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The effect of physical exercise among post-COVID-19 survivors: A scoping review

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Abstract

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

Objective: This study aims to explore the effect of physical exercise among post-COVID-19 survivors.

Methods: Desain of this study was scoping review. Literature was searched from seven databases, including CINAHL, Cochrane, Embase, Ovid-MEDLINE, PubMed, Scopus, and Web of Science. A manual search from Google Scholar, and a previous systematic review were also performed. The keywords are "physical exercise" OR "physical activity" AND "post-COVID" OR "Long COVID". Studies were included in this scoping review if involving patients with post-COVID diagnosis. However, studies will be excluded if focused on COVID-19 instead of Post-COVID-19, focused on respiratory rehabilitation, and have no complete data.

Results: Overall, 33 studies from 1,909 studies were included (30 from databases and three from previous SR). 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 (such as white blood cell, hemoglobin, creatinine, urea, etc).

Conclusions: 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: Physical exercise, Post-COVID-19, Lung function, Exercise capacity, QoL

INTRODUCTION

COVID-19 is the disease caused by SARS-CoV-2, which rised in December 2019 (World Health Organization, 2023). Even though the WHO has officially revoked the Public Health Emergency of International Concern (PHEIC) status for COVID-19, people can be 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 (World Health Organization, 2023). Currently, the status of COVID-19 pandemic in Indonesia 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 the World Health Organization (WHO) level 1 standard (Tarmizi, 2023).

Some individuals infected COVID-19 may have long-term consequences from their infection. This condition is referred to as chronic COVID, post-acute COVID, long-haul COVID, or long-COVID (Araujo et al., 2023). A meta-analysis found that 63.2, 71.9 and 45.9% of the patients exhibited ≥ 1 post-COVID-19 symptom at 30, 60, or ≥ 90 days after onset or hospitalization. The most common symptoms were dyspnea and fatigue, with a pooled prevalence that varied depending on the follow-up from 35 to 60% (Fernández-de-Las-Peñas et al., 2021). Long COVID is characterized by multiple symptoms affecting respiratory and cardiovascular capacities, as well as general symptoms such as, fatigue, fever, pain, and several other symptoms (e.g., neurological, gastrointestinal, musculoskeletal, and psychological) (Colas et al., 2022). Such symptoms can occur at least 60 days after diagnosis or for at least 30 days after recovery from acute illness or discharge from the hospital (Coscia et al., 2023). Moreover, a meta-analysis by Durstenfeld et al. (2022) revealed that exercise capacity is reduced in people with symptoms consistent with long-COVID after SARS-CoV-2 infection. Since many of COVID's symptoms are similar to those of other illnesses and conditions, diagnosing the virus can be difficult (World Health Organization, 2023).

Even in mild cases, the presence of fatigue, exhaustion, dyspnea, and neurocognitive derangements during the recovery period makes daily life activities difficult and has a negative impact on the quality of life for post-COVID survivors (Jimeno-Almazán, Franco-López, et al., 2022). WHO issued living guideline for clinical management of post-COVID-19, which consists of 16 recommendations, one of which is physical exercise; however, exertional desaturation and cardiac impairment following COVID-19 should be ruled out and managed before consideration of physical exercise training (World Health Organization, 2023). Physical exercise or physical activity has health benefits, including 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).

The previous study discusses physical activity for post-COVID and found physical activity is effective in improving fatigue, ability to walk, 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). In addition, respiratory rehabilitation enhanced post-COVID-19 patients' quality of life, exercise capacity, and lung function (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 includes education, airway clearance techniques, physical exercise, breathing exercises, stretching, manual therapy, and physical activity, that can be given for acute and post-acute condition (Gloeckl et al., 2021; Spielmanns et al., 2023). While physical exercise is a core component of pulmonary rehabilitation and can also be performed independently (Rahayu et al., 2023; Spielmanns et al., 2023). To our knowledge, limited study has been conducted to examine physical exercise among post-COVID. By knowing the impact of physical exercise comprehensively, we can promote and encourage post-COVID survivor to perform this activity. Therefore, we intended to in conducting research related to the effect of physical exercise among post-COVID survivors.

METHOD

Design

A systematic scoping review was used as design this study. Scoping reviews are a type of evidence synthesis that seeks to identify and map the breadth of evidence available on a specific topic, field, concept, or issue (Munn et al., 2022). The framework used has five main steps: identification of research questions; identification of relevant studies; study selection; mapping data; collating, summarizing, and reporting results (Bradbury-Jones et al., 2021). The PRISMA Extension for Scoping Reviews (PRISMA-ScR) is used in this literature review as guidance on reporting scoping reviews.

Search Methods

Literature was searched from seven databases, including CINAHL, Cochrane, Embase, Ovid-MEDLINE, Pubmed, Scopus, and Web of Science. A manual search from Google

Scholar and a previous systematic review were also performed. This research starts by determining a research question using the PCC approach (population, concept, and context) (**Table 1**). Next, we conducted 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. Example of Search Strategy

Databases	Keywords
Pubmed	("Exercise"[Mesh]) AND ("Post-Acute COVID-19 Syndrome"[Mesh])
Embase	'long covid'/exp OR 'covid long-hauler' OR 'covid-19 long-hauler' OR 'chronic covid syndrome' OR 'chronic covid-19' OR 'long covid' OR 'long haul covid' OR 'long haul covid-19' OR 'long hauler covid' OR 'post covid 19 fatigue' OR 'post covid 19 neurological syndrome' OR 'post covid 19 syndrome' OR 'post covid fatigue' 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 neurological syndrome' OR 'post-acute covid-19 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 inclusion and exclusion criteria. Studies were included in this scoping review if involving patients with post-COVID diagnosis, physical exercise or activity, and the study design was an experimental study, case study, or observational study. However, studies will be excluded if focused on COVID-19 instead of post-COVID-19, focused on respiratory rehabilitation, and non-research articles (study protocol or review article) (**Figure 1**).

Data Extraction and Analysis

For the articles that have met the inclusion criteria, an in-depth screening process will be carried out by reading the abstract, purpose, research methods, and result, and extracted using a manual table by authors. Contents of the table include author, year, country, research design, sample, characteristics of the intervention, and result of the study. After being analyzed, the effect of physical activity in post-COVID was classified based on similar effects and then described **(Table 3)**.

RESULTS

Description of Study

We retrieved 1,909 studies from electronic databases, and 352 duplicate studies were first excluded. After that, 1,557 studies were screened based on the title and abstract, and 30 studies were eligible for further full-text checks. 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 **(Figure 1, Table 3).**

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, inspiratory muscle training, resistance training, and one study with aquatic training. The duration of physical exercise ranged from 4-12 sessions. 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). However, a study by Mayer et al. (2021) didn't show an 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) didn't show an improvement in muscular strength **(Table 3)**.

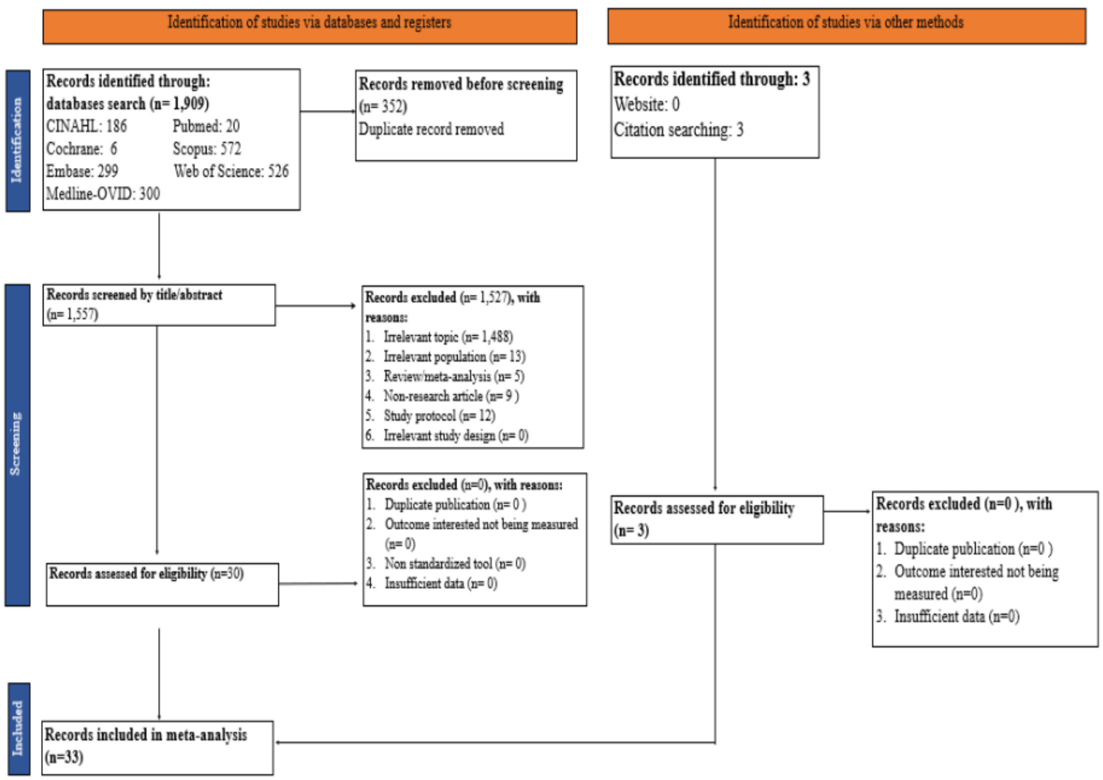

Figure 1. PRISMA Flow Diagram

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. Exercise was performed on a treadmill for 40 min: 5 min of warm-up, 30 min of conditioning, and 5 min of cooldown. Duration: twice a week in three sets of 8–12 repetitions.	Improved oxygen consumption (VO2peak), submaximal exercise tolerance, and quality of life; reduced perceived fatigue.
2	(Calvo-Paniagua et al., 2022); Spain	Quasi-experimental	Age= 25 to 65 years Sample=68 participants	A tele-rehabilitation program based on patient education, physical activity, airway clearing, and breathing exercise interventions. Duration: eighteen sessions (3 sessions/week).	Improved 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) 6 participants (control group)	The rehabilitation program included exercises for skeletal muscles using a gymnastic stick, elastic band, dumbbells weighing, and a stepper. To train the inspiratory Duration: 10 sessions.	The 6-MWD, heart rate at rest and after walking, dyspnea after walking, and O2 saturation at rest and after walking improved significantly in the rehabilitation.
4	(Colas et al., 2022); France	Nonrandomized controlled pilot study	Age= >18 years old Sample= 9 participants (in tele group), and 9 patients (control group).	Telerehabilitation program at home with 12 supervised personalized exercise sessions. Activities: 1st week with an adapted physical activity teacher (three sessions of 1 h, 45min of aerobic exercise, and 15min of resistance exercise); then supervised sessions were realized at home by video conferencing for 3 weeks (three live sessions of 1 h/week, 45min of aerobic	Reduced fatigue; aerobic parameters were significantly improved, e.g., maximal O2 uptake, walking distance, or hyperventilation values. The anaerobic parameter (muscular strength) was not improved.

				exercise, and 15 min of resistance exercise.	
5	(Coscia et al., 2023); Italy	Prospective observational study	Age= ≥20 or ≤40 years with a body mass index of 18.0–29.9 kg/m2. Sample=506 participants. All enrolled subjects presented, six months after the end of the COVID-19 positive period.	Participants were divided into the following four categories (3 physical activity & 1 sedentary activity).	The long COVID-19 fatigue was lower in active subjects.
6	(Dalbosco-Salas et al., 2021): Chile	Prospective observational study	Age= >18 years Sample= 115 participants	Telerehabilitation, the program included warm-up (5 min), breathing exercises (3 min), aerobic and/or strength exercises (20–30 min), and stretching (5 min). Duration: nine weeks; 2 - 3 sessions per week (total 24 sessions).	1-min sit-to-stand test (1-min STST), quality of life, fatigue, and dyspnea were improved.
7	(De Avila et al., 2023); Virginia, USA	Prospective observational study	Age= >18 years Sample= 218 participants	All participants were asked to verbally answer specifically curated questions about post-COVID changes to health behaviors such as exercise, alcohol consumption, smoking, diet, weight, and sleep.	Patients who report less exercise have low grip strength, higher levels of fatigue, memory loss, shortness of breath, depression, and poorer quality of life.
8	(Estebanez-Pérez et al., 2022); Spain	Quasi-experimental	Age= >18 years Sample= 32 participants	Personalized digital physiotherapy program including walking, jogging, or swimming added to the supervised digital interventions based on individual patient needs, starting at a low intensity and duration and increasing gradually. Duration: 4 weeks, 20–30-min per session, 3–5 sessions/week.	A medium effect size for the SPPB test and a small effect size for the 1-minute STS test. All of the SPPB test parameters were assessed: balance test, gait speed test, and chair stand test, with improvements in each of the records.
9	(Hockele et al., 2022); Brazil	Pilot clinical trial	Sample= 29 participants	The rehabilitation (inspiratory muscle training, aerobic	Improvement in the functional capacity, pulmonary function

				exercise & peripheral muscle strength). Duration: 16 sessions	& respiratory muscle strength.
10	(Galluzzo et al., 2023); Italy	Observational study	Age= >18 years Sample= 1,846 participants (inactive: 873, formerly active: 458, active: 515)	Participants were interviewed concerning their usual physical activity levels. Regular participation in physical activity was operationalized as the engagement in aerobic PA, associated or not with resistance training, for a minimum of 150 min per week in the last 3 months.	Active participants had higher handgrip strength and performed better on both the 6-MWT & the one-minute sit-to-stand test (1-MSTST)
11	(Hasenoehrl et al., 2022); Austria	Quasi-experimental	Age= >18 years Sample= 32 participants	Exercise resistance intervention program plus individual aerobic exercise recommendations. Duration: 8 weeks, 2 sessions per week.	Improved physical fitness, psychological outcomes, and workability in HCWs. Cases with severe fatigue showed higher benefit levels compared to those with mild symptoms.
12	(Hsu et al., 2022); Taiwan	Case study	The patient RW (male, age 56). After weaning off mechanical ventilation after 2 months of hospitalization, he was transferred to our post-acute rehabilitation facility	The patient received physical therapy aimed at improving his functional capacity.	Improved in the 30-second chair stand test, 69.5% improvement in walking distance in the 6-minute walk test, and 132.4% longer time to exhaustion during level ground ambulation.
13	(Ibrahim et al., 2023); Saudi Arabia	Randomized controlled study	Age= >18 years Sample= 72 participants	The exercise was done 40 min/4 times per week for 10 weeks. There are three groups: 1).Moderate-intensity aerobic group 2).Low-intensity aerobic group and received low-intensity aerobic exercises. 3). The group was the control group &	Improved exercise capacity, quality of life, and psychological status after COVID-19.

				received medical care and advice.	
14	(Jimeno-Almazán et al., 2023); Spain	Four-arm, parallel experimental design	Age= >18 years Sample= 80 participants. Participants were randomly to four groups: inspiratory muscle training (CTRM) or without it, autonomous inspiratory muscle training program (RM), or control group (CON).	Participants from the CT and CTRM groups completed a tailored multicomponent exercise program. They completed a three-days-a-week concurrent training routine: two days of resistance training [50% 1RM (one-repetition maximum), 3 sets, 8 repetitions, 4 exercises (squat, bench press, deadlift, and bench pull)] followed by moderate intensity variable training. Duration: 8 weeks.	Lower body muscle strength significantly improved in the CT and CTRM. The CT and CTRM groups improved significantly for dyspnea and fatigue.
15	(Jimeno-Almazán, Franco-López, et al., 2022); Spain	Randomized controlled trial	Sample= 39 participants (randomly into two groups)	Tailored multicomponent exercise program based on concurrent training for 8 weeks (two supervised sessions per week comprised resistance training combined with aerobic training [moderate intensity variable training], plus a third day of monitored light intensity continuous training).	There were changes in physical outcomes in both groups, however, the magnitude of the change pre– post intervention favored the IG in cardiovascular and strength muscle (VO2max, sit-to-stand, and load-velocity profiles in bench press and half squat). In addition, IG has significantly better quality of life, less fatigue, less depression, and improved functional status.
16	(Jimeno-Almazán, Martínez-Cava, et al., 2022); Spain	Cross-sectional	Age= >18 years Sample= 39 participants	Physical activity levels were recorded by patient reported Global Physical Activity Questionnaire.	Greater physical activity levels were associated with fewer symptoms and less-severe fatigue, dyspnea, physical fitness & cardiopulmonary function.

17	(Lobanov et al., 2022); Italy	Randomized controlled trial	Age= >18 years Sample= 23 participants	Basic therapy with an exercise therapy instructor, underwent 7-10 sessions of aquatic training in tap water (water temperature 30-32°C) for two weeks (30 min, 6 days per week). The treatment consisted of 5 exercises based on walking in water, including: 3 minutes of normal deambulation; 5 minutes of walking with high knees; 5 minutes of walking with the support of a device; 5 minutes of walking with special handholds (a variant involving the upper limbs and trunk muscles); 2 minutes of normal relaxed walking.	Correct the impaired upright posture, increase exercise capacity, QoL, & reduce anxiety/depression.
18	(Longobardi et al., 2021); Brazil	Case report	Sample=67-year-old woman	Home-based exercise training (HBET) was conducted during 10-week. Aerobic training sessions initially consisted of two bouts of10 min/day of walk. Strengthening exercises comprised exercises for the major muscle groups.	Improvement in cardiorespiratory functional capacity (VO2peak, dyspnea), functionality (handgrip strength, sit to stand, timed-up-and-go), fatigue, exertional dyspnea, and other persistent symptoms in COVID-19 survivors.
19	(Longobardi et al., 2023); Brazil	Randomized controlled trial	Sample= 41 participants	The intervention was a 16- week, 3- times- a-week (60–80 min/session), semi-supervised, HBET programme. One weekly session was individually supervised through online live videocalls with an experienced physical trainer.	HBET is an effective and safe intervention to improve physical domains of HRQoL, functional capacity and persistent symptoms in survivors of severe/critical COVID-19.
20	(Mayer et al., 2021); USA	Case report	Sample=37-year-old woman	Physical therapist, which included aerobic training, strengthening	Muscle strength, physical function, & exercise capacity

				exercises, diaphragmatic breathing techniques, and mindfulness training. Duration: biweeklny, 8 weeks	were improved. 6-MWD increased by 199 m, equating to 80% of their age-predicted distance. QoL and PTSD scores did not improve. At evaluation after physical therapy, the patient was still experiencing migraines, dyspnea, fatigue, & cognitive dysfunction.
21	(Nambi et al., 2022); Saudi Arabia	Randomized controlled trial	Sample=76 participants were randomly into two group (low intensity aerobic & high intensity).	High-intensity aerobic training group. In low-intensity aerobic exercises, 40%–60% of maximum heart rate was used with same duration. Duration: 30 minutes/session, 1 session/day, 4 days/week for 8 weeks	Improving the clinical (muscle strength) & psychological (kinesiophobia & QoL) measures than high-intensity aerobic training in post-COVID 19 Sarcopenia. However, muscle mass both groups did not show any significant difference
22	(Ostrowska et al., 2023); Poland	Prospective observational study	Sample=97 participants	The rehabilitation program was composed of physical training (aerobic, resistance, and breathing exercises), education, and group psychotherapy, with duration 6 weeks	Improvement in: 1). body composition: increase in skeletal muscle mass & reduction of fat; 2). physical capacity: significant increase in walking distance, gait speed, & chair stand as assessed with the 6MWT, the 30CST, and the SPPB; 3). decreasing dyspnea & fatigue.
23	(Özlü et al., 2022); Turkey	Randomized controlled trial	Sample=82 participants	The home exercise program was implemented 5 days a week for 4 weeks.	Improvement in the QoL, balance, pain levels & kinesiophobia.
24	(Palau et al., 2022); Spain	Randomized controlled trial	Sample=26 participants (randomly into two	12- week home- based inspiratory muscle training (IMT)	Improvement in exercise (functional) capacity and QoL in

No.	Study	Design	Sample	Intervention	Findings
			groups)	programme	the IG.
25	(McNarry et [illegible] Kingdom	Randomized [illegible]	Sample=281 [illegible] 111, CG: 37)	Intervention participants [illegible] (inspiratory muscle [illegible] training) sessions per week, on non-consecutive days, for 8 weeks.	IMT elicited [illegible] severity of dyspnea [illegible] severity of dyspnea & chest-related symptoms, as well as improved respiratory muscle strength & aerobic fitness.
26	(Piquet et al., 2021); France	Retrospective study.	Sample=100 participants	Physical therapy (PT). The therapy program primarily included overall motor strengthening with body weight exercises (sit-to-stand, tiptoe stands, squats), elastics, and weights, with approximately 3 series of 10 repetitions for each exercise, according to the patient's abilities. Respiratory rehabilitation exercises & aerobics. Duration: 2 sessions perday	Inpatient rehabilitation for COVID-19 patients was associated with substantial motor, respiratory, and functional improvement, especially in severe cases.
27	(Rausch et al., 2022); Austria	Retrospective case series	Sample=82 participants (Females: 94, Males: 139)	Exercise therapy. Each week, patients participated in a maximum of 3 exercise therapy sessions per day (Monday to Friday). The exercise therapy sessions consisted of individual respiratory muscle training, pulmonary group exercises, individual strength exercises (3 to 5 exercises for large muscle groups in three series of 8 to 12 repetitions per exercise with or without weight machines), individual endurance training (cycling, treadmill, in and outdoor walking) and relaxation group exercises.	Females showed a significantly smaller improvement in maximal inspiration capacity & forced expiratory volume compared to males. Exercise capacity improvements between men & women did not differ statistically.

				Duration: 5–6 sessions weekdays	
28	(Rolando et al., 2022); Spain	Prospective observational study	Sample=39 participants	Strengthening exercises of the lower limbs (quadriceps, hamstrings, and gluteus muscles) and upper limbs (biceps, anterior and middle deltoids, and dorsal muscles) were performed with elastic bands. Duration: 2 sessions perweek, 7 weeks, total 14 sessions.	Significant improvement in cardio-respiratory performance, health status, disability due to dyspnea, & aerobic capacity and endurance after the intervention; & an increase in health status and reduction in disability due to dyspnea at the 2-year follow-up
29	(Romanet et al., 2023); France	Randomized controlled trial	Sample=60 participants (randomly into IG: 27 & CG: 33)	ETR (endurance training rehabilitation) & muscle strength training during every session. Duration: 2x60 min sessions, 10 weeks	IG had significantly improved dyspnea when treated with ETR therapy.
30	(Santos & Flores, 2022); Peru	Case report	Sample= 60-year-old woman	Musculoskeletal physiotherapy (including Transcutaneous Electrical Nerve Stimulation, stretching exercises, balance & coordination exercises) Duration: 5 weeks distributed over 15 visits.	The patient's pain was reduced, the strength of the musculature increased, and initial joint ranges were expanded.
31	(Tartibian et al., 2022); Iran	Randomized controlled trial	Sample=296 participants (randomly into 4 groups: MICT (n:74), RT (n:74), CET (n:74), or CG (n:74).	The MICT protocol consisted of progressive low- to moderate-intensity walking. The RT exercise sessions lasted about 15–40 min, depending on the patient’s tolerance, and included a 5-minute warm-up (low-intensity flexibility/ stretching) followed by a 15- to 40-minute lower- and upper-body resistance workout. CTE protocol:	All 3 MICT, RT, & CET interventions caused significant improvements in the levels of creatine kinase (CK), lactate dehydrogenase, C-reactive protein (CRP), troponin-I, d-dimer, creatinine, urea, potassium (K), sodium (Na), white blood cell (WBC), neutrophils, lymphocytes, red blood cells (RBC), platelets,

				The main program consisted of MICT followed by the RT and lasted about a minimum of 15 min and a maximum of 40 min. Duration for all groups: 8 weeks	hemoglobin, & hematocrit concentrations. CET was effectively superior to MICT and RT in the improvements in the biochemical & hematological variables studied.
32	(Udina et al., 2021); Spain	Experimental study	Sample=33 participants	The intervention was a 30-minute daily multicomponent therapeutic exercise intervention that combined resistance, endurance & balance training.	Greater improvement in functional status (SPBB, gait speed).
33	(Wright et al., 2022); United Kingdom	Cross-sectional study	Sample=477 participants	The participant's PA levels pre- and post-COVID-19 were compared to the UK PA guidelines i.e., completed over 150 min of MPA (moderate PA), 75 min of VPA, or any combination of the two in a week.	Participants reported the effect of PA on long-COVID symptoms as worsened (74.84%), improved (0.84%), mixed effect (20.96%), or no effect (28.72%).

Notes:
HRQoL: health-related quality of life; PTSD: Post-traumatic stress disorder; MWD: minute walk distance; MWT: minute walk test; SPPB: short physical performance battery test; HCW: health care workers; IG: intervention group; CG: control group; MICT: moderate-intensity continuous training; RT: resistance training; CET: combined aerobic and resistance training; PA: physical activity.

DISCUSSION

This current review revealed that physical exercise could improve lung function and exercise capacity, which is measured using VO2 max, dyspnea, forced vital capacity, heart rate, the 6-minute walk test (6MWT), 1-minute sit-to-stand test (1-STS), and others. A meta-analysis by Durstenfeld et al. (2022) found that exercise capacity was decreased more than three months after SARS-CoV-2 infection among individuals with long-COVID. Potential mechanisms for this problem include altered autonomic function (e.g., chronotropic incompetence, dysfunctional breathing), endothelial dysfunction, and muscular or mitochondrial pathology (Durstenfeld et al., 2022). The effect of exercise on lung function may be because aerobic exercise accelerates the respiratory rate and strengthens respiratory muscles, thus contributing to the stretching of airway smooth muscle and sustained bronchial dilation (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; releasing neurotransmitters such as serotonin dopamine, and endorphin (Wender et al., 2022). These hormones significantly impact mood, behavior, sleep regulation, and overall 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 showed that moderate-intensity exercise interventions for at least six weeks are beneficial for fatigue, energy, and vitality in healthy individuals and those with chronic health conditions (Wender et al., 2022).

Physical exercise plays a role in immune system modulation, and the exercise-induced anti-inflammatory response appears to be one of the mechanisms implicated in physical exercise's protective role against a variety of conditions, including infectious diseases. (Galluzzo et al., 2023). Moreover, physical activity elicits potent effects on the immune system by reducing the risk, duration, and severity of different viral infections, presumably 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 induces a marked increase in serum levels of cytokines involved in the regulation of inflammation, such as IL-10, IL-1 receptor antagonist (IL-1ra) and IL-37, which helps suppress the production of pro-inflammatory; 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 percent 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). Although the precise mechanism for the effect of exercise on mental health is unknown, several physiological and psychological mechanisms, including increased feelings of self-efficacy, self-perceptions of control, reduced emotional strain and physiological responses to stress, and beneficial effects on neurotransmitters, have been proposed (Abd El-Kader & Al-Jiffri, 2016). Higher physical activity levels are also correlated with lower cortisol levels, lower negative mood, fewer symptoms of depression and anxiety, fewer sleep disturbances, and, eventually, improved quality of life (Trajkovic et al., 2023).

The limitation of this is that the research design in this study is quite diverse, and information regarding intervention protocol is less complete. So the discussion is not comprehensive.

CONCLUSIONS

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

This research suggests that future research can perform a meta-analysis to examine the pooled effect of physical 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.

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