INDONESIAN JOURNAL OF NURSING PRACTICES OPEN ACCESS

Volume 8, Issue 2, December 2024, p. 105-124

The Effect of Physical Exercise on Post-COVID-19 Survivors: A Scoping Review

Nur Aini[1]*, Rosita Devi Angganita[1], Zakiah Wahyu Darojat[1]

[1]Nursing Department, Faculty of Health Sciences, University of Muhammadiyah Malang, Indonesia

Corresponding Author: Nur Aini
Email: nuraini_fikes@umm.ac.id

Article Info
Online : http://journal.umy.ac.id/index.php/ijnp
ISSN : 2548 4249 (Print)
: 2548 592X (Online)
DOI :10.18196/ijnp.v8i2.21002

Article History
Received : 25 December 2023
Revised : 21 July 2024
Accepted : 28 August 2024

Abstract

Background: Post-COVID-19 survivors or patients show deterioration in respiratory function, physical symptoms, musculoskeletal strength, quality of life (QoL), and psychological problems due to persistent symptoms. These symptoms are associated with mitochondrial dysfunction, reduced antioxidants, and oxidative stress. Physical exercise has been proven to positively affect general and psychological health.

Objective: This study intended to explore physical exercise's effect on post-COVID-19 survivors.

Methods: Literature in this scoping review was searched from seven databases, including Embase, PubMed, CINAHL, Cochrane, Scopus, Ovid-MEDLINE, and Web of Science. A manual search from Google Scholar and citations from previous meta-analyses were also performed. The keywords are “physical exercise” OR “physical activity” AND “post-COVID” OR “Long COVID.” Studies were included if involving patients with post-COVID diagnosis. However, studies that did not focus on post-COVID-19 focused on respiratory rehabilitation and had no complete data were excluded from this review.

Results: 33 studies from 1.909 were included (30 from databases and three citations from previous meta-analyses). Physical activity for post-COVID survivors can improve lung function, exercise capacity, functional capacity, physical symptoms (for instance, pain, fatigue), psychological or QoL, and also biochemical and hematological variables (for example, platelets, red blood cells, white blood cells, hemoglobin, hematocrit, creatinine, and urea).

Conclusion: Physical activity programs may represent an important supportive therapy for post-COVID-19 survivors. Therefore, health workers are encouraged to closely monitor respiratory parameters or post-COVID-19 patient symptoms and motivate patients to perform physical exercise.

Keywords: exercise capacity; lung function; physical exercise; post-COVID-19; QoL

INTRODUCTION

COVID-19, raised in December 2019, is a respiratory infection caused by SARS-CoV-2 (World Health Organization, 2023). Although the WHO has officially revoked the PHEIC, a Public Health Emergency of International Concern status for COVID-19, people might reinfected if their immune systems are not good, especially for patients with comorbidities, they are more likely at risk of suffering from severe symptoms if infected with COVID-19 (World Health Organization, 2023). Currently, in Indonesia, the status of the COVID-19 pandemic has been shifted to endemic, with the transmission rate as of June 2023 seeming to fluctuate in the range of 1.000-2.000 cases per day, still below WHO level 1 standard (Tarmizi, 2023).

Some individuals infected with COVID-19 may have long-term consequences from their infection. This condition is called post-acute COVID-19, chronic COVID-19, or long-COVID-19 (Araujo et al., 2023). A meta-analysis found that 63.2%, 71.9%, and 45.9% of the patients presented ≥ 1 post-COVID-19 symptom at 30, 60, or 90 days after COVID onset or hospitalization. The most common symptoms were fatigue and dyspnea, with a pooled prevalence varied depending on the follow-up from 35 to 60% (Fernández-de-Las-Peñas et al., 2021). In addition to general symptoms like fatigue, fever, and pain, long-term COVID-19 is described by several symptoms that affect respiratory and cardiovascular functions (e.g., neurological, musculoskeletal, gastrointestinal, and psychological) (Colas et al., 2022). Such symptoms can occur at least 60 days following diagnosis or 30 days following hospital discharge or recovery from acute disease (Coscia et al., 2023). Moreover, a meta-analysis by Durstenfeld et al. (2022) reported decreased exercise capacity in individuals exhibiting symptoms associated with long-term infection. Since many of COVID-19's symptoms are similar to other illnesses and conditions, diagnosing the virus can be challenging (World Health Organization, 2023).

Moreover, in mild cases, post-COVID survivors' quality of life (QoL) is negatively impacted by the existence of exhaustion, fatigue, dyspnea, and neurocognitive derangements during the recovery phase, which makes daily tasks challenging (Jimeno-Almazán, Franco-López, et al., 2022). WHO issued a guideline for clinical management of post-COVID-19, which consists of 16 recommendations, one of which is physical exercise; however, before considering physical activity training, exertional desaturation and cardiac dysfunction after COVID-19 should be diagnosed and treated (World Health Organization, 2023). Physical exercise or physical activity has been linked to improved sleep, mood, and chronic pain for long COVID survivors. Furthermore, physical activity can enhance the immune system, facilitating long COVID recovery (Wright et al., 2022).

Previous studies on physical activity following COVID-19 indicated that it improves fatigue, walking abilities, balance, and cognitive function (Rahayu et al., 2023). However, this study only focuses on older adults and includes three studies regarding physical activity (Rahayu et al., 2023). Respiratory rehabilitation in post-COVID-19 survivors enhanced lung function, exercise capacity, and QoL (Ashra et al., 2023). This meta-analysis focused on respiratory rehabilitation (Ashra et al., 2023). Long COVID survivors can be given pulmonary/respiratory rehabilitation or physical exercise; however, this current study will focus on physical exercise. Pulmonary rehabilitation is different from physical exercise. Pulmonary rehabilitation is a multidisciplinary approach that involves physical exercise and activity, stretching, breathing exercises, stretching, airway clearance techniques, education, and manual therapy that can be given for acute and post-acute phases (Gloeckl et al., 2021; Spielmanns et al., 2023). In contrast, physical exercise is essential to pulmonary rehabilitation and can be performed independently (Rahayu et al., 2023; Spielmanns et al., 2023). To our knowledge, limited studies have examined physical exercise among post-COVID. By comprehensively knowing the impact of physical exercise, we can promote and encourage post-COVID survivors to perform this activity. As a result, this review aims to explore the effects of physical exercise on post-COVID-19 survivors.

METHOD

Design

The study was designed as a systematic scoping review. Scoping reviews are evidence synthesis that seeks to identify and outline the breadth of evidence available on a specific topic, concept, field, or issue (Munn et al., 2022). The framework has five main steps: identifying research questions, finding relevant studies, selecting studies, mapping data, and collating, summarizing, and reporting findings (Bradbury-Jones et al., 2021). This literature study used the PRISMA Extension for Scoping Reviews as a guide for reporting scoping reviews (PRISMA-ScR).

Search Method

Literature was searched from seven databases, including Cochrane, CINAHL, Embase, Ovid-MEDLINE, Web of Science, Scopus, and PubMed. A manual search from Google Scholar and citations from previous meta-analyses or systematic reviews were also performed. This research starts by determining a research question using the PCC approach (population, concept, and context) (Table 1). Next, we performed a literature search from databases using keywords, MesH, and Boolean operator "physical exercise" OR "physical activity" AND "post-COVID" OR "Long COVID" (Table 2).

Table 1. PCC Approach Concept

Population	Concept	Context
Long COVID patients or survivors	Physical exercise or activity	Effect of physical exercise

Table 2. of Search Strategy

Databases	Keywords
Pubmed	("Exercise"[Mesh]) AND ("Post-Acute COVID-19 Syndrome"[Mesh])
Embase	Long covid'/exp OR 'Chronic covid-19' OR 'Long covid' OR 'Covid long-hauler' OR 'Covid-19 long-hauler' OR 'Long haul covid' OR 'Long haul covid-19' OR 'Long hauler covid' OR 'Post covid-19 fatigue' OR 'Post covid fatigue' OR 'Post covid 19 neurological syndrome' OR 'Post covid-19 syndrome' OR OR 'Post covid impairment' OR 'Post covid syndrome' OR 'Post-covid condition' OR 'Post-covid-19 condition' OR 'Post-acute covid syndrome' OR 'Post-acute covid-19' OR 'Post-acute covid-19 fatigue' OR 'Post-acute covid-19 syndrome' OR 'Post-acute covid-19 neurological syndrome' OR 'Post-acute sequelae of sars-cov-2 infection' AND 'Physical activity'/exp OR 'Activity, physical' OR 'Physical activity'
Scopus	(TITLE-ABS-KEY("Physical activity" OR Exercise)) AND (TITLE-ABS-KEY("Post Covid-19" OR "Long COVID" OR "Long Haul COVID-19")) AND (LIMIT-TO (DOCTYPE , "ar"))

Eligibility Criteria and Study Selection

We selected articles based on the inclusion and exclusion criteria. Studies were admitted in the current scoping review if they involved patients with post-COVID diagnosis, physical exercise, or activity, and the study design was an experimental, case, or observational study. However, studies focusing on COVID-19, respiratory rehabilitation, and non-research articles (study protocol or review article) were excluded (Figure 1).

Data Extraction and Analysis

The authors will thoroughly screen the articles that have satisfied the inclusion requirements, examining the abstract, purpose, research methods, and results before extracting them using a manual table. The table contains the following information: authors, year, country, research design, sample, intervention characteristics, and study outcome. Following analysis, the impact of physical exercise in post-COVID was categorized according to comparable effects and subsequently explained (Table 3).

RESULT

Description of Study

We retrieved 1.909 studies from electronic databases, and 352 duplicate studies were first excluded. Following that, 30 papers qualified for additional full-text checks after 1.557 studies were filtered according to title and abstract. Next, we added three included studies from the citation in previous meta-analyses (Fernández-Lázaro et al., 2022). Finally, 33 studies with 4,861 participants published between 2021 and 2023 were included in the analysis (Table 3, Figure 1).

Of these included studies, 17 were experimental studies (Randomized controlled trial and quasi-experimental), four were case reports, and the remaining were observational studies. The type of physical exercise includes aerobic exercise (AE), inspiratory muscle training, resistance training (RT), and one study with aquatic training. The frequency of physical exercise ranged from 2-6 x/week, duration ranged from 20-80 minutes, total sessions ranged from 10-24 sessions, and length of intervention ranged from 4-16 weeks. According to the result from the data analysis, we can categorize that physical exercise for post-COVID survivors affects improvement: *1). lung function* (Araujo et al., 2023; Calvo-Paniagua et al., 2022; Chikina et al., 2022; Colas et al., 2022; De Avila et al., 2023; Hockele et al., 2022; Jimeno-Almazán et al., 2023; Longobardi et al., 2021; McNarry et al., 2022; Ostrowska et al., 2023; Piquet et al., 2021; Rausch et al., 2022; Rolando et al., 2022; Romanet et al., 2023), *2). exercise capacity* (Araujo et al., 2023; Calvo-Paniagua et al., 2022; Chikina et al., 2022; Colas et al., 2022; Dalbosco-Salas et al., 2021; Estebanez-Pérez et al., 2022; Galluzzo et al., 2023; Hockele et al., 2022; Hsu et al., 2022; Ibrahim et al., 2023; Jimeno-Almazán, Franco-López, et al., 2022; Lobanov et al., 2022; Mayer et al., 2021; Ostrowska et al., 2023; Palau et al., 2022; Piquet et al., 2021), *3). functional capacity* (Calvo-Paniagua et al., 2022; Hockele et al., 2022; Longobardi et al., 2023), *4). psychological (anxiety and depression)* (De Avila et al., 2023; Ibrahim et al., 2023; Jimeno-Almazán, Franco-López, et al., 2022; Lobanov et al., 2022), *and QoL* (Longobardi et al., 2023; Mayer et al., 2021; Özlü et al., 2022), 5). *physical symptoms, for instance, pain and fatigue* (Araujo et al., 2023; Calvo-Paniagua et al., 2022; Colas et al., 2022; Coscia et al., 2023; Dalbosco-Salas et al., 2021; De Avila et al., 2023; Hasenoehrl et al., 2022; Jimeno-Almazán et al., 2023; Longobardi et al., 2021; Ostrowska et al., 2023). Conversely, Mayer et al. (2021) found no effect on this outcome, *6). biochemical and hematological variables* (Tartibian et al., 2022), *7). muscular strength* (De Avila et al., 2023; Galluzzo et al., 2023; Jimeno-Almazán et al., 2023; Longobardi et al., 2021; Nambi et al., 2022). However, a study by Colas et al. (2022) did not show an improvement in muscular strength (Table 3).

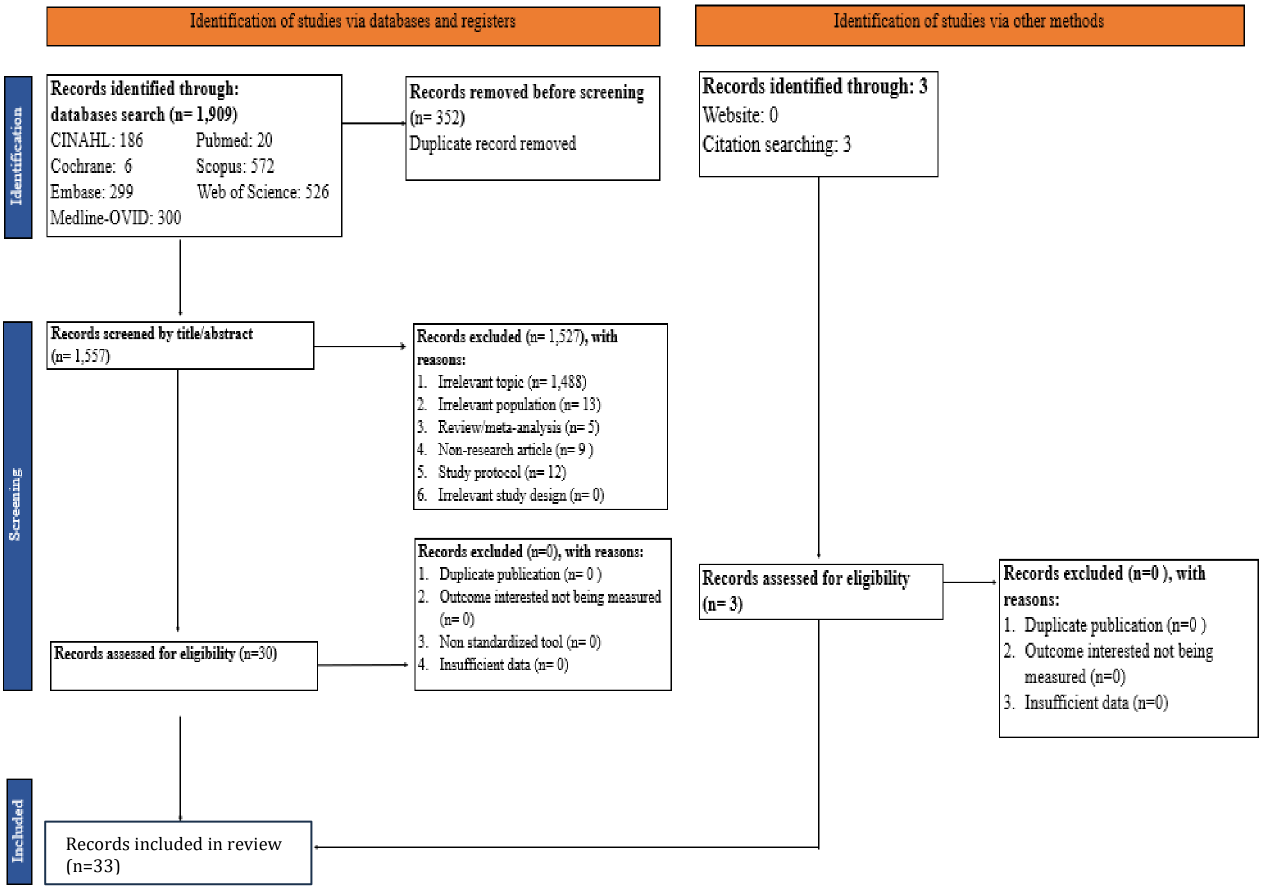

Figure 1. PRISMA Flow Diagram

Table 3. Extraction Data

No	Authors, Year & Country	Study design	Characteristics of participant	Characteristics of intervention	Result
1	Araujo et al., 2023; Brazil	Quasi-experimental	Age= > 18 years. Sample=26 participants	Aerobic exercise & resistance training. The treadmill duration was 40 minutes (5-minute warm-up, 30-minute conditioning, and 5-minute cooldown). Frequency: 2x/week in 3 sets of 8 – 12 repetitions; total session was 12 sessions.	Improved oxygen consumption (VO2peak), submaximal exercise tolerance, and QoL; reduced perceived fatigue.
2	Calvo-Paniagua et al., 2022; Spain	Quasi-experimental	Age= 25 to 65 years Sample=68 participants	The telerehabilitation program (including physical activity, airway clearing, breathing exercises, and health education). Duration: 40-min, total session: 18, frequency: 3x/week).	Daily living activities, dyspnea, and QoL improved; a significant increase in O2 saturation; heart rate adaptations at rest; perceived exertion & distance walked during the 6-MWD.
3	Chikina et al., 2022; Russia	Prospective non-randomized open controlled study	Sample= 24 participants (rehabilitation group) and 6 participants (control group)	The rehabilitation program included exercises for skeletal muscles using a gymnastic stick, elastic band, dumbbells weighing, and a stepper. Total session: 10 sessions.	6-MWD, resting and post-walk heart rates, dyspnea after walking, and O2 saturation at rest and after walking improved significantly.
4	Colas et al., 2022; France	Non-randomized controlled pilot study	Age= >18 years old Sample= 9 participants (in tele group), and 9 patients (control group).	Telerehabilitation program at home. Activities: 1). 1st week= adapted physical activity (3 sessions, 45-min of AE, and 15-min of RE); 2). supervised sessions at home by live video	Reduced fatigue; improved aerobic parameters (maximal O2 uptake, walking distance, and hyperventilation values). The anaerobic parameter (muscular strength) was not improved.

No	Authors, Year & Country	Study design	Characteristics of participant	Characteristics of intervention	Result
				conferencing during 3 weeks (3 sessions, 1 hour/week).	
5	Coscia et al., 2023; Italy	Observational study	Age= ≥20 or ≤40 years, BMI was 18.0 – 29.9 kg/m2. Sample= 506 participants.	Participants were divided into four categories (3 physical activity & 1 sedentary activity).	Fatigue was lower in the physical activity group.
6	Dalbosco-Salas et al., 2021; Chile	Observational study	Age= >18 years Sample= 115 participants	Telerehabilitation program, including 5-minute warm-up, 3-minute breathing exercises, 20-30 mins aerobic and/or strength exercises, and 5-minute stretching. Length of intervention: 9 weeks; 2-3 x/week, total session: 24.	Sit-to-stand test (1-min), QoL, fatigue, and dyspnea were improved.
7	De Avila et al., 2023; Virginia, USA	Observational study	Age= >18 years Sample= 218 participants	Participants verbally answer curated questions about the health behaviors changes after post-COVID (for instance, exercise, drinking alcohol, smoking, diet, weight, and sleep).	Low grip strength, fatigue, memory loss, dyspnea, depression, and poorer QoL were found in patients with less exercise.
8	Estebanez-Pérez et al., 2022; Spain	Quasi-experimental	Age= >18 years Sample= 32 participants	The supervised digital interventions are supplemented with customized digital physiotherapy regimens like swimming, running, or walking. Beginning with low intensity and duration and progressively increasing. Length of intervention:	The SPPB has a medium effect size, and 1-minute STS tests have a small effect size. All of the SPPB tests improved (such as balance, gait speed test, and CST).

No	Authors, Year & Country	Study design	Characteristics of participant	Characteristics of intervention	Result
				4 weeks, 20–30 minutes per session, 3–5x/week.	
9	Hockele et al., 2022; Brazil	Pilot clinical trial	Sample= 29 participants	The rehabilitation (inspiratory muscle training, AE & peripheral muscle strength). Length of intervention: 2 months, duration: 60 minutes, frequency: 2 x/week, total session: 16 sessions	Increased functional capacity, lung function, and respiratory muscular strength.
10	Galluzzo et al., 2023; Italy	Observational study	Age= >18 years Sample= 1,846 participants (inactive: 873, formerly active: 458, Active: 515)	Interview concerning participant's daily physical activity (around 150 min/week during the last 3 months).	Active individuals performed better on the 6-MWT and 1-minute STS and had stronger handgrips.
11	Hasenoehrl et al., 2022; Austria	Quasi-experimental	Age= >18 years Sample= 32 participants	Exercise resistance intervention program plus individual aerobic exercise recommendations. Length of intervention: 8 weeks, frequency: 2x/week, total session: 16.	Enhanced workability, psychological results, and physical fitness in healthcare workers. The benefit levels were more significant in cases with severe fatigue than in individuals with mild symptoms.
12	Hsu et al., 2022; Taiwan	Case study	RW is a 56-year-old male patient. He spent 2 months in the hospital before being moved to a post-acute rehabilitation center and weaned off of artificial ventilation.	To increase his functional ability, the patient receives physical therapy.	Improved in the 30-second CST, 69.5% walking distance in the 6-MWT.

No	Authors, Year & Country	Study design	Characteristics of participant	Characteristics of intervention	Result
13	Ibrahim et al., 2023; Saudi Arabia	RCT	Age= >18 years Sample= 72 participants	AE with a duration of 40 minutes, 4 x/week for 10 weeks. There are three groups: 1).Moderate-intensity 2).Low-intensity 3).Control group, received medical care and advice.	Exercise capacity, QoL, and psychological status after COVID-19 were improved.
14	Jimeno-Almazán et al., 2023; Spain	Four-arm, parallel experimental design	Age= >18 years Sample= 80 participants. Participants were randomly divided into four groups: autonomous inspiratory muscle training (RM), inspiratory muscle training (CTRM) or without it, and control group (CON).	CTRM and CT groups underwent a designed multicomponent exercise program that included 3 days/week concurrent training routine: 2-days of RT [50% 1RM, 3-sets, 8-repetitions, 4-exercises (squat, bench press, deadlift, and bench pull)] followed by moderate-intensity training. Length of intervention: 8 weeks.	Dyspnea, fatigue, and lower body muscle strength were increased in both groups.
15	Jimeno-Almazán, Franco-López, et al., 2022; Spain	RCT	Sample= 39 participants (randomly into two groups)	Multicomponent customized exercise program based on concurrent training for 8 weeks (2 supervised sessions per week); combines RT with moderate-intensity AE.	Both groups experienced physical outcome changes. However, the magnitude of cardiovascular and strength muscle changes were favored in IG. In addition, IG has better QoL, less depression and fatigue, and improved functional status.

No	Authors, Year & Country	Study design	Characteristics of participant	Characteristics of intervention	Result
16	Jimeno-Almazán, Martínez-Cava, et al., 2022; Spain	Cross-sectional study	Age= >18 years Sample= 39 participants	Patient recorded physical activity levels reported Global Physical Activity Questionnaire.	Higher PA was linked with fewer symptoms, including fatigue, dyspnea, physical fitness & and cardiopulmonary function.
17	Lobanov et al., 2022; Italy	RCT	Age= >18 years Sample= 23 participants	Exercise therapy consists of 7-10 sessions of aquatic training in tap water for 2 weeks (30-min, 6 days/week). The intervention consists of five exercises based on walking in water; including 3-min normal deambulation, 5-min walking with device support, 5-min walking with high knees, 5-min walking with special handholds, and 2-min of normal relaxed walking.	Correct the impaired upright posture, increase exercise capacity and QoL, and reduce anxiety/depression.
18	Longobardi et al., 2021; Brazil	Case study	Sample=67-year-old woman	Home-based exercise training (HBET) was conducted for 10 weeks. AE comprised of two 10-minute walking sessions every day. SE involved exercises in major muscle groups.	Improvement in cardiorespiratory functional capacity (VO2peak, dyspnea), functionality (handgrip strength, STS, timed-up-and-go), fatigue, dyspnea, and other persistent symptoms.
19	Longobardi et al., 2023; Brazil	RCT	Sample= 41 participants	Length of intervention: 16 weeks, 3x/week, 60–80 min/session, and a semi-supervised HBET program. Weekly session was individually supervised via video calls by an expert physical trainer.	HBET is a safe and effective interventions for improving the physical domain of HRQoL, persistent symptoms, and functional capacity.

No	Authors, Year & Country	Study design	Characteristics of participant	Characteristics of intervention	Result
20	Mayer et al., 2021; USA	Case study	Sample=37-year-old woman	Physical therapies comprised AE, SE, diaphragmatic breathing techniques, and mindfulness training. Frequency: biweekly, length of intervention: 8 weeks	Exercise capacity, physical function, and muscle strength all improved. Given their age, 6-MWD rose by 199 meters or 80% of the distance expected. PTSD and QoL scores were unchanged. The patients were still experiencing migraines, fatigue, dyspnea, and cognitive impairment at the time of examination following physical treatment.
21	Nambi et al., 2022; Saudi Arabia	RCT	Sample=76 participants (randomly divided into two groups, low & high intensity).	AE group with a high level of intensity. During low-intensity AE, 40-60% of the maximum heart rate. 30 minutes every session, 4 days/week for 8 weeks, 1 session/day	Improving the clinical (muscle strength) & psychological (kinesiophobia & QoL) measures over high-intensity AE post-COVID-19. However, muscle mass in both groups was significantly not different.
22	Ostrowska et al., 2023; Poland	Observational study	Sample=97 participants	The rehabilitation program (including AE, RE, and breathing exercises), education, and group psychotherapy, length of intervention: 6-weeks	Improvement in: 1). body composition (increasing skeletal muscle mass & reduction of fat); 2). physical capacity (significant increase in 6-MWT, 30-CST, and SPPB); 3). decreasing dyspnea & fatigue.

No	Authors, Year & Country	Study design	Characteristics of participant	Characteristics of intervention	Result
23	Özlü et al., 2022; Turkey	RCT	Sample=82 participants	The home exercise program, with the frequency of 5 days/ week for 4 weeks.	Improvement in the QoL, balance, pain levels & kinesiophobia.
24	Palau et al., 2022; Spain	RCT	Sample=26 participants (randomly into two groups)	Home-based inspiratory muscle training (IMT) program for 12 weeks.	Improvement in functional capacity and QoL for IG.
25	McNarry et al., 2022; United Kingdom	RCT	Sample=281 participants (randomly divided to IG: 111, CG: 37)	IG was asked to perform 3 sessions/week of unsupervised IMT on non-consecutive days for 8 weeks.	IMT improved respiratory muscle strength and aerobic fitness and clinically significant decreases in the intensity of chest-related symptoms and dyspnea.
26	Piquet et al., 2021; France	Retrospective study	Sample=100 participants	Program comprised overall motor strengthening with bodyweight exercises (tiptoe stands, STS, and squats), respiratory rehabilitation exercises & aerobics. Frequency: 2 sessions per day.	Inpatient rehabilitation was linked with substantial motor, respiratory, and functional improvement in severe COVID-19.
27	Rausch et al., 2022; Austria	Retrospective case series	Sample=233 participants (Female: 94, Male: 139)	The participants attended three exercise treatment sessions daily (Monday to Friday). Exercise sessions consist of: 1) individual respiratory muscle training, 2) pulmonary group exercises, 3) individual strength exercises, 4) individual endurance training (cycling, treadmill, in and outdoor walking), and 5) relaxation group exercises.	Females have smaller improvement in maximal inspiration capacity & forced expiratory volume compared to males. Exercise capacity improvements between both did not statistically differ.

No	Authors, Year & Country	Study design	Characteristics of participant	Characteristics of intervention	Result
				Frequency: 5–6 x/week, length of intervention: 3 weeks, duration: 30-45 minutes, total session: 18.	
28	Rolando et al., 2022; Spain	Observational study	Sample=39 participants	Strengthening exercises with elastic bands were performed on the lower limbs (hamstrings, quadriceps, and gluteus muscles) and upper limbs (dorsal muscles, biceps, anterior and middle deltoids). Frequency: 2x/week, length of intervention: 7 weeks, total session: 14.	Substantial improvement in aerobic capacity endurance, health status, dyspnea, and cardio-respiratory performance following the intervention, as well as a rise in health status and decreased disability from dyspnea at the 2-year follow-up.
29	Romanet et al., 2023; France	RCT	Sample=60 participants (randomly into IG: 27 & CG: 33)	ETR (endurance training rehabilitation) & muscle strength training during every session. Frequency: 2 x/week, duration: 60 minutes, Total session: 20 sessions, length of intervention: 10 weeks	IG had significantly improved dyspnea.
30	Santos & Flores, 2022; Peru	Case study	Sample= 60-year-old woman	Musculoskeletal physiotherapy (including Transcutaneous Electrical Nerve Stimulation, stretching exercises, balance & coordination exercises) Length of intervention: 5 weeks distributed over 15 visits.	Reduced the patient's pain, increased musculature strength, and expanded initial joint ranges.

No	Authors, Year & Country	Study design	Characteristics of participant	Characteristics of intervention	Result
31	Tartibian et al., 2022; Iran	RCT	Sample=296 participants (randomly divided into 4 groups: MICT, n:74; RT, n:74; CET, n:74; or CG, n:74).	The MICT consisted of progressive low-to-moderate-intensity walking. Depending on the patient's tolerance, the RT sessions lasted about 15–40 min included a 5-min warm-up (low-intensity stretching). CTE protocol: comprised MICT followed by the RT, which lasted about 15-40 min. Length of intervention: 8 weeks	MICT, RT, & CET groups showed significant improvements in the levels of lactate-dehydrogenase, creatine kinase, C-reactive protein, d-dimer, troponin-I, urea, creatinine, potassium, Na, WBC, RBC, neutrophils, lymphocytes, platelets, hemoglobin, & hematocrit concentrations. CET outperformed MICT and RT in terms of improving biochemical and hematological indicators.
32	Udina et al., 2021; Spain	Experimental study	Sample=33 participants	Multicomponent therapeutic exercise combined RE, endurance & balance training during 30-min daily.	More significant improvement in functional status (SPBB, gait speed).
33	Wright et al., 2022; United Kingdom	Cross-sectional study	Sample=477 participants	Compare the PA levels among COVID-19 vs United Kingdom PA's guidelines (i.e., finished >150 min of moderate PA, 75-min of vigorous PA, or both combinations).	The effect of PA on long-COVID symptoms was worsened (74.84%), improved (0.84%), mixed (20.96%), or no effect (28.72%).

Notes:

AE: Aerobic exercise, RT: Resistance training, PA: Physical activity, RE: Resistance exercise, SE: Strengthening exercises, MICT: Moderate-intensity-continuous training, CET: Combined aerobic and resistance training, HCW: Health care workers, HRQoL: Health-related quality of life, PTSD: Post-traumatic stress disorders, MWD: Minutes walk distance, 6-MWT: 6-minutes walk test, CST= Chair-sit-test, SPPB: Short physical performance battery test, WBC: White blood cells, RBC: Red blood cells, IG: Intervention groups, CG: Control groups, RCT: Randomized controlled trial.

DISCUSSION

This review revealed that physical exercise could improve lung function and exercise capacity, measured using VO2 max, dyspnea, forced vital capacity, heart rate, 6MWT, 1-STS, and others. The meta-analysis by Durstenfeld et al. (2022) revealed that exercise capacity among individuals with long-term COVID-19 will decrease more than three months after SARS-CoV-2 infection. Potential mechanisms for this problem comprise altered autonomic function (dysfunctional breathing and chronotropic incompetence), endothelial dysfunction, and muscular or mitochondrial pathology (Durstenfeld et al., 2022). The effect of physical exercise on lung function is that aerobic activity helps to stretch the smooth muscle in the airways and maintain bronchial dilatation by increasing the respiratory rate and strengthening the respiratory muscles.
(Jing et al., 2023).

Physical exercise will reduce pain and fatigue through several mechanisms, including helping build muscle strength and flexibility; increasing cerebral blood flow; reducing muscle tension, reducing inflammation, which is a common cause of pain and fatigue; increasing energy level; and releasing neurotransmitters (for instance dopamine, serotonin, and endorphin) (Wender et al., 2022). These hormones significantly impact mood, behavior, sleep regulation, and brain function. At the same time, endorphins function in pain modulation, mood enhancement, stress reduction, and immune system modulation (Lima et al., 2017). A meta-analysis revealed that six weeks of moderate-intensity exercise interventions benefit energy, fatigue, and vitality in healthy people and those with chronic health conditions (Wender et al., 2022).

Exercise impacts immune system regulation, and one of the processes linked to its protective effect against a range of illnesses, including infectious diseases, is the exercise-induced anti-inflammatory response (Galluzzo et al., 2023). Additionally, exercise strengthens the immune system by lowering the incidence, severity, and duration of viral infections, most likely including COVID-19 (Nigro et al., 2020). There are several mechanisms in how physical exercise is involved in anti-inflammatory regulation; for instance, moderate physical exercise promotes a marked increase in serum levels of cytokines involved in the regulation of inflammation, such as IL-10, IL-37, and IL-1 receptor antagonist (IL-1ra), which helps suppress the pro-inflammatory production; in addition, physical exercise reduces fat adipose tissue and excess body weight, which contribute to secretes pro-inflammatory cytokines (Nigro et al., 2020).

Approximately 35% of patients have been reported to have post-COVID-19 depressive symptoms during short-, medium-, and long-term follow-up following infection. After COVID-19, depressive symptoms have psychopathological mechanisms primarily linked to the peripheral immune-inflammatory response that the virus triggered (Mazza et al., 2022). Numerous physiological and psychological mechanisms, such as enhanced self-perceptions, self-efficacy, decreased emotional strain and physiological responses to stress, and positive effects on neurotransmitters, have been proposed as explanations for the impact of exercise on mental health, even though the exact mechanism is unknown (Abd El-Kader & Al-Jiffri, 2016). Higher physical activity also correlates with lower cortisol levels and negative mood; fewer symptoms of depression, anxiety, and sleep disturbances; which eventually improve QoL (Trajkovic et al., 2023).

Physical exercise is strongly associated with improved QoL (Gill et al, 2013; Marquez et al., 2020). Regular exercise enhances QoL, decreases the chronic diseases risk, and improves physical and mental health. It promotes mental health by reducing stress, increasing well-being, and releasing mood-enhancing hormones. Exercise enhances cognitive performance by increasing blood flow to the brain, which is necessary for mental clarity and overall cognitive function. Frequent exercise also improves sleep quality, directly affecting overall life satisfaction and daily functioning. Exercise helps older people stay mobile and independent, essential for preserving a high standard of living as they age. Additionally, social bonds and community growth are fostered by exercise, and these are important for mental health (Gill et al, 2013; Marquez et al., 2020). Furthermore, studies have demonstrated that muscle-strengthening exercises, such as weightlifting, bodyweight, and resistance band exercises, effectively develop muscular strength, which is crucial for overall physical function and health. Research on older populations has shown a positive correlation between muscular strength and physical performance, indicating that maintaining muscle strength is essential for sustaining mobility and independence, both of which are significant features of QoL (Kristiana et al., 2020). The limitation of the present review is that the study design was quite diverse, and information regarding intervention protocol was less complete.

CONCLUSION

This scoping review summarizes that physical exercise for post-COVID survivors has positive outcomes, including improved lung function, exercise and functional capacity, psychological and QoL, physical symptoms, biochemical and hematological variables, and muscular strength.

This research suggests that future research can perform a meta-analysis study to explore the pooled effect of exercise for post-COVID survivors and analyze the response dose of intervention to know the appropriate intervention protocol. Moreover, health professionals play an essential role in conducting assessments for post-COVID survivors before doing physical exercise to ensure their safety and address any unique challenges or limitations associated with COVID-19 recovery; motivate and guiding individuals through post-COVID physical exercise, and collaborate with other members of the healthcare team to provide holistic care and address any medical or rehabilitation needs.

REFERENCES

Abd El-Kader, S. M., & Al-Jiffri, O. H. (2016). Aerobic exercise improves quality of life, psychological well-being and systemic inflammation in subjects with Alzheimer's disease. *Afr Health Sci*, *16*(4), 1045-1055. https://doi.org/10.4314/ahs.v16i4.22

Aini, N., Angganita, R. D., Marta, O. F. D., Octary, T., Setyowati, L., & Mashfufa, E. W. (2023). Association Between The Frequency of Stroke Recurrence and Cognitive Function: A Cross-sectional Study. *Kontakt/Journal of nursing and social sciences related to health and illness*, *25*(1), 37–43. https://doi.org/10.32725/kont.2023.006

Araujo, B. T. S., Barros, A. E. V. R., Nunes, D. T. X., Remigio de Aguiar, M. I., Mastroianni, V. W., de Souza, J. A. F., Fernades, J., Campos, S. L., Brandao, D. C., & Dornelas de Andrade, A. (2023). Effects of continuous aerobic training associated with resistance training on maximal and submaximal exercise tolerance, fatigue, and quality of life of patients post-COVID-19. *Physiotherapy research international : the journal for researchers and clinicians in physical therapy*, *28*(1), e1972. https://doi.org/https://dx.doi.org/10.1002/pri.1972

Ashra, F., Jen, H. J., Liu, D. R. S., Lee, T. Y., Pien, L. C., Chen, R. Y., Lin, H. C., & Chou, K. R. (2023). Effectiveness of respiratory rehabilitation in patients with COVID-19: A meta-analysis. *Journal of clinical nursing*. https://doi.org/10.1111/jocn.16692

Bradbury-Jones, C., Aveyard, H., Herber, O. R., Isham, L., Taylor, J., & O'malley, L. (2021). Scoping reviews: the PAGER framework for improving the quality of reporting. *International Journal of Social Research Methodology*, *2021*, 1-14. https://doi.org/https://doi.org/10.1080/13645579.2021.1899596

Calvo-Paniagua, J., Díaz-Arribas, M. J., Valera-Calero, J. A., Gallardo-Vidal, M. I., Fernández-De-las-Peñas, C., López-De-Uralde-Villanueva, I., del

Corral, T., & Plaza-Manzano, G. (2022). A telehealth primary care rehabilitation program improves self-perceived exertion in COVID-19 survivors experiencing Post-COVID fatigue and dyspnea: A quasi-experimental study [Article]. *PLoS ONE*, *17*(8 August). https://doi.org/10.1371/journal.pone.0271802

Chikina, S. Y., Kuleshov, A. V., Nikitina, N. V., & Meshcheryakova, N. N. (2022). Effects of physical rehabilitation on exercise tolerance in post-COVID patients: Results of an open controlled trial [Article]. *Pulmonologiya*, *32*(5), 728-736. https://doi.org/10.18093/0869-0189-2022-32-5-728-736

Colas, C., Bayle, M., Labeix, P., Botelho-Nevers, E., Gagneux-Brunon, A., Cazorla, C., Schein, F., Breugnon, E., Garcin, A., Feasson, L., Roche, F., & Hupin, D. (2022). Management of long COVID—the CoviMouv' pilot study: Importance of adapted physical activity for prolonged symptoms following SARS-CoV2 infection [Article]. *Frontiers in Sports and Active Living*, *4*, Article 877188. https://doi.org/10.3389/fspor.2022.877188

Coscia, F., Mancinelli, R., Gigliotti, P. V., Checcaglini, F., & Fanò-Illic, G. (2023). Physical activity effects on muscle fatigue in sport in active adults with long COVID-19: An observational study [Article]. *Diagnostics*, *13*(7). https://doi.org/10.3390/diagnostics13071336

Dalbosco-Salas, M., Torres-Castro, R., Leyton, A. R., Zapata, F. M., Salazar, E. H., Bastías, G. E., Díaz, M. E. B., Allers, K. T., Fonseca, D. M., & Vilaró, J. (2021). Effectiveness of a primary care telerehabilitation program for post-covid-19 patients: A feasibility study [Article]. *Journal of Clinical Medicine*, *10*(19), Article 4428. https://doi.org/10.3390/jcm10194428

De Avila, L., Price, J. K., Stepanova, M., Lam, B., Weinstein, A. A., Pham, H., Austin, P., Keo, W., Younossi, Z., Afendy, M., Nader, S., Terra, K., Cable, R., Younossi, E., Golabi, P., Verma, M., Nader, F., Racila, A., Gerber, L. H., & Younossi, Z. M. (2023). Regular exercise is associated with low fatigue levels and good functional outcomes after COVID-19: A prospective observational study [Article]. *American Journal of Physical Medicine and Rehabilitation*, *102*(5), 433-443. https://doi.org/10.1097/PHM.0000000000002197

Durstenfeld, M. S., Sun, K., Tahir, P., Peluso, M. J., Deeks, S. G., Aras, M. A., Grandis, D. J., Long, C. S., Beatty, A., & Hsue, P. Y. (2022). Use of cardiopulmonary exercise testing to evaluate long COVID-19 symptoms in adults: A systematic review and meta-analysis. *JAMA Network Open*, *5*(10), e2236057-e2236057. https://doi.org/10.1001/jamanetworkopen.2022.36057

Estebanez-Pérez, M. J., Pastora-Bernal, J. M., & Martín-Valero, R. (2022). The effectiveness of a four-week digital physiotherapy intervention to improve functional capacity and adherence to intervention in patients with long COVID-19 [Article]. *International Journal of Environmental Research and Public Health*, *19*(15), Article 9566. https://doi.org/10.3390/ijerph19159566

Fernández-de-Las-Peñas, C., Palacios-Ceña, D., Gómez-Mayordomo, V., Florencio, L. L., Cuadrado, M. L., Plaza-Manzano, G., & Navarro-Santana, M. (2021). Prevalence of post-COVID-19 symptoms in hospitalized and non-hospitalized COVID-19 survivors: A systematic review and meta-analysis. *Eur J Intern Med*, *92*, 55-70. https://doi.org/10.1016/j.ejim.2021.06.009

Fernández-Lázaro, D., Santamaría, G., Sánchez-Serrano, N., Lantarón Caeiro, E., & Seco-Calvo, J. (2022). Efficacy of therapeutic exercise in reversing decreased strength, impaired respiratory function, decreased physical fitness, and decreased quality of life caused by the post-COVID-19 syndrome [Review]. *Viruses*, *14*(12). https://doi.org/10.3390/v14122797

Galluzzo, V., Zazzara, M. B., Ciciarello, F., Tosato, M., Martone, A. M., Pais, C., Savera, G., Calvani, R., Picca, A., Marzetti, E., & Landi, F. (2023). Inadequate physical activity is associated with worse physical function in a sample of COVID-19 survivors with post-acute symptoms. *Journal of Clinical Medicine*, *12*(7). https://doi.org/https://dx.doi.org/10.3390/jcm12072517

Gill, D. L., Hammond, C. C., Reifsteck, E. J., Jehu, C. M., Williams, R. A., Adams, M. M., Lange, E. H., Becofsky, K., Rodriguez, E., & Shang, Y. T. (2013). Physical activity and quality of life. Journal of preventive medicine and public health = Yebang Uihakhoe chi, 46 Suppl 1(Suppl 1), S28–S34. https://doi.org/10.3961/jpmph.2013.46.S.S28

Gloeckl, R., Leitl, D., Jarosch, I., Schneeberger, T., Nell, C., Stenzel, N., Vogelmeier, C. F., Kenn, K., & Koczulla, A. R. (2021). Benefits of pulmonary rehabilitation in COVID-19: A prospective observational cohort study. *ERJ Open Res*, *7*(2). https://doi.org/10.1183/23120541.00108-2021

Hasenoehrl, T., Palma, S., Huber, D. F. X., Kastl, S., Steiner, M., Jordakieva, G., & Crevenna, R. (2022). Post-COVID: Effects of physical exercise on functional status and work ability in health care personnel [Article]. *Disability and Rehabilitation*. https://doi.org/10.1080/09638288.2022.2111467

Hockele, L. F., Sachet Affonso, J. V., Rossi, D., & Eibel, B. (2022). Pulmonary and functional rehabilitation improves functional capacity, pulmonary function and respiratory muscle strength in post COVID-19 patients: Pilot clinical trial [Article]. *International Journal of Environmental Research and Public Health*, *19*(22), Article 14899. https://doi.org/10.3390/ijerph192214899

Hsu, Y. T., Turner, K., & Lee, S. P. (2022). Post-acute physical therapy for a patient with critical illness associated with COVID-19: A case report. *Physiotherapy Theory and Practice*, *38*(13), 3226-3232. https://doi.org/10.1080/09593985.2021.1972499

Ibrahim, A. A., Hussein, H. M., Ali, M. S., Kanwal, R., Acar, T., Shaik, D. H., Alghamdi, W., & Althomali, O. W. (2023). A randomized controlled trial examining the impact of low vs. moderate-intensity aerobic training in post-discharge COVID-19 older subjects [Article]. *European review for medical and pharmacological sciences*, *27*(9), 4280-4291. https://doi.org/10.26355/eurrev_202305_32338

Jimeno-Almazán, A., Buendía-Romero, Á., Martínez-Cava, A., Franco-López, F., Sánchez-Alcaraz, B. J., Courel-Ibáñez, J., & Pallarés, J. G. (2023). Effects of a concurrent training, respiratory muscle exercise, and self-management recommendations on recovery from post-COVID-19 conditions: The RECOVE trial [Article]. *Journal of applied physiology (Bethesda, Md. : 1985)*, *134*(1), 95-104. https://doi.org/10.1152/japplphysiol.00489.2022

Jimeno-Almazán, A., Franco-López, F., Buendía-Romero, Á., Martínez-Cava, A., Sánchez-Agar, J. A., Sánchez-Alcaraz Martínez, B. J., Courel-Ibáñez, J., & Pallarés, J. G. (2022). Rehabilitation for post-COVID-19 condition through a supervised exercise intervention: A randomized controlled trial [Article]. *Scandinavian journal of medicine & science in sports*, *32*(12), 1791-1801. https://doi.org/10.1111/sms.14240

Jimeno-Almazán, A., Martínez-Cava, A., Buendía-Romero, Á., Franco-López, F., Sánchez-Agar, J. A., Sánchez-Alcaraz, B. J., Tufano, J. J., Pallarés, J. G., & Courel-Ibáñez, J. (2022). Relationship between the severity of persistent symptoms, physical fitness, and cardiopulmonary function in post-COVID-19 condition. A population-based analysis [Article]. *Internal and emergency medicine*, *17*(8), 2199-2208. https://doi.org/10.1007/s11739-022-03039-0

Jing, Z., Wang, X., Zhang, P., Huang, J., Jia, Y., Zhang, J., Wu, H., & Sun, X. (2023). Effects of physical activity on lung function and quality of life in asthmatic children: An updated systematic review and meta-analysis. *Front Pediatr*, *11*, 1074429. https://doi.org/10.3389/fped.2023.1074429

Kristiana, T., Widajanti, N., & Satyawati, R. (2020). Association between muscle mass and muscle strength with physical performance in elderly in Surabaya. Surabaya Phys Med Rehabil J, 2(1), 24.

Lima, L. V., Abner, T. S. S., & Sluka, K. A. (2017). Does exercise increase or decrease pain? Central mechanisms underlying these two phenomena. *J Physiol*, *595*(13), 4141-4150. https://doi.org/10.1113/jp273355

Lobanov, A. A., Grishechkina, I. A., Andronov, S. V., Barashkov, G. N., Popov, A. I., Fesyun, A. D., Ivanova, E. P., Maccarone, M. C., & Masiero, S. (2022). Can aquatic exercises contribute to the improvement of the gait stereotype function in patients with Long COVID outcomes? [Article]. *European Journal of Translational Myology*, *32*(3). https://doi.org/10.4081/ejtm.2022.10698

Longobardi, I., do Prado, D. M. L., Goessler, K. F., de Oliveira Junior, G. N., de Andrade, D. C. O., Gualano, B., & Roschel, H. (2021). Benefits of home-based exercise training following critical SARS-CoV-2 infection: A case report. *Frontiers in Sports and Active Living*, *3*, 791703. https://doi.org/https://dx.doi.org/10.3389/fspor.2021.791703

Longobardi, I., Goessler, K., de Oliveira, G. N., do Prado, D. M. L., Santos, J. V. P., Meletti, M. M., de Andrade, D. C. O., Gil, S., Boza, J., Lima, F. R., Gualano, B., & 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*. https://doi.org/10.1136/bjsports-2022-106681

Mayer, K. P., Steele, A. K., Soper, M. K., Branton, J. D., Lusby, M. L., Kalema, A. G., Dupont-Versteegden, E. E., & Montgomery-Yates, A. A. (2021). Physical therapy management of an individual with post-COVID syndrome: A case report. *Physical therapy*, *101*(6). https://doi.org/10.1093/ptj/pzab098

Mazza, M. G., Palladini, M., Poletti, S., & Benedetti, F. (2022). Post-COVID-19 depressive symptoms: Epidemiology, pathophysiology, and pharmacological treatment. *CNS Drugs*, *36*(7), 681-702. https://doi.org/10.1007/s40263-022-00931-3

Marquez, D. X., Aguiñaga, S., Vásquez, P. M., Conroy, D. E., Erickson, K. I., Hillman, C., Stillman, C. M., Ballard, R. M., Sheppard, B. B., Petruzzello, S. J., King, A. C., & Powell, K. E. (2020). A systematic review of physical activity and quality of life and well-being. Translational behavioral medicine, 10(5), 1098–1109. https://doi.org/10.1093/tbm/ibz198

McNarry, M. A., Berg, R. M. G., Shelley, J., Hudson, J., Saynor, Z. L., Duckers, J., Lewis, K., Davies, G. A., & Mackintosh, K. A. (2022). Inspiratory muscle training enhances recovery post-COVID-19: A randomised controlled trial. *Eur Respir J*, *60*(4). https://doi.org/10.1183/13993003.03101-2021

Munn, Z., Pollock, D., Khalil, H., Alexander, L., McLnerney, P., Godfrey, C. M., Peters, M., & Tricco, A. C. (2022). What are scoping reviews? Providing a formal definition of scoping reviews as a type of evidence synthesis. *JBI Evid Synth*, *20*(4), 950-952. https://doi.org/10.11124/JBIES-21-00483

Nambi, G., Abdelbasset, W. K., Alrawaili, S. M., Elsayed, S. H., Verma, A., Vellaiyan, A., Eid, M. M., Aldhafian, O. R., Nwihadh, N. B., & Saleh, A. K. (2022). Comparative effectiveness study of low versus high-intensity aerobic training with resistance training in community-dwelling older men with post-COVID 19 sarcopenia: A randomized controlled trial [Article]. *Clinical rehabilitation*, *36*(1), 59-68. https://doi.org/10.1177/02692155211036956

Nigro, E., Polito, R., Alfieri, A., Mancini, A., Imperlini, E., Elce, A., Krustrup, P., Orru, S., Buono, P., & Daniele, A. (2020). Molecular mechanisms involved in the positive effects of physical activity on coping with COVID-19. *Eur J Appl Physiol*, *120*(12), 2569-2582. https://doi.org/10.1007/s00421-020-04484-5

Ostrowska, M., Rzepka-Cholasińska, A., Pietrzykowski, Ł., Michalski, P., Kosobucka-Ozdoba, A., Jasiewicz, M., Kasprzak, M., Kryś, J., & Kubica, A. (2023). Effects of multidisciplinary rehabilitation program in patients with long COVID-19: Post-COVID-19 rehabilitation (PCR SIRIO 8) study [Article]. *Journal of Clinical Medicine*, *12*(2). https://doi.org/10.3390/jcm12020420

Özlü, A., Yaman, F., Leblebicier, M. A., & Özkaya, D. B. (2022). Efficacy of a home exercise program on balance, kinesiophobia, pain and quality of life in post-COVID-19 patients: Efficacy of a home exercise program in post COVID [Article]. *Annals of Clinical and Analytical Medicine*, *13*(5), 563-567. https://doi.org/10.4328/ACAM.21033

Palau, P., Domínguez, E., Gonzalez, C., Bondía, E., Albiach, C., Sastre, C., Martínez, M. L., Núñez, J., & López, L. (2022). Effect of a home-based inspiratory muscle training programme on functional capacity in postdischarged patients with long COVID: The InsCOVID trial [Article]. *BMJ Open Respiratory Research*, *9*(1), Article e001439. https://doi.org/10.1136/bmjresp-2022-001439

Piquet, V., Luczak, C., Seiler, F., Monaury, J., Martini, A., Ward, A. B., Gracies, J. M., & Motavasseli, D. (2021). Do patients with COVID-19 benefit from rehabilitation? functional outcomes of the first 100 patients in a COVID-19 rehabilitation unit. *Arch Phys Med Rehabil*, *102*(6), 1067-1074. https://doi.org/10.1016/j.apmr.2021.01.069

Rahayu, T., Pertiwi, K. R., Kushartanti, W., & Arovah, N. I. (2023). Physical activity and post-COVID-19 syndrome in older adults: A systematic review [Article]. *International Journal of Kinesiology and Sports Science*, *11*(1), 42-52. https://doi.org/10.7575/aiac.ijkss.v.11n.1p.42

Rausch, L., Puchner, B., Fuchshuber, J., Seebacher, B., Loffler-Ragg, J., Pramsohler, S., Netzer, N., & Faulhaber, M. (2022). The effects of exercise therapy moderated by sex in rehabilitation of COVID-19. *INTERNATIONAL JOURNAL OF SPORTS MEDICINE*, *43*(12), 1043-1051. https://doi.org/10.1055/a-1866-6092

Rolando, L. M., Villafane, J. H., Garcia, S. C., Arguello, A. S., Rosa, M. V., & Romero, E. A. S. (2022). Multicomponent exercise program to improve the immediate sequelae of COVID-19: A prospective study with a brief report of 2-year follow-up. *International Journal of Environmental Research and Public Health*, *19*(19), Article 12396. https://doi.org/10.3390/ijerph191912396

Romanet, C., Wormser, J., Fels, A., Lucas, P., Prudat, C., Sacco, E., Bruel, C., Plantefeve, G., Pene, F., Chatellier, G., & Philippart, F. (2023). Effectiveness of exercise training on the dyspnoea of individuals with long COVID: A randomised controlled multicentre trial. *Annals of Physical and Rehabilitation Medicine*, *66*(5), 101765. https://doi.org/https://dx.doi.org/10.1016/j.rehab.2023.101765

Santos, S., & Flores, J. A. (2022). Musculoskeletal physiotherapy in physical sequelae of SARS-CoV-2 infection: A case report. *Physiother Res Int*, *27*(2), e1938. https://doi.org/10.1002/pri.1938

Spielmanns, M., Schaer, C. E., Pekacka-Egli, A. M., Spielmanns, S., Ibish, O., Gafina, G., Stiube, A., & Hermann, M. (2023). Pulmonary rehabilitation outcomes of post-acute COVID-19 patients during different waves of the pandemic. *Int J Environ Res Public Health*, *20*(10). https://doi.org/10.3390/ijerph20105907

Tarmizi, S. N. (2023). *Situasi COVID-19 di Indonesia pasca pencabutan status kedaruratan global*. Retrieved 19 Juni from https://sehatnegeriku.kemkes.go.id/baca/umum/20230509/2842954/situasi-covid-19-di-indonesia-pasca-pencabutan-status-kedaruratan-global/

Tartibian, B., Khayat, S. M. A., Maleki, B. H., & Chehrazi, M. (2022). The effects of exercise training on recovery of biochemical and hematological outcomes in patients surviving COVID-19: A randomized controlled assessor-blinded trial. *Sports Medicine - Open*, *8*(1), 1-14. https://doi.org/10.1186/s40798-022-00546-4

Trajkovic, N., Mitic, P. M., Baric, R., & Bogataj, S. (2023). Editorial: Effects of physical activity on psychological well-being. *Front Psychol*, *14*, 1121976. https://doi.org/10.3389/fpsyg.2023.1121976

Udina, C., Ars, J., Morandi, A., Vilaró, J., Cáceres, C., & Inzitari, M. (2021). Rehabilitation in adult post-COVID-19 patients in post-acute care with therapeutic exercise [Article]. *Journal of Frailty and Aging*, *10*(3), 297-300. https://doi.org/10.14283/jfa.2021.1

Wender, C. L. A., Manninen, M., & O'Connor, P. J. (2022). The effect of chronic exercise on energy and fatigue states: A systematic review and meta-analysis of randomized trials. *Front Psychol*, *13*, 907637. https://doi.org/10.3389/fpsyg.2022.907637

World Health Organization. (2023). *Post COVID-19 condition*. Retrieved June, 16 from https://www.who.int/teams/health-care-readiness/post-covid-19-condition

Wright, J., Astill, S. L., & Sivan, M. (2022). The relationship between physical activity and long COVID: A cross-sectional study [Article]. *International Journal of Environmental Research and Public Health*, *19*(9). https://doi.org/10.3390/ijerph19095093