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ISSN: 2455-5460 DOI: https://dx.doi.org/10.17352/ada

Research Article

Effect of Pulmonary Rehabilitation on the Health-Related Quality of Life (Hqol), Activities of Daily Living (ADL) and mental health among COVID-19 patients; A systematic review

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Received: 04 March, 2022
Accepted: 16 March, 2022
Published: 17 March, 2022

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Keywords: COVID-19; Pulmonary rehabilitation; HQol; ADL; Coronavirus; Anxiety; Depression; Mental health

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Abstract

Objective: It is a systematic review on the COVID-19 and its post complication by using pulmonary rehabilitation as an intervention. This review paper aims at collecting, focusing, and presenting the current evidence and information on pulmonary rehabilitation to patients with COVID-19 and also its effect upon the HRQoL, ADL and mental health.

Design: It is a systematic review, where 3756 studies were searched on the web of science, Scopus, PubMed, PEDro, and google scholar. published from 18th Jan 2020-19th Sep 2020. We searched the reference lists of selected studies, registries, international clinical trials, and respiratory conference abstracts to look for qualifying studies. Selection criteria; Randomised controlled trial, case reports, cohort and cross-sectional studies in which pulmonary rehabilitation as an intervention in COVID-19 patients and its effect on the HRQoL, ADL and mental anxiety depression health were included.

Result: Eleven, out of 3765 studies were included, consisting of 4 RCTs, 4, cross-sectional, 2 case reports, and one cohort the studies evaluated effects of PR on HQoL, ADL, mental health, anxiety, and depression. In COVID-19 patients. The 11 studies included evaluated HQoL, ADL and mental health. among these Four studies reported using SF-36, IE (impact of the event) scale, and VAS. Three studies evaluated ADL through the FIM scale and Barthel index. Five studies evaluated mental health, depression, and anxiety using SDS (Self-Rating Depression Scale), SAS (Self-Rating Anxiety Scale), STAI (State-Trait Anxiety Scale), PHQ-9 (physical health questionnaire), MHLS(Mental Health Lifestyle Scale) and HADS(hospital anxiety and depression scale).

Conclusion: The studies included in this systematic review showed that PR is an effective treatment option for patients with COVID-19, its post complications, and the effects upon HQoL, ADL, mental health, depression, and anxiety. There is a future need for more studies of a high methodological quality addressing PR effects on COVID-19 patients.

Trial registration number: PROSPERO CRD42020209619.

Summary

What is known: It is known that the COVID-19 is detrimental to humans and it has worsened the condition of people with chronic lung diseases. There have been new and numerous studies to find out the appropriate method to rehabilitate such patients. There is a need for new studies regarding the effectiveness of Pulmonary rehabilitation and its effect.

What is new: This systematic review throws light on the COVID-19 pandemic? Pulmonary rehabilitation is an intervention that includes exercise training and is beneficial for patients with any chronic lung conditions. Studies included in this review showed that PR is an effective treatment option for patients with COVID-19, post complications, and its effects upon the HQoL, ADL, mental health, anxiety and depression.

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Introduction

COVID-19 , caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), was reported firstly on December 31, 2019 [1]. According to WHO, 17 September 2020, with 30 055 710 confirmed cases, international partners and all countries marked World Patient Safety Day focusing on increasing public awareness and engagement globally, in light of this pandemic [2]. The studies show that the lung is the most affected organ in COVID-19 [3]. In the acute stage, patients present with increased respiratory secretions, intrapulmonary exudation, multiple airway obstruction, atelectasis, and other respiratory system lesions, as well as degeneration, necrosis, and other pathological changes in multiple organs outside the lungs. It targets mostly the elderly or the severe and critical patients with underlying diseases as such hypoxemia, fatigue, decreased airway clearance ability, incapacity, decreased muscle strength/endurance, and limitation in activity leading to declining in the quality of life [4]. There is a severe impact of COVID-19 in terms of rehabilitation needs and an important information gap exists into the efficacy of rehabilitation care to promote functional recovery [5]. Pulmonary Rehabilitation after COVID-19 is much similar to that provided to the patients in geriatric rehabilitation units/clinics. Often they present with sequelae associated with the viral illness, the prolonged ICU stay, and mechanical ventilation with pre-existing comorbidities [1].

An epidemic outbreak has negative effects the individuals and society requiring efficient and effective disaster-related mental health needs. With disease progression, the psychological problems in covid infected patients change requiring any psychological intervention. It has been confirmed that the individuals who have experienced emergencies of public health have stress-related disorders, even after the event subsides, they might be even cured and discharged from the hospital, indicating mental health priority. The health-care workers over the front have become the main outsource of mental health care to patients [6]. During an epidemic, the population experiences the risk factors to depression and anxiety including food and resource insecurity, high mortality rate, discrimination, and experience with the infected, leading to detrimental mental health [7].

The Health-Related Quality of Life (HRQoL) is increasing with social progress and the transformation of medical care [8]. As per definition, HRQoL is the subjective feeling of the patients of multifaceted effect to any disease [9]. The most common complications after discharge in patients with acute respiratory distress syndrome include a decline in life quality and exercise restriction lasting for 5 years. They have a problem with stair-climbing, reduced functional exercise capacity, bending low down, and activities in daily life [10,11]. There has been decreased QoL and ADL followed by the decreased mental and physical function among community-acquired pneumonia in the elderly [12]. It has been observed that patients with COVID-19 tend to experience increased depression and anxiety post isolation treatment [13]. Pulmonary rehabilitation focusing on functional exercise can effectively limit muscle atrophy and improve the body functions such as muscle strength/endurance [14].

Aim and objective

The review paper aims at collecting, focusing, and then presenting the current evidence of pulmonary rehabilitation in patients with COVID-19 and its effect upon the HRQoL, ADL and mental health. To execute this research well, we will comply with the methodological aspect.

Significance

The whole world presently is suffering from a dreadful pandemic. The public health significance of this study lies in the fact that pulmonary rehabilitation and its effect on the health-related quality of life, ADL and mental health will help to narrow the gap, overcoming post-COVID-19 complications and spreading awareness.

Methods

Protocol and registration

The protocol for this review paper was registered in the International Prospective Register of Systematic Reviews (PROSPERO CRD42020209619) on Sat, 16th Sep 2020. This systematic review is following Preferred Reporting Items for Systematic Reviews and Meta-Analyses- PRISMA guidelines [15].

Eligibility criteria

Inclusion criteria: 1] It included experimental studies, cohort studies, and cross-sectional studies; 2] Studies including confirmed diagnosis of COVID-19. 3] Those studies were included whose intervention was pulmonary rehabilitation; 4] There was no restriction in age, gender and ethnicity.

Exclusion criteria: 1]All the expert advice, and editorials were excluded; 2] Those articles which were published between 18th January 2020 to 19th September 2020 were included; 3] Articles related to diverse coronavirus diseases (such as; Severe Acute Respiratory Syndrome (SARS) or Middle East Respiratory Syndrome (MERS)) were also excluded.

Search strategy and information sources

The articles were searched using keywords, "COVID-19", "pulmonary rehabilitation", "COVID-19 and HQoL"," COVID-19 and the mental health", " COVID-19 and ADL" using the following databases, web of science, Scopus, PubMed, Pedro and google scholar. There was no restriction to publication language, and the reference list of the primary articles was cross-checked and reviewed for additional references.

Study selection and process of data collection

As there was heterogeneity of research being published in this pandemic [16] the studies relevant to the effect of Pulmonary Rehabilitation (PR) on activities of daily living, quality of life, and mental health among the COVID-19 subjects

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were taken into account by the two reviewers (JAD and SA). The duplicates were removed from the searched articles and the selected articles were screened at the title or the abstract stage and the full-text stage segregation for eligibility. In case of further disagreement, it was resolved through discussion.

The data was extracted from each article including general information (publication date, author, country, experimental dates), and the study characteristics (aim of the study, population, number of participants, clinical presentation, interventions, adverse events, and main findings). The outcomes (mental health, health-related quality of life, activities in daily living,) were specified and selected. The two reviewers (JAD, SA) independently extracted the data from the selected studies. The agreements were resolved through discussion.

Risk of bias

Two reviewers (JAD, SA) individually assessed the risk of bias for each study by using the criteria outlined in the Cochrane Handbook for Systematic Reviews of Interventions) domains [17].

1. Random sequence generation.

2. Allocation concealment.

3. Blinding of the participants and personnel.

4. Blinding of the outcome assessment.

5. Incomplete outcome data.

6. Selective outcome report.

8. Other biases.

Each of the potential sources of bias was graded as high, low, or unclear, and the quote was given from the article along with a justification for our judgment in the ROB (Risk of bias) table. The risk of bias across different studies for each domain was summarized (Table 1) The review by the Cochrane Collaboration tool, for assessing the risk of bias (table 8.5. a in the Cochrane Handbook for Systematic Reviews). The non-RCT'S risk of bias was done using JBI critical appraisal checklist [18]. The disagreements were solved through discussion. The quality of the articles was checked using OCEBM (Oxford Centre for Evidence-Based Medicine) 2011 Levels of Evidence [19].

Result

Study selection

We identified 3756 articles including duplicates. The articles composed of (n=626 web of science) (n= 220 from Scopus) (n= 1142 from PubMed) (n= 1760 from google scholar), (n= 8 from Pedro). Among the articles assessed for eligibility, (n= 1091) were excluded as the content did not address any relevant research question, being of no rehabilitation interest; the remainder (n= 2600) were excluded due to the lack of required data, as they conveyed opinions of an expert or the secondary research papers. (n= 65) were assessed for eligibility out of which 55 were excluded because they didn't match the criteria of inclusion, so eleven articles (n= 11) were included in qualitative analysis (Figure 1).

Included studies

Four RCT'S [13,20-22] four cross-sectional studies [23-26], two case reports [27,28] and retrospective study [29] were included. Nine of the included studies were conducted in China, one in Italy, and one in Spain.

Table 2 details the publication data, methodological aspects (e.g., study design, research question, intervention, and outcome measures), of all the full-text 11articles.

Estimation of risk of bias within studies was done using, Cochrane Collaboration tool for assessing the risk of bias [17] (Table 1) and JBI critical appraisal checklist [18].

Intervention: Table 2 depicts eleven studies [13,20-29] where patients underwent Pulmonary rehabilitation through diaphragmatic training, cough exercise, active cycle of breathing technique, and Jacobson relaxation technique, 20minute sit to stand training, aerobic training with cycle ergometer. In Liu, et al. [20], studied data from subjects of COVID-19 who received PR in a hospital through the stretching exercise, respiratory muscle training, diaphragmatic training, cough exercise, and home exercise 10 minutes a day, twice in a week. In Zhao, et al. [21] all individuals in the intervention group were given training sessions 15 minutes each time twice a day in the hospital. In Gonzalez-Gerez, et al. [22], the subjects performed an active cycle of breathing techniques through telemetric control in home-setting. In Liu, et al., 2020[13], the patients were administered Jacobson's relaxation

Table 1: Risk of Bias.

Liu, et al.	Zhao, et al.	Gerez, et al.	Liu, et al.	
+	+	+	+	Random sequence generation. (selection bias)
+	+	+	+	Allocation concealment
-	-	+	-	Blinding of participants and personnel (performance bias)
-	-	+	-	Blinding of outcome assessment. (detection bias)
+	-	+	-	Incomplete outcome data (attrition bias)
-	-	-	-	Selective outcome reporting. (reporting bias)
-	-	-	-	Other bias

Quality appraisal- + (green), low risk of bias; ? (yellow), unclear risk of bias; - (red), high risk of bias [13,20-22].

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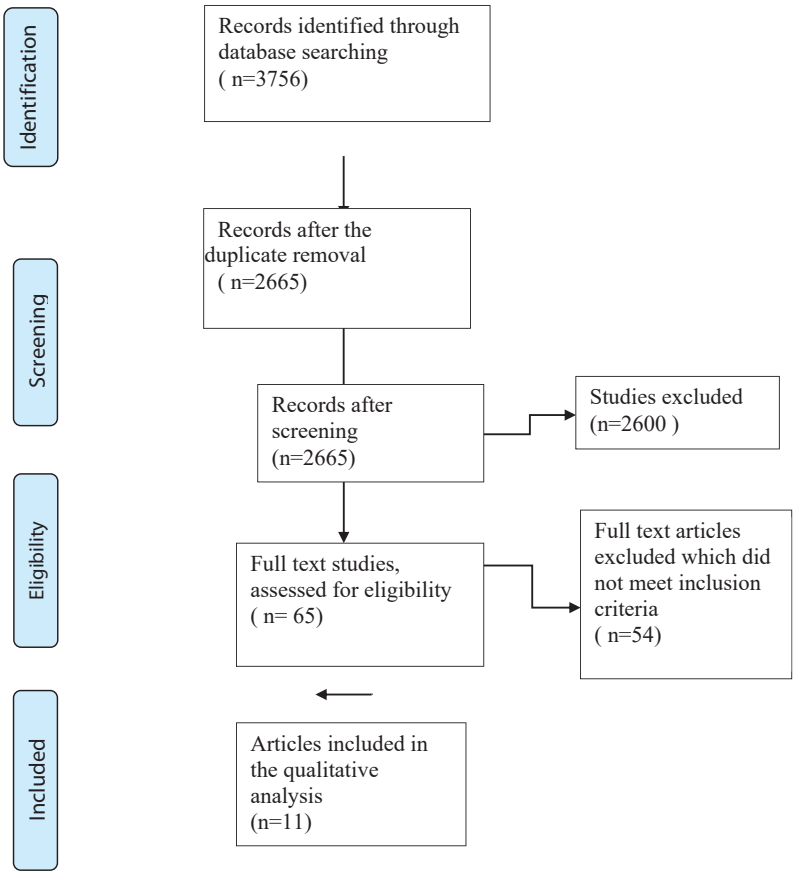

Figure 1: Prisma Flow Diagram [15].

Table 2: Article's Summary.

Reference, publication year.	Study Design	Country	Participants	Interventions	Outcomes
Liu, et al. 2020 [20]	RCT	China	Inclusion Criteria: diagnosis of COVID-19; 65 years or above; 6 months after onset of other acute diseases; (MMSE) score > 21; no COPD or other respiratory disease; and forced expiratory volume in 1 s (FEV1) more than 70%. Exclusion criteria: moderate or severe heart disease (Grade III or IV, New York Heart Association); severe ischemic or neurodegenerative diseases or hemorrhagic stroke.	Pulmonary rehabilitation includes respiratory muscle training; cough exercises; diaphragmatic training; stretching exercise; and a home exercise program.	Primary Outcome Measures: Respiratory function exercise; Secondary Outcomes Measure: Exercise capacity (the 6-min walk distance), ADL and QoL, the psychological status assessment (anxiety, depression scores).
Liu, et al. 2020 [13]	RCT	China	Total 51 patients with confirmed COVID-19 were included in the study. The patients were randomly divided into two groups (experimental group and control group), and the participants were intervened in the order of the bed.	Jacobson's Relaxation techniques (progressive muscle relaxation and deep breathing), was performed for 20–30 min each day, training for 5 consecutive days. It was done once at noon and before falling asleep, each for 20–30 min...	Outcome: The Spielberger State-Trait Anxiety Scale (STAI) was used to assess the state of anxiety. The Sleep State Self-Rating Scale (SRSS) was used to assess the sleep state.
Zhao, et al. 2019 [21]	RCT	China	Inclusion criteria:18 to 70 years; percutaneous oxygen saturation (SpO2) > 90% while the patients were on ambient air, well oriented; disease onset of > 2 weeks and hospitalized for more than 72 hours. Exclusion criteria, ; unstable coronary heart disease; severe hepato-renal dysfunction; mean blood pressure < 60mmHg, or blood pressure > 140/90 mmHg; peak temperature > 38^{0}C; unstable hemodynamics; deep venous thrombosis; pregnant women	Pulmonary rehabilitation - muscle training exercise, including bedside and in-bed exercises. Patients who were able to stand (in step 1 to step 6), respiratory muscle training, torso and limb movements. For the bedridden patients (step 1 to step 3) movement of lower and upper limbs and change of the body position. Breathing rehabilitation for15 minutes, twice a day.	Primary outcome: improvement in ADL. Secondary outcome: changes of ABG, MMT, and length of the hospital stay (LOS).

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Gonzalez-Gerez, et al. 2020 [22]	RCT	Spain	Inclusion criteria: Age 18–75 years Patients with positive polymerase chain reaction (PCR) test, patients who are affected by a coronavirus (COVID-19) and are in home isolation	Pulmonary rehabilitation included; Ten exercises by the physiotherapist, postural changes, active cycle of breathing techniques through telematic control by video-conference with the patient.	Outcomes included: Forced expiratory volume in 1 s, The Visual Analog Scale Fatigue (VASF), for fatigue, Six-Minute Walk Test, Peak expiratory flow, Multidimensional Dyspnoea-12 (MD12), Borg Scale, Thirty Seconds Sit-To-Stand Test
Pancera, et al. 2020 [27]	Case-report	Italy	A 51-yr old man, resident in Lombardy (Italy), with nonsmoking history and no comorbidities, was referred to the center for rehabilitation from a local hospital, with the diagnosis of COVID-19 severe ARDS.	The respiratory rehabilitation program was carried out from the ICU till the day of discharge and included: the weaning procedure from MV., quadriceps strengthening with neuromuscular electrical stimulation with amplitude between 15 and 20 mA for 30 min., sit-to-stand training, and seated leg or arm cranking for 20-30 min., aerobic training with cycle ergometer with the resistance of 20 W for 20-30 min.	Outcomes included: Barthel index; Barthel index based on dyspnea; EuroQol questionnaire; MEP, maximal expiratory pressure; MIP, maximal inspiratory pressure; SPPB (Short Physical Performance Battery)
Shan, et al. 2020 [28]	Case-report	China	An independent female in her early 80s with a medical history of diabetes mellitus type II, obesity, and hypertension presented to the emergency room 8 days post fever, chills, cough, and lethargy and positive outpatient COVID-19 test.	Pulmonary rehabilitation is an important component of inpatient rehabilitation to improve functional exercise capacity, aerobic capacity, and quality of life. Activity tolerance and endurance exercises were focused.	The functional outcome included-Chair Stand Test, TUG test with FWW, TUG test without assistive device, Gait speed (15 feet), 6MWT Heart rate after ambulation, Oxygen saturation after ambulation (%), Incentive spirometer volume (cc)
Shi, et al. 2020 [23]	Cross-sectional	China	71 227 individuals clicked on the survey link, and 57 006 individuals commenced the survey, among whom 74 individuals refused to provide informed consent and 56 932 participants provided informed consent. 156 questionnaires that did not provide valid age information were excluded from the analysis. Ninety-seven respondents who were younger than 18 years were excluded because obtaining online informed consent from their parents was not realistic under present conditions.	The survey lasted for 15 minutes and had 4 parts. The first part included demographic information of participants. The second part, epidemic-related questions. The third part evaluated social attitudes and isolation conditions toward the COVID-19 pandemic. The fourth part consisted of 4 standardized scales.	The outcomes of depression, anxiety, acute stress, and insomnia, were evaluated using the Patient Health Questionnaire–9, Generalized Anxiety Disorder–7, Insomnia Severity Index, and Acute Stress Disorder Scale.
Chen, et al. 2020 [24]	Cross-sectional	China	The included patients diagnosed with COVID-19 were discharged from the 12 hospitals in Wenzhou, Zhejiang between Jan 17, 2020, to Mar 20, 2020. The data was collected and analyzed prospectively including clinical symptoms, demographics, comorbidity, and chest CT imaging features at the first follow-up, 1 month after discharge.	The Chinese version of SF-36 was translated from the International Quality of Life Assessment (IQOLA) SF-36. It is composed of subscales: (1) the physical function (PF), limitations due to physical health (role physical, RP), (3) body pain (BP), (4) social functioning (SF), (5) general health (GH), (6) vitality (VT), (7) limitations due to the emotional health problems and (8) mental health. The scores of SF-36, from 0 and 100 were assigned to each domain.	Outcome: QoL The SF-36 questionnaire was used and its 8 components were studied. The mental component was also summarized.
Zhang, et al. 2020 [26]	Cross-sectional	China	263 participants (106 males and 157 females) completed the study performed from 28 January 2020 till 5 February 2020. Adults (aged ≥18 years) of the Chinese nationality were recruited in the study.	Participants were asked to complete an online questionnaire on Impact on Social and Family Support, Indicators of Negative Mental Health Impact, and Impact on Mental Health-Related Lifestyle Changes with Mental Health Lifestyle Scale (MHLS) and Impact of Event Scale (IES).	Outcome: Quality of life and mental health using IE scale and MHL scale.
Guo, et al. 2020 [25]	Cross-sectional	China	Participants of18 years or above were recruited through a snowball sampling process through WeChat between February 26-29, 2020 during community- or home-based quarantine in China.	The questions included family relationships, demographics, chronic diseases, quarantine conditions, lifestyle, and anxiety and depressive symptoms.COVID-19 infection. Data on family relationships, demographics, chronic diseases, quarantine conditions (eg duration, frequency of going out during the quarantine), COVID-19 infection (eg, confirmed or suspected cases among family members, friends), and anxiety and depressive symptoms were collected.	Outcome: Anxiety and depression. It was assessed by the 14-item Hospital Anxiety and Depression Scale (HADS) comprising of two 7-item subscales.
Li, et al. 2020 [29]	Cohort-study	China	43 patients with severe / critically severe COVID-19 pneumonia were included and then divided into conserved intervention (C-I group) and advanced intervention (A-I group) according to the initiation time of PR intervention.	PR intervention included respiratory rehabilitation, education, (breathing exercise, positioning management, Balloon blowing Incentive spirometry (IS) exercise) physical training, nutrition management, and psychological counseling.	Outcome after PR included: 1) Fever 2) Oxygenation Index,3) Lymphocytopenia, 4) DVT, and d-dimer.

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technique for 20-30 minutes a day. In Zhang, et al. [26], data were evaluated from 263 patients who underwent PR, using IES and MHLS. In Li, et al. [29], PR sessions were given 3 times 8 weeks, including psychological counseling. In Shan, et al. [28], the patient underwent PR, focused on endurance and activity-tolerance exercises to increase aerobic capacity.

Outcomes: The 11 studies included [13,20-28] evaluated HQoL, ADL, and mental health. Four studies reported [20,22,24,26] HQoL using SF-36, IE(impact of the event) scale, and VAS. Three studies [20,21,27] evaluated ADL through the FIM scale and Barthel index. Five studies [13,20,23,25,26] evaluated mental health, depression, and anxiety using the SDS (self-rating depression scale), SAS (self-rating anxiety scale), STAI (state-trait anxiety scale), PHQ-9 (physical health questionnaire), MHLS (mental health lifestyle scale), and the HADS (hospital anxiety and depression scale).

Risk of bias: It was done in four RCTs, detail for risk of bias can be found in Table 1. Four studies showed adequate sequence generation, the allocation concealment and were judged with a low risk of bias [13,21,22]. The Gonzales, et al. [22] risks of bias were low in blinding of the participants whereas in [13,20,21] did not describe the blinding so it was judged with a high risk of bias. The Gonzalez, et al. [22] studies were judged with a high risk of bias because they did not assess if the groups were similar at baseline or not. All of the four studies were registered on clinical trial and the primary and secondary outcomes were reported in a pre-specific way, depicting a higher risk of the reporting bias. There was bias in most of the studies about the compliance and adherence of the patients, duration, inappropriate guidelines, and synthesis of the data.

Synthesis of the results: Four out of eleven studies included a reported improvement in the QoL. In Liu, et al. [20] SF-36 showed statistically significant improvement in all the domains and also in mental health components after PR (61.5±6.5 to 73.7±7.6, $p<0.05$). In Gonzalez, et al. [22], there was a significant change in HQoL after using VAS. In Chen, et al. [24], a comparison of HRQoL outcomes using SF-36, between the COVID19 patients and healthy subjects of different gender following PR showed lower significance in males as to females. In Zhang, et al. [26], overall the mean IES score in participants was 13.6±7.7, reflecting a stressful mild impact. There was no difference in the mean IES scores between females and the males (14.2 vs. 12.8, respectively) (P= 0.173), and mean intrusive scores in the males were significantly higher than in females (13.0 vs. 12.3) (P= 0.027).

Three studies out of eleven reported an improvement in ADL. In Liu, et al. [20] showed no significant improvement in the intervention group (109.2±13to 109.4±11.1) ($p<0.05$) post six weeks of PR using the FIM scale. In the exercise program by Zhao, et al. [21] results reported clinically and a statistically significant increase in the ADL using Barthel index in the PR exercise group (75.00 [66.25,90.00] vs. 100.00 [100.00,100.00], $p<0.001$). In the study by Pancera, et al. [27], the ADL changed significantly post PR assessed through the Barthel index (19/100 to 100/100).

Five out of eleven studies evaluated improvement in mental health, anxiety, and depression. In Liu, et al. [20] anxiety showed significant changes (56.+-8.1 to 47.4 +- 6.3) ($p<0.05$) whereas depression did not show a significant change (56.4±7.9 to 54.5±5.9) ($p<0.05$) post 6 weeks PR in elderly using SAS and SDS scales. In Liu, et al. [13] STAI showed significant changes (57.88±11.51 to 44.96±12.68) ($p<0.001$) after the relaxation technique for 5 days. In Guo, et al. [25] using HAD scale, 32.7% of participants experienced an elevation in anxiety or depressive symptoms related to COVID-19 infection. In Zhang, et al. [26] they reported the mental health and lifestyle through MHLS and found the participants aged 18–30, 31–40, and >50 years who spent significantly more time relaxing (P = 0.028). However, age and education levels were insignificantly associated with questions related to mental health-related changes in lifestyle. In Shi, et al. [23] subjects with confirmed/suspected COVID-19 had a minimum twice the risk for 4 mental health symptoms as compared with those not infected with COVID-19 for depression, 2.48 [95% CI, 1.43-4.31] in anxiety, 3.06 [95% CI, 1.73-5.43] in insomnia, and 3.50 [95% CI, 2.02-6.07] in case of symptoms of acute stress.

Discussion

Summary of results

The systemic review estimated the effect of PR in COVID-19 patients and its complications. Eleven studies were included irrespective of gender, age, and ethnicity. These studies met inclusion criteria through different characteristics and methods. The meta-analysis of the review was impossible due to data heterogeneity. COVID-19 and its post complication have a dreadful impact on our general health leading to the deterioration of HQoL, ADL, mental health, anxiety, and depression. The studies in this review reported the PR as a significant intervention for these factors in the post-COVID-19 patients.

According to ATS and ERS, PR is defined as a component of the management of lung/pulmonary diseases [30]. Recommendation of Pris for the patients with advanced lung condition due to increase in HQoL scores and decrease in the dyspnea. Similar results were extracted in patients with COPD which depicted significant results in the quality of life post, PR [31]. Under CT, the COVID-19 patients have residual fibrotic lesion lungs following current treatment and the discharge protocols [32], which may differ the patient's respiratory function. The endurance exercise measures assessed through the six-min walk test [20] led to significant improvements in exercise capacity following the 6 week PR. These results were similar as reported by Giansanti, et al. [33], who predicted significant improvement in the 6MWD post 6–9 weeks of respiratory rehabilitation, showing improved exercise capacity. The health-related quality of life is an important component in determining chronic diseases' impact on patients' perceptions about their health [34]. The core of respiratory rehabilitation is exercise training and is affected by place, intensity, time, and mode of exercise training, and such exercise training has a positive impact on the physical and mental health and the QoL of COVID-19 patients [35]. The rehabilitation training related

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to the respiratory muscles includes the enthusiastic muscles, intercostal muscles, abdominal wall muscles, etc. which play an important role in maintaining respiratory function. The decay in this function leads to the abdominal breathing with the labial constriction, dyspnea, increase in expansion range of pectoralis muscle during breathing, slowing down of the respiratory rate to decrease power consumption encourages the patients to exercise their abdominal wall while breathing to reduce chest wall movement and also increases blood oxygen content and pulmonary ventilation [36]. Maki, et al. [37] reported 2504 patients with chronic obstructive disorder being administered exercise intervention and found patients' muscle endurance increased by 92%, muscle strength increased to 78%, and muscle mass increased to 88%. The COPD rehabilitation action-mechanism of exercises is related to improvement in the gas exchange function and ventilation, limb muscle function, and cardiovascular function [38]. In one of the studies, ADL didn't improve significantly following PR, due to the short duration of the program [20]. Past studies found that the six weeks of PR significantly improved the anxiety in elderly COVID-19 patients and was consistent following the effect of PR in COPD by Rebelo [39]. There were no positive changes in depression scores in one included study after PR [20] and was consistent with findings of McNamara, et al. [40] who depicted no improvement in depression in elderly COPD patients after 6-9 weeks of the PR. Dowman, et al. [41] studied PR in ILD patients and found benefits in improving dyspnea, functional exercise capacity, and the quality of life apart from improvement in the activity of daily, and restoration of an independent function.

Strength and limitation

This is the first article focusing on Pulmonary rehabilitation in COVID-19 patients and its post complication. Future studies need to be well-conducted to assess the PR benefits in COVID-19 and the post complications Also, attention needs to be given to the high-quality study design and good reporting. The meta-analysis was not performed due to an insufficient number of studies.

Conclusion

The studies included in this review showed that PR is an effective treatment for COVID-19 patients, post complications, and the effects upon HQoL, ADL, anxiety, mental health, and depression. The present review depicts that there is a need for more studies of high methodological quality addressing the effects of PR on the COVID-19 patients.

Contributors

JAD and SA were the main reviewers and worked across all the stages of the systematic review from inception till the draft completion.

Acknowledgment

We are thankful to all our friends and family members for guiding us throughout and helping us complete it on time.

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