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Post-Covid Respiratory Rehabilitation: A Systematic Review of Physiotherapy Protocols Across Countries

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Abstract

Background

Persistent respiratory symptoms and functional limitations after COVID-19 may require physiotherapy rehabilitation. However, rehabilitation protocols and outcomes vary across countries. This review synthesized physiotherapy protocols for post-COVID respiratory rehabilitation and evaluated their effects on functional, pulmonary, physiological, and patient-reported outcomes.

Methods

A systematic review and meta-analysis were conducted following PRISMA and Cochrane guidance. PubMed/MEDLINE, Cochrane Library, CINAHL, PEDro, Scopus, and Google Scholar were searched from January 2020 to November 2025. Randomized controlled trials evaluating physiotherapy-based respiratory rehabilitation in people with post-COVID-19 conditions were included. Intervention characteristics and outcomes were extracted, methodological quality was assessed using the PEDro scale, and certainty of evidence using GRADE. Random-effects meta-analysis was performed where studies were sufficiently comparable; otherwise, findings were synthesized narratively.

Results

Thirty-five randomized controlled trials were included. Interventions included pulmonary rehabilitation, aerobic and resistance exercise, breathing exercises, inspiratory muscle training, home-based rehabilitation, and telerehabilitation. Nine trials involving 465 participants contributed to the 6MWD meta-analysis, showing a significant improvement (MD = 66.75 m, 95% CI 47.60–85.89; $P < 0.00001$; $I^2 = 64\%$). Six trials involving 470 participants contributed to the FEV_1 and FVC analyses. Effects on FEV_1 (MD = 0.21 L, 95% CI − 0.01–0.43; P = 0.06; $I^2 = 72\%$) and FVC (MD = 0.28 L, 95% CI − 0.02–0.57; P = 0.07; $I^2 = 82\%$) were not statistically significant. Evidence for dyspnoea, fatigue, quality of life, respiratory muscle strength, and oxygen saturation generally favoured rehabilitation but was heterogeneous. GRADE certainty was low for 6MWD and FEV_1 and very low for FVC.

Conclusion

Physiotherapy-based respiratory rehabilitation improves functional exercise capacity in people with post-COVID-19 conditions, while effects on pulmonary function remain uncertain. Variation in protocols and outcome measures highlights the need for standardized reporting and further high-quality trials with longer follow-up.

INTRODUCTION

The COVID-19 pandemic has resulted in a substantial population of survivors experiencing persistent health complications, including respiratory symptoms and functional limitations [1–3]. Post-COVID syndrome, commonly referred to as long COVID, encompasses a wide spectrum of symptoms that persist beyond the acute phase of infection and may continue for several months [1, 2]. Persistent respiratory complications have been reported following COVID-19, particularly among individuals who experienced substantial pulmonary involvement during the acute illness, with respiratory dysfunction and reduced exercise capacity observed during the post-acute period [3, 4]. These persistent symptoms and impairments may adversely affect quality of life and physical functioning [2, 3].

Physiotherapy is an important component of rehabilitation for individuals recovering from COVID-19, particularly those with respiratory, physical, and functional impairments [5]. Pulmonary rehabilitation approaches may include breathing exercises, aerobic and strengthening exercises, respiratory muscle training, mobilisation, and airway clearance techniques when clinically indicated [5–7]. These interventions are intended to address respiratory symptoms, exercise intolerance, physical deconditioning, and functional limitations and to support recovery of physical function [5, 6].

Individuals with post-COVID respiratory and functional impairments may experience persistent dyspnoea, fatigue, cough, chest discomfort, reduced exercise tolerance, and physical deconditioning [1–3]. Breathing exercises are commonly incorporated into pulmonary rehabilitation programmes for individuals recovering from COVID-19, with the aim of improving respiratory symptoms, ventilatory function, and exercise tolerance [6]. Airway clearance techniques, including manual techniques and selected assistive devices, may facilitate the clearance of retained respiratory secretions in individuals with productive cough or impaired airway clearance [7]. Multidisciplinary rehabilitation programmes integrating aerobic exercise, muscle-strengthening exercises, and patient education can address physical deconditioning and functional limitations in individuals recovering from COVID-19 [5, 6]. Additionally, targeted inspiratory muscle training has demonstrated benefits for respiratory muscle strength and pulmonary function in patients recovering from COVID-19 [8]. Early mobilisation and appropriately prescribed physical activity may also help minimise the consequences of prolonged inactivity, including physical deconditioning and functional decline [5, 7]. Telerehabilitation has emerged as an alternative mode of service delivery that may facilitate continuity of rehabilitation while reducing geographical and logistical barriers to care [9].

Despite the recognition of physiotherapy as an important component of post-COVID rehabilitation, approaches to rehabilitation may vary according to healthcare systems, available resources, workforce capacity, and clinical guidance [5, 10]. Early international recommendations emphasised the need to adapt rehabilitation services according to the severity of patients' impairments, available resources, and the organisation of healthcare systems [5, 10]. These contextual differences may influence the accessibility, scope, and delivery of post-COVID respiratory physiotherapy services [5, 10].

Although the importance of post-COVID respiratory rehabilitation is increasingly acknowledged, evidence regarding the implementation and effectiveness of physiotherapy interventions across diverse

healthcare and socioeconomic contexts remains limited [10–12]. Rehabilitation services in low- and middle-income countries (LMICs) face documented barriers related to resources, workforce capacity, education, health policy, technology, and standards of care, which may constrain access to and delivery of rehabilitation services [11]. Evidence on the integration of rehabilitation within LMIC health systems also remains limited, highlighting the need for context-sensitive rehabilitation models and evidence [12]. These disparities represent an important knowledge gap and highlight the need for evidence to inform rehabilitation practice across diverse healthcare contexts [11, 12].

Therefore, this review aims to synthesise existing evidence on physiotherapy interventions used for post-COVID respiratory rehabilitation across different countries. Specifically, it seeks to identify commonly used rehabilitation protocols, compare intervention characteristics and outcome measures across regions and income levels, and evaluate the effectiveness of physiotherapy interventions on respiratory, functional, and patient-reported outcomes following COVID-19. Addressing these objectives will contribute to a more comprehensive understanding of global post-COVID respiratory physiotherapy practices and support the development of equitable, evidence-based recommendations applicable across diverse healthcare settings.

METHODS

Study Design and Protocol Registration

This systematic review was conducted to identify, critically appraise, and synthesize evidence from randomized controlled trials (RCTs) evaluating physiotherapy interventions for respiratory rehabilitation among individuals recovering from COVID-19. The review aimed to identify and compare physiotherapy intervention characteristics, including rehabilitation protocols, intervention parameters, and outcome measures, across different geographical and healthcare settings. The review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement [13] and guided by the Cochrane Handbook for Systematic Reviews of Interventions [14].

The review protocol was prospectively registered with the International Prospective Register of Systematic Reviews (PROSPERO; Registration No. CRD420251229014). The protocol specified the eligibility criteria, search strategy, outcomes, data extraction procedures, risk-of-bias assessment, and planned methods of synthesis. No amendments were made to the registered protocol after registration.

Eligibility Criteria

Eligibility criteria were developed using the Population, Intervention, Comparator, and Outcome (PICO) framework [15].

Study Designs

Only randomized controlled trials published in English were eligible for inclusion. Eligible trials were required to evaluate the effectiveness of physiotherapy or physiotherapist-led rehabilitation interventions for respiratory or functional recovery following COVID-19. Non-randomized studies, observational studies, qualitative studies, case reports or case series, reviews, protocols, conference abstracts without sufficient outcome data, and duplicate publications were excluded.

Participants

Studies involving individuals recovering from COVID-19 who experienced respiratory symptoms, respiratory impairment, reduced exercise tolerance, or related functional limitations following SARS-CoV-2 infection were eligible. Participants could be recruited from hospital, outpatient rehabilitation, community, or other clinical settings. No restrictions were imposed on sex or gender.

Studies involving participants with pre-existing chronic respiratory diseases unrelated to COVID-19 were excluded where the pre-existing condition was the primary cause of the reported respiratory outcomes or could not be distinguished from post-COVID-19 respiratory impairment.

Interventions

Eligible interventions comprised structured physiotherapy or physiotherapist-led rehabilitation programmes designed to improve respiratory function, exercise capacity, physical functioning, or recovery following COVID-19. Interventions included breathing exercises, airway clearance techniques, aerobic or endurance training, inspiratory muscle training, strengthening exercises, mobilisation, pulmonary rehabilitation, and combined rehabilitation programmes.

No restrictions were imposed on intervention duration, frequency, intensity, supervision, or mode of delivery.

Comparators

Eligible comparator groups included usual or standard medical care, no intervention, wait-list control, attention control, or alternative rehabilitation approaches. Standard care could include routine medical management, pharmacological treatment, monitoring, education, and supportive clinical care. Details of comparator conditions were extracted from each included study.

Outcomes

The primary outcome was exercise capacity, assessed primarily using the six-minute walk test (6MWT).

Secondary outcomes included pulmonary function, oxygen saturation, respiratory muscle strength, dyspnoea, fatigue, health-related quality of life, physical function, hospital length of stay, and hospital

readmission. Pulmonary function outcomes included forced expiratory volume in one second (FEV_1) and forced vital capacity (FVC). Respiratory muscle strength included maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP), where reported. Health-related quality of life included validated instruments such as the Short Form-36 (SF-36) and EuroQol-5 Dimension (EQ-5D).

Studies were eligible if they reported outcomes following completion of the intervention. Where multiple post-intervention assessments were reported, the assessment immediately following completion of the intervention was considered the primary post-intervention time point for the main synthesis.

Publication Period and Language

Studies published between January 2020 and January 2025 and available in English were eligible for inclusion.

Information Sources and Search Strategy

A comprehensive electronic literature search was conducted in PubMed/MEDLINE, Cochrane Library, CINAHL, PEDro, Scopus, and Google Scholar to identify eligible studies. The search covered publications from January 2020 to November 2025. Reference lists of included studies and relevant systematic reviews were also screened manually to identify additional potentially eligible studies.

The search strategy combined controlled vocabulary and free-text terms relating to COVID-19, physiotherapy, respiratory rehabilitation, and specific physiotherapy interventions. The core search concepts included COVID-19, post-COVID-19, SARS-CoV-2, physiotherapy, physical therapy, respiratory rehabilitation, pulmonary rehabilitation, breathing exercises, inspiratory muscle training, airway clearance, and randomized controlled trial. Boolean operators (AND/OR) were used to combine search concepts, and database-specific search syntax was applied where appropriate. The complete search strategies for all databases, including search terms, Boolean operators, filters, and limits, are presented in Supplementary File 1.

Study Selection

All records retrieved from the electronic database searches were imported into EndNote reference management software, where duplicate records were identified and removed before screening.

Titles and abstracts were independently screened by MSI and KEF against the predefined eligibility criteria. Records considered potentially eligible, as well as those for which eligibility could not be determined from the title and abstract, were retrieved for full-text assessment. Full-text articles were independently assessed by MSI and KEF against the prespecified inclusion and exclusion criteria.

Any disagreements between MSI and KEF during the screening process were resolved through discussion and consensus. Where consensus could not be reached, CIU was consulted as the third

reviewer and made the final decision. Reasons for exclusion were documented at the full-text screening stage. The study selection process was reported using a PRISMA 2020 flow diagram.

Data Extraction

Data were extracted using a standardized and pre-piloted data extraction form developed in accordance with recommendations from the Cochrane Handbook for Systematic Reviews of Interventions [14]. The form was pilot-tested using five eligible studies to assess its clarity, completeness, and consistency before full data extraction.

The extracted data included study characteristics (author, year of publication, country, study design, setting, and sample size); participant characteristics (age, sex/gender distribution, clinical characteristics, and relevant baseline characteristics following COVID-19 infection); intervention characteristics (intervention type, treatment components, frequency, intensity, duration, session length, mode of delivery, level of supervision, and adherence where reported); comparator characteristics (usual care, standard medical management, no intervention, or alternative rehabilitation interventions); and outcome characteristics (outcome measure, measurement instrument, assessment time point, sample size, and reported summary statistics).

The primary outcome was exercise capacity, principally assessed using the six-minute walk test (6MWT). Secondary outcomes included forced expiratory volume in one second (FEV_1), forced vital capacity (FVC), oxygen saturation, respiratory muscle strength, dyspnoea, fatigue, health-related quality of life, physical function, hospital length of stay, and hospital readmission.

Where relevant data were unclear or incompletely reported, attempts were made to obtain clarification from the study authors where feasible. Where missing information could not be obtained, analyses were based on the available data, and the potential implications of missing information were considered during interpretation.

AIO and LUA independently extracted data from the included studies. The extracted data were subsequently compared for consistency and accuracy. Disagreements were resolved through discussion and consensus; where consensus could not be reached, KEF was consulted as the third reviewer. JLE and IJI independently verified the extracted data, with CIU consulted as the third reviewer where disagreements could not be resolved through discussion. The final extracted data were organized into structured evidence tables to facilitate comparison across studies and support narrative synthesis and quantitative meta-analysis.

Risk of Bias Assessment

The methodological quality of the included RCTs was assessed using the Physiotherapy Evidence Database (PEDro) scale, a commonly used methodological quality assessment tool in physiotherapy and rehabilitation research [16, 17]. The PEDro scale comprises 11 items, with 10 items contributing to the final score. These items assess methodological characteristics including random allocation, concealed

allocation, baseline comparability, blinding, adequacy of follow-up, intention-to-treat analysis, and appropriate statistical reporting.

Each included study was independently assessed by JLE and IJI using the PEDro scale. PEDro scores were reported out of 10 and interpreted according to prespecified thresholds. The PEDro scores were used to describe methodological quality and were not treated as a direct equivalent of an overall risk-of-bias judgment.

Disagreements between JLE and IJI were resolved through discussion and consensus. Where consensus could not be reached, CIU was consulted as the third reviewer and provided the final decision.

The certainty of evidence for the major outcomes was additionally assessed using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) framework [18]. The GRADE assessment considered five domains: risk of bias, inconsistency, indirectness, imprecision, and publication or reporting bias. The certainty of evidence was classified as high, moderate, low, or very low.

Effect Measures

For continuous outcomes, treatment effects were expressed as mean differences (MDs) with 95% confidence intervals (CIs) when studies used the same measurement scale. Where the same outcome construct was assessed using different measurement scales, standardized mean differences (SMDs) with 95% CIs were calculated. For dichotomous outcomes, such as hospital readmission, risk ratios (RRs) with 95% CIs were calculated where appropriate.

Data Synthesis and Statistical Analysis

Both quantitative and narrative approaches were used to synthesize the findings. Meta-analysis was undertaken where sufficient clinical, methodological, and statistical similarity existed among studies in terms of participants, interventions, comparators, outcome definitions, and assessment time points.

Quantitative analyses were performed using Review Manager (RevMan), version 5.4. A random-effects model was used as the primary model where variation in populations, interventions, settings, and implementation was expected to result in differences in the underlying intervention effects.

Where quantitative pooling was inappropriate because of substantial clinical or methodological heterogeneity, insufficient statistical information, or incompatible outcome measures, findings were synthesized narratively.

Assessment of Heterogeneity

Statistical heterogeneity was assessed using Cochran's chi-square (χ^2) test and quantified using the I^2 statistic. I^2 values were interpreted alongside the magnitude and direction of effects, confidence intervals, and clinical and methodological differences between studies rather than being used as the sole basis for determining whether meta-analysis was appropriate.

Subgroup and Sensitivity Analyses

Where sufficient data were available, subgroup analyses were conducted to explore potential sources of heterogeneity according to:

1. type of physiotherapy intervention (e.g., breathing exercises, inspiratory muscle training, pulmonary rehabilitation, or combined interventions);
2. duration of the rehabilitation programme; and
3. level of supervision (supervised versus unsupervised programmes).

Sensitivity analyses were conducted where appropriate by excluding studies with lower methodological quality and, where justified, studies with substantially smaller sample sizes to assess the robustness of pooled estimates.

Narrative Synthesis

Where meta-analysis was not feasible, findings were synthesized narratively according to intervention type, participant characteristics, comparator conditions, outcome domains, and direction and consistency of effects. Evidence tables were used to facilitate comparison across studies.

Assessment of Reporting Bias

Potential risk of bias due to missing results was assessed by comparing prespecified outcomes and analyses reported in study protocols, trial registries, or the methods sections of published reports with those presented in the final publications, where such information was available.

Where a meta-analysis included 10 or more studies, funnel plots were visually inspected for asymmetry as a potential indication of small-study effects. Funnel-plot asymmetry was interpreted cautiously because asymmetry may arise from factors other than publication bias.

Certainty of Evidence

The certainty of evidence for the major outcomes was assessed using the GRADE framework [18]. Evidence was evaluated across five domains: risk of bias, inconsistency, indirectness, imprecision, and publication or reporting bias. The certainty of evidence was classified as high, moderate, low, or very low.

Reporting of the Review

The review was reported in accordance with the PRISMA 2020 statement [13]. A PRISMA flow diagram was used to illustrate the study identification, screening, eligibility assessment, and inclusion processes. The completed PRISMA 2020 checklist is provided in Appendix II.

RESULTS

Study Selection

The electronic database searches identified 730 records. After removal of 45 duplicate records, 685 unique records remained for title and abstract screening. Of these, 606 records were excluded because they did not meet the predefined eligibility criteria, leaving 79 records for full-text assessment. Following full-text review, 44 articles were excluded for reasons including inappropriate study design, absence of an eligible physiotherapy intervention, irrelevant outcomes, or insufficient methodological information. Consequently, 35 randomized controlled trials (RCTs) met the eligibility criteria and were included in the systematic review.

The included studies evaluated a range of physiotherapy interventions for respiratory rehabilitation following COVID-19, including breathing exercises, pulmonary rehabilitation, inspiratory muscle training, airway clearance techniques, aerobic or endurance training, and combined rehabilitation programmes. The reported outcomes included pulmonary function, exercise capacity, oxygen saturation, respiratory muscle strength, dyspnoea, fatigue, physical function, and health-related quality of life. The complete study selection process is presented in the PRISMA 2020 flow diagram (Fig. 1).

Characteristics of Included Studies

Study Design, Setting, and Geographical Distribution

Thirty-five randomized controlled trials (RCTs) conducted across 16 countries were included. Brazil contributed the largest number of studies (6/35, 17.1%), followed by Türkiye (5/35, 14.3%) and Spain (4/35, 11.4%). Egypt contributed three studies (8.6%), while India, Poland, Iran, Indonesia, and Saudi Arabia each contributed two (5.7%). Pakistan, China, the Republic of Korea, Austria, Australia, France, and Kazakhstan each contributed one study (2.9%). Overall, the evidence was concentrated in Europe, Asia, the Middle East, and South America, with limited representation from Oceania.

The studies used various randomized designs, including parallel-group, single- or double-blind, assessor-blinded, and randomized pretest–posttest controlled designs [19, 20, 23, 24, 35, 42]. Settings included hospitals, pulmonary and rehabilitation units, outpatient services, university facilities, and participants' homes. Several studies used home-based or technology-supported rehabilitation, including smartphone- or internet-based telerehabilitation, videoconferencing, telephone support, and hybrid models [20, 24, 29, 35, 45]. Participants were recruited through hospitals, outpatient and rehabilitation services, post-discharge follow-up, and community or home-based settings. The detailed characteristics of included studies of included study are presented in Table 1.

Participants and Clinical Characteristics

Across the 35 studies, 2,128 participants were included, with sample sizes ranging from 20 to 209. Participants were adults recovering from COVID-19, with reported ages ranging from approximately 18 to 80 years. Both mixed-sex and single-sex samples were represented. Clinical characteristics varied considerably, ranging from individuals recovering from mild-to-moderate disease to patients with

previous hospitalization, intensive-care admission, mechanical ventilation, non-invasive ventilation, or high-flow oxygen therapy [20, 31, 42].

Common persistent symptoms included dyspnoea, fatigue, reduced exercise tolerance, impaired pulmonary function, respiratory muscle weakness, cough, and reduced physical function, with some studies also reporting pain, sleep disturbance, headache, cognitive difficulties, and altered smell or taste [20, 24]. Recruitment occurred from the early post-acute period to several months after infection or hospital discharge.

Characteristics of Rehabilitation Interventions

Interventions varied in content, duration, intensity, and mode of delivery. Major intervention categories included breathing exercises, pulmonary rehabilitation, inspiratory/respiratory muscle training, aerobic or endurance exercise, strengthening exercises, airway-clearance techniques, and multimodal rehabilitation [20–26, 28, 35, 42, 45, 47].

Breathing interventions included diaphragmatic and pursed-lip breathing, thoracic expansion, respiratory control, deep-breathing exercises, and active cycle of breathing techniques. Respiratory muscle training was delivered independently or combined with breathing, aerobic, and strengthening exercises. Multimodal programmes commonly incorporated combinations of respiratory exercises, aerobic/endurance training, resistance exercise, lung-expansion techniques, and functional training [20, 24–26, 28, 35, 42].

Intervention duration ranged from approximately 2 to 12 weeks, with frequency ranging from several sessions per week to multiple daily sessions. Intensity and progression were prescribed using measures such as perceived exertion, heart rate, maximal inspiratory pressure, walking duration/speed, and progressive resistance loading [21, 25, 26, 42].

Delivery models included facility-based, home-based, telemedicine, videoconferencing, and hybrid rehabilitation [20, 24, 26, 29, 35, 45]. Adherence was inconsistently reported, with monitoring approaches including exercise diaries, supervision cards, telephone or videoconference follow-up, telemonitoring, family monitoring, and therapist feedback. Where reported, adherence was generally monitored through these mechanisms, although numerical adherence rates were not consistently provided [20, 24, 26, 29, 45, 47]. The detailed characteristics of Rehabilitation Interventions of the included study are presented in Table 1.

Comparators

Comparator groups included usual/standard medical care, usual activity or no additional intervention, educational interventions, and alternative rehabilitation approaches [20, 29, 41, 43]. Some studies compared different rehabilitation delivery models, such as inpatient versus home pulmonary rehabilitation [41]. Comparator content therefore varied across studies and was considered when assessing clinical comparability for quantitative synthesis.

Outcomes Assessed

Outcomes covered pulmonary function, oxygenation, respiratory muscle strength, exercise capacity, physical function, symptoms, fatigue, health-related quality of life, and psychological outcomes. Pulmonary outcomes included FEV_1, FVC, SpO_2, MIP, and MEP [20, 21, 24, 25, 29, 41]. Exercise capacity and physical function were assessed using measures such as the 6-minute walk test (6MWT/6MWD), timed up-and-go, sit-to-stand tests, and strength measures [20, 24, 25, 29, 41, 43].

Patient-reported outcomes included dyspnoea, fatigue, health-related quality of life, physical functioning, psychological symptoms, and post-COVID-19 symptom burden, measured using instruments such as the SGRQ, SF-36, EQ-5D, mMRC, FSS, and HADS [41, 43]. The 6MWT/6MWD was the most consistently reported functional outcome and was therefore selected as the primary outcome for quantitative synthesis. The detailed outcomes assessed of the included study are presented in Table 1.

Safety and Clinical Outcomes

Safety outcomes were inconsistently reported and included adverse events, hospitalization, hospital length of stay, and readmission. Where reported, rehabilitation interventions were generally well tolerated, with no significant adverse events or additional safety concerns [23, 42, 48, 53]. However, inconsistent reporting limited comparisons of safety outcomes across studies.

Timing of Outcome Assessment

Most studies assessed outcomes at baseline and immediately after completion of the intervention. Intervention durations ranged from approximately 2 to 12 weeks, with post-intervention assessments commonly conducted following 4- to 6-week programmes [20, 21, 24, 25, 41, 47]. The immediate post-intervention assessment was selected as the primary time point for the main synthesis, consistent with the prespecified methodology. Longer-term follow-up assessments, where available, were considered separately.

Risk of Bias

Risk of bias was assessed using the PEDro scale, comprising 11 methodological criteria, with the eligibility criterion excluded from the total score, giving a maximum score of 10. Across the 35 included studies, PEDro scores ranged from 3/10 to 9/10. Overall, 14 studies (40.0%) were classified as having low risk of bias, 13 (37.1%) as having high risk of bias, 5 (14.3%) as having some concerns, and 3 (8.6%) as having moderate risk of bias. The detailed PEDro scores and individual methodological criteria for each included study are presented in Table 2.

The highest methodological quality was observed in Nagy et al. (9/10) [21] and del Corral et al. (9/10) [50], while Li et al. [37], Alsharidah et al. [38], Indrani et al. [39], Elgayar et al. [33], and de Moraes Sirydakis et al. [52] each achieved 8/10. Studies scoring 7/10 included Sánchez Milá et al. [22], Sari et al.

[24], Gomes dos Santos et al. [25], Elyazed et al. [26], Rodriguez-Blanco et al. [29], da Costa et al. [30], Pehlivan et al. [31], Yasacı et al. [36], Amin et al. [46], and Omarova et al. [48] (Table 2).

The most frequent methodological limitations concerned participant and therapist blinding, which were generally not feasible because of the nature of rehabilitation interventions. Concealed allocation and baseline similarity were also inconsistently reported in several studies. In contrast, between-group comparisons and reporting of point estimates with measures of variability were generally well addressed across the included trials.

Generally, the PEDro assessment indicates substantial variation in methodological quality, with more than one-third of studies classified as high risk of bias. These methodological limitations were considered when interpreting the findings and the certainty of evidence from the quantitative synthesis.

Effects of Rehabilitation Interventions: Meta-analysis

Exercise Capacity: Six-Minute Walk Test (6MWT)

A total of 10 studies reported 6-minute walk distance (6MWT) as an outcome [21, 24–26, 28, 37–38, 40, 42, 49]. Sari et al. [24] reported post-intervention 6MWT results as median and interquartile range rather than mean and standard deviation, with median distances of 623.4 m (IQR: 604.8–658.2) in the intervention group and 540.6 m (IQR: 480.0–599.4) in the control group. The reported between-group treatment effect was 30 m (IQR: 26.0–75.6; $P < 0.05$). Because mean and standard deviation were not reported, this study was retained in the systematic review but excluded from the pooled quantitative analysis. The remaining nine studies [21, 25–26, 28, 37–38, 40, 42, 49] were included in the meta-analysis.

Using a random-effects model, rehabilitation interventions were associated with a statistically significant improvement in 6MWD compared with comparator conditions (MD = 66.75 m, 95% CI: 47.60 to 85.89; $Z = 6.83$, $P < 0.00001$). The pooled effect favoured rehabilitation. Moderate statistical heterogeneity was observed across the studies ($\tau^2 = 440.12$; $\chi^2 = 22.26$, df = 8, $P = 0.004$; $I^2 = 64\%$) (Fig. 2).

Individual study estimates generally favoured rehabilitation, with effects ranging from 39.00 m to 99.85 m. The largest effects were reported by Gomes dos Santos et al. [25] (MD = 99.85 m, 95% CI: 6.71 to 192.99), de Araújo Furtado et al. [49] (MD = 97.00 m, 95% CI: 33.01 to 160.99), and Elyazed et al. [26] (MD = 92.70 m, 95% CI: 77.91 to 107.49). Nagy et al. [21] reported the smallest effect (MD = 39.00 m, 95% CI: 19.02 to 58.98). Although Mashhadi et al. [29] and Şahın et al. [42] had confidence intervals crossing the null effect, their point estimates remained in favour of rehabilitation.

Sensitivity Analysis

A sensitivity analysis was performed by excluding Elyazed et al. [26], which contributed a relatively large treatment effect (MD = 92.70 m, 95% CI: 77.91 to 107.49) and accounted for 19.2% of the weight in the

primary analysis.

Following exclusion, the pooled effect remained statistically significant and favoured rehabilitation (MD = 54.37 m, 95% CI: 42.13 to 66.62; P < 0.00001). Statistical heterogeneity decreased from I^2 = 64% in the primary analysis to I^2 = 0% (τ^2 = 0.00; χ^2 = 6.96, df = 7, P = 0.43) (Fig. 3).

The persistence of a statistically significant benefit after excluding Elyazed et al. [26] indicates that the overall treatment effect was robust to this study. However, the reduction in the pooled effect from 66.75 m to 54.37 m and the reduction in heterogeneity suggest that Elyazed et al. [26] contributed substantially to the variability observed in the primary analysis.

Publication Bias

Publication bias was not formally assessed for 6MWD because fewer than 10 studies contributed to the quantitative synthesis. Therefore, funnel-plot asymmetry and formal statistical tests for small-study effects were not considered sufficiently reliable for this outcome.

Pulmonary Function: Forced Expiratory Volume in One Second (FEV_1)

A total of six studies reported FEV_1 as an outcome [22, 28, 34, 37, 38, 50]. The studies included Alsharidah et al. [38], del Corral et al. [50], Li et al. [37], Mashhadi et al. [28], Rutkowski et al. [34], and Sánchez Milá et al. [22]. A total of 236 participants in the intervention groups and 234 in the control groups contributed to the primary quantitative synthesis.

Using a random-effects model, rehabilitation interventions were associated with a small but statistically non-significant improvement in FEV_1 compared with comparator conditions (MD = 0.21 L, 95% CI: −0.01 to 0.43; Z = 1.85, P = 0.06). Substantial statistical heterogeneity was observed across the studies (τ^2 = 0.05; χ^2 = 18.12, df = 5, P = 0.003; I^2 = 72%) (Fig. 4).

Individual study estimates generally favoured rehabilitation, although the magnitude of effects varied considerably. The largest effect was reported by Sánchez Milá et al. [22] (MD = 0.57 L, 95% CI: 0.37 to 0.77), while Mashhadi et al. [29] reported the smallest study-specific effect among the positive estimates (MD = 0.74 L, 95% CI: −0.30 to 1.78). The remaining studies showed relatively small effects, with confidence intervals crossing the null effect [28, 34, 37–38, 50].

Sensitivity analysis

A sensitivity analysis was performed by excluding Sánchez Milá et al. [22], which reported the largest effect estimate. The remaining five studies [29, 34, 37–38, 50] showed a pooled MD of 0.10 L (95% CI: −0.01 to 0.21; Z = 1.74, P = 0.08). Following exclusion, statistical heterogeneity was substantially reduced from I^2 = 72% to I^2 = 0% (τ^2 = 0.00; χ^2 = 1.84, df = 4, P = 0.77).

Thus, exclusion of Sánchez Milá et al. [22] reduced the heterogeneity observed in the primary analysis, but did not alter the overall direction or statistical significance of the pooled effect, which remained non-significant.

Pulmonary Function: Forced Vital Capacity (FVC)

A total of six studies reported forced vital capacity (FVC) as an outcome [22, 28, 34, 37–38, 50]. The included studies were Alsharidah et al. [38], del Corral et al. [50], Li et al. [37], Mashhadi et al. [28], Rutkowski et al. [34], and Sánchez Milá et al. [22]. A total of 236 participants in the intervention groups and 234 in the control groups contributed to the primary quantitative synthesis.

Using a random-effects model, rehabilitation interventions showed a non-significant tendency toward improvement in FVC compared with comparator conditions (MD = 0.28 L, 95% CI: −0.02 to 0.57; Z = 1.82, $P = 0.07$). Substantial statistical heterogeneity was observed across the studies ($\tau^2 = 0.09$; $\chi^2 = 27.15$, df = 5, $P < 0.0001$; $I^2 = 82\%$) (Fig. 6).

Individual study estimates generally favoured rehabilitation, although the magnitude of effects varied considerably. Mashhadi et al. [28] reported the largest effect (MD = 1.73 L, 95% CI: 0.34 to 3.12), followed by Sánchez Milá et al. [22] (MD = 0.62 L, 95% CI: 0.42 to 0.82). The remaining studies reported smaller effects, with confidence intervals crossing the null value: Alsharidah et al. [38] (MD = 0.18 L, 95% CI: −0.05 to 0.41), del Corral et al. [50] (MD = 0.10 L, 95% CI: −0.44 to 0.64), Li et al. [37] (MD = 0.02 L, 95% CI: −0.14 to 0.18), and Rutkowski et al. [34] (MD = 0.06 L, 95% CI: −0.52 to 0.64).

Sensitivity Analysis

A sensitivity analysis was performed by excluding Sánchez Milá et al. [22], which contributed a relatively large positive effect (MD = 0.62 L, 95% CI: 0.42 to 0.82) and accounted for 23.0% of the weight in the primary analysis. Following exclusion, five studies involving 136 intervention and 134 control participants remained in the quantitative synthesis.

The pooled effect was reduced to MD = 0.12 L (95% CI: −0.08 to 0.33; Z = 1.17, $P = 0.24$) and remained statistically non-significant. Heterogeneity was substantially reduced from $I^2 = 82\%$ to $I^2 = 41\%$ ($\tau^2 = 0.02$; $\chi^2 = 6.73$, df = 4, $P = 0.15$) (Fig. 7).

Thus, exclusion of Sánchez Milá et al. [22] reduced both the magnitude of the pooled effect and the observed heterogeneity, but did not alter the overall conclusion, as the pooled effect remained statistically non-significant. The sensitivity analysis suggests that Sánchez Milá et al. [22] contributed substantially to the heterogeneity observed in the primary FVC analysis.

Oxygen Saturation (SpO_2)

Oxygen saturation (SpO_2) was assessed in several studies, primarily as a physiological or safety outcome. However, measurement and reporting varied substantially, and comparable data were

insufficient for quantitative synthesis.

Alsharidah et al. [38] monitored SpO_2 throughout a six-week pulmonary telerehabilitation programme using pulse oximetry, with participants instructed to stop exercise if SpO_2 decreased by 4% or fell below 95%. Gomes dos Santos et al. [25] similarly monitored SpO_2 during a six-week cardiopulmonary rehabilitation programme and provided supplemental oxygen when SpO_2 fell to ≤ 90%; however, neither study reported SpO_2 as a comparative post-intervention outcome.

Ashraf et al. [23] assessed oxygen saturation using pulse oximetry and reported a statistically significant between-group difference favouring postural drainage over deep-breathing exercises. The reported pulse-oximetry values changed from 3.50 ± 0.51 to 1.50 ± 0.59 in the postural-drainage group and from 3.25 ± 0.61 to 2.25 ± 0.68 in the deep-breathing group. However, these values were not reported in conventional SpO_2 percentage units, despite the study describing pulse oximetry as a measure of oxygen saturation. Therefore, the numerical values were not interpreted as conventional SpO_2 percentages.

Bagherzadeh-Rahmani et al. [51] did not assess oxygen saturation and identified this as a limitation of the study.

Generally, three studies provided information on SpO_2 monitoring or measurement [23, 25, 38], although only Ashraf et al. [23] reported comparative pre- and post-intervention values. Given the heterogeneity in measurement and reporting, together with the unclear metric reported by Ashraf et al. [23], meta-analysis was not performed, and the findings were synthesized narratively.

Respiratory Muscle Strength

Respiratory muscle strength was assessed in Pietranis et al. [19], Nagy et al. [21], Sánchez Milá et al. [22], and del Corral et al. [50], using measures including maximum inspiratory pressure (PImax/MIP), maximum expiratory pressure (PEmax/MEP), and inspiratory or expiratory muscle strength and endurance. Overall, findings generally favoured rehabilitation, although effects were not consistent across outcomes and comparisons.

Pietranis et al. [19] reported improvements in PImax and PEmax following a six-week comprehensive pulmonary rehabilitation programme with inspiratory muscle training. PImax increased from 95 (86–108) to 104 (94–111) cmH_2O in the IMT group and from 86.5 (75–100) to 89 (82.5–101) cmH_2O in the placebo-IMT group. However, the reported between-group association was not statistically significant ($r = 0.141$, $P = 0.280$). Similarly, no significant between-group difference was observed for PEmax ($r = 0.002$, $P = 0.987$).

Nagy et al. [21] reported a significant improvement in PImax following six weeks of manual diaphragm release combined with inspiratory muscle training. PImax increased from 82.00 ± 16.86 to 121.50 ± 13.52 cmH_2O in the intervention group, compared with 80.50 ± 17.52 to 84.00 cmH_2O in the control group ($P < 0.001$). Sánchez Milá et al. [22] also reported significantly greater improvement in MIP/PImax with respiratory rehabilitation incorporating inspiratory muscle training and aerobic exercise, with MIP

increasing from 70.04 ± 10.25 to 94.96 ± 4.94 cmH_2O in the intervention group compared with 71.08 ± 14.09 to 71.77 ± 4.24 cmH_2O in the control group ($P < 0.01$).

Del Corral et al. [50] reported improvements in inspiratory muscle strength and endurance following an eight-week home-based respiratory muscle training programme delivered through videoconferencing. Combined inspiratory and expiratory muscle training additionally improved expiratory muscle strength and peak expiratory flow compared with inspiratory muscle training and sham interventions.

Overall, rehabilitation programmes incorporating inspiratory muscle training generally improved inspiratory muscle strength, particularly PImax/MIP, although superiority over control conditions was not consistently demonstrated. Evidence for expiratory muscle strength was less consistent. Because the studies differed in respiratory muscle measures, intervention comparisons, and statistical reporting, quantitative meta-analysis was not performed and respiratory muscle strength was synthesized narratively.

Patient-Reported Outcomes

Patient-reported outcomes included dyspnoea, fatigue, health-related quality of life (HRQoL), psychological symptoms, physical activity, and broader post-COVID-19 symptom burden. Measurement instruments varied considerably and included the modified Medical Research Council (mMRC) dyspnoea scale, modified Borg scale, St George's Respiratory Questionnaire (SGRQ), SF-36, EQ-5D, Fatigue Severity Scale (FSS), Chalder Fatigue Scale, Multidimensional Fatigue Inventory (MFI), Hospital Anxiety and Depression Scale (HADS), Beck Depression Inventory (BDI), and Nottingham Health Profile (NHP) [21, 22, 24, 26, 27, 31, 32, 42, 43, 50, 52].

Dyspnoea was among the most frequently reported patient-reported outcomes. Significant improvements were reported following rehabilitation in several studies, including Nagy et al. [21], Sánchez Milá et al. [22], Pehlivan et al. [31], Elyazed et al. [26], and Şahın et al. [42]. Nagy et al. [21] reported a reduction in mMRC from 2.63 ± 0.60 to 1.38 ± 0.49 in the intervention group, compared with 2.42 ± 0.49 to 2.11 ± 0.33 in controls, with a significant between-group difference. Pehlivan et al. [31] also reported significant improvement in mMRC following telerehabilitation, while Sánchez Milá et al. [22] reported significant group × time effects for modified Borg dyspnoea and mMRC.

Fatigue was assessed using FSS, Chalder Fatigue Scale, MFI, and modified Borg fatigue measures [21, 22, 24, 26, 27, 32, 42, 43, 50]. Nagy et al. [21] reported a significant reduction in FSS with a significant between-group difference. Elyazed et al. [26] reported significantly greater improvement in Chalder fatigue with home-based pulmonary rehabilitation than usual care. Vallier et al. [27] reported reductions in MFI fatigue in both rehabilitation groups, although improvements in general fatigue were greater following inpatient rehabilitation. In contrast, Jeong et al. [32] reported a significant within-group reduction in FSS but no significant between-group difference ($P = 0.125$).

HRQoL was assessed using the SGRQ, SF-36, VQ11, and EQ-5D-5L [22, 26, 27, 31, 42, 43, 52]. Pehlivan et al. [31] reported significant improvements in the SGRQ activity and impact domains following telerehabilitation. Elyazed et al. [26] reported significantly greater improvement in SF-36 scores in the rehabilitation group than in the control group (66.4 ± 3.7 vs 47.6 ± 2.6; P < 0.001). Vallier et al. [27] reported improvements in VQ11 scores in both inpatient and home rehabilitation groups, although the group × time interaction was not statistically significant.

Psychological and other patient-reported outcomes were less consistently reported. Sari et al. [24] reported improvements in HADS-A, HADS-D, HADS-T, NHP, IPAQ, and FSS, although the magnitude and statistical significance of effects varied across outcomes. Pehlivan et al. [31] assessed the BDI alongside dyspnoea, fatigue, and HRQoL, while Şahın et al. [42] assessed mMRC, modified Borg dyspnoea and fatigue, SGRQ, SF-36, and HADS.

Generally, patient-reported outcomes generally showed favourable changes with rehabilitation, particularly for dyspnoea, fatigue, and selected health-related quality-of-life measures, although effects were not consistently significant across studies. Considerable variation in outcome instruments, scoring systems, intervention characteristics, and reporting formats limited direct comparison between studies. Patient-reported outcomes were therefore synthesized separately; where sufficiently comparable data were available, outcomes were considered for quantitative synthesis, while the remaining findings were synthesized narratively.

Certainty of Evidence

The certainty of evidence for the major quantitative outcomes was assessed using the GRADE framework. As all contributing studies were randomized controlled trials, evidence initially started at high certainty and was downgraded where serious concerns were identified regarding risk of bias, inconsistency, indirectness, imprecision, or publication bias. Risk-of-bias judgments were informed by study-level methodological assessments rather than PEDro scores alone. Certainty was assessed separately for each outcome.

For 6-minute walk distance (6MWD), nine RCTs involving 465 participants contributed to the meta-analysis. Rehabilitation significantly improved 6MWD (MD = 66.75 m, 95% CI 47.60 to 85.89; P < 0.00001), with moderate heterogeneity (I^2 = 64%). Evidence was downgraded one level for risk of bias and one level for inconsistency. No downgrading was made for indirectness or imprecision. Overall certainty was low (⊕⊕◯◯).

For FEV_1, six RCTs involving 470 participants contributed to the analysis. Rehabilitation produced a small, non-significant improvement (MD = 0.21 L, 95% CI − 0.01 to 0.43; P = 0.06), with substantial heterogeneity (I^2 = 72%). Evidence was downgraded one level for risk of bias and one level for inconsistency. No downgrading was made for indirectness or imprecision. Overall certainty was low (⊕⊕◯◯).

For FVC, six RCTs involving 470 participants contributed to the analysis. Rehabilitation showed a non-significant improvement (MD = 0.28 L, 95% CI − 0.02 to 0.57; P = 0.07), with substantial heterogeneity (I^2 = 82%). Evidence was downgraded one level each for risk of bias, inconsistency, and imprecision. No downgrading was made for indirectness. Overall certainty was very low (⊕◯◯◯). Publication bias was not formally assessed because fewer than 10 studies contributed to each meta-analysis; therefore, no downgrade was applied for publication bias. The detailed GRADE Summary of Findings are presented in Table 3.

Discussion

This systematic review examined physiotherapy interventions used for post-COVID respiratory rehabilitation across different countries, focusing on rehabilitation protocols, intervention characteristics, outcome measures, and treatment effects. The included studies demonstrated substantial variation in intervention content and delivery, including pulmonary rehabilitation, aerobic and resistance exercise, breathing exercises, inspiratory muscle training, home-based rehabilitation, and telerehabilitation. Despite this variation, rehabilitation significantly improved functional exercise capacity, whereas effects on conventional pulmonary function were less conclusive. Findings for respiratory muscle outcomes, oxygen saturation, dyspnoea, fatigue, and health-related quality of life were generally favourable but could not be quantitatively synthesized consistently because of differences in measurement and reporting.

Physiotherapy Rehabilitation Protocols Used Across Countries

The included studies demonstrated considerable variation in physiotherapy rehabilitation protocols [19–53]. Interventions ranged from single-component approaches, such as breathing exercises and inspiratory muscle training, to multicomponent programmes incorporating aerobic exercise, resistance training, respiratory exercises, functional training, education, and symptom management.

Nagy et al. [21] evaluated manual diaphragm release combined with inspiratory muscle training, whereas Sari et al. [24] investigated inspiratory muscle training. Other studies evaluated broader pulmonary or cardiopulmonary rehabilitation programmes [25–27]. Home-based and telerehabilitation approaches were also investigated by Rodríguez-Blanco et al. [29], Pehlivan et al. [31], Yasacı et al. [36], Li et al. [37], and Alsharidah et al. [38].

This variation indicates that post-COVID respiratory rehabilitation has been implemented through different combinations of exercise conditioning, respiratory muscle training, breathing techniques, functional training, and remote care. However, the available evidence does not establish one protocol as superior to another. Rehabilitation may therefore need to be tailored according to individual clinical presentation, functional limitations, intervention feasibility, and available healthcare resources.

Intervention Characteristics and Delivery Across Settings

Intervention characteristics varied in duration, intensity, frequency, supervision, progression, and delivery mode [19–53]. Some programmes were delivered through direct professional supervision, whereas others used home-based or remote approaches. These differences may partly explain the variability in treatment effects observed across studies.

Home-based and telerehabilitation models may improve access for individuals facing geographical, transportation, workforce, or service-access barriers. However, the current evidence does not demonstrate that remote rehabilitation is superior to conventional centre-based rehabilitation. Rather, different delivery models may provide feasible alternatives depending on patient needs and healthcare context.

The cross-country evidence therefore demonstrates variation in implementation rather than superiority of any particular country, healthcare system, or delivery model. Differences in rehabilitation infrastructure, professional availability, technology, and healthcare resources may influence how interventions are implemented.

Outcome Measures

The included studies used a broad range of outcomes reflecting the multidimensional nature of post-COVID recovery. Functional exercise capacity was commonly assessed using the six-minute walk distance (6MWD), while pulmonary function was assessed using FEV_1 and FVC. Other outcomes included respiratory muscle strength, oxygen saturation, dyspnoea, fatigue, and health-related quality of life.

Dyspnoea was assessed using instruments such as the modified Medical Research Council and modified Borg scales [21, 22, 24, 29, 31, 42], while quality of life was assessed using instruments including SF-36, SGRQ, and EQ-5D [22, 26, 27, 31, 42, 43]. Differences in instruments, scoring systems, assessment procedures, and reporting formats limited direct comparison and quantitative synthesis for several outcomes.

Standardized outcome measurement and reporting would therefore improve comparability and facilitate future evidence synthesis.

Effectiveness on Functional Exercise Capacity

Functional exercise capacity demonstrated the strongest quantitative evidence. Nine RCTs involving 465 participants contributed to the 6MWD meta-analysis, showing a significant pooled improvement of 66.75 m (95% CI 47.60–85.89; $P < 0.00001$), with moderate heterogeneity ($I^2 = 64\%$).

This finding is consistent with previous systematic reviews. Oliveira et al. [54] reported an improvement of approximately 60.56 m following pulmonary rehabilitation, while a systematic review of telerehabilitation reported an improvement of approximately 76.90 m [55]. Yue et al. [56] similarly reported an improvement of approximately 76.85 m following pulmonary rehabilitation. The consistency

of these estimates supports the beneficial effect of rehabilitation on functional exercise capacity following COVID-19.

Individual studies also support the pooled finding. Nagy et al. [21] reported improved 6MWD following manual diaphragm release combined with inspiratory muscle training, while Pehlivan et al. [31] and Rodríguez-Blanco et al. [29] reported favourable functional outcomes following telerehabilitation. Elyazed et al. [26] also reported favourable effects following home-based pulmonary rehabilitation.

The moderate heterogeneity indicates that the magnitude of benefit varied between studies. Differences in intervention content, duration, exercise intensity, supervision, delivery mode, baseline functional status, and participant characteristics may account for this variation. The sensitivity analysis further showed that an individual study contributed to the observed heterogeneity, although the direction of effect remained favourable.

Overall, the findings suggest that improvement in functional exercise capacity may be achieved through different physiotherapy rehabilitation approaches rather than one specific protocol.

Effectiveness on Pulmonary Function

The effects of rehabilitation on conventional pulmonary function were less conclusive. Six RCTs involving 470 participants contributed to the FEV_1 analysis. Rehabilitation produced a small improvement in FEV_1 (MD = 0.21 L, 95% CI − 0.01 to 0.43; P = 0.06), while FVC also showed a non-significant improvement (MD = 0.28 L, 95% CI − 0.02 to 0.57; P = 0.07) with substantial heterogeneity (I^2 = 82%).

Although both estimates favoured rehabilitation, their confidence intervals crossed the null value. This suggests that evidence for consistent improvements in conventional spirometric measures remains uncertain. The difference between functional and pulmonary outcomes may reflect the multidimensional nature of exercise capacity, which depends on respiratory, cardiovascular, and musculoskeletal function, whereas FEV_1 and FVC primarily reflect pulmonary mechanics.

Rehabilitation may therefore improve exercise tolerance and peripheral conditioning without producing equivalent changes in lung volumes or expiratory flow. The substantial heterogeneity observed for FVC may also reflect differences in baseline pulmonary impairment, intervention characteristics, duration, and assessment procedures.

Respiratory Muscle and Physiological Outcomes

Several studies incorporated respiratory muscle training or breathing-focused interventions [21, 24, 30, 45]. Nagy et al. [21] evaluated manual diaphragm release combined with inspiratory muscle training, while Sari et al. [24] investigated inspiratory muscle training. Other studies incorporated respiratory muscle training within broader cardiopulmonary rehabilitation programmes [25, 30].

The available evidence suggests potential improvements in respiratory muscle performance, consistent with previous evidence reporting improvements in maximal inspiratory pressure following pulmonary rehabilitation [56]. However, differences in assessment methods prevented quantitative pooling. The evidence therefore supports respiratory muscle training as a potentially useful component of rehabilitation but does not establish superiority over general exercise-based rehabilitation.

Oxygen saturation was inconsistently reported and was often monitored as a safety or physiological parameter rather than a primary treatment outcome [23, 25, 38]. Consequently, the available evidence was insufficient for quantitative synthesis.

Patient-Reported Outcomes

Patient-reported outcomes generally favoured rehabilitation, particularly for dyspnoea, fatigue, and health-related quality of life, although findings varied between studies.

Dyspnoea was assessed using the modified Medical Research Council and modified Borg scales [21, 22, 24, 29, 31, 42], with improvements reported following different rehabilitation approaches. Fatigue also generally improved, although findings were not uniformly significant. Nagy et al. [21] reported improvement in fatigue, whereas Jeong et al. [32] found a significant within-group reduction without a significant between-group difference. This distinction highlights the importance of interpreting between-group effects when determining treatment effectiveness.

Health-related quality of life was assessed using SF-36, SGRQ, and EQ-5D [22, 26, 27, 31, 42, 43]. Several studies reported favourable changes, but differences in instruments and domains prevented a single pooled estimate.

Overall, rehabilitation appears to improve several patient-perceived outcomes, but standardized outcome assessment is needed to facilitate comparison across studies.

Certainty of Evidence

The GRADE assessment indicated low-certainty evidence for 6MWD and FEV_1 and very-low-certainty evidence for FVC. Evidence for 6MWD was downgraded for risk of bias and inconsistency, while FEV_1 was downgraded for risk of bias and inconsistency. FVC was additionally downgraded for imprecision.

These ratings indicate that the improvement in functional exercise capacity is encouraging but should be interpreted cautiously because the magnitude of benefit may vary across populations and rehabilitation protocols. The lower certainty for pulmonary function similarly limits confidence in the pooled FEV_1 and FVC estimates.

Publication bias was not formally assessed because fewer than 10 studies contributed to each principal meta-analysis.

Strengths and Limitations

This review has several strengths. It specifically examined physiotherapy interventions and rehabilitation protocols for post-COVID respiratory rehabilitation across different countries and healthcare settings, addressing both intervention characteristics and clinical outcomes. The review included randomized controlled trials and quantitatively synthesized outcomes where sufficient comparability existed, while heterogeneous outcomes were synthesized narratively to avoid inappropriate pooling. The review also considered functional capacity, pulmonary function, respiratory muscle outcomes, physiological measures, symptoms, and health-related quality of life. Sensitivity analysis was conducted for the 6MWD analysis, and GRADE was used to assess certainty of evidence.

Several limitations should also be considered. First, rehabilitation protocols varied considerably in content, intensity, duration, supervision, and delivery mode, which may have contributed to heterogeneity. Second, methodological limitations were present across several trials, contributing to reduced certainty of evidence. Third, pooled estimates represent effects across related but non-identical rehabilitation approaches rather than one standardized physiotherapy protocol. Fourth, several outcomes could not be quantitatively pooled because of differences in instruments and reporting formats, particularly dyspnoea, fatigue, health-related quality of life, respiratory muscle outcomes, and oxygen saturation. Finally, fewer than 10 studies contributed to each principal meta-analysis, limiting formal assessment of publication bias, and most studies used short-term follow-up, limiting conclusions regarding the durability of treatment effects.

Implications for Physiotherapy Practice

The findings support physiotherapy-based respiratory rehabilitation as an important component of recovery for individuals with persistent functional limitations following COVID-19. The significant improvement in 6MWD suggests that functional exercise capacity may be particularly responsive to rehabilitation.

Clinical assessment should therefore extend beyond conventional pulmonary function testing to include functional capacity, dyspnoea, fatigue, respiratory muscle performance, and health-related quality of life.

The diversity of interventions supports an individualized approach incorporating aerobic exercise, resistance training, breathing exercises, inspiratory muscle training, or multicomponent pulmonary rehabilitation according to patient needs. However, the evidence does not establish one universal protocol as superior.

Home-based and telerehabilitation approaches may provide useful alternatives where access to conventional rehabilitation is limited. Their use should consider clinical status, exercise tolerance, monitoring requirements, digital access, and professional support. Protocols should also be adapted to available healthcare resources to promote equitable access across different settings.

Implications for Future Research

Future RCTs should provide detailed descriptions of rehabilitation protocols, including frequency, intensity, duration, progression, supervision, adherence, and specific therapeutic components. Standardized reporting would improve reproducibility and help determine which intervention components contribute most to treatment effects.

Future studies should also use standardized measures of functional capacity, pulmonary function, respiratory muscle strength, dyspnoea, fatigue, and health-related quality of life. Direct comparisons of individual rehabilitation components and multicomponent programmes would help determine whether specific approaches provide greater benefits for particular post-COVID impairments.

Longer-term follow-up is needed to determine whether improvements are sustained. Comparative studies of centre-based, home-based, and telerehabilitation are also warranted, particularly across healthcare settings with different levels of rehabilitation resources.

Future research should additionally report healthcare-setting and regional characteristics systematically to determine how resources, infrastructure, and service availability influence rehabilitation delivery and outcomes.

Conclusion

This systematic review demonstrates that post-COVID respiratory rehabilitation is delivered through diverse physiotherapy protocols and delivery models across countries and healthcare settings. Interventions included pulmonary rehabilitation, aerobic and resistance exercise, breathing exercises, inspiratory muscle training, home-based rehabilitation, and telerehabilitation.

Despite this diversity, rehabilitation significantly improved functional exercise capacity, with a pooled 6MWD improvement of 66.75 m (95% CI 47.60–85.89). In contrast, pooled effects on FEV_1 and FVC were not statistically significant, although both estimates favoured rehabilitation.

Overall, the findings support physiotherapy-based respiratory rehabilitation as an important component of post-COVID-19 recovery, particularly for improving functional exercise capacity. However, the low certainty of evidence for 6MWD and FEV_1 and very-low-certainty evidence for FVC warrants cautious interpretation. Further high-quality research using standardized protocols and outcome measures, detailed reporting of intervention characteristics and healthcare settings, and longer-term follow-up is needed to identify effective, feasible, and equitable approaches to post-COVID respiratory rehabilitation.

Abbreviations

6MWD
Six-Minute Walk Distance
C19-YRS
COVID-19 Yorkshire Rehabilitation Scale

EQ-5D
EuroQol Five-Dimension Questionnaire
FEV_1
Forced Expiratory Volume in One Second
FSS
Fatigue Severity Scale
FVC
Forced Vital Capacity
HADS
Hospital Anxiety and Depression Scale
HRQoL
Health-Related Quality of Life
MFI
Multidimensional Fatigue Inventory
mMRC
Modified Medical Research Council
NHP
Nottingham Health Profile
SGRQ
St George's Respiratory Questionnaire
SF-36
36-Item Short Form Health Survey
SpO_2
Peripheral Oxygen Saturation

Declarations

Ethics approval and consent to participate

Not applicable. This study was a systematic review and meta-analysis of previously published studies and did not involve the collection of primary data from human participants.

Consent to publish

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Additional Searching

Reference lists of all included studies and relevant systematic reviews were screened manually to identify additional potentially eligible studies that were not retrieved through the electronic database searches. Citation tracking was also undertaken where relevant.

Search Limits

Searches were limited to studies published between January 2020 and November 2025. Studies were considered eligible according to the prespecified inclusion and exclusion criteria, with the review focusing on randomized controlled trials evaluating physiotherapy-based respiratory rehabilitation interventions in individuals with post-COVID-19 conditions.

Author Contribution

CIU, KEF and MSI conceived the study, participated in the literature search and review, and contributed to the development of the study design. MSI and KEF independently screened titles, abstracts, and full-text articles, with CIU providing third-reviewer adjudication where required. AIO and LUA independently extracted data, while JLE and IJI independently verified the extracted data and assessed the methodological quality of the included studies using the PEDro scale. KEF contributed to data synthesis, statistical analysis, and interpretation of findings. CIU provided third-reviewer adjudication for disagreements arising during data verification and risk-of-bias assessment. All authors contributed to manuscript review and critical revision for intellectual content and read and approved the final manuscript.

Data Availability

All data analysed in this systematic review and meta-analysis were extracted from publicly available published studies. The extracted data supporting the findings of this review are available from the corresponding author on reasonable request.

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Figures

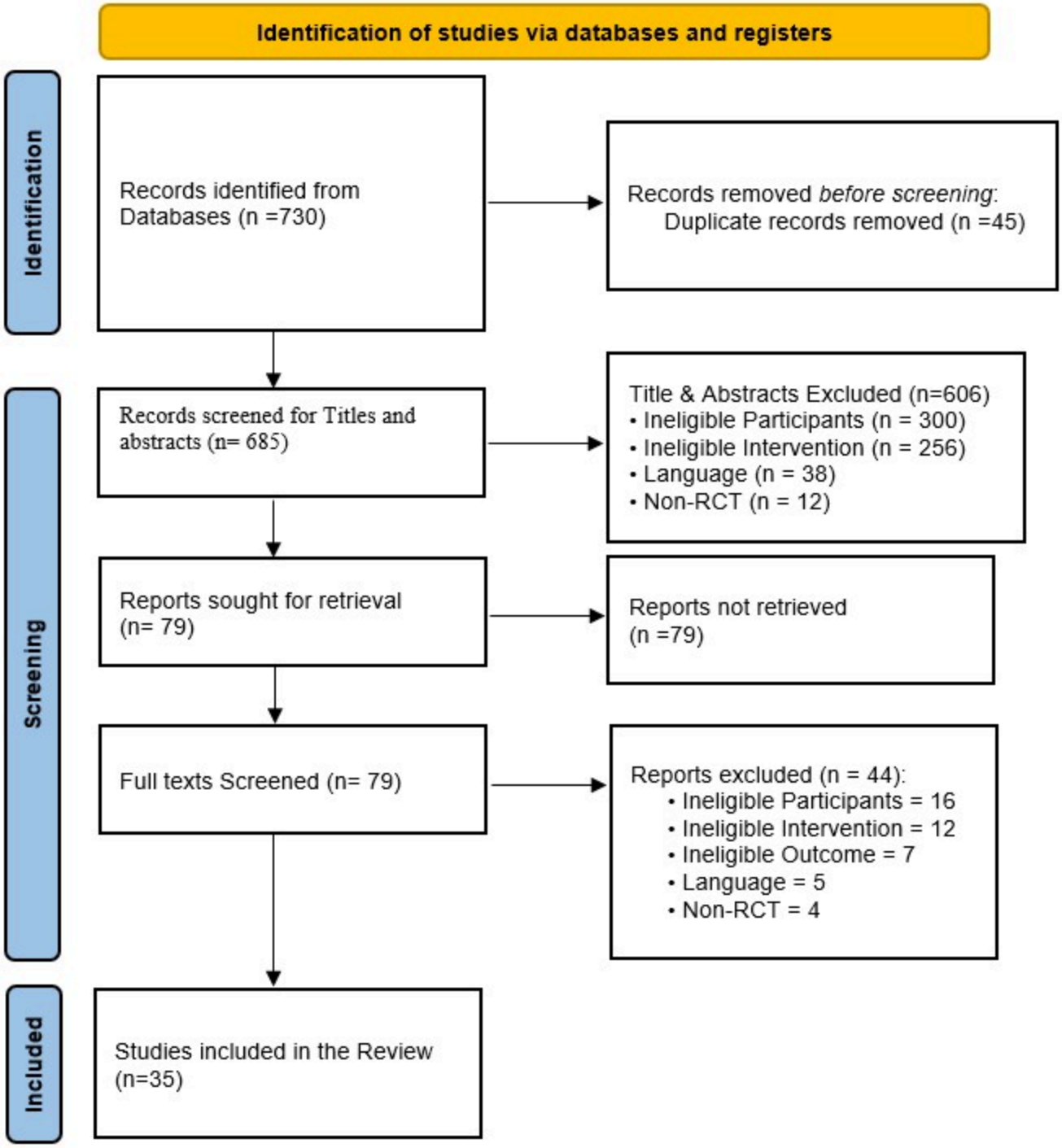


Figure 1

PRISMA Flow Diagram

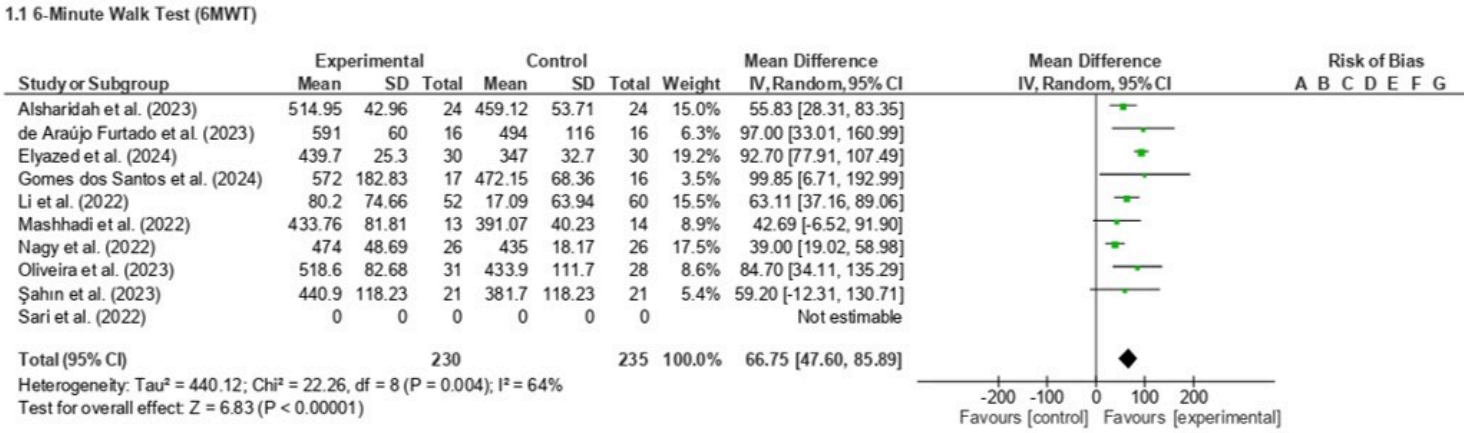


Figure 2

Effects of Rehabilitation Interventions on Exercise Capacity: Six-Minute Walk Test (6MWT)

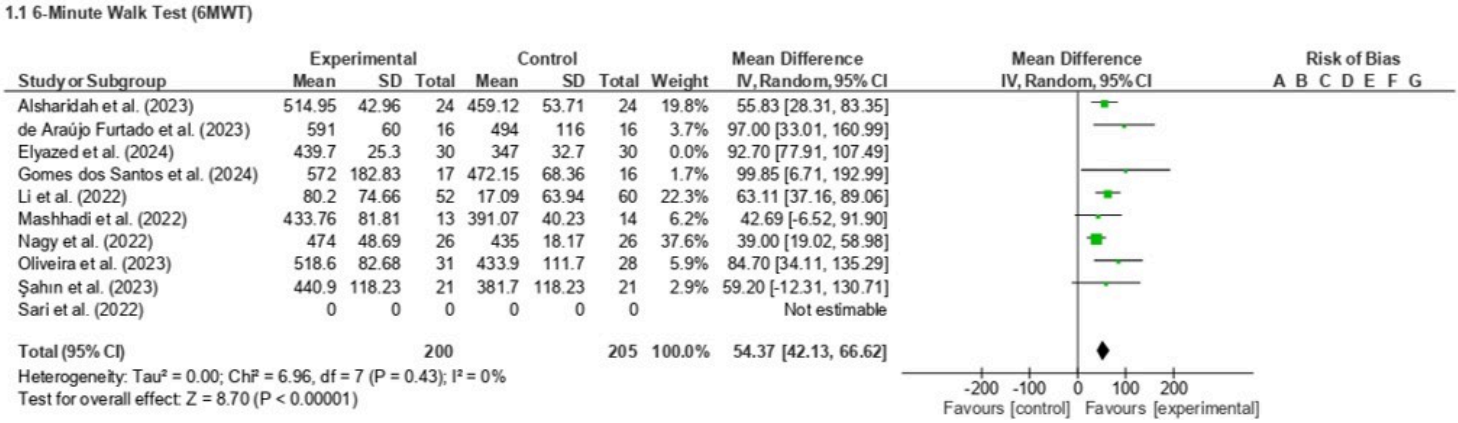


Figure 3

Sensitivity Analysis on the Effects of Rehabilitation Interventions on Exercise Capacity: Six-Minute Walk Test (6MWT)

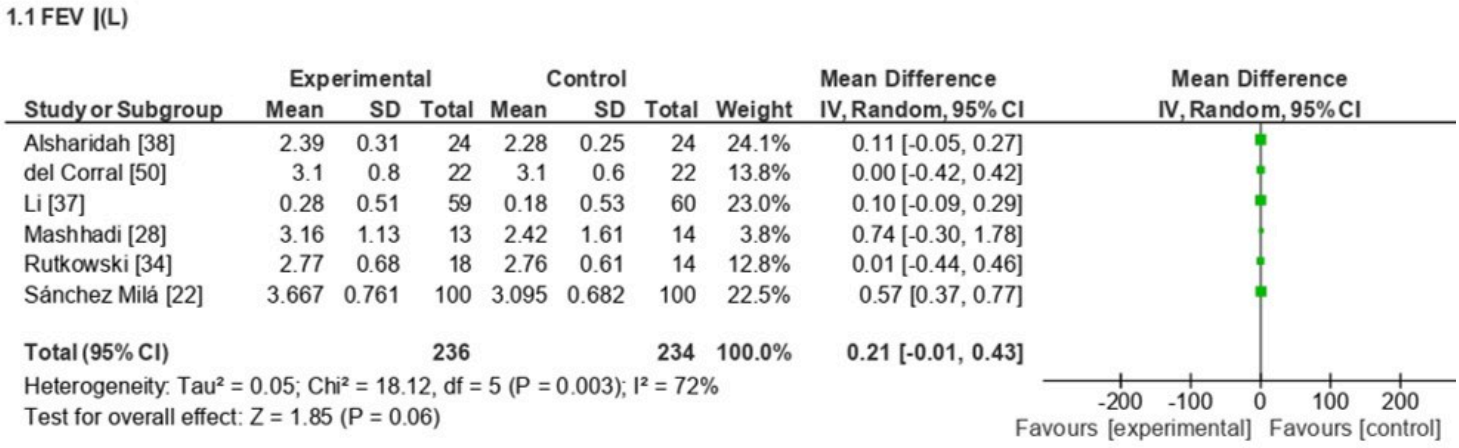


Figure 4

Effects of Rehabilitation Interventions on Pulmonary Function: Forced Expiratory Volume in One Second (FEV_1)

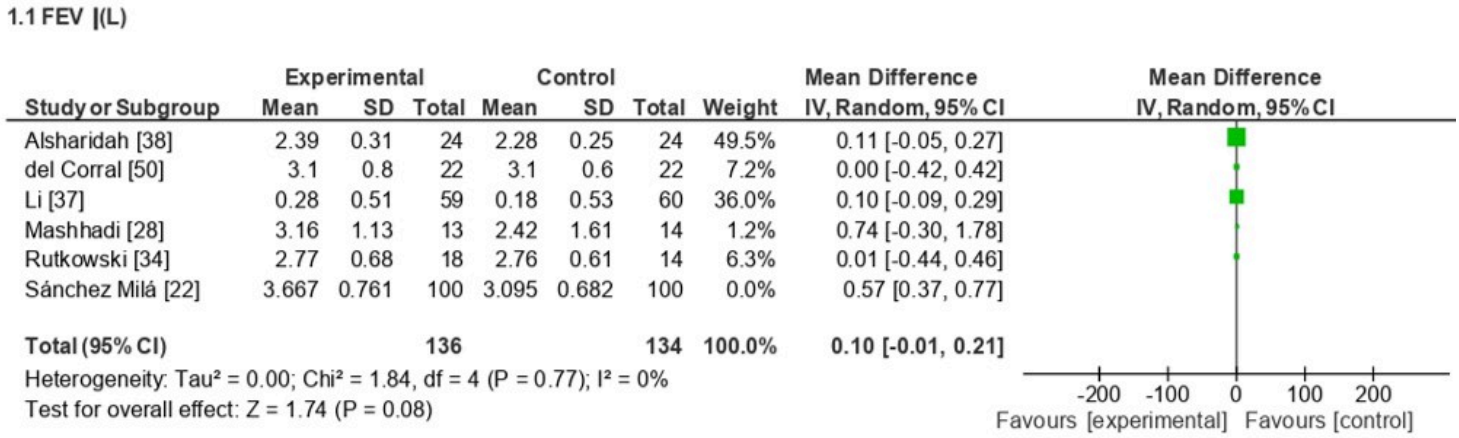


Figure 5

Sensitivity Analysis on the Effects of Rehabilitation Interventions on Pulmonary Function: Forced Expiratory Volume in One Second (FEV_1)

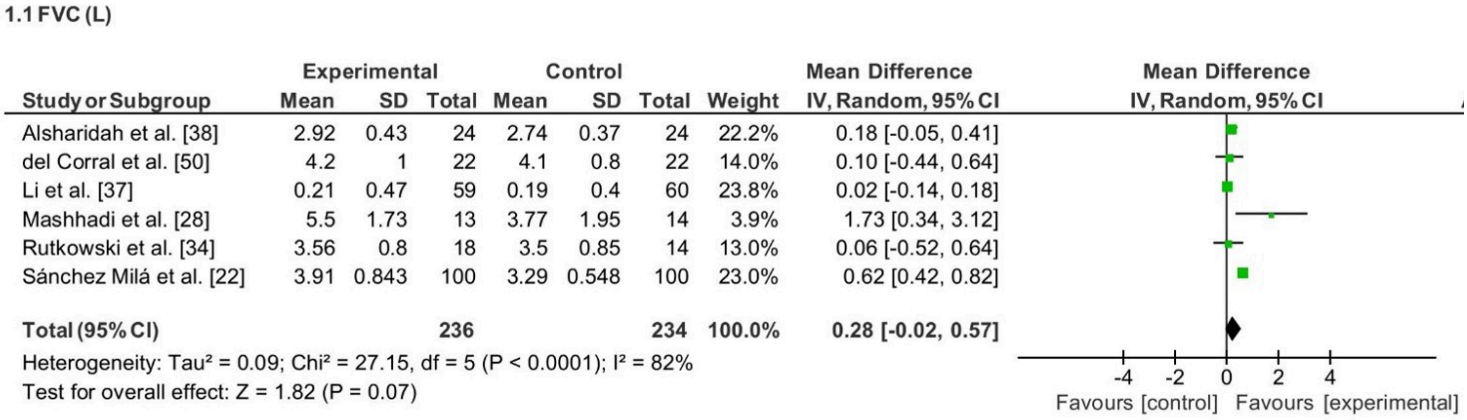


Figure 6

Effects of Rehabilitation Interventions on Pulmonary Function: Forced Vital Capacity (FVC)

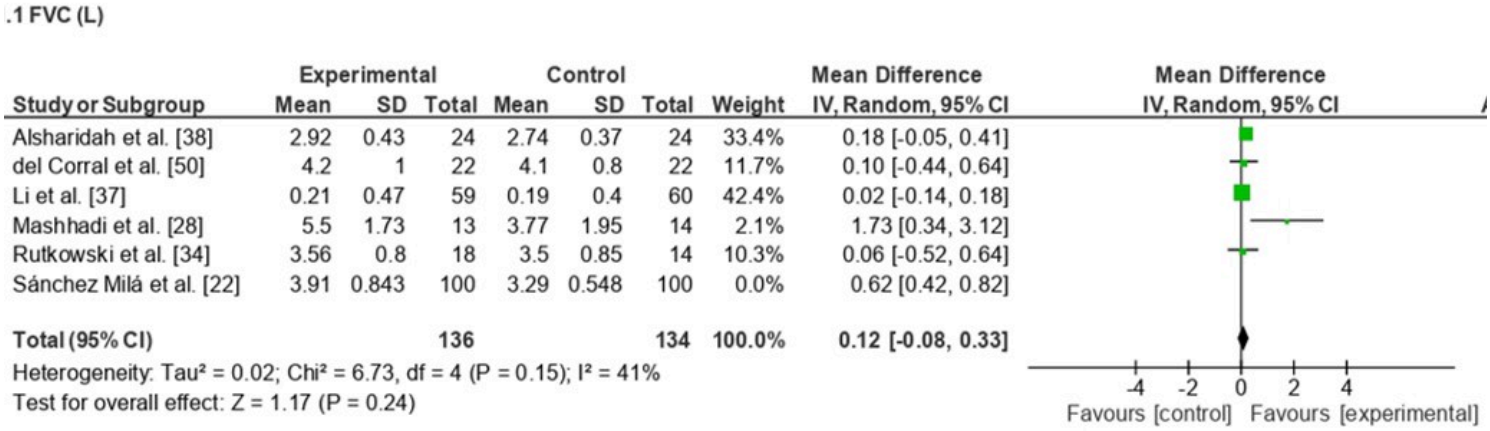


Figure 7

Sensitivity Analysis of the Effects of Rehabilitation Interventions on Forced Vital Capacity (FVC)

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