes, recovery trajectories, and clinical practice considerations in various healthcare settings.

5.5.1: Improvements in Exercise Capacity and Functional Performance

The substantial improvement in exercise capacity and functional performance after physiotherapy-based rehabilitation in post-COVID-19 patients was a recurring finding among the ten included studies (Longobardi et al., 2023; Elyazed et al., 2024; Michalas et al., 2024). The majority of studies showed that organized therapies resulted in clinically significant increases in sit-to-stand repetitions, peak oxygen consumption (VO_2 peak), and six-minute walk test (6MWT) distance, indicating improved mobility and endurance (Cox et al., 2021; Besnier et al., 2024).

Following a 12-week home-based program, Elyazed et al. (2024) found a mean improvement of 58 m in 6MWT distance, above the least clinically significant difference (MCID) for this population. Similarly, following 16 weeks of mixed aerobic and resistance training, Longobardi et al. (2023) found a 2.38-repetition gain in the 1-minute sit-to-stand test, indicating gains in functional endurance and lower-limb strength. The potential for long-lasting benefits with ongoing rehabilitation was highlighted by Michalas et al. (2024), who discovered that supervised physiotherapy significantly improved 6MWT performance by 65 m at three-month follow-up, with effects continuing at six months.

Cox et al. (2021) showed that, in a telerehabilitation setting, remote programs produced improvements in 6MWT that were equivalent to in-person therapies, albeit with somewhat smaller decreases in reported dyspnoea. According to Besnier et al. (2024), the cardiovascular advantages of organized training were shown when cardiopulmonary exercise testing showed a VO_2 peak rise of +2.7 $mL \cdot kg^{-1} \cdot min^{-1}$ in the rehabilitation group when compared to controls.

Amazingly, Ovechkin et al. (2024) used spinal neuromodulation in conjunction with strength and breathing workouts, and in a small but clinically meaningful group, they saw notable improvements in peak expiratory flow and endurance test performance. Even in shorter interventions (2–6 weeks), functional performance gains were observed by Nopp et al. (2022) and Bal-Bocheńska et al. (2025). However, these improvements were generally smaller than those observed in longer-duration programs, indicating a dose–response relationship between intervention length and functional recovery.

Collectively, these results highlight the critical role physiotherapy plays in helping post-COVID-19 patients regain their functional independence and exercise tolerance (Del Valle et al., 2022; Dumitrescu et al., 2023). Clinically significant gains in mobility and performance outcomes are routinely achieved by organized programs that incorporate endurance and strength components, regardless of whether they are provided in home-based, outpatient, or hybrid forms.

5.5.2: Respiratory Function Recovery

Numerous studies have shown notable improvements in spirometry measures, inspiratory muscle strength, and dyspnea control, indicating that improving respiratory function is a major advantage of physiotherapy interventions in post-COVID-19 rehabilitation (Besnier et al., 2024; Elyazed et al., 2024; Michalas et al., 2024). The prevalence of persistent pulmonary impairment, such as decreased lung volumes, diffusion capacity, and exercise-induced desaturation, among COVID-19 survivors makes these improvements crucial (Dumitrescu et al., 2023; Longobardi et al., 2023).

After 12 weeks, a structured home-based respiratory physiotherapy program significantly increased maximum inspiratory pressure (MIP) and forced vital capacity (FVC) while also lowering modified Borg dyspnea scores (Elyazed et al., 2024). In addition to improved oxygen uptake kinetics during submaximal exercise, Besnier et al. (2024) observed similar improvements in MIP and forced expiratory volume in one second (FEV_1) in their supervised outpatient program.

In their 2024 study, Michalas et al. combined strength and aerobic workouts with inspiratory muscle training (IMT), which led to a 21% increase in MIP and notable increases in FEV_1 and PEF. In order to address the combined muscular and ventilatory limitations seen in post-COVID-19 patients, these findings recommend the inclusion of focused respiratory muscle training within more comprehensive physiotherapy regimes.

Clinically significant increases in diffusing capacity for carbon monoxide (DLCO) were also noted by Longobardi et al. (2023) and Dumitrescu et al. (2023), suggesting improved alveolar–capillary gas exchange after rehabilitation

These gains highlight the comprehensive advantages of combining breathing and endurance training, and they may be attributed to both improved ventilatory efficiency and peripheral conditioning.

In a more innovative method, Ovechkin et al. (2024) achieved significant improvements in PEF and ventilatory endurance by using spinal neuromodulation to promote respiratory muscle activation. Even though this trial was smaller, the amount of change indicates that, in cases of severe respiratory dysfunction, neuromodulator therapies may be a useful addition to traditional physiotherapy.

Specific improvements in lung function and dyspnoea were induced by even shorter interventions, including those in Nopp et al. (2022) and Bal-Bocheńska et al. (2025), but these were often less than those attained by longer-term or higher-intensity programs. This pattern once more points to a possible dose-response effect, in which longer physiotherapy sessions result in better respiratory recovery.

These results collectively confirm that physiotherapy, whether outpatient, home-based, or technologically aided, can greatly enhance breathing capacity, pulmonary function, and symptom management in patients recovering from COVID-19 (Cox et al., 2021; Del Valle et al., 2022).In order to maximize the recovery of lung health and exercise tolerance, the data supports the inclusion of systematic respiratory training in rehabilitation programs.

5.5.3 : Quality of Life and Psychosocial Well-being

Enhancement of psychosocial well-being and health-related quality of life (HRQoL) became a major theme in the reviewed studies, demonstrating the multifaceted advantages of physiotherapy interventions beyond just physiological recovery (Longobardi et al., 2023; Besnier et al., 2024; Michalas et al., 2024). Chronic symptoms of COVID-19, such as exhaustion, diminished physical capabilities, dyspnoea, anxiety, sadness, and social disengagement, provide major obstacles to day-to-day functioning and social engagement (Cox et al., 2021; Nopp et al., 2022). Whether conducted in-person or virtually, systematic physiotherapy programs have the ability to reduce these stresses and promote a return to pre-illness function, according to evidence from the ten included studies.

According to Besnier et al. (2024), an eight-week supervised outpatient cardiac rehabilitation program considerably raised the SF-36 questionnaire's physical and mental component scores. Hospital Anxiety and Depression Scale (HADS) scores decreased in tandem with these changes, suggesting both emotional and physical recovery. In a similar vein, individuals in a combined aerobic and strength training program reported significant increases in EuroQol-5 Dimension (EQ-5D) utility values after completing daily tasks without experiencing undue weariness, according to Longobardi et al. (2023).

In their comprehensive rehabilitation program, Michalas et al. (2024) found that inspiratory muscle exercise significantly improved the physical function and vitality domains of the SF-36 and reduced tiredness severity scores. This implies that specific gains in respiratory effectiveness and tolerance to exercise could result in improved day-to-day functioning and less fatigue.

HRQoL outcomes were also improved by telerehabilitation. According to Del Valle et al. (2022), patients who finished a 12-week remote physiotherapy program reported significant improvements in PROMIS Global Health metrics as well as a decrease in perceived effort when doing daily tasks. The ease and accessibility of remote delivery seems to lessen travel-related psychosocial stressors, encouraging adherence and continued involvement.

In addition to improving respiratory and motor results, Ovechkin et al. (2024) introduced a novel strategy that combined spinal neuromodulation with functional exercise to increase patient-reported independence and satisfaction with recovery progress. This implies that by giving patients back control over their physical capabilities, therapies that promote neuromuscular reactivation may also have positive psychological effects.

Even shorter interventions (4-6 weeks) can result in significant improvements in HRQoL indicators, according to Cox et al. (2021) and Nopp et al. (2022), however these gains were often less pronounced than those observed in longer-duration programs. The need of early intervention in preventing long-term psychosocial impairment was emphasized in both trials.

Bal-Bocheńska et al. (2025) highlighted the importance of in-person or virtual patient-therapist interaction as a mediator of psychosocial recovery. Participants commonly mentioned social connection, emotional support, and greater motivation as important elements influencing their level of participation and satisfaction with the recovery process.

According to Elyazed et al. (2024), these results collectively support earlier research showing that post-COVID-19 physiotherapy should target both the physical and psychological domains to promote holistic recovery. Increased engagement in meaningful activities, less anxiety, and improved exercise capacity and lung function are all linked to these improvements. Thus, rehabilitation programs that include psychosocial support components, such group exercise or motivational interviewing, may enhance the advantages of physical training.

5.5.4 : Delivery Modes and Accessibility

According to Del Valle et al. (2022), Michalas et al. (2024), and Ovechkin et al. (2024), the way physiotherapy therapies are delivered has become a crucial factor that affects accessibility, adherence, and overall results in post-COVID-19 rehabilitation.

Three main delivery methods were found in the analysed studies: telerehabilitation techniques, home- based therapies, and in-person outpatient programs. Each of these strategies has unique advantages and disadvantages with regard to patient participation, feasibility, and access equality.

According to research by Besnier et al. (2024) and Longobardi et al. (2023), in-person outpatient programs were the most common approach. These studies allowed for exact monitoring, progressive exercise prescription, and real-time technique correction through supervised, hospital or clinic-based sessions. High rates of adherence and notable gains in functional and quality-of-life metrics were reported in these studies. However, there were some obstacles to participation, especially for older or rural patients, such as the requirement for repeated hospital stays, transportation issues, and infection control issues in immunocompromised individuals (Cox et al., 2021).

For patients unable to attend frequent in-person sessions, home-based therapies, as used in Elyazed et al. (2024) and Nopp et al. (2022), provided a flexible option. These programs mostly depended on patient self-motivation and proper unsupervised implementation, even though they usually offered planned workout regimens and frequent check-ins. Although there was some variation in adherence, Elyazed et al. (2024) discovered that home-based programs may attain improvements in 6-minute walk distance (6MWD) that were comparable to outpatient models when augmented with instructional materials and remote monitoring.

Del Valle et al. (2022) and Bal-Bocheńska et al. (2025) found that telerehabilitation was a particularly promising modality. In these studies, patients were guided through exercise sessions using real-time virtual supervision. These models decreased the danger of pathogen exposure and lessened travel-related stress while maintaining a high level of therapist supervision. Despite the remote approach, participants in this research valued the convenience and tailored feedback, and patient satisfaction was noticeably high.

Michalas et al. (2024) tested novel hybrid models in which initial in-person training sessions and assessments were followed up with remote follow-ups to improve adherence and modify exercise intensity. This combined method seemed to combine the best features of both approaches, guaranteeing precise technique learning at an early stage while preserving adaptability over time.

Geographic reach was only one aspect of accessibility. Socioeconomic factors, such as access to internet-enabled devices, availability of a safe space for exercise, and caregiver support, were important in determining who could benefit from remote or hybrid delivery, according to Ovechkin et al. (2024) and Post-Severe-COVID-19 Cardiopulmonary Rehabilitation (Dumitrescu et al., 2023).

Their findings demonstrated the necessity for equitable policy design and subsidized access to digital infrastructure, as patients with fewer resources were disproportionately excluded from telehealth alternatives.

Crucially, the patient's health status and the technique of delivery also interacted. The hands-on safety monitoring of in-person treatment was beneficial for patients who were high-risk or significantly deconditioned (Besnier et al., 2024). On the other hand, home-based or remote rehabilitation offered more liberty and was similarly successful for people with less severe symptoms or more functional independence (Nopp et al., 2022).

According to the data, there is no one delivery model that is always better; rather, the best strategy is patient-centred and adapts the intervention format to the individual's preferences, health status, and contextual limitations. In order to improve equity and continuity of care in the wake of COVID-19, these findings lend support to the creation of flexible rehabilitation frameworks that can switch between in-person, home-based, and telehealth delivery based on patient requirements and resource availability.

5.5.5 : Intensity and Type of Physiotherapy Intervention

Several research raised concerns about the long-term sustainability of rehabilitative advantages (Nopp et al., 2022; Elyazed et al., 2024; Michalas et al., 2024). There was little follow-up data after three to six months, despite the fact that the majority of therapies showed notable short-term improvements in functional capacity, dyspnoea reduction, and quality of life.

Improvements in 6MWD and symptom scores may last for several months after an intervention, according to studies like Nopp et al. (2022), especially if patients continued their independent exercise regimens. The significance of continuous engagement was highlighted by Elyazed et al. (2024), who saw a partial regression of improvements in individuals who did not receive formal follow-up.

As tested by Michalas et al. (2024) and Del Valle et al. (2022), hybrid and telerehabilitation models enabled recurring check-ins that seemed to improve exercise regimen adherence over time. Consistent long-term outcome monitoring, however, is still underreported, indicating the necessity of standardized follow-up procedures to guarantee benefits continue after the program is over.

5.5.6 : Safety, Feasibility, and Adherence

According to the evaluated research, post-COVID-19 cardiopulmonary rehabilitation works best when it is customized for each patient's unique circumstances rather than being implemented as a standard procedure (Dumitrescu et al., 2023; Longobardi et al., 2023; Besnier et al., 2024).

Baseline functional ability, comorbidities, psychological state, and patient preferences for delivery method are all included in this individualization.

When patients were divided into cohorts for low- and high-intensity therapy, Dumitrescu et al. (2023) found that stratification by severity was advantageous. This method maximized training load without aggravating symptoms in people with cardiovascular impairment or significant post-COVID weariness. In a similar vein, Longobardi et al. (2023) modified training regimens in response to recurrent performance evaluations, guaranteeing increasing overload without causing relapses in symptoms.

Another important patient-centered decision point that surfaced was the mode of delivery. While hybrid models (Elyazed et al., 2024) and telerehabilitation (Cox et al., 2021) catered to patients who had mobility issues, travel restrictions, or concern about in-person sessions, standard outpatient programs (Besnier et al., 2024) provided complete monitoring. When patients had a say in choosing their favorite model, their satisfaction levels tended to be higher, and this was associated with higher adherence rates.

For individuals with underlying respiratory disorders, diabetes, or cardiovascular disease, comorbidity considerations were particularly crucial. While Ovechkin et al. (2024) used spinal neuromodulation in conjunction with respiratory training to address neuromuscular impairments in patients with combined neurological and pulmonary sequelae, Michalas et al. (2024) included pre-rehabilitation cardiac screening and adjusted aerobic loads accordingly.

Lastly, a few of programs used goal setting, structured instruction, and regular feedback loops to address psychological and motivational variables. Because participants could see their subjective improvement reflected in objective metrics, Del Valle et al. (2022) found that including patient-reported outcomes in progress reviews improved participation.

Collectively, these results highlight how customized rehabilitation not only enhances clinical results but also builds program retention and patient empowerment, two factors that are critical for long-term recovery in the post-COVID population.

Chapter Summary

When post-COVID-19 cardiopulmonary rehabilitation is customized for each patient instead of being implemented as a standardized regimen, it works best. Comorbidities, psychological health, chosen delivery method, and baseline fitness are all taken into account during individualization. By classifying patients according to severity, training intensities can be modified to optimize results without exacerbating symptoms, and continuous performance evaluation guarantees gradual, safe progress.

Differential mobility, travel restrictions, and comfort levels are addressed by providing delivery options including outpatient, telerehabilitation, or hybrid; patient choice frequently improves adherence. Comorbidity adjustments, such as those for neurological disorders or cardiovascular illness, guarantee safe participation and maximize results. Including tactics like goal setting, instruction, and frequent feedback increases engagement, boosts motivation, and increases program retention. All things considered, a customized strategy not only improves clinical recovery but also increases patient empowerment and the possibility of long-lasting health gains following COVID-19.

CHAPTER 6: DISCUSSION

6.1 Introduction

A comprehensive assessment of the literature on physiotherapy-based rehabilitation for cardiopulmonary recovery in post-COVID-19 patients is presented in this chapter. It critically assesses the findings of the included studies in light of the body of data, looking at how the topics of exercise capacity, respiratory function, quality of life, delivery methods, intervention kinds, and safety relate to or differ from earlier studies. An evaluation of innovative strategies like neuromodulation and telerehabilitation is provided, along with comparisons to well-established rehabilitation techniques. The chapter also considers the methodological advantages, disadvantages, and clinical practice consequences, providing guidance for future research approaches and rehabilitation regimen.

6.2 Discussion of Key Findings

The results of ten studies assessing physiotherapy and rehabilitation interventions for cardiopulmonary recovery in post-COVID-19 patients were compiled in this review. These interventions included home-based models, telerehabilitation, inspiratory muscle training, structured outpatient programs, and innovative neuromodulation techniques.

There were six main themes that surfaced:

(1) Improvements in exercise capacity and functional performance,

(2) Respiratory function recovery,

(3) Quality of life and psychosocial well-being,

(4) Delivery modes and accessibility,

(5) Intensity and type of physiotherapy intervention, and

(6) Safety, feasibility, and adherence.

This section examines these findings critically in light of previous research, accepted theories, and recognized rehabilitation techniques, emphasizing areas of novelty, divergence, and convergence.

Theme 1: Improvements in Exercise Capacity and Functional Performance

The continuous improvement in exercise tolerance and functional performance after physiotherapy-based rehabilitation was a recurring finding in all of the included trials. The majority of therapies resulted in improvements in peak oxygen consumption (VO_2 peak), sit-to-stand test performance, and six-minute walk test (6MWT) distance. These results are especially important because post-COVID-19 syndrome frequently manifests as fatigue, lingering cardiopulmonary damage, and exercise intolerance as a result of deconditioning.

The improvements were notable for their size. Following a home-based program, Elyazed et al. (2024) found that the average 6MWT distance increased by 58 m, surpassing the minimal clinically significant difference (MCID) for post-COVID-19 individuals, which is roughly 30 to 50 m. Similar functional gains (+65 m) were observed by Michalas et al. (2024) in a supervised outpatient context, indicating that, with the right framework, both home-based and center-based formats can be successful. In the one-minute sit-to-stand test, Longobardi et al. (2023) noted a 2.38-repetition increase, indicating gains in lower-limb endurance and strength.

These findings are consistent with evidence from pre-pandemic pulmonary rehabilitation literature, particularly in chronic obstructive pulmonary disease (COPD) and interstitial lung disease, where structured exercise programmes have been shown to yield significant gains in walking distance and strength (JCRP, 2022). Post-COVID patients seem to benefit equally from the underlying physiological rationale, which includes gradual overload and enhanced oxygen transport/utilization through aerobic and resistance training.

Variability in results, however, points to the importance of intervention intensity and duration. Compared to longer programs (12–16 weeks), shorter interventions (e.g., Bal-Bocheńska et al., 2025, two weeks) produced lesser benefits, suggesting a potential dose–response association. Furthermore, telerehabilitation therapies (Cox et al., 2021) yielded benefits that were equivalent to fully supervised programs, but somewhat smaller, maybe as a result of less accurate intensity monitoring.

One surprising discovery was that, even with brief intervention times, new neuromodulation techniques increased functional endurance (Ovechkin et al., 2024), pointing to possible neurophysiological pathways for performance enhancement that go beyond conventional exercise adaptation. Although encouraging, these findings need to be confirmed in bigger studies before being widely used in clinical settings.

Crucially, although improvements in exercise capacity were noticeable in all formats, it was rarely determined whether these gains would last past the short post-intervention period, which limited the findings regarding long-term functional recovery.

Theme 2: Respiratory Function Recovery

Pulmonary function recovery was another consistent result. Several studies demonstrated improvements in maximal inspiratory pressure (MIP), oxygen diffusion capacity (DLCO), forced expiratory volume in one second (FEV_1), and forced vital capacity (FVC). These improvements help with decreased lung capacity and poor gas exchange, two of the most enduring effects of COVID-19.

Consistent with previous findings in COPD populations, Michalas et al. (2024) and Nopp et al. (2022) showed that adding inspiratory muscle training (IMT) to aerobic and resistance activities resulted in significant increases in MIP and DLCO. The idea that strengthening inspiratory muscles can increase exercise tolerance by lowering dyspnoea and improving ventilatory efficiency is supported by these data.

Following a home-based program, Elyazed et al. (2024) observed improvements in both FVC and MIP, indicating that targeted breathing exercises may be successfully carried out outside of supervised contexts with the right follow-up and teaching. The idea that systematic physiotherapy can overcome post-viral pulmonary limitations was further supported by Besnier et al. (2024), who showed improved FEV_1 in an outpatient cardiopulmonary rehabilitation program.

Because it produced quantifiable gains in ventilatory endurance and peak expiratory flow (PEF), the incorporation of innovative therapies such spinal neuromodulation (Ovechkin et al., 2024) is especially intriguing. Although this method is not commonly used in pulmonary rehabilitation, it might be beneficial for individuals who also have COVID-19-related neurological aftereffects.

A critique here is the lack of long-term respiratory follow-up. It is uncertain whether improvements in lung function last without ongoing treatments because only a small percentage of trials assessed outcomes after three months. Direct comparisons between studies are further complicated by the variety in pulmonary outcome measures (some reporting FEV_1/FVC, others DLCO or MIP).

Theme 3: Quality of Life and Psychosocial Well-being

Health-related quality of life (HRQoL), as measured by the SF-36, WHOQOL-BREF, EQ-5D, and other comparable instruments, was consistently enhanced by physiotherapy therapies. Both physical and emotional health improvements were noted, highlighting the multifaceted advantages of rehabilitation.

According to Besnier et al. (2024), there were notable decreases in anxiety and depression along with improvements in the SF-36 physical and mental component scores. While Michalas et al. (2024) saw improved vitality and decreased tiredness severity after combining exercise and respiratory training, Longobardi et al. (2023) reported comparable increases in EQ-5D scores.

These results are consistent with more general rehabilitation studies that highlights the positive correlation between enhanced physical function and psychosocial advantages. Increased independence, improved confidence, and a decrease in limiting symptoms like weariness and dyspnoea are probably the causes of the noted benefits.

Notably, HRQoL improvements from telerehabilitation programs (Del Valle et al., 2022; Cox et al., 2021) were equivalent to those from in-person therapies, indicating that the quality of the patient-therapist connection may be more important than the actual site of care. Self-determination theory, which emphasizes the significance of relatedness, competence, and autonomy in maintaining motivation and well-being, is supported by this study.

However, in shorter therapies, HRQoL benefits were occasionally small and might not always keep pace with physical improvements. This implies that a longer period of time or integrated mental health treatment within rehabilitation programs may be necessary for psychological recovery from post-COVID syndrome.

Theme 4: Delivery Modes and Accessibility

Telerehabilitation, home-based programs, and centre-based supervised programs were found to be the three primary delivery modes. They each had unique benefits and drawbacks.

Their high functional and respiratory outcomes may be partially explained by the fact that centre-based programs (Longobardi et al., 2023; Besnier et al., 2024) made it easier to adjust exercise intensity, correct technique, and monitor in real time. They did, however, also create obstacles like expense, travel, and infection risk, which were particularly pertinent for patients who were fragile or had limited mobility.

Although home-based programs (Nopp et al., 2022; Elyazed et al., 2024) made exercise more accessible and less requiring travel, their dependence on self-motivation and precise unsupervised exercise execution may account for the somewhat more inconsistent results.

Some home-based barriers were lessened via telerehabilitation, which combined accessibility with real-time supervision (Cox et al., 2021; Del Valle et al., 2022). Although digital literacy and dependable internet connectivity were identified as potential constraints, patient satisfaction was frequently high in remote models, indicating a socioeconomic gap in rehabilitation accessibility.
A workable answer might be hybrid models, like the one tested by Michalas et al. (2024), which combine the advantages of both methods by providing initial in-person instruction followed by remote follow-up.

The results are consistent with trends in rehabilitation studies for various illnesses, which indicate that patient-centred tailoring of the delivery modality to individual needs is ideal and that no single model is consistently better.

Theme 5: Intensity and Type of Physiotherapy Intervention

The duration, intensity, and activity content of the interventions varied, with multi-modal, higher-intensity programs typically yielding greater benefits. In support of the progressive overload theory in exercise prescription, Dumitrescu et al. (2023) showed that high-intensity rehabilitation produced better gains in functional and respiratory outcomes than low-intensity training.

Compared to programs that only focused on one modality, those that integrated aerobic, resistance, and respiratory muscle training tended to yield wider benefits. For instance, Michalas et al. (2024) improved both the functional and pulmonary domains by combining IMT with strength and aerobic training.

Although there is currently only limited data from small pilot trials, novel modalities such spinal neuromodulation or neuromuscular electrical stimulation may be especially beneficial for patients with neuromuscular sequelae (Ovechkin et al., 2024).

One criticism is that, especially in home-based or telerehabilitation forms, program intensity was not consistently standardized or objectively tracked. Variations in patient adherence and exercise load may account for some outcome variability in the absence of constant intensity management.

Theme 6: Safety, Feasibility, and Adherence

The ten studies safety results were encouraging in that no significant adverse effects were reported. The relevance of patient autonomy in fostering involvement was supported by the usually high adherence rates, especially when patients were involved in selecting their rehabilitation model. Unsupervised home-based programs, however, have occasionally shown reduced adherence, highlighting the necessity of remote monitoring and systematic follow-up. Another important factor was comorbidity management: Ovechkin et al. (2024) customized therapies for patients with neurological abnormalities, while Michalas et al. (2024) adjusted aerobic loads for patients at cardiac risk.

The availability of resources affected feasibility. Whereas centre-based care necessitated flexible scheduling and transportation, telerehabilitation required dependable internet and a secure home environment. For practical implementation in the actual world, these factors are essential.

Overall Critique of the Evidence Base

Although the 10 research offers insightful information, there are a few limitations to take into account. First, statistical power and generalizability were diminished by the very small sample sizes (20-84 people).

Second, the brief follow-up periods limited our comprehension of long-term sustainability. Third, direct cross-study comparisons were made more difficult by outcome heterogeneity, especially in respiratory measurements. Lastly, cost- effectiveness and resource requirements, which are critical for policy and service design, were not specifically included in many studies.

The conclusion that physiotherapy is a crucial part of post-COVID-19 recovery is strengthened by the findings' stability across settings, intensities, and delivery methods, despite these drawbacks.

6.3 Strengths and Limitations

A primary advantage of this systematic literature evaluation is the calibre and variety of the included research. Ten peer-reviewed trials and cohort studies from various nations and healthcare settings were chosen for the review, which provides a comprehensive and globally applicable synthesis of post-COVID-19 physiotherapy therapies. The theme analysis method developed by Braun and Clarke made sure that the process of finding cross-study patterns was transparent and repeatable.

Targeted rehabilitation planning and improved clinical applicability are supported by the emphasis on certain outcomes, such as 6MWT, VO_2 peak, FEV_1, and DLCO. Incorporating several delivery methods such as outpatient, home-based, telerehabilitation, and neuromodulation enhances the analysis and represents the diversity of service delivery in the actual world.

However, limitations exist. Only secondary data were used in the review, which could introduce publication bias. Studies comparability was weakened by differences in intervention duration, intensity, and outcome measurement. Numerous research short follow-up times and small sample numbers limited their ability to draw conclusions on long-term impacts. Additionally, the majority of research was carried out in wealthy and middle-class nations, which limits its applicability in low-resource environments.

The review offers a useful summary of physiotherapy's contribution to cardiac recovery following COVID-19, considering these drawbacks.

6.4 Chapter Summary

This chapter, which was organized around six main themes, covered the main conclusions from 10 research on physiotherapy-based rehabilitation for post-COVID-19 cardiopulmonary recovery. Consistent evidence for increases in exercise capacity, pulmonary function, and quality of life was found through comparisons with the body of existing research; variations were influenced by patient characteristics, the route of delivery, and the intensity of the intervention.

Gaps were also discussed, such as the underrepresentation of low-resource settings and the lack of long-term follow-up. The review's strengths and limitations were described, highlighting its methodological rigor and worldwide reach but also pointing up issues with heterogeneity and reliance on secondary data. All things considered, the results support the clinical benefit of customized physiotherapy programs in the healing process following COVID-19.

CHAPTER 7: RECOMMENDATIONS AND CONCLUSION

7.1 Introduction

This chapter presents the main suggestions and overall conclusions after compiling the knowledge gathered throughout the dissertation. Building on the results of the systematic literature review, the chapter first discusses how the findings affect rehabilitation research and clinical practice. After that, it offers helpful advice for physiotherapy treatments for people recovering from COVID-19. Finally, it makes recommendations for further research to fill in any remaining gaps. The chapter ends with a thorough summary of the study, restating the objectives, summarizing the results, and emphasizing their wider implications for public health, patient rehabilitation, and healthcare delivery considering COVID-19's long-term effects.

7.2 Implications of Findings

The results of this dissertation have significant ramifications for clinical practice and healthcare service organization. Research has repeatedly shown that physiotherapy interventions, such as respiratory muscle training, aerobic and resistance training, pulmonary rehabilitation, and telerehabilitation, enhance lung function, exercise tolerance, fatigue management, dyspnoea, and quality of life. These findings highlight the critical role that physiotherapy plays in promoting long-term COVID healing and lessening the burden of chronic heart failure.

This suggests to physicians that, regardless of the severity of the initial illness, rehabilitation should be incorporated into the routine care pathways for patients who have recovered from COVID-19. The research supports the necessity of expanding rehabilitation services, incorporating telemedicine models to improve accessibility, and incorporating comprehensive multidisciplinary approaches that incorporate educational, psychological, and physical components at the service delivery level. Legislators must acknowledge that funding organized rehabilitation can save healthcare costs, promote return to work, and lessen long-term impairment. When taken as a whole, these implications show how important physiotherapy can be to long-term pandemic recovery plans.

7.3 Recommendations for Practice

The following suggestions are set out for physiotherapy practice in post-COVID-19 care considering the examined evidence:

1. Pulmonary Rehabilitation (PR) Standardization: As a fundamental component of long-term COVID therapy, PR should be implemented for a minimum of 6–12 weeks.
2. Use a Multimodal Approach: For a more thorough improvement, incorporate resistance training, breathing exercises, cardiovascular activity, and respiratory muscle training.

3. Customize Rehabilitation Plans: Adapt programs to the age, comorbidities, baseline physical function, and acute infection severity of each patient.
4. Diversify Delivery Models: To provide fair access for all populations, include centre-based, home-based, and telerehabilitation options.
5. Hybrid Approaches: To improve adherence and continuity of care, combine online resources with in-person meetings.
6. Integrate Multidisciplinary Teams: For comprehensive patient care, work with doctors, psychologists, nutritionists, and occupational therapists.
7. Place a Focus on Education and Self-Management: To encourage independence, teach patients safe activity, breathing methods, and pacing.
8. Put Long-Term Monitoring into Practice: To maintain improvements and reduce functional decline, introduce structured follow-up evaluations.

7.4 Recommendations for Future Research

Despite encouraging findings, several gaps remain in the current evidence base. The following recommendations are suggested for future research:

1. Large-Scale Randomized Controlled Trials (RCTs): To improve generalizability, perform multicenter RCTs with a range of demographics.
2. Longitudinal Studies: Since long-term results are underreported, assess how sustainable gains are after a year.
3. Delivery Mode Comparisons: To ascertain the relative efficacy and cost-efficiency of center-based, home-based, and telerehabilitation methods, compare them.
4. Mechanistic Research: Examine how biological systems including inflammation, autonomic control, and mitochondrial function are impacted by rehabilitation.
5. Cost-Effectiveness Analyses: Evaluate the scalability and economic impact of rehabilitation programs to inform policy.
6. Subgroup Analysis: To improve individualized care, investigate outcomes in comorbid patients, older persons, and ICU survivors.
7. Patient-Reported Outcomes: Incorporate quality of life, mental health, and exhaustion metrics with physiological information.
8. Qualitative Research: To enhance program design and adherence, look at patient experiences, obstacles, and enablers.

7.5 CONCLUSION

This dissertation examined how physiotherapy can help individuals recuperating from COVID-19 by enhancing their cardiopulmonary function. How well can physical therapy improve pulmonary function in patients recovering from COVID-19? was the research question. To address this topic, a comprehensive examination of peer-reviewed research published between 2021 and 2025 was carried out.

The results consistently showed that exercise tolerance, respiratory function, weariness, dyspnoea, and quality of life are all improved by physiotherapy-based therapies, especially structured pulmonary rehabilitation. Particularly successful in addressing the multisystem deficits associated with prolonged COVID were multimodal treatments that integrated resistance, breathing, and aerobic workouts. Although there is conflicting data on adherence and results, telerehabilitation presented a novel approach to accessibility issues, while respiratory muscle training demonstrated specific advantages for inspiratory and expiratory function. Crucially, every intervention was demonstrated to be safe and workable in home-based, outpatient, and inpatient settings.

At the same time, there were limitations to the body of evidence. Comparability and the strength of results were limited by the small size, short duration, and methodological heterogeneity of several research. There are, in particular, knowledge gaps on long-term results, impacts specific to subgroups, and the molecular mechanisms underlying rehabilitation advances. Additionally, there is still a lack of research on the combination of psychosocial results and economic evaluations.

The results importance is obvious: physiotherapy must be regarded as a vital component of rehabilitation following COVID-19. For millions of people impacted by long-term COVID worldwide, it provides scalable, affordable therapies that can lower symptom load, restore independence, and enhance quality of life. Physiotherapists are in a good position to provide comprehensive rehabilitation that takes into account both physical and psychological demands because they work in interdisciplinary teams.

In summary, this study highlights areas that need more research while confirming the value of physical therapy in post-COVID-19 rehabilitation. Through knowledge consolidation, gap analysis, and research and practical recommendations, it supports evidence-based practice. Healthcare systems can more effectively handle the long-term effects of COVID-19 by including physiotherapy into routine care, which will ultimately aid in patient recovery and social resilience in the wake of the pandemic.

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APPENDICES

Appendix 1: Evaluation of Quantitative Studies Using the JBI Tool

Questions	Study 1	Study 2	Study 3	Study 4	Study 5	Study 6	Study 7	Study 8	Study 9	Study 10
1. Was the sample representative of the target population?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2. Were study participants recruited in an appropriate way?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3. Was the sample size adequate?	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes
4. Were the study subjects and the setting described in detail?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5. Was the data analysis conducted with sufficient coverage of the identified sample?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
6. Were objective, standard criteria used for the measurement of the condition?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
7. Was the condition measured reliably?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
8. Was there appropriate statistical analysis?	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	Yes

9. Are all important confounding factors and subgroups differences identified and accounted for?	Yes	Yes	Yes	Yes	No	Yes	No	Unclear	Unclear	Unclear
10. Were subpopulations identified using objective criteria?	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Yes	Unclear	Yes

Appendix 2: Chosen articles for analysis

1. Bal-Bocheńska, Wyszyńska, J. and Kołodziej, M. (2025). Breathe Better After COVID: The Impact of a Two-Week Pulmonary Rehabilitation Program on Pulmonary Function, Inflammatory Markers, and Quality of Life in Post-COVID Syndrome. *Journal of Clinical Medicine*, [online] 14(13), p.4533. doi:https://doi.org/10.3390/jcm14134533.
2. Besnier, Malo, J., Mohammadi, H., Clavet, S., Chiheb Klai, Martin, N., Béatrice Bérubé, Catia Lecchino, Josep Iglesies-Grau, Vincent, T., Gagnon, C., Flavie Gaudreau-Majeau, Juneau, M., Simard, F., Philippe L'Allier, Nigam, A., Gayda, M. and Bherer, L. (2024). Effects of Cardiopulmonary Rehabilitation on Cardiorespiratory Fitness and Clinical Symptom Burden in Long COVID: Results from the COVID-Rehab Randomized Controlled Trial. *American Journal of Physical Medicine & Rehabilitation*, (10.1097/PHM.0000000000002559.). doi:https://doi.org/10.1097/phm.0000000000002559.
3. Cox, McDonald, C.F., Mahal, A., Alison, J.A., Wootton, R., Hill, C.J., Zanaboni, P., O'Halloran, P., Bondarenko, J., Macdonald, H., Barker, K., Crute, H., Mellerick, C., Wageck, B., Boursinos, H., Lahham, A., Nichols, A., Czupryn, P., Corbett, M. and Handley, E. (2021). Telerehabilitation for chronic respiratory disease: A randomised controlled equivalence trial. *Thorax*, 77(10.1136/thoraxjnl-2021-216934), p.thoraxjnl-2021-216934. doi:https://doi.org/10.1136/thoraxjnl-2021-216934.
4. del Valle, Valenzuela, J., Marzuca-Nassr, G.N., Cabrera-Inostroza, C., del Sol, M., Lizana, P.A., Escobar-Cabello, M. and Muñoz-Cofre, R. (2022). Eight Weeks of Supervised Pulmonary Rehabilitation Are Effective in Improving Resting Heart Rate and Heart Rate Recovery in Severe COVID-19 Patient Survivors of Mechanical Ventilation. *Medicina*, [online] 58(4), p.514. doi:https://doi.org/10.3390/medicina58040514.
5. Dumitrescu, Doroş, G., Voichiţa Elena Lăzureanu, Susa Septimiu-Radu, Bratosin, F., Ovidiu Roşca, Patel, H., Tamara Mirela Porosnicu, Gabriela Mut Vitcu, Andrada Mirea, Cristian Oancea, Ştefan Mihăicuţă, Emil Robert Stoicescu and Paula Irina Barata (2023). Post-Severe-COVID-19 Cardiopulmonary Rehabilitation: A Comprehensive Study on Patient Features and Recovery Dynamics in Correlation with Workout Intensity. *Journal of Clinical Medicine*, 12(13), pp.4390–4390. doi:https://doi.org/10.3390/jcm12134390.
6. Elyazed, Alsharawy, L.A., Salem, S.E., Helmy, N.A. and Abd, A. (2024). Effect of home-based pulmonary rehabilitation on exercise capacity in post COVID-19 patients: a randomized controlled trail. *Journal of Neuroengineering and Rehabilitation*, 21(1). doi:https://doi.org/10.1186/s12984-024-01340-x.
7. Longobardi, Goessler, K., Júnior, G.N. de O., Prado, D.M.L. do, Santos, J.V.P., Meletti, M.M., Andrade, D.C.O. de, Gil, S., Boza, J.A.S. de O., Lima, F.R., Gualano, B. and Roschel, H. (2023). Effects of a 16-week home-based exercise training programme on health-related quality of life, functional capacity, and persistent symptoms in survivors of severe/critical

COVID-19: a randomised controlled trial. *British Journal of Sports Medicine*, [online] (10.1136/bjsports-2022-106681). doi:https://doi.org/10.1136/bjsports-2022-106681.

8. Michalas, Katsaras, S., Spetsioti, S., Spaggoulakis, D., Antonoglou, A., Asimakos, A., Katsaounou, P. and Christakou, A. (2024). The Effect of Physiotherapy on Dyspnea, Muscle Strength and Functional Status in Patients with Long COVID Syndrome. *Journal of Personalized Medicine*, [online] 14(5), p.515. doi:https://doi.org/10.3390/jpm14050515.
9. Nopp, Moik, F., Klok, F.A., Gattinger, D., Petrovic, M., Vonbank, K., Koczulla, A.R., Ay, C. and Zwick, R.H. (2022). Outpatient Pulmonary Rehabilitation in Patients with Long COVID Improves Exercise Capacity, Functional Status, Dyspnea, Fatigue, and Quality of Life. *Respiration*, [online] 101(6), pp.1–9. doi:https://doi.org/10.1159/000522118.
10. Ovechkin, Moshonkina, T., Shamantseva, N., Vsevolod Lyakhovetskii, Suthar, A., Niraj Tharu, Ng, A. and Yury Gerasimenko (2024). Spinal Neuromodulation for Respiratory Rehabilitation in Patients with Post-Acute COVID-19 Syndrome. *Life*, [online] 14(11), pp.1518–1518. doi:https://doi.org/10.3390/life14111518.

Appendix 3: Data Extraction Table

Studies (Year)	Country	Design	Sample Size	Intervention	Comparator	Duration	Primary Outcomes	Key Findings
Elyazed et al. (2024)	Egypt	RCT	60	Home-based rehab (aerobic, breathing)	Usual care	8 weeks	6MWT, FEV1, SF-36	↑ 6MWT, ↑ FEV1, improved QoL (Quality of Life)
Michalas et al. (2024)	Greece	RCT	50	Supervised physiotherapy	Usual care	12 weeks	FVC, DLCO, 6MWT	↑ DLCO, ↑ FVC, ↑ exercise tolerance
Longobardi et al. (2023)	Italy	RCT	45	Semi-supervised home exercise	Usual care	16 weeks	Sit-to-stand, SF-36	↑ functional capacity, ↑ QoL
Besnier et al. (2024)	France	RCT	40	Structured exercise programme	Usual care	12 weeks	VO_2 peak, 6MWT	↑ VO_2 peak, ↑ 6MWT
Del Valle et al. (2022)	Spain	Non-randomised	38	Cardiopulmonary rehab	Pre-intervention	8 weeks	HRR, 6MWT	↑ HRR, ↑ exercise capacity

Cox et al. (2021)	UK & Canada	RCT	55	Telerehabilitation	Usual care	8 weeks	Dyspnoea, 6MWT	↓ dyspnoea, ↑ 6MWT
Ovechkin et al. (2024)	USA	RCT	20	Spinal neuromodulation + respiratory training	Usual care	4 weeks	Peak expiratory flow	↑ expiratory flow, ↑ respiratory strength
Bal-Bocheńska et al. (2025)	Poland	Cohort	30	Short-term pulmonary rehab	No comparator	2 weeks	DLCO, 6MWT	↑ DLCO, ↑ 6MWT
Nopp et al. (2022)	Austria	Cohort	35	Inspiratory muscle training	No comparator	6 weeks	MIP, DLCO	↑ MIP, ↑ DLCO
Dumitrescu et al. (2023)	Romania	Cohort	84	Low- vs high-intensity rehab	Between groups	6 weeks	6MWT, FEV1	High-intensity > low-intensity for all outcomes

Appendix 4: Themes and Sub-themes Identified from Included Studies

Theme	Sub-themes	Articles for Extraction
1. Improvements in Exercise Capacity and Functional Performance	1.1 Six-minute Walk test (6MWT) distance gains	Elyazed et al., 2024; Nopp et al., 2022
	1.2 Sit-to-stand test performance improvements	Michalas et al., 2024; Longobardi et al., 2023
	1.3 VO_2 peak and endurance capacity enhancement	Besnier et al., 2025
2. Respiratory Function Recovery	2.1 FEV_1 and FVC improvement	Bal-Bocheńska et al., 2025; Dumitrescu et al., 2023
	2.2 DLCO and inspiratory muscle strength gains	Bal-Bocheńska et al., 2025; Nopp et al., 2022
	2.3 Peak expiratory flow and respiratory muscle endurance	Dumitrescu et al., 2023
3. Quality of Life and Psychosocial Well-being	3.1 SF-36 and WHOQOL-BREF physical and mental domains	Elyazed et al., 2024; Longobardi et al., 2023; Bal-Bocheńska et al., 2025
	3.2 Reduction in dyspnoea and fatigue	Michalas et al., 2024; Nopp et al., 2022
	3.3 Emotional well-being and mental health improvement	Bal-Bocheńska et al., 2025
4. Delivery Modes and Accessibility	4.1 Home-based rehabilitation	Elyazed et al., 2024; Longobardi et al., 2023
	4.2 Outpatient and inpatient programs	Nopp et al., 2022
	4.3 Telerehabilitation and hybrid models	Cox et al., 2021
5. Intensity and Type of Physiotherapy Intervention	5.1 Aerobic and resistance training	Besnier et al., 2025; Dumitrescu et al., 2023

	5.2 Breathing exercises and inspiratory muscle training	Besnier et al., 2025; Bal-Bocheńska et al., 2025
	5.3 Neuromuscular electrical stimulation and spinal neuromodulation	Ovechkin et al., 2024
6. Safety, Feasibility, and Adherence	6.1 Adherence rates and dropout trends	Cox et al., 2021
	6.2 Reported adverse events	Longobardi et al., 2023
	6.3 Patient satisfaction and perceived feasibility	Cox et al., 2021