Research Paper

The Effect of Respiratory and Core Stability Tele-exercises on Pulmonary and Functional Status in COVID-19 Survivors: A Randomized Clinical Trial

Mohammad Mashhadi[1*], Mansour Sahebozamani[1], Abdolhamid Daneshjoo[1], Seyyed Hassan Adeli[2]

1. Department of Sports Injuries and Corrective Exercises, Faculty of Sport Science, Shahid Bahonar University of Kerman, Kerman, Iran.
2. Department of Internal Medicine, Faculty of Medicine, Qom University of Medical Sciences, Qom, Iran.

Use your device to scan and read the article online

Citation Mashhadi M, Sahebozamani M, Daneshjoo A, Adeli SH. The Effect of Respiratory and Core Stability Tele-exercises on Pulmonary and Functional Status in COVID-19 Survivors: A Randomized Clinical Trial. Physical Treatments. 2022; 12(2):85-92. http://dx.doi.org/10.32598/ptj.12.2.526.1

http://dx.doi.org/10.32598/ptj.12.2.526.1

Article info:
Received: 01 Jan 2022
Accepted: 22 Mar 2022
Available Online: 01 Apr 2022

Keywords:
COVID-19, Survivors, Core stability, Respiratory function tests, Telerehabilitation

ABSTRACT

Purpose: Various complications, including physical, cognitive, and functional disorders, have been identified in patients discharged and recovered from COVID-19. Pulmonary rehabilitation (PR) can be considered a strategy for these disorders. This study aimed to investigate the effect of respiratory and core stability tele-exercises on pulmonary function and functional capacity in survivors discharged and recovered from COVID-19.

Methods: This randomized clinical trial study was performed in Qom Province, Iran, in 2021. Thirty discharged patients voluntarily participated in this study and were randomly divided into two groups of 15 patients. Eventually, 27 patients in two groups of exercise (13 patients) and control (14 patients) completed this study. The exercise group performed respiratory and core stability tele-exercise for 8 weeks. Before and after the exercise program, pulmonary function, including forced vital capacity (FVC), forced expiratory volume in 1 s (FEV1), FEV1/FVC ratio, and six-minute walk test (6MWT) were assessed in both groups. Mixed repeated measures test in SPSS software v. 27, was used to compare the mean of pre-test-post-test information of the groups. The significance level for this study was considered 0.05.

Results: In the exercise group, a significant improvement was observed in FVC, FEV1, and 6MWT after the intervention ($P \leq 0.05$), but no significant difference was observed in the FEV1/FVC ratio ($P>0.05$). Furthermore, a significant interaction was observed in 6MWD, FVC, FVC (predicted), FEV1, and FEV1 (predicted). However, in FEV1/FVC ratio, no significant interaction was observed between the two groups ($P>0.05$).

Conclusion: The results of the study showed that in the new crisis resulting from persistent complications of COVID-19, respiratory and core stability exercises by the tele-exercise method could be used as a helpful method in the rehabilitation of patients discharged and recovered from COVID-19 disease.

*** Corresponding Author:**
Mohammad Mashhadi
***Address:** Department of Sports Injuries and Corrective Exercises, Faculty of Sport Science, Shahid Bahonar University of Kerman, Kerman, Iran.*
***Phone:** +98 (916) 2491404*
***E-mail:** md.mashhadi@gmail.com*

Highlights

● Pulmonary rehabilitation can be considered as a strategy for physical, cognitive and functional persistent symptoms of COVID-19 Survivors.

● The diaphragm both creates inspiratory airflow and helps to mechanically stabilize the spine.

● There is no evidence on effect of core stability tele exercise in addition to respiratory exercise on pulmonary function and functional capacity in COVID-19 survivors.

Plain Language Summary

COVID-19 acute respiratory syndrome has spread around the world. Various complications including physical, cognitive and functional disorders have been identified in COVID-19 Survivors. Considering the persistent symptoms and clinical condition of COVID-19 disease, motor and pulmonary rehabilitation is necessary for the recovering. Respiratory and core stability exercises by tele-exercise method can be used as a useful method in rehabilitation of recovered persistent symptoms of discharged patients from COVID-19 diseases.

1. Introduction

A substantial proportion of patients with severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) still have symptoms that have long passed since they recovered from the initial phases of COVID-19 [1]. Recent evidence suggests that a wide range of symptoms may persist after acute infection in many survivors of COVID-19, known as long COVID [2]. According to the results of review studies on persistent post-acute symptoms of COVID-19 survivors, fatigue, pulmonary dysfunction, psychological problems (such as depression and post-traumatic stress), decreased quality of life, movement disorders (such as balance and gait pattern), and musculoskeletal problems (such as myalgia and joint pain) were the most persistent symptoms [3].

Several studies have shown that dyspnea is a common manifestation after COVID-19 infection, and one study reported that 43.4% of evaluated patients still had dyspnea 60 days after COVID-19 infection [4]. At 90 days after discharge, residual abnormalities of pulmonary function were observed in 25. 45% of the group, mostly demonstrating a decrease in the diffusing capacity for carbon monoxide, which should be considered in routine clinical follow-up for recovered patients, especially in recovered patients of severe cases [5]. At 4 months after discharge, physical and psychological complications were common among recovered patients from COVID-19 [6]. After the acute phase, COVID-19, primarily respiratory disease, may become a movement disorder associated with time spent in intensive care [7].

At 6 months, persistent dyspnea has been reported to be associated with decreased physical fitness. People with persistent dyspnea should be offered appropriate rehabilitation intervention, including muscle reconditioning, breathing retraining, and respiratory muscle training [8]. The importance of post-acute COVID-19 rehabilitation has been emphasized in the context of the international classification of functioning (ICF), disability, and health [9]. Pulmonary Rehabilitation (PR) is a safe, feasible, and effective therapeutic intervention in COVID-19 patients, regardless of the severity of the disease, which can be considered an option for treating pulmonary disorders caused by COVID-19 [10]. Patients may improve muscle function, strengthen the respiratory muscles, and improve pulmonary function via PR exercises [11].

For COVID-19 patients, breathing exercises aim to improve shortness of breath, reduce anxiety and depression, prevent and improve dysfunction, reduce complications, maintain function, and improve quality of life as much as possible [12]. According to the results of some studies, pulmonary functional impairments have been reported in the recovery of COVID-19 even after rehabilitation programs [13]. After discharge from the hospital, telemedicine services can be used to follow recovered patients at home. Motor telerehabilitation is recommended to maintain and increase independence, especially for patients who have lost some of their function in daily activities after discharge [14]. Tele-rehabilitation seems a good option for patients discharged from inpatient rehabilitation to continue treatment and further their recovery [15, 16].

On the other hand, the core muscles play a vital role in lung function and also in spinal stability and postural control. The diaphragm is the main respiration muscle, but it is also active in spinal oscillations. Therefore, in addition to PR exercises, core stability exercises appear useful for COVID-19 survivors. Therefore, the present study aimed to evaluate the effect of selected respiratory and core stability tele-exercise on pulmonary function and functional capacity in COVID-19 survivors.

2. Materials and Methods

This study was an RCT conducted from September to December 2021. Thirty survivors of COVID-19 voluntarily participated in this study with a history of hospitalization due to definite COVID-19 in Shahid Beheshti and Forghani hospitals in Qom Province, Iran. Because of leaving three patients (due to heart surgery, pregnancy, and neck surgery), finally, 27 people (14 female and 13 male, mean age 47.04±9.68 years, mean body mass index [BMI] 28.45±4.93 kg/m^2) in two groups of exercise (n=13) and control (n=14) completed this study. G×Power software was used to estimate the sample size. The values applied in the software included effect size: 0.4, test power: 0.95, and α level: 0.05. First, the list of 300 people discharged from the hospital was numbered. Then, according to these numbers, individuals were selected from the list of patients. To read the numbers after selecting the starting point from the list, the counting direction was down. Even numbers were assigned to the experimental group and odd numbers to the control group. We wrote down the numbers until the sample size reached 15 people in both groups.

The inclusion criteria include hospitalization due to COVID-19 approved in the hospital, the age range between 35 and 59 years, and the hospitalization period of at least one week. The exclusion criteria included orthopedic and neurological injuries and follow-up and implementation of an exercise program apart from the present study. Before and after the exercise program, pulmonary function tests (PFTs), including FVC, FEV1, and FEV1/FVC ratio, were assessed in both groups by spirometry (SpirolabII, MIR, Italy). For this purpose, after placing the nasal clip, the person was asked to sit down, and after two or three normal inhalations and exhalations, take a deep breath and exhale quickly and powerfully for 6 s. This test is performed at least three and at most eight times for each person. The six-minute walk test (6MWT) was used to assess the functional capacity (FC) in this study. In this test, people walked forward at maximum speed in a straight hall for 6 minutes. Although this test emphasizes non-stop and maximum speed (if possible), the subjects will be allowed to rest during the test. Finally, the walking distance during the 6-minute test was recorded for each individual. All tests were performed in the office of a sports medicine specialist, and participants signed a consent form before the tests.

Exercise program

The exercise group conducted the exercise protocol in the form of tele-exercise through video calls for 8 weeks and 3 sessions per week. The content of each session lasted about 45-60 min. The exercise and control groups were allowed to do their normal activities. Respiratory exercises consisted of several parts:

1) Breathing muscle training, in which the participants used a breathing instrument, for three sets of 10 deep breaths in each set, with 1 min rest between the sets;

2) Cough exercise, including three sets of 5 active coughs and the progress of 10 coughs;

3) Diaphragmatic breathing, including deep abdominal breathing and holding breath for 2-3 s. To progress in the exercise by placing a medium weight (1-3 kg) on the anterior abdominal wall in the open arch position, the patient performed 30 maximal voluntary diaphragmatic contractions to resist diaphragmatic decline;

4) pursed-lip breathing, including 3 sets of 10 repetitions in which the patient exhales slowly and exhales with the pursed lips; and

5) Chest muscle stretch, in which the patients were asked to move their arms in three 10-repetition sets in horizontal extension, abduction, and external rotation [17, 18].

The core stability exercises suggested by Jeffrey include five levels [19]: level 1 is the mastery of core contraction, level 2 is static with slow movements in a stable environment, and level 3 also includes static in an unstable environment and dynamic movement in a stable environment, level 4 is dynamic movements in an unstable environment, and level 5 is resisted dynamic movement in an unstable environment. In the present study, due to the limitations of COVID-19 disease, level one to three exercises were used (Table 1) [20].

Table 1. Protocol of core stability exercises

Week	Form of Exercise	Set/Rep
1	Contracting abdominal muscles, supine position (first level) Contracting abdominal muscles, prone position (first level) Contracting abdominal muscles, cat position (first level)	Three sets, 20 repetitions
2	Contracting abdominal muscles, supine position (first level) Contracting abdominal muscles, prone position (first level) Contracting abdominal muscles, cat position (first level)	Three sets, 20 repetitions
3	Contracting abdominal muscles, supine position, one leg stretched (second level) Contracting abdominal muscles, prone position with one leg stretched and the other leg bent at the knee (second level) Side bridge (second level)	3 sets, 10 repetitions
4	Bending 45 degrees to the left or right (second level) Leaning forward (second level) Back lunges (second level) Lifting the leg, lying on its side (second level)	3 sets, 15 repetitions
5	Straighten one leg, bend other knees, supine position (second level) Abduction of one leg, knees bent, supine position (second level) Lifting the pelvis, supine position, knees on the floor (second level) Lifting a straight leg lying on its side (second level)	3 sets, 20 repetitions
6	Raise one leg, knees bent, supine position (third level) Moving one leg from behind, cat position (level three) Bridging by lifting the body (third level) Bending forward with straight arms at the side of the body (third level)	3 sets, 10 repetitions
7	Back lunge with straight arms beside the body (Level 3) Lifting one leg, bending one knee, lying on the side (third level) Straighten the leg, bending one knee, and supine position (level 3) Hip abduction, bending one knee, and supine position (level 3)	3 sets, 15 repetitions
8	Lifting the pelvis and legs off with extended knees (third level) Lifting two legs straight, knees lying on the side (third level) Straightening the opposite arm and leg in the cat position (third level) Bridging by extending one knee lying on the back (third level)	3 sets, 20 repetitions

PHYSICAL TREATMENTS

Data were analyzed using SPSS software v. 22. The Shapiro-Wilk and Levene's tests were employed to evaluate the normality of the distribution of scores and homogeneity of variance among groups ($P>0.05$). Also, a mixed repeated measures test was used to compare pulmonary function and functional capacity (Table 2). The significance level was considered 0.05 for all calculations.

3. Results

Table 3 presents the individual characteristics of participants, including age, weight, height, and length of hospital stay (LOHS). The mean 6-minute walking distance in the control group increased by 24.57 m, and in the exercise group increased by 95.76 m after participating in the exercise rehabilitation program. Mixed ANOVA repeated measures test results showed that significant differences were observed between Pretest-posttest results ($F_{1,25}=30.48$, $P=0.000$).

The mean absolute values of FVC and FVC (predicted) ratio in the control group increased by 0.34 L and 11.57%, respectively, and in the exercise group increased by 2.15 L and 65.04%, respectively, after participating in the exercise rehabilitation program. Mixed ANOVA results showed that significant differences were observed between Pretest ($F_{1,25}=14.32$, $P=0.001$) and Posttest ($F_{1,25}=14.63$, $P=0.001$) results. Also, the mean absolute values of FEV1, FEV1 (predicted) ratio were $F_{1,25}=6.176$ ($P=0.020$) and $F_{1,25}=10.474$ ($P=0.003$), respectively. A significant difference was observed in the exercise group after the intervention. But the FEV1/FVC ratio did not change significantly ($F_{(1,25)}=1.623$, $P=0.214$).

Furthermore, in 6MWD ($F_{1,25}=10.66$, $P=0.003$), FVC ($F_{1,25}=7.49$, $P=0.011$), FVC (predicted) ($F_{1,25}=6.60$, $P=0.017$), FEV1 ($F_{1,25}=4.88$, $P=0.036$), and FEV1 (predicted) ($F_{1,25}=9.19$, $P=0.006$), a significant interaction was observed in the exercise group. But in FEV1/FVC ratio, no significant interaction was observed between the two groups ($F_{1,25}=0.38$, $P=0.846$).

4. Discussion

This study aimed to evaluate the effect of selected respiratory and core stability tele-exercises on pulmonary

Table 2. Repeated measures analysis of variance for study variables

Variables	Groups	Mean±SD		Difference	Between Group df (1,25)	Interaction df (1,25)	Within Group df (1,25)
		Pre-test	Post-test				
FVC	Exercise	3.35±1.32	5.50±1.73	2.15	2.143 (0.156)	7.491 (0.011)*	14.323 (0.001)*
	Control	3.43±1.68	3.77±1.95	0.34			
FVC Pred %	Exercise	90.63±33.83	149.58±38.99	65.04	1.435 (0.242)	6.604 (0.017)*	14.630 (0.001)*
	Control	96.58±47.43	108.16±56.35	11.57			
FEV1	Exercise	2.23±1.12	3.16±1.13	0.93	0.447 (0.510)	4.888 (0.036)*	6.176 (0.020)*
	Control	2.36±1.20	2.42±1.61	0.06			
FEV1Pred %	Exercise	67.32±25.13	108.54±33.44	41.22	0.296 (0.591)	9.192 (0.006)*	10.474 (0.003)*
	Control	80.37±38.14	81.72±46.90	1.344			
FEV1/FVC %	Exercise	63.76±21.48	58.19±13.78	-5.59	2.578 (0.121)	0.038 (0.846)	1.623 (0.214)
	Control	73.55±20.54	65.95±21.06	-7.6			
6MWT	Exercise	338.00±95.85	433.76±81.81	95.76	0.072 (0.791)	10.66 (0.003)*	30.48 (0.000)*
	Control	366.50±70.44	391.07±40.23	24.57			

FVC: forced vital capacity; FEV: forced expiratory volume in 1 s; 6MWT: six-minute walk test.

* Significance at P≤0.05.

function and functional capacity in COVID-19 survivors. Most studies on the effect of exercise on functional capacity and pulmonary function after discharge from COVID-19 hospital are currently limited to observational studies [21]. However, the results of previous studies showed that exercise therapy in COVID-19 survivors had a significant effect on functional capacity, especially 6-minute walking distance [18-32] and pulmonary function [9, 10].

The results showed that PFTs (except FEV1/FVC) and 6MWT scores had significant interaction in the exercise group. The graph of changes in the research variables shows that (Figure 1) the exercise group had a much greater slope in improving pulmonary function and functional capacity than the control group. This means that performing respiratory and core stability tele-exercise significantly affected PFTs (FVC and FEV1) and functional capacity (6MWT) of COVID-19 survivors discharged from the hospital. These results are similar to those reported by Sheehy [9] and Puchner [13], who reported a significant improvement in pulmonary function and functional capacity (6MWD, FEV1, FVC, FEV1/FVC) after respiratory exercises at the rehabilitation center. However, in these two studies, they reported a significant change in the FEV1/FVC ratio, but in the present study, no significant change was observed in this variable.

In a clinical trial, Amaral et al. examined the cardiorespiratory and functional effects of a remotely supervised home-based exercise program in people recover-

Table 3. Demographic information of the studied groups

Group	Mean±SD			
	Weight (kg)	Height (cm)	Age (y)	Length of Hospital Stay (d)
Exercise (n=13)	75.92±12.95	166.53±9.83	48.84±9.82	10.69±6.76
Control (n=14)	79.67±15.01	164.71±8.13	45.35±9.59	10.64±3.93
Total (n=27)	77.87±13.92	165.59±8.86	47.04±9.68	10.66±5.37

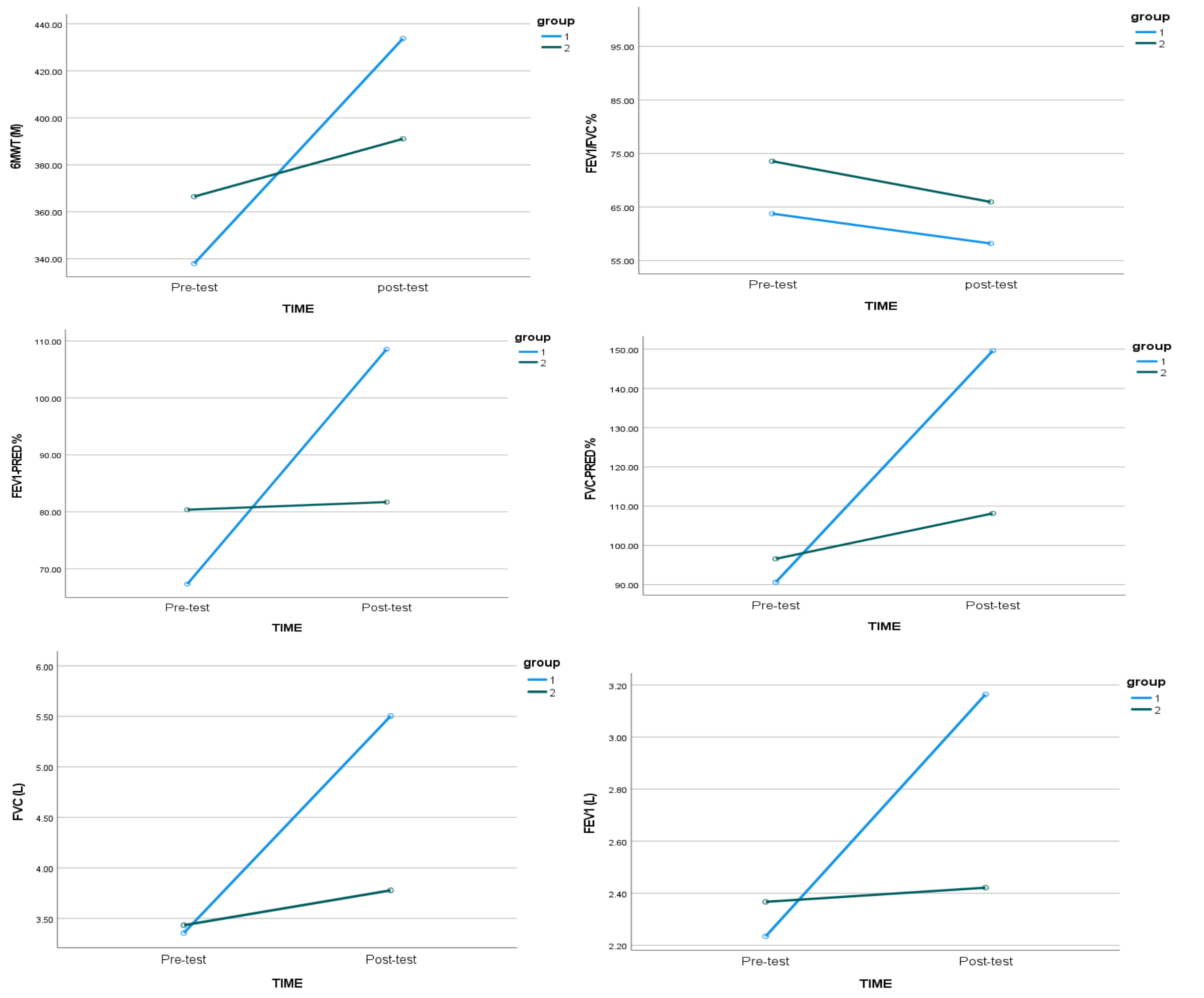

Figure 1. Distribution of changes in study variables

PHYSICAL TREATMENTS

ing from COVID-19 [21]. They reported that after 12 weeks of follow-up, both exercise and control groups similarly increased FVC (absolute and % of predicted), FEV1 (absolute and % of predicted), and no significant differences were observed in FEV1/FVC ratio and the 6MWT after the intervention period.

Contrary to these results, Li et al. did not report significant changes in any pulmonary function tests of COVID-19 survivors but they reported a significant difference in the 6MWD test in the exercise group. Their intervention was a 6-week unsupervised home-based exercise program delivered via smartphone [33]. A possible explanation is that, in contrast to physical function, lung function was not sufficiently targeted by the exercises included in the unsupervised home-based exercise program. While all sessions of our tele rehabilitation program were supervised by a trainer. Our intervention included breathing control, with diaphragm recruitment and chest-abdomen coordination as well as core stability training. Diaphragm atrophy that occurs during mechanical ventilation affects clinical conditions. Targeting an inspiratory effort level similar to healthy subjects at rest may accelerate liberation from ventilation [34]. Dysfunctional breathing patterns can result in muscular imbalance, motor control alterations, and physiological adaptations that can alter movement [35]. Respiratory symptoms lead to sedentary or physical inactivity, and both respiratory symptoms and sedentary also increase several impairments, including muscle weakness, poor coordination, poor balance, loss of activity confidence, and risk of falls [36].

A weak diaphragm can lead to respiratory failure because it is the main muscle of respiration. The diaphragm has both postural and respiratory functions, and impairment in one function can adversely affect another [37]. Diaphragm contraction increases the vertical and transverse diameter of the chest cavity. This is done by pulling the central tendon down and raising the lower ribs, which leads to inspiratory airflow. In addition, the diaphragm helps stabilize the spine mechanically because it increases intra-abdominal pressure by cooperating with the abdominal muscles and the pelvic floor. Synergistic activation of the diaphragm and abdominal muscles increases intra-abdominal pressure constantly, while inspiration and expiration are controlled by the opposite action of the diaphragm and abdominal muscles [38].

Future research on the effectiveness of exercise programs on symptoms persisting in COVID-19 survivors after recovery from the acute phase is still required. It is suggested that respiratory and core stability tele-exercise be used to evaluate the effect of exercise rehabilitation on other long-lasting and persistent symptoms of COVID-19 survivors discharged from the hospital. This study is one of the few RCT studies in the physical rehabilitation of COVID-19 survivors. The main limitation of the present study was the separate training instructor for men and women due to cultural limitations. Another limitation of the present study was the lack of more groups to compare the effects of the two types of respiratory exercises and core stability training. Future research can focus on comparing the effectiveness of respiratory exercises and core stability training on pulmonary function and functional capacity of COVID-19 survivors.

5. Conclusion

The present study showed that selected respiratory and core stability exercises by the tele-exercise method can be helpful in the rehabilitation of pulmonary function and functional capacity of COVID-19 survivors.

Ethical Considerations

Compliance with ethical guidelines

All ethical principles were observed in this research. This study was registered in the Iranian registry of the clinical trial (Code: IRCT20211015052777N1). Also, ethical approval was received from the Qom University of Medical Sciences (IR.MUQ.REC.1400.136).

Funding

This study was extracted from the PhD. dissertation of Mohammad Mashhadi submitted to the Shahid Bahonar University of Kerman.

Authors' contributions

All authors equally contributed to the preparation of this article.

Conflict of interest

The authors declared no conflict of interests.

References

[1] Salamanna F, Veronesi F, Martini L, Landini MP, Fini M. Post-COVID-19 syndrome: The persistent symptoms at the post-viral stage of the disease. A Systematic Review of the Current Data. Frontiers in Medicine. 2021; 4(8):653516. [DOI:10.3389/fmed.2021.653516] [PMID] [PMCID]

[2] Crook H, Raza S, Nowell J, Young M, Edison P. Long COVID-mechanisms, risk factors, and management. British Medical Journal. 2021; 374:n1648. [DOI:10.1136/bmj.n1648] [PMID]

[3] Mashhadi M, Sahebozamani M, Daneshjoo A, Adeli S H, Venarji N. [Persistent symptoms in recovered patient from COVID-19 and the importance of post-acute rehabilitation: A systematic review (Persian)]. Qom University of Medical Sciences Journal. 2021; 15(10):660-73. [DOI:10.32598/qums.15.10.2346.1]

[4] Carfì A, Bernabei R, Landi F. Persistent symptoms in patients after acute COVID-19. Journal of the American Medical Association. 2020; 324(6):603-5. [DOI:10.1001/jama.2020.12603] [PMID] [PMCID]

[5] Xiaoneng Mo, Wenhua Jian, Zhuquan Su, Mu Chen, Hui Peng, Ping Peng, et al. Abnormal pulmonary function in COVID-19 patients at time of hospital discharg. European Respiratory Journal 2020; 55(6):2001217. [DOI:10.1183/13993003.01217-2020] [PMID] [PMCID]

[6] Bellan M, Soddu D, Balbo PE, Baricich A, Zeppegno P, Avanzi GC, et al. Respiratory and psychophysical sequelae among patients with COVID-19 four months after hospital discharge. JAMA Network Open. 2021. 4(1):e2036142. [DOI:10.1001/jamanetworkopen.2020.36142] [PMID] [PMCID]

[7] Piquet V, Luczak C, Seiler F, Monaury J, Martini A, Ward AB, et al. Do patients with COVID-19 benefit from rehabilitation? functional outcomes of the first 100 patients in a COVID-19 rehabilitation unit. Archives of Physical Medicine and Rehabilitation. 2021; 102(6):1067-74. [DOI:10.1016/j.apmr.2021.01.069] [PMID] [PMCID]

[8] Debeaumont D, Boujibar F, Ferrand DE, Artaud ME, Tamion F, Gravier FE, et al. Cardiopulmonary exercise testing to assess persistent symptoms at 6 months in people with COVID-19 who survived hospitalization: A pilot study. Physical Therapy. 2021; 101(6):pzab099. [DOI:10.1093/ptj/pzab099] [PMID] [PMCID]

[9] Sheehy LM. Considerations for postacute rehabilitation for survivors of COVID-19. Journal of Medical Internet Research. 2020; 6(2):e19462. [DOI:10.2196/19462] [PMID] [PMCID]

[10] Gloeckl R, Leitl D, Jarosch I, Schneeberger T, Nell C, Stenzel N, et al. Benefits of pulmonary rehabilitation in COVID-19: A prospective observational cohort study. European Respiratory Society Open Research 2021; 7(2):00108-2021. [DOI:10.1183/23120541.00108-2021] [PMID] [PMCID]

[11] Chen JM, Wang ZY, Chen YJ, Ni J. The application of eight-segment pulmonary rehabilitation exercise in people with coronavirus disease 2019. Frontiers in Physiology. 2020; 11:646. [DOI:10.3389/fphys.2020.00646] [PMID] [PMCID]

[12] Zhao HM, Xie YX, Wang C. Recommendations for respiratory rehabilitation in adults with coronavirus disease 2019. Chinese Medical Journal. 2020; 133(13):1595-1602. [DOI:10.1097/CM9.0000000000000848] [PMID] [PMCID]

[13] Puchner B, Sahanic S, Kirchmair R, Pizzini A, Sonnweber B, Wöll E, et al. Beneficial effects of multi-disciplinary rehabilitation in postacute COVID-19: An observational cohort study. European Journal of Physical and Rehabilitation Medicine. 2021; 57(2):189-98. [DOI:10.23736/S1973-9087.21.06549-7] [PMID]

[14] Iannaccone S, Castellazzi P, Tettamanti A, Houdayer E, Brugliera L, de Blasio F, et al. Role of rehabilitation department for adult individuals with COVID-19: The experience of the San Raffaele hospital of Milan. Archives of Physical Medicine and Rehabilitation. 2020; 101(9):1656-61. [DOI:10.1016/j.apmr.2020.05.015] [PMID] [PMCID]

[15] Salawu A, Green A, Crooks MG, Brixey N, et al. A proposal for multidisciplinary tele-rehabilitation in the assessment and rehabilitation of COVID-19 survivors. International Journal of Environmental Research and Public Health 2020; 17(13):4890. [DOI:10.3390/ijerph17134890] [PMID] [PMCID]

[16] Smith SR, Jenq G, Claflin T, Magnant C, et al. Proposed workflow for rehabilitation in a field hospital setting during the COVID-19 pandemic. Physical Medicine and Rehabilitation. 2020; 12(8):823-8. [DOI:10.1002/pmrj.12405] [PMID] [PMCID]

[17] Xu X, Shi YN, Wang RY, Liu T, Xu J, Mao W, et al. Home-based traditional Chinese medicine nursing interventions for discharged patients with COVID-19: A rapid review of Chinese guidelines. Integrative Medicine Research. 2020; 9(3):100479. [DOI:10.1016/j.imr.2020.100479] [PMID] [PMCID]

[18] Liu K, Zhang W, Yang Y, Zhang J, Li Y, Chen Y. Respiratory rehabilitation in elderly patients with COVID-19: A randomized controlled study. Complementary Therapies in Clinical Practice. 2020; 39:101166. [DOI:10.1016/j.ctcp.2020.101166] [PMID] [PMCID]

[19] Jeffrey MW. Core stability training. Journal of Strength and Conditioning Research. 2007; 21(3):979-85. [PMID]

[20] Shahrokhi H, Letafatkar A, Barati A, Daneshmandi H, Jamshidi A A. [The effect of core stability exercises on functional capacity and fatigue in patients with multiple sclerosis (Persian)]. Yafte. 2017; 19(1):63-76. [Link]

[21] Amaral D, Teixeira V, Heubel A, Linares S, Martinelli B, Henrique P, et al. Cardiovascular, respiratory and functional effects of tele-supervised home-based exercise training in individuals recovering from COVID-19 hospitalization: A randomized clinical trial. medRxiv. 2022; 1(24):22269745. [DOI:10.1101/2022.01.24.22269745]

[22] Akturk A, Kılıç G, Alğantekin Y. The effects of 6 weeks home rehabilitation program for non-ventilated COVID-19 patients after discharge: A case report. Journal of Surgery and Medicine. 2021; 5(5):563-5. [DOI:10.28982/josam.922882]

[23] Shirado K, Furuno Y, Kanamaru K, Kawabata N, Okuno S, Yamashita T. Effect of rehabilitation nutrition on a post-acute severe COVID-19 patient: A case report. Health Care. 2021; 9(8):1034. [DOI:10.3390/healthcare9081034] [PMID] [PMCID]

[24] Betschart M, Rezek S, Unger I, Beyer S, Gisi D, Shannon H, et al. Feasibility of an outpatient training program after COVID-19. International Journal of Environmental Research and Public Health. 2021; 18(8):3978. [DOI:10.3390/ijerph18083978] [PMID] [PMCID]

[25] Al Chikhanie Y, Veale D, Schoeffler M, Pépin JL, Verges S, Hérengt F. Effectiveness of pulmonary rehabilitation in COVID-19 respiratory failure patients post-ICU. Respiratory Physiology & Neurobiology. 2021; 287:103639. [DOI:10.1016/j.resp.2021.103639] [PMID] [PMCID]

[26] Curci C, Negrini F, Ferrillo M, Bergonzi R, Bonacci E, Camozzi DM, et al. Functional outcome after inpatient rehabilitation in postintensive care unit COVID-19 patients: Findings and clinical implications from a real-practice retrospective study. European Journal of Physical and Rehabilitation Medicine. 2021; 57(3):443-50. [DOI:10.23736/S1973-9087.20.06660-5] [PMID]

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

[28] Daynes E, Gerlis C, Chaplin E, Gardiner N, Singh SJ. Early experiences of rehabilitation for individuals post-covid to improve fatigue, breathlessness exercise capacity and cognition - A cohort study. Chronic Respiratory Diseases. 2021; 18:14799731211015691. [DOI:10.1177/14799731211015691] [PMID] [PMCID]

[29] Spielmanns M, Pekacka-Egli AM, Schoendorf S, Windisch W, Hermann M. Effects of a comprehensive pulmonary rehabilitation in severe post-COVID-19 patients. International Journal of Environmental Research and Public Health. 2021; 18(5):2695. [DOI:10.3390/ijerph18052695] [PMID] [PMCID]

[30] Imamura M, Mirisola AR, Ribeiro FQ, De Pretto LR, Alfieri FM, Delgado VR, et al. Rehabilitation of patients after COVID-19 recovery: An experience at the physical and rehabilitation medicine institute and lucy Montoro rehabilitation institute. Clinics. 2021; 76:e2804. [DOI:10.6061/clinics/2021/e2804] [PMID] [PMCID]

[31] Barmatz C, Barzel O, Reznik J. Case report: Hydrotherapy rehabilitation of a post-COVID-19 patient with muscle weakness. Journal of Aquatic Physical Therapy 2021; 29(1):29-34. [DOI:10.1097/PXT.0000000000000001]

[32] Ramalingam MB, Huang Y, Lim PAC. Rehabilitation of a post-intensive care unit patient after severe COVID-19 pneumonia. American Journal of Physical Medicine & Rehabilitation. 2020; 99(12):1092-5. [DOI:10.1097/PHM.0000000000001606] [PMID]

[33] Li J, Xia W, Zhan C, Liu S, Yin Z, Wang J, et al. A telerehabilitation programme in post-discharge COVID-19 patients (TERECO): A randomised controlled trial. Thorax. 2021; 26:thoraxjnl-2021-217382. [DOI:10.1136/thoraxjnl-2021-217382] [PMID] [PMCID]

[34] Goligher EC, Dres M, Fan E, Rubenfeld GD, Scales DC, Herridge MS, et al. Mechanical ventilation-induced diaphragm atrophy strongly impacts clinical outcomes. American Journal of Respiratory and Critical Care Medicine. 2018; 197(2):204-13. [DOI:10.1164/rccm.201703-0536OC] [PMID]

[35] Bradley H, Esformes J. Breathing pattern disorders and functional movement. International Journal of Sports Physical Therapy. 2014; 9(1):28-39. [PMID] [PMCID]

[36] Chuatrakoon B, Ngai SPC, Sungkarat S, Uthaikhup S. Balance impairment and effectiveness of exercise intervention in chronic obstructive pulmonary disease-a systematic review. Archives of Physical Medicine and Rehabilitation. 2020; 101(9):1590-602. [DOI:10.1016/j.apmr.2020.01.016] [PMID]

[37] Dubé BP, Dres M. Diaphragm dysfunction: Diagnostic approaches and management strategies. Journal of Clinical Medicine. 2016; 5(12):113. [DOI:10.3390/jcm5120113] [PMID] [PMCID]

[38] Hodges PW, Gandevia SC. Changes in intra-abdominal pressure during postural and respiratory activation of the human diaphragm. Journal of Applied Physiology. 2000; 89(3):967-76. [DOI:10.1152/jappl.2000.89.3.967] [PMID]