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Long Haulers Post COVID-19 and Home-Based Cardio-Respiratory Physiotherapeutic Scheme via Telerehabilitation: A Narrative Review

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ABSTRACT

The long-term consequence of COVID-19 resulting from SARS-COV-2 can have direct and indirect impacts mainly on cardio-respiratory, neuromuscular systems and may affect mental health. These long-term effects may also be experienced by those who have remitted from COVID-19 infection, which is precisely denoted as "long COVID" or "long Haulers". Such patients can be provided with effective cardio pulmonary therapy with functional rehabilitation and stress management in their remote areas through telerehabilitation. In broad terms, online rehabilitation is less expensive, more practicable, and safer than traditional inpatient or face-to-face rehabilitation. The aim of the study is to find out the current Evidence based literatures from various research protocols of cardio-respiratory related interventions available for long haulers COVID 19 patients via telerehabilitation program with other standard interventions. The present literature search was conducted through PubMed, Scopus, Cochrane library, Google Scholar and PEDro with the following search terms: ["post COVID-19" or "long COVID" or "novel Coronavirus" or "long haulers COVID-19" or "SARS-CoV-2"] and ["Telerehabilitation" or "home based exercise"].In conclusion, this paper shows that Telerehabilitation is a new and interesting medium but, unfortunately there is less evidence based protocols on post covid conditions. Henceforth, we advocate for more research on improving electronic devices to be user friendly. In the future, telerehabilitation will be successful only if practitioners are properly trained and guided. This will lead to more productive rehabilitation outcomes for patients.

Keywords: COVID-19, long COVID, Telerehabilitation, Cardio Respiratory Therapy.

INTRODUCTION

COVID-19 DISEASE

Coronavirus disease 2019 (COVID-19) is a highly infectious emerging respiratory infection caused by a novel Coronavirus

called Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2) which was initially detected in the wholesale market in Wuhan, Hubei province, China in late December 2019 and spread worldwide 2 months later. [1]

LONG HAULERS

The term "Long Covid" was initially used by Perego in social media and "Long haulers" by Watson and Yong. [2,3] Long Covid also known as Post covid syndrome, Long Haulers/Long Haul COVID-19, Post-Acute Sequelae of SARS-CoV - 2(PASC) [is] the long-term health consequences of COVID-19 which involves the multi-organ dysfunction. Further long-term COVID-19 is classified based on the duration of persistent symptoms such that the presence of symptoms extending beyond 3 weeks is known as post-acute COVID-19, whereas symptoms beyond 12 weeks are known to be chronic COVID-19. [4,5]

RISK FACTORS

The critically ill patients who require Oxygen supplementation, are admitted to the Intensive Care Unit, and undergo mechanical ventilation face prolonged functional impairment after discharge, which may last several years. Male gender and older age are the known risk factors for the impairment. [6] Including the history of comorbidities such as Cardiovascular disease, Immune disorders, Thyroid and Kidney dysfunction, and Chronic Respiratory Disease. [7]

DIAGNOSTIC APPROACH FOR LONG COVID

People affected with long-term complications may have 4 clinical syndromes namely Post Intensive Care Syndrome, Post Viral Fatigue Syndrome, Permanent Organ Damage, and Long-Term Covid Syndrome. [8] Post COVID-19 consequences may arise from drug side effects, psychological issues, or associated infections, making long COVID-19 diagnosis challenging, especially in asymptomatic individuals. Raveendran's diagnostic criteria, based on experience and literature, aid in categorizing cases into confirmed, probable, possible, and doubtful using essential, clinical, and duration criteria. [9]

SYMPTOMS

The most common clinical symptoms found in long covid are fatigue (58%), headache (44%), attention disorder (27%), hair loss (25%), dyspnea (24%), anosmia (21%), ageusia (23%), difficulty sleeping, anxiety and with abnormal CT scan/chest x-ray 34%. Other symptoms are Brain fog and Neuropathy. [10]

AFTERMATHS OF LONGHAUL COVID

Respiratory sequelae

Severe disease manifested with fever and pneumonia leads to the acute respiratory distress syndrome (ARDS) described in up to 20% of COVID-19 cases. SARS survivors are found with Lung dysfunction and Pulmonary fibrosis signs after one year of follow-up study. [11,12]

Cardiovascular sequelae

20% of patients admitted with covid 19 have clinically significant cardiac involvement. Cardiovascular complications include myocarditis, pericarditis, myocardial infarction, cardiomyopathy, arrhythmias, and heart failure also common in pre-existing cardiovascular disease. [13,14]

Central nervous system sequelae

Broad clinical syndromes associated with neuropsychiatric complications are Cerebrovascular accidents, Seizures, Encephalitis, Cranial and Peripheral neuropathies. [15] Neurological features can be presented with dizziness, headache, impaired consciousness, and ataxia.[16] Other symptoms included brain fog which describes mental fatigue and confusion/cognitive blunting after COVID-19. [17]

Mental health sequelae

Anxiety disorders, insomnia, and dementia were the most prevalent mental health disorders reported. Sleep disturbances might contribute to the presentation of psychiatric disorders. [18] Multiple psychological stressors have emerged as a result of the COVID-19 pandemic, including financial, social isolation and uncertainty and fear regarding the infection presented with low mood, depression, loneliness, and post-traumatic stress disorder. [19]

Gastrointestinal and Musculoskeletal Sequelae

Patients may also have gastrointestinal symptoms, with diarrhea and vomiting, sore throat, abdominal pain, pancreatitis, hepatitis, and gastrointestinal bleeding. Some patients may have taste and smell disturbances too. [20] Acute kidney injury seems to be continued even after the resolution of COVID-19. A relatively prevalent muscle-skeletal condition symptoms included myalgic pain, fatigue, and Arthralgia in long haulers. [21]

Others

Autonomic dysfunction such as tachycardia with exercise, night sweats, temperature dysregulation, pyrexia, constipation, peripheral vasoconstriction including lymphadenopathy. [22]

TELEREHABILITATION

Telehealth involves health care services, support, and information provided remotely using electronic means and gadgets. It intends to facilitate the effective delivery of health services such as physical therapy by improving access to care and information and managing healthcare resources. [23]

Telerehabilitation represents to be "Digital health application through electronic communication devices, the online environment merchandise to manage the services for rehabilitation ensuring that the patient obtains fostered rehabilitation at residence, while the rehab trained professionals is at the hospital". [24]

Even though the majority of the new waivers offer possibilities for advancements in residence-based health services, home care is not new. Patients choose to get medical treatment at home, if possible, rather than in a hospital. Care within one's home is as secure and efficient as care at other locations for many clinical conditions, and it is more affordable. [25]

TELEREHABILITATION BEFORE COVID-19

The very first publication on telerehabilitation was in 1998 and in the last few years, the no of practices and evidence have been increased due to the emerging needs of the people. A significant enhancement in the number of individuals treated with telerehabilitation is noticeable from 2002 -2004 probably due to support of exciting technologies. [26] There are many Telerehabilitation programs implemented in various areas including neurology in the name of instrumented insoles (eSHOE),[27] cardiology (SAPHIRE system),[28] musculoskeletal with the use of Microsoft Kinect, [29] and pulmonary Doxy.me® was used by another 30%, and Epic® was used by 9%.[30] Using these applications has significantly increased the exercise endurance and self-efficacy of the patients.

TELEREHABILITATION DURING COVID-19

The pandemic posed a challenge to carrying out the study thanks to recent advances in communication and technology, which allow the use of low-cost internet connections, smartphones, and tablets, and the appearance of applications that facilitate video calls have allowed the rapid adaptation of rehabilitation teams. [31,32]

TELEREHABILITATION IN POST COVID-19

Studies have revealed that exercises done after COVID-19 in a home environment have improved the quality of living compared to patients who perform a sedentary lifestyle. At the moment, much

more verification is needed to evaluate this modality as a viable option for managing these patients. Experience in using digital technology may be more beneficial if used in COPD. Simplicity and usability are more important for engagement with the SMART-COPD intervention than personalization; therefore, the intervention should be simplified for future use. Individual variables will need to be regarded in future appraisals. Thus, advanced apps can be used to maintain and improve the Quality of Life. [33]

TECHNIQUE OF APPLICATION

Telerehabilitation is being utilized, with mobile phones, particularly their messaging services and calls being the most commonly studied approach. Additionally, growing evidence supports the effectiveness of smartphone applications as digital tools for rehabilitation. [34] The internet, including web pages with educational content, videos, or interactive games, is often studied as a way to deliver telerehabilitation. Studies have also looked into electronic devices that can be utilized to remotely monitor patients throughout physical therapy interventions, including 2-way real-time visits with audio, video, or both; asynchronous e-visits; virtual check-ins; remote evaluations of recorded videos or images; and telephone assessment and management services. [34,35] The mobile applications (respiraConNostros) and computer technologies have been created and designed to guide users in performing respiratory rehabilitation exercises, especially for COVID-19 patients, and it also facilitates patient physiotherapist contact via chat or video calling to help patients. [36]

ADVANTAGES AND DISADVANTAGES

Telerehabilitation has the potential to increase access to therapy in structurally weak areas deprived of suitable healthcare structures and offers. In addition, considering telerehabilitation can be carried out at any time that is convenient for the patient, it has the potential to improve adherence and compliance, particularly among employed patients. [37] The risk concerning data leakage related to digital care is always present and should be discussed with patients, and safer channels for professionals ought to be used in all circumstances. [38] The drawbacks of telerehabilitation are a lack of skills and expertise for interacting with technologies. Healthcare providers must make sure that the technology needed for telerehabilitation is working properly, offer help with technical problems, and train all users because the technology can be difficult to use. [39] The document reports that telerehabilitation has several advantages, including saving transportation costs and healthcare system resources, reducing patient time, providing continuity of care, and allowing for greater control over the timing, intensity, and sequencing of interventions. [40]

BARRIERS

Telehealth barriers can be categorized into intervention, context of use, and user-related challenges. Intervention barriers include usability issues, technical problems like poor connectivity and device adaptation, complicated designs, incomprehensible language, lack of personalization, false or insufficient information, and missing guidelines. Context-related barriers involve costs, data security concerns, organizational issues like time constraints, incompatibility with daily routines, forgetfulness, and lack of trust due to poor communication and limited provider contact. User-related barriers stem from sociodemographic factors like old age, low education levels, physical impairments, disease burden, lack of technical literacy, and low self-efficacy. [41]

NEED FOR TELEREHABILITATION

The complexity of needs in people with Long Covid mirrors the needs of people with multiple long-term conditions who benefit from holistic, integrated rather than

symptom-by-symptom management. Many people with Long Covid complaint of fragmented care and 23% of the survey respondents wanted a case worker/key worker to co-ordinate care. [42] Telerehabilitation provides a viable alternative that could be superior to no rehabilitation and as effective as conventional rehabilitation. [43]

NEED FOR THE STUDY

The complexity of the clinical setting and the speed of spread leads to rapid occupation of beds in the Intensive Care Unit and wards especially in this COVID pandemic. Additionally, it can be difficult while in isolation to access rehabilitation services. To overcome these complications, home-based Telerehabilitation for "Long Haulers" in remote locations enhances the Quality of Life by upgrading the prognosis and maximizing functional preservation. The current evidence available is very preliminary and our finding suggests that this innovative approach warrants further study.

MATERIALS & METHODS

The present literature search was conducted through PubMed, Scopus, Cochrane Library, Google Scholar, and PEDro with the following search terms: ["post COVID-19" or "long COVID" or "novel Coronavirus" or "long haulers COVID-19" or "SARS-CoV-2"] and ["Tele Rehabilitation" or "home-based exercise" or "virtual rehabilitation"]. A total of 207 articles has been identified, out of which we excluded 197 articles during the full-text analysis, language limitation and because of the undergoing clinical trials, and finally, 10 articles were included in this study. Further articles were identified from the reference lists of extracted articles. This review was carried out by means of major online repositories of scientific studies, including randomized controlled trials, recommendations, guidelines, quasi-randomized or prospective controlled clinical trials, reports and field updates, and case series.

DISCUSSION

ROLE OF TELEREHABILITATION IN POST COVID-19 PATIENTS

EFFECT OF BREATHING EXERCISE:

Breathlessness to some extent is a common occurrence following acute COVID-19. Breathing techniques such as diaphragmatic breathing, slow deep breathing, and pursed lip breathing are used in strategies to manage patients' breathing patterns and breathlessness. [44]

Jian Li, et al., (2021) RCT shows the superiority of the Telerehabilitation program in post-discharge COVID-19 patients over no rehabilitation with 61 participants in the control and 59 in the TERECO group provided with a 6-week home exercise program, done without supervision, which includes breathing control and exercises to expand the chest cavity via smartphone which was analyzed with mMRC dyspnea scale showed the improvement immediately after intervention though not at the other time points. [45]

Siddhi Godge (2020) conducted a retrospective study on 10 (8 males, 2 females) participants based on inclusion criteria of post covid-19 survivors with Respiratory system involvement, who underwent a minimum of 6 weeks of pulmonary telerehabilitation at least 3 days per week. Pulmonary telerehabilitation was given with breathing exercises via video calling with a mobile phone or laptop and found improvement in oxygen diffusing capacity which led to a reduction in desaturation levels in the patients. Also helped in reducing the fatigue scores. [46]

Pamela Tanguay, et al., (2021) in their pilot study showed the impact of 8 weeks of physiotherapy sessions with an additional 30 minutes of breathing exercise daily via videoconferencing components, a web link to activate the session on covid 19 patients returned home after hospitalization to measure the impact of pulmonary symptoms on QOL and functional health where only

one patient had dyspnea grading from 6-8 (borg scale) indicating difficulty in breathing during exercise. [47]

A pilot trial - RCT **(2021)** conducted for 1 week with a breathing exercise program based on a proposal composed of 10 exercises through telematic control with videoconferencing appeared to provide a promising strategy for improving outcomes related to physical condition, dyspnea, and perceived effort among people exhibiting mild to moderate COVID-19 symptoms in the acute stage. [48]

Marcello dalbosco, et al., (2021) in their prospective study on telerehabilitation under 24 sessions of supervised home exercise training for 9 weeks which includes breathing exercises for 3 minutes per session showed significant improvement in fatigue and dyspnea. [49]

Pratibha Sharma et al., (2022) carried out a Randomized Controlled Trial study with 30 Post COVID Patients meeting inclusion criteria randomly allocated into two groups. The experimental Group received the therapeutic Protocol of Telerehabilitation with breathing exercises and the Controlled Group received conventional care for 6 weeks. The results showed significant improvement in both the groups and showed that there was a statistically significant difference between Pre rehabilitation (MBDS) and Post rehabilitation (MBDS) i.e., (p=0.005605 & p= 0.01121). [50]

EFFECT OF AIRWAY CLEARANCE TECHNIQUES:

ACTIVE CYCLE BREATHING TECHNIQUE

An Indian study found that Pulmonary Telerehabilitation with other exercises for 6-8 weeks including the Active Cycle of Breathing Technique / Autogenic drainage for patients having difficulty in secretion removal was improved in a way that one of the patients with 5 liters of oxygen at the start of rehabilitation and eventually over 8 weeks he was off oxygen and shown improvement in lung volumes and capacity. [46]

A pilot study was accomplished at their homes, with evaluators carrying out all measurements on the first and seventh days. The participants were instructed and monitored remotely using telemedicine. The Active Cycle of Breathing Techniques (ACBT) uses alternating breathing depths to move mucus from the small airways at the bottom of the lungs to the larger airways, where it can be more fairly coughed up. The study displayed that ACBT was statistically and clinically significant in contrast to the control group. [48]

OTHERS

A home-based rehabilitation program following COVID-19 illness includes various Airway Clearance Techniques, such as:

1. Positive Expiratory Pressure (PEP) Devices – Used to enhance airway clearance.
2. Diaphragmatic Training – Performed in a supine position with a weight of approximately 1-3 kg placed on the patient's abdomen, encouraging controlled inhalation and exhalation.
3. Pursed Lip Breathing – The patient sits with a straight back, inhales through the nose for about 2 seconds, then exhales slowly through pursed lips for 4–6 seconds. This technique is repeated 5-6 times, twice daily.
4. ACBT – Integrated with self-management strategies to support daily activities, aiding in the recovery of independence post-COVID-19.

Additionally, virtual care therapy is strongly recommended as part of the rehabilitation process. [1]

POSITIONING

Different bed positions, including high-side lying, forward-leaning sitting with or without hand support, and backward-leaning standing, along with breathing exercises such as controlled and paced breathing techniques, can be beneficial for individuals recovering from COVID-19 or those recently discharged from the hospital. [1]

EFFECT OF STRENGTHENING EXERCISE:

In a prospective observational study by **Ines Martin et al. (2021),** researchers assessed the effectiveness of a telerehabilitation program in improving physical activity levels among patients with severe COVID-19. The program involved home-based exercises conducted twice a week for six weeks, with each session lasting 50 minutes. These sessions included 30 minutes of endurance training targeting both upper and lower body muscles, using household items such as water bottles and a chair. Participants were advised to perform 2–3 sets of 8–12 repetitions for each exercise, along with unsupervised exercises three times a week. After a three-month follow-up, both the telerehabilitation and control groups showed significant improvements in the sit-to-stand test (STST) results ($p < 0.001$ and $p = 0.002$, respectively). However, only one participant in the telerehabilitation group achieved a result above the 50th percentile, while 37% of participants in both groups remained below the 2.5th percentile. Despite this, the telerehabilitation group demonstrated a significantly greater clinical improvement compared to the control group ($p = 0.005$). [51]

Strengthening exercises for the upper limb with a filled water bottle, wall push-ups for lower limb squatting, lunges, dynamic quadriceps etc., at home for the patients who survived COVID-19 infection. These patients were given lower limb strengthening exercises during their exercise sessions. This led to an increase in the lower limb strength thereby improving the squat test score. The number of squats increased from 13 to 24 which was statistically significant. [46]

Resistance training leads to a number of changes in the muscle fibers like changes in the fiber type, muscle hypertrophy, increase in the cross-sectional area. It has been noticed that giving resistance training at least twice a week is beneficial for muscle growth. [52]

Two weekly supervised and additional 30-minute unsupervised sessions for 8 weeks of strengthening exercises and intensive patient education on self-management skills in a consolidation phase. Since COVID-19 may produce heterogeneous symptoms, intervention was individualized according to the participant's needs, for example, some required more strengthening exercises to counteract muscle weakness which improved their physical outcomes and functional performance. [47]

A pilot RCT trial by **Cleofas Rodriguez et al., (2021)** with both experimental and control groups of COVID-19 patients confined in homes. The experimental group was given 10 exercises based on nonspecific tonic exercises of strength and resistance to try to improve the physical deconditioning and physiological deterioration that implies no rehabilitation in the control group. The outcomes were assessed with a Six-minute walk test (6MWT) via "Steps App" to rule out the functional status precisely. The 30-second sit-to-stand test (30STST) assesses the strength and endurance of the muscles in the lower limbs, while the Borg scale (BS) measures the perceived exertion of the entire body during physical activity. The findings indicated that all of these variables substantially modified, lowering the level of perceived exertion and enhancing these patients' potential in basic exercises ($p < 0.05$) such as sitting or walking and getting up from their chairs ($p < 0.001$). [53]

EFFECT OF AEROBIC EXERCISE

In a pilot study, 10 participants were given cardiovascular exercise in the shape of mobilization-related intervention (walking) and gold-directed practices (stair training) in two phases Initial phase is comprehensive rehabilitation and learning, and the second phase is consolidation follow-up up 8 weeks which was measured for physical activity level with Baecke Physical Activity Questionnaire passing from a low level of physical activity to a moderate level. Two participants increased their physical activity scores by 0.2 and 1.0 points, but they

remained in the low activity category. The two participants maintained their satisfactory level of physical activity throughout the intervention. [47]

Few studies show that the aerobic exercise intervention in the post covid patients via telerehabilitation has resulted in their overall improvement in functional exercise capacity, fatigue scores, and saturation rate which was measured with 6MWT and 1MSTST. [45,46]

A Prospective study on post- covid patients in primary care telerehabilitation consisted of 24 sessions of supervised home-based exercise training which included a 5-minute warm-up, 3-minute breathing exercises, 20-30 minutes of aerobic and/or strength exercises, and a 5-minute stretch. And weekly phone calls to track the user. The efficacy was measured with the 1 min STST which was improved after the intervention from 20.5+10.2 to 29.4+11.9, repetitions ($p < 0.001$). [49]

Esra Pehlivan et al., (2022) conducted a RCT study on subjects with a history of hospitalization with a diagnosis of COVID-19 and discharged within 4 weeks. The subjects were divided into two groups randomly, namely the telerehabilitation group (TeleGr) and the control group (CGr). TeleGr received supervised pulmonary rehabilitation, consisting of free exercise and 3 days of aerobic training per week for 6weeks, while CGr got an exercise document with the same content. Subjects were evaluated with a 30-second Sit-to-stand test (30STST) and a Short Physical Performance Battery (SPPB). Each evaluation was conducted at home via teleconferencing. Even though the 5 times sit-to-stand test, which is one of the SPPB sub scores, was found to be reduced in TeleGr, a significant improvement was observed in TelerGr in terms of 30STST ($p = 0.005$) and a positive development in the TUG test. [54]

STRESS MANAGEMENT:

Sari Harenwall et al. (2021) conducted a 7-week pilot study on post-COVID-19 syndrome through a psychology-led interdisciplinary virtual rehabilitation program, "Recovering from COVID," aimed at addressing post-viral fatigue and stress management. Intervention mainly focuses on inducing relaxation, breathing optimization, managing setbacks, and signposting to appropriate resources and services with sessions lasting for 1 hour. Cognitive Behavioral Therapies (CBT) such as Acceptance and Commitment Therapy (ACT), Compassion Focused Therapy (CFT), mindfulness-based cognitive therapy, and polyvagal theory consider bi-directional pathways between the mind and body. Finally, the overall impact was analyzed with EQ-5D-5L which shows that Anxiety, Depression was improved by a frequency range of 36.8%. [55]

QUALITY OF LIFE:

The intervention of pulmonary rehabilitation which consists of strengthening, cardiovascular, and breathing exercises with intensive patient self-education via video conference assessed the impact of symptoms over QOL with (COPD Assessment Test) CAT score. At the end of the 8-week intervention, two participants had no effect of respiratory symptoms on their quality of life, two had a low impact, one had a moderate impact, and one still had a high impact. [47]

One of the primary goals of all rehabilitation studies is to improve one's quality of life. In RCT research, Telerehabilitation has been found to be practical and well accepted by patients when weighed against standard PR, though the technology was sometimes noticed to be harder to use. Stretching/relaxation and exercises to strengthen were applied to patients for 28 sessions in the previously mentioned bicycle ergometer study. The experimental group's SGRQ scores indicated an improvement. [54]

CONCLUSION

With limited scientific data available about long COVID and with global medical care

primarily focusing on treating acute COVID-19 cases mainly long COVID sufferers are neglected and even turning to social media to discuss their persistent symptoms, find others with similar symptoms and identify potential solutions to improve their Quality of Life.

Hence, it is imperative that care for this vulnerable patient population take a multidisciplinary approach with a thoughtfully integrated research agenda, with a primary focus on the devastating health effects of COVID-19 on various organ systems, as well as overall well-being. Despite well-established guidelines on COVID-19 disease, physiotherapy rehabilitation via virtual care therapy either in a hospital or home-based setting looked to be a potential technique for improvement of the outcomes related to physical and mental conditions in COVID-19 survivors.

This research assessed the success rate of home-based cardio-respiratory physiotherapeutic telerehabilitation in COVID patients, highlighting its advantages and disadvantages. Finally, this article demonstrates that Telerehabilitation is a viable option.

A novel and intriguing medium but, unfortunately, there are fewer evidence-based protocols on post-COVID conditions. Henceforth, we advocate for more research on improving electronic devices to be user-friendly. In the future, telerehabilitation will be successful only if practitioners are properly trained and guided. This will lead to more productive rehabilitation outcomes for patients.

Declaration by Authors

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