Published online 2023 May 15 **Original Article**

Home-based Pulmonary Rehabilitation in Patients with COVID-19: The Efficiency in Pulmonary Function

Fahime Hashemi[1*], Shayan Vafaei[2], Mehdi Sadeghi[3], Atena Samarehfekri[4], Mitra Samarehfekri[5], Hossein Mirzaei[6], Niloofar Rashidipour[7*] and Mozhgan Taebi[8]

[1] MSc of Nursing, Instructor, Department of Nursing, Nursing and Midwifery School, Islamic Azad University, Kerman Branch, Kerman, Iran
[2] PhD. student, Department of Anatomical Science, School of Medicine, Kerman University of Medical Sciences, Kerman, Iran
[3] PhD. of physiotherapy, Assistance Professor, Department of physiotherapy, Paramedicine School, Kerman University of medical science, Kerman, Iran
[4] MSc of Nursing, Instructor Department of Anesthesiology, Faculty of Allied Medical Sciences, Kerman University of medical science, Kerman, Iran
[5] Associate Professor of Pulmonary Diseases, Department of Internal Medicine, Kerman University of medical science, Kerman, Iran
[6] PhD. student in Epidemiology, HIV/STI surveillance research center, and WHO Collaborating Center for HIV Surveillance, Institute for Futures Studies in Health, Kerman University of Medical Sciences, Kerman, Iran
[7] MSc, Instructor, Department of Anesthesiology, Faculty of Allied Medical Sciences, Kerman University of medical science, Kerman, Iran
[8] PhD. of Nursing, Assistance Professor, Department of Anesthesiology, Faculty of Allied Medical Sciences, Kerman University of medical science, Kerman, Iran

*** *Corresponding author:*** Fahime Hashemi, Department of Nursing, Nursing and Midwifery School, Islamic Azad University, Kerman Branch, Kerman, Iran. Email: Fahimehashemi0@gmail.com
Niloofar Rashidipour, Department of Anesthesiology, Faculty of Allied Medical Sciences, Kerman University of medical science, Kerman, Iran. Email: niloofarrashidipour1993@gmail.com

Received 2022 January 04; **Revised** 2023 April 13; **Accepted** 2023 April 29.

Abstract

Background: Coronavirus disease (COVID-19) is a viral disease that mostly affects the respiratory system and leads to respiratory failure. Alongside, pulmonary rehabilitation is one of the most important components in the management of respiratory system diseases and can rehabilitate persons after lung-damaged disease.
Objectives: The present study aimed to determine the efficiency of Home-Based Pulmonary Rehabilitation in pulmonary function in patients with COVID-19
Methods: This simple randomized interventional study was conducted on 70 COVID-19 patients in Kerman, Iran. They were assigned to two equal groups of control and intervention. In the control group, patients received only routine post-discharge care, and in the intervention group, patients received home-based pulmonary rehabilitation procedures containing some movements to improve pulmonary function for four weeks after discharge.
Results: Forced expiratory volume in 1 second ($P<0.001$), vital capacity ($P<0.001$) and these two parameters ratio ($P<0.02$), peak expiratory flow ($P<0.001$), in four weeks after discharge from the hospital in the intervention group was significantly higher than in the control group. Moreover, 6-min walk distance ($P<0.001$) was significantly increased, and the severity of dyspnea ($P<0.001$) was significantly reduced in the intervention group. As well, the number of patients with severe dyspnea decreased significantly ($P<0.001$).
Conclusion: It seems that our home-based program can result in a marked improvement in vital capacity and other pulmonary function tests, as well as a reduction in dyspnea after discharge. In conclusion, this rehabilitation procedure is effective in pulmonary recovery in COVID-19 patients and can be used as a treatment procedure for recovery in these patients.

Keywords: COVID-19, Dyspnea, Rehabilitation, Respiratory function tests

1. Background

Coronavirus 2019 (COVID-19), caused by a novel coronavirus called severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), was first reported in December 2019 in China (1). This virus spread rapidly worldwide due to its very high infection rate and influenced almost all countries worldwide in less than four months (2, 3). The World Health Organization (WHO) declared it a pandemic on March 11, 2020 (4). COVID-19 disease, which is caused by an RNA virus, mostly affects the respiratory system of infected people (5). Symptoms of COVID-19 can vary from mild flu-like symptoms to respiratory failure, and approximately 80% of patients can come down with mild to moderate illness, 15% with severe illness, and 5% with a critical illness (6). SARS-CoV-2 enters lung cells via the angiotensin-converting enzyme-2 (ACE-2) receptor, resulting in inflammatory reactions and cellular infection (7-9). This disease affects the lungs, as mentioned above, leads to acute hypoxemic respiratory failure, and in most cases, requires mechanical ventilation (10). Pulmonary fibrosis is recognized as a potential consequence of lung damage among survivors, which is associated with a significant reduction in life quality (11). Functional impairment after COVID-19 can limit individuals' ability to perform daily activities, alter professional performance, and impede social interaction. On the other hand, infected people become less active, and their risk of comorbidities will be increased. Medical centers should adjust their strategies toward improving physical and functional recovery in survivors, as well as their social reintegration through pulmonary rehabilitation especially home-based programs called Home-Based Pulmonary Rehabilitation (HBPR), which can be carried out at

home by the patients themselves (12). Our home-based program, or HBPR in abbreviation, will be fully explained in the following.

Pulmonary Rehabilitation (PR) is one of the most important components in the management of lung diseases and can increase physical activity, reduce dyspnea, increase muscle strength, improve life quality, and increase self-efficacy (13). One of the important aims of rehabilitation is to help the patient to perform daily life activities so that the person can meet his/her daily needs and reach the maximum possible level of independence (14). The PR methods include respiratory maneuvers, such as bud lip breathing and diaphragmatic breathing, which can improve respiratory muscle strength and function, increases the oxygen blood level, creates an effective respiratory pattern, and finally improves pulmonary function (15).

Considering that health policies put an emphasis on accelerating the patient's discharge from the hospital and reducing the patient's residence in health institutions and more community involvement in treatment protocols, home-based health services are more considered a care solution with features of ease of access, low cost, better patient acceptance, and more family participation (16). Previous studies demonstrated that HBPR programs have positive effects on patients with chronic obstructive pulmonary disease (COPD) and can improve their symptoms, function, and pulmonary situation (16, 17). As well our previous study illustrated that HBPR could reduce anxiety and depression in COVID-19 survivors (18). Alongside this, the COVID-19 pandemic has led to travel restrictions in PR centers.

2. Objectives

Moreover, to the best of our knowledge, no study has been conducted on the effect of the HBPR program on pulmonary status in COVID-19 patients. In light of the aforementioned issues, the present study aimed to determine the effect of the HBPR training program on pulmonary status in COVID-19 patients after hospital discharge.

3. Methods

3.1. Study design and participants

The present study was a parallel interventional study based on a simple randomization method. The study population included patients with COVID-19 admitted to Afzalipour Hospital in Kerman, Iran, from August 14 to September 23, 2021. Afzalipour Hospital was one of the referral hospitals for COVID-19 patients in Kerman. The clinical trial registration code is IRCT20190702044074N1, which is registered in the Iranian Registry of Clinical Trials.

Based on a previous study, the mean scores of VC (L) after PR in the intervention and control group were 2.36± 0.49 and 2.08±0.37, respectively (19). According to α=0.05 and power=0.80, we estimated that 35 participants were required for each group. A total of 76 patients were assessed for eligibility, and all of them were eligible for inclusion. A total of 76 patients were randomly assigned to the intervention group (n=38) and control group (n=38). At the commencement of the study, all patients in the intervention and control groups received the allocated intervention. Nonetheless, during the study period, three patients in the intervention group were excluded due to failure to comply with more than 50% of the training program at home. As well, three patients in the intervention group were excluded from the study due to losses to follow-up. Finally, 35 patients in each group completed the study and were included in the statistical analysis. (Figure 1).

The inclusion criteria were the age range of 30-65 years old, absence of motor or orthopedic disease, no drug or smoking addiction, no chronic illness (including chronic respiratory disease, kidney, thyroid, and cancer), no history of severe physical illness (such as a pacemaker, right and left heart failure, uncontrolled hypertension, and patients with Deep Venous Thrombosis and Pneumo Thrombo Embolism), no history of heart or chest surgery, minimum literacy, and having a caregiver at home. On the other hand, the exclusion criteria were as the following. If the patient was a professional athlete, he (she) and his (her) family members were a part of the treatment team, had SPO2 less than 90% at the time of discharge, hypoxia with little activity, heart rate of more than 120, or non-compliance with more than 50% of the home training program, he/she was excluded from the study. Moreover, if making telephone calls after discharge was impossible or patients had a history of non-invasive mechanical ventilation, they were ruled out.

3.2. Data collection

For data collection, a demographic information form, including five questions related to patients' characteristics, a modified Medical Research Council Dyspnea Scale (mMRC) (20-22), including six items, and pulmonary function tests (PFTs), including four items, and six-minute walk test (6-MWT) were used (23).

It must be pointed out that dyspnea is a complex subjective sensation that is difficult to assess in clinical practice. The mMRC scale is the most commonly used validated scale to assess dyspnea in daily living in respiratory diseases (20-22). In applying this scale, the patient was asked to express the severity of dyspnea in the range of 0 to 5, once during discharge from the hospital and once after four weeks after discharge from the hospital. On this scale, 0 indicates no dyspnea and 5 is in the range of dyspnea when leaving home or changing clothes.

The 6-MWT was performed using the

methodology specified by the American Thoracic Society (ATS-2002) (23). The patients were instructed that the objective was to walk as far as possible in a flat corridor for 6 minutes on the first day of discharge, as well as two and four weeks after discharge. Heart rate, oxygen saturation, blood pressure, and respiration rate were collected at the beginning and end of MWT6. It was explained to the patient that if dyspnea or fatigue is excessive, stop the test. At the end of the experiment, the distance traveled was calculated by a smartwatch. PFTs included forced expiratory volume in 1 second (FEV1), vital capacity (VC), peak expiratory flow (PEF), and FEV1/VC (24). The test was completed four weeks after the patients were discharged from the hospital by a pulmonologist visiting.

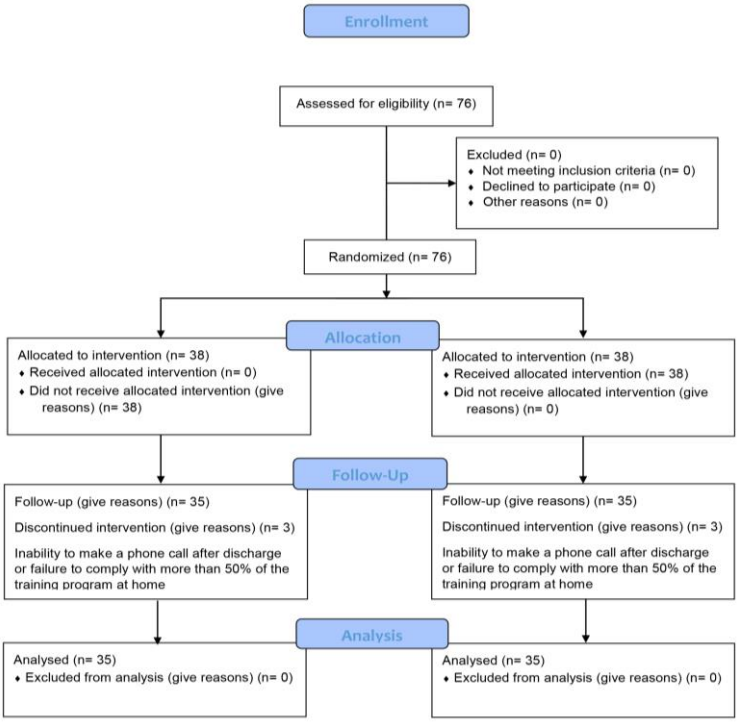

Figure 1. CONSORT flow diagram: recruitment and allocation to study groups

3.3. Intervention

After selecting the eligible patient and determining the patient group by simple randomization method, the research questionnaires were provided to the patients. They were asked to complete the mMRC scale once on the first day of discharge and then four weeks after discharge and 6-MWT on the first day of discharge, as well as two and four weeks after discharge. Thereafter, the patients were referred to the physician's office for PFTs four weeks after discharge, and the results were collected by the researcher. It is noteworthy that the patients included in the study were discharged from COVID-19-specific wards, and the pamphlets and education were given to them immediately after discharge and just before leaving the hospital by the research team.

In the control group, patients received only routine post-discharge care, and in the intervention group, patients received PR after discharge. In the intervention group, the HBPR program, which was collected as an educational pamphlet, was given to the patients; moreover, the rehabilitation program was fully explained to the patients by the researcher after discharge from the hospital. Note that The HBPR program is designed based on the guidelines by Johns Hopkins University, USA, which includes five human movement groups that lead to deep breathing, turning on the vestibular system, passing through the body, increasing strength, and increasing endurance/ (25). Total HBPR program lasted four weeks, which included the first two weeks (one day in between; one week on even days, one week on odd days, two sessions every day, and each session for 10 minutes), the second two weeks (one day in between; one week on even days one week on odd days, two sessions every day, and each session for 15 minutes), while patients in the control group received routine care.

3.4. Measured outcomes

The outcomes of this study were divided into primary and secondary outcomes contractually. The primary outcome in this clinical trial was respiratory functions that were measured through spirometry. The main parameters of respiratory function were FEV1, VC, PEF, and FEV1/VC in four weeks after discharge from the hospital. Moreover, the secondary outcomes in this clinical trial were 6-MWT and severity of dyspnea two and four weeks after discharge from the hospital.

3.5. Ethical considerations

All of the ethical protocols in medical sciences studies throughout the study were considered, and the ethics code of IR.KMU.REC.1400.151 was given to the study by the Ethics Committee of Kerman University of Medical Sciences, Kerman, Iran. All participants gave full consent to participate in the study, and written informed consent was taken individually from all subjects.

3.6. Statistical analysis

Data analysis was performed in STATA software (version 17.0). For continuous data (age, duration of hospitalization, and 6-min walk distance), median and interquartile range (IQR) were used, while for nominal and categorical data (Gender, Marital Status, level of education, and severity of dyspnea), numbers and percentages were reported. Chi-square and Fisher's exact tests were used to compare gender, marital status, level of education, and severity of dyspnea between the intervention and control groups. Mann Whitney U test was used to compare age, duration of hospitalization, 6-MWT, FEV1, VC, PEF, and FEV1/V between the two groups. Wilcoxon rank-sum test was used to compare 6-MWT in baseline, as well as after two and four weeks. At the end of the study, P<0.05 was considered significant.

4. Results

There was no statistically significant difference between the intervention and control groups regarding gender, age, marital status, educational status, time of hospitalization, the severity of dyspnea on the first day of discharge, and 6-MWT distance on the first day of discharge (Table 1). The main parameters of respiratory function as primary outcomes were; FEV1, VC, PEF, and FEV1/VC four weeks after discharge from the hospital, which was significantly improved. The median (IQR) of FEV1, VC, PEF, and FEV1/VC in four weeks after discharge in the intervention group was significantly higher than in the control group (P<0.001) (Table 2).

Table 1. Baseline demographic and clinical characteristics by the group at the time of discharge

	Intervention (N=35) n (%)	Control (N = 35) n (%)	P-Value
Gender n (%)			
Male	19 (45.3)	19 (45.3)	1.000
Female	16 (45.7)	16 (45.7)	
Marital Status			
Single	6 (17.1)	4 (11.4)	0.460
Married	28 (80.0)	31 (88.6)	
Divorced	1 (2.9)	0	
Age Median (IQR)	44 (39-51)	43 (39 -53)	0.980
Education			
Primary school or lower	3 (8.6)	4 (11.4)	0.920
Middle school	3 (8.6)	3 (8.6)	
High school and above	29 (82.8)	28 (80.0)	
Time of hospitalization Median (IQR)	10 (8-10)	10 (8-12)	0.300
dyspnea on the first day of discharge			
No Dyspnea	0	0	0.300
Moderate	7 (20.0)	3 (8.6)	
Sever	28 (80.0)	32 (91.4)	
6-MWT distance on the first day of discharge Median (IQR)	150 (130-180)	150 (130-180)	1.000

Chi-square and Fisher exact tests were used to compare gender, marital status, level of education, and severity of dyspnea between intervention and control group. Mann Whitney U test was used to compare age, duration of hospitalization, 6-MWT, FEV1, VC, PEF, and FEV1/V between two groups

Table 2. Comparison of primary and secondary outcomes between intervention and control group after four weeks of PR

	Intervention (35)	Control (35)	P- value
FEV1 (Liter) Median (IQR)	4.25 (4 – 4.6)	3 (2.8 – 3.8)	<0.0001
VC (Liter) Median (IQR)	5 (4.8 – 5.3)	4 (3.2 – 4.8)	<0.0001
PEF (Liter per Second) Median (IQR)	9 (9 -10)	7 (6 – 8)	<0.0001
FEV1/VC Median (IQR)	0.83 (0.8 – 0.87)	0.76 (0.71 – 0.85)	0.02
6-MWT Median (IQR)- After two weeks	230 (200 -160)	180 (150 – 200)	<0.001
6-MWT distance after four weeks Median (IQR)	320 (280 – 350)	200 (165 – 230)	<0.001
Dyspnea after four weeks			
No Dyspnea	32 (91.4)	3 (8.6)	<0.001
Moderate	3 (8.6)	24 (68.6)	
Sever	0	8 (22.8)	

Chi-square and Fisher exact tests were used to compare gender, marital status, level of education, and severity of dyspnea between intervention and control group. Mann Whitney U test was used to compare age, duration of hospitalization, 6-MWT, FEV1, VC, PEF, and FEV1/V between two groups

The secondary outcomes in this clinical trial were 6-MWT and severity of dyspnea two and four weeks after discharge from the hospital. The median of 6-MWT after two weeks of PR in the intervention group was significantly higher than in the control group (P<0.001). The median (IQR) of 6-MWT after four weeks of HPBR in the intervention group was significantly higher than in the control group (Table 2) (P<0.001). Median (IQR) of 6-MWT significantly increased from 150 (130-180) in discharge time to 320 (280-350) after four weeks of HPBR in the intervention group and from 150 (130-180) to 200 (165-230) in the control group (P<0.001) (Figure 2). The proportion of patients with severe dyspnea after four weeks of PR in the intervention group was significantly lower than in the control group (P<0.001) (Table 2). Furthermore, the proportion of patients with severe dyspnea decreased from 80% to 0 in the intervention group and from 91.4% to 22.8% in the control group, and these changes were also significant (P<0.001) (Figure 3).

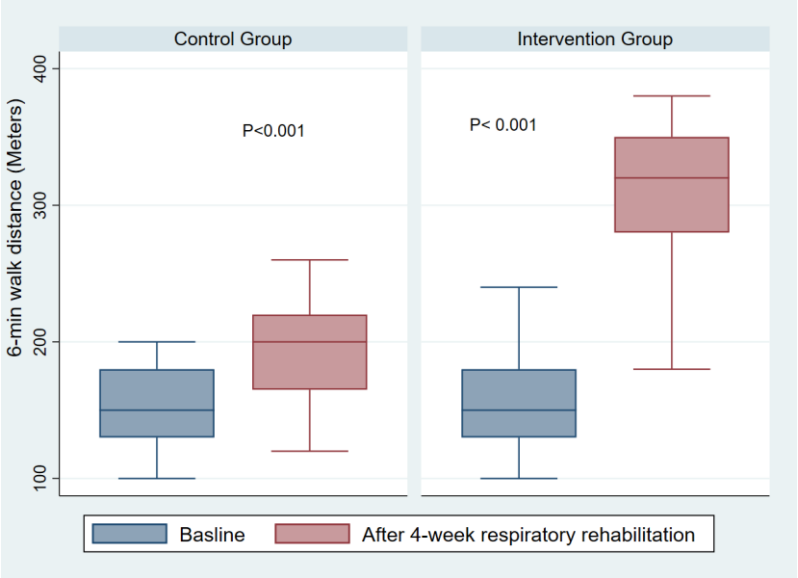

Figure 2. Median (IQR) of 6-MWT in baseline and after four weeks of PR in the intervention group

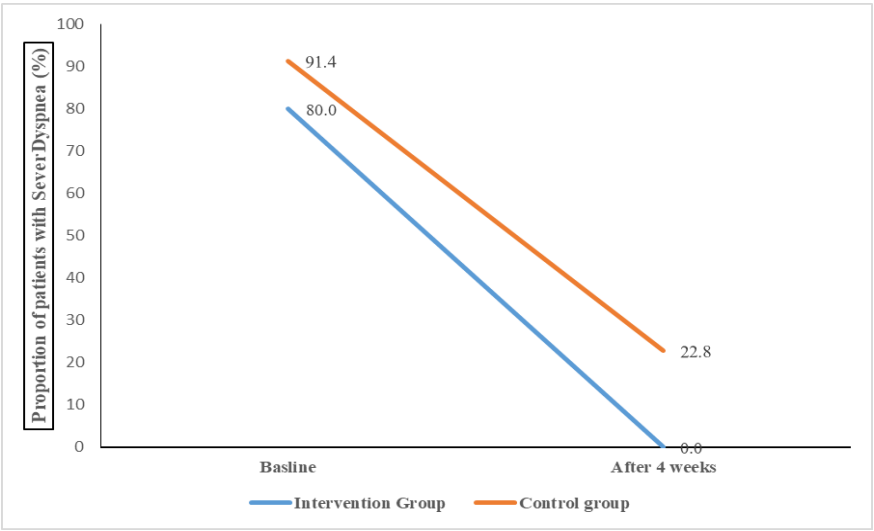

Figure 3. Proportion of patients with severe dyspnea in baseline and after four weeks of PR in the intervention group (P<0.001)

5. Discussion

The present study aimed to determine the effect of an HBPR program on pulmonary status in patients with COVID-19. The median (IQR) of the main parameters of respiratory function of FEV1, VC, PEF, and FEV1/VC in four weeks after discharge in the intervention group was significantly higher than that in the control group. As the secondary outcomes, the Median of 6-MWT after two and four weeks PR in the intervention group was significantly higher than in the control group. The proportion of patients with

severe dyspnea after four weeks of PR in the intervention group was significantly lower than in the control group.

As mentioned above, PFTs and 6-MWT after discharge in the intervention group were significantly higher than in the control group. Moreover, the severity of dyspnea after four weeks of respiratory rehabilitation in the intervention group was significantly lower than that in the control group. Gloeckl et al., in a prospective observational cohort study entitled "Benefits of pulmonary rehabilitation in COVID-19 in 2021", administrated a comprehensive 3-week inpatient pulmonary rehabilitation program for COVID-19 patients. They demonstrated that 6-MWT, impaired FVC, and low 36-question short-form health survey SF-36 mental health scores were improved after this program in COVID-19 patients. Altogether, these results demonstrate that PR is beneficial in COVID-19 patients' recovery and can be used safely (26). The results of our study also illustrated that an HBPR program after patient discharge from the hospital also improves respiratory status, including 6-MWT and FVC. Liu et al. pointed out that after six weeks of pulmonary rehabilitation, there were significant differences in PFTs, 6-MWT, and SF-36. Therefore, the results of the stated study demonstrated that PR improves COVID-19 pulmonary side effects (measured by PFTs, 6-MWT, and SF-36) in elderly patients (21). In line with the results of the referred study, the findings of the current research indicated that PFTs and 6-MWT improved after four weeks of rehabilitation. In the study by Hermann et al. (2020), 28 patients with severe COVID-19 received cardiopulmonary rehabilitation. In conclusion, the safety and effectiveness of this method are shown in agreement with previous studies (27). The mentioned study was also in accordance with the results of our study. To the best of our knowledge, the current study is the first research that used an HBPR program after the discharge of COVID-19 patients from the hospital.

Previous studies pointed out that the outcomes and advantages of HBPR are effective in patients' recovery (28-30). Regarding the COVID-19 pandemic, these out-of-hospital programs seem helpful and are advised (28). The benefits of home-based studies have been proven previously in patients with chronic obstructive pulmonary disease (COPD) (16, 31-33). For example, in a study by Vilarinho et al. in 2021, the 1-min sit-to-stand test (to assess functional capacity), COPD Assessment Test (to determine the impact of COPD on a person's life), London Chest Activity of Daily Living (to evaluate the limitations of daily activities by dyspnea), and mMRC (a Dyspnea Scale) were improved after HBPR in 30 patients with severe COPD. In conclusion, the stated study suggested that HBPR is safe and feasible in COPD patients (34). Consistent with the results of the present study, Jose et al. (2017) studied HBPR in 48 patients with bronchiectasis and reported that this program improved functional capacity, peripheral muscle strength, and quality of life (35).

The strength of this study is the applicability of HBPR at home and by the whole community. It can be stated that the use of this strategic method is effective in developing the principle of justice-oriented to provide health services to all individuals. Furthermore, the presence of people in public is reduced and can help reduce disease transmission during the pandemic.

5.1. Study Limitations

One of the limitations of this study was the impossibility of performing a spirometry test immediately after the patient's discharge, which was not possible for us due to respiratory problems and the possibility of virus transmission through the test. Moreover, due to the possibility of errors in the implementation of the HBPR protocol by the patients, after teaching the patient, an educational pamphlet was prepared and given to the patients. Furthermore, the researcher's mobile number was provided to the patients to solve possible problems.

6. Conclusion

As evidenced by the results of this study, home-based pulmonary rehabilitation is effective in forced expiratory volume in 1 second, vital capacity, and these two parameters ratio, peak expiratory flow, 6-min walks distance, and the severity of dyspnea in four weeks after discharge from the hospital. Altogether, these results demonstrate that a home-based pulmonary rehabilitation program can be used as a safe and efficient recovery plan for patients with COVID-19 at home, reducing patients' referrals to health centers.

Acknowledgments

The research team is grateful to the volunteers who participated in this study. The present study was financially supported by the Research Vice-Chancellor of Kerman University of Medical Sciences with approval code IR.KMU.REC.1400.151.

Footnotes

Conflicts of Interest:

The authors declared no conflict of interest.

References

1. Song F, Shi N, Shan F, Zhang Z, Shen J, Lu H, et al. Emerging 2019 novel coronavirus (2019-nCoV) pneumonia. *Radiology*. 2020;**295**(1):210-7. doi: 10.1148/radiol.2020200274. [PubMed: 32027573].
2. Remuzzi A, Remuzzi G. COVID-19 and Italy: what next?. *Lancet*.

2020;**395**(10231):1225-8. doi: 10.1016/S0140-6736(20)30627-9. [PubMed: 32178769].
3. Zangrillo A, Beretta L, Silvani P, Colombo S, Scandroglio AM, Dell'Acqua A, et al. Fast reshaping of intensive care unit facilities in a large metropolitan hospital in Milan, Italy: facing the COVID-19 pandemic emergency. *Crit Care Resusc*. 2020;**22**(2):91-4. [PubMed: 32227819].
4. Edis EÇ. Chronic pulmonary diseases and COVID-19. *Turk Thorac J*. 2020;**21**(5):345-9. [PubMed: 33031727].
5. Lai CC, Shih TP, Ko WC, Tang HJ, Hsueh PR. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and coronavirus disease-2019 (COVID-19): The epidemic and the challenges. *Int J Antimicrob Agents*. 2020;**55**(3):105924. doi: 10.1016/j.ijantimicag.2020.105924. [PubMed: 32081636].
6. Wu Z, McGoogan JM. Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: summary of a report of 72 314 cases from the Chinese Center for Disease Control and Prevention. *JAMA*. 2020;**323**(13):1239-42. doi: 10.1001/jama.2020.2648. [PubMed: 32091533].
7. Ni W, Yang X, Yang D, Bao J, Li R, Xiao Y, et al. Role of angiotensin-converting enzyme 2 (ACE2) in COVID-19. *Crit Care*. 2020;**24**(1):422. doi: 10.1186/s13054-020-03120-0. [PubMed: 32660650].
8. Shang J, Ye G, Shi K, Wan Y, Luo C, Aihara H, et al. Structural basis of receptor recognition by SARS-CoV-2. *Nature*. 2020;**581**(7807):221-4. doi: 10.1038/s41586-020-2179-y. [PubMed: 32225175].
9. Bahadori M, Dabiri S, Javadi A, Meymandi SS, Movahedinia S, Meymandi MS, et al. Pathogenesis of COVID-19; Acute Auto-inflammatory Disease (Endotheliopathica & Leukocytoclastica COVIDicus). *Arch Iran Med*. 2021;**24**(5):419-26. doi: 10.34172/aim.2021.60. [PubMed: 34196208].
10. Huang C, Wang Y, Li X, Ren L, Zhao J, Hu Y, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet*. 2020;**395**(10223):497-506. doi:
11. Ojo AS, Balogun SA, Williams OT, Ojo OS. Pulmonary fibrosis in COVID-19 survivors: predictive factors and risk reduction strategies. *Pulm Med*. 2020;**2020**:1-10. doi: 10.1155/2020/6175964. [PubMed: 32850151].
12. Santana AV, Fontana AD, Pitta F. Pulmonary rehabilitation after COVID-19. *J Bras Pneumol*. 2021;**47**(1):e20210034. doi: 10.36416/1806-3756/e20210034. [PubMed: 33656096].
13. Vestbo J, Hurd SS, Agustí AG, Jones PW, Vogelmeier C, Anzueto A, et al. Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease: GOLD executive summary. *Am J Respir Crit Care Med.* 2013;**187**(4):347-65. doi: 10.1164/rccm.201204-0596PP. [PubMed: 22878278].
14. Azevedo JA, Barbosa FD, Seixas VM, Scipioni KR, Sampaio PY, Cruz DM, et al. Effects of constraint-induced movement therapy on activity and participation after a stroke: Systematic review and meta-analysis. *Front Hum Neurosci*. 2022;**774**:3-11. doi: 10.3389/fnhum.2022.987061.
15. Román M, Larraz C, Gómez A, Ripoll J, Mir I, Miranda EZ, et al. Efficacy of pulmonary rehabilitation in patients with moderate chronic obstructive pulmonary disease: a randomized controlled trial. *BMC Fam Pract.* 2013;**14**(1):1-9. doi: 10.1186/1471-2296-14-21. [PubMed: 23399113].
16. Jokar Z, Mohammadi F, Khankeh HR, Tafti SF. Effect of home-based pulmonary rehabilitation on fatigue in patients with COPD. *Hayat.* 2012;**18**(5).
17. Holland AE, Malaguti C, Hoffman M, Lahham A, Burge AT, Dowman L, et al. Home-based or remote exercise testing in chronic respiratory disease, during the COVID-19 pandemic and beyond: a rapid review. *Chron Respir Dis.* 2020;**17**:1-18. doi: 10.1177/1479973120952418. [PubMed: 32840385].
18. Hashemi F, Sadeghi M, Vafaei S, Mirzaei H, Samarehfekri A, Rashidipour N, et al. Effect of home-based pulmonary rehabilitation program on anxiety and depression in COVID-19 Patients. *Medsurg Nurs.* 2022;**11**(2):e129612. doi: 10.5812/msnj-129612.
19. Liu K, Zhang W, Yang Y, Zhang J, Li Y, Chen Y. Respiratory rehabilitation in elderly patients with COVID-19: A randomized controlled study. *Complement Ther Clin Pract*. 2020;**39**:101166. doi: 10.1016/j.ctcp.2020.101166. [PubMed: 32379637].
20. Sunjaya AP, Homaira N, Corcoran K, Martin A, Berend N, Jenkins C. Assessment and diagnosis of chronic dyspnoea: a literature review. *NPJ Prim Care Respir Med.* 2022;**32**(1):10. doi: 10.1038/s41533-022-00271-1. [PubMed: 35260575].
21. Stevens JP, Baker K, Howell MD, Banzett RB. Prevalence and predictive value of dyspnea ratings in hospitalized patients: pilot studies. *PLoS One*. 2016;**11**(4):e0152601. doi: 10.1371/journal.pone.0152601. [PubMed: 27070144].
22. Nishiyama O, Taniguchi H, Kondoh Y, Kimura T, Kato K, Kataoka K, et al. A simple assessment of dyspnoea as a prognostic indicator in idiopathic pulmonary fibrosis. *Eur Respir J.* 2010;**36**(5):1067-72. doi: 10.1183/09031936.00152609. [PubMed: 20413545].
23. Fell BL, Hanekom S, Heine M. Six-minute walk test protocol variations in low-resource settings–A scoping review. *S Afr J Physiother*. 2021;**77**(1):1549. doi: 10.4102/sajp.v77i1.1549. [PubMed: 34230901].
24. Ponce MC, Sankari A, Sharma S. Pulmonary Function Tests. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2023.
25. Zanni J, Lien P, Johnson K, Pandey R, Anderson T, Almeyda D. Bouncing Back From COVID-19 your guide to restoring movement. Baltimore, USA: John Hopkins Medicine; 2022.
26. 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. *ERJ Open Res*. 2021;**7**(2):00108-2021. doi: 10.1183/23120541.00108-2021. [PubMed: 34095290].
27. Hermann M, Pekacka-Egli AM, Witassek F, Baumgaertner R, Schoendorf S, Spielmanns M. Feasibility and efficacy of cardiopulmonary rehabilitation following COVID-19. *Am J Phys Med Rehabil*. 2020;**99**(10):865-9. doi: 10.1097/PHM.0000000000001549. [PubMed: 32732746].
28. Neves LF, Reis MH, Gonçalves TR. Home or community-based pulmonary rehabilitation for individuals with chronic obstructive pulmonary disease: a systematic review and meta-analysis. *Cad Saude Publica*. 2016;**32**(6):S0102. doi: 10.1590/0102-311X00085915. [PubMed: 27333130].
29. Rochester CL, Vogiatzis I, Holland AE, Lareau SC, Marciniuk DD, Puhan MA, et al. An official American Thoracic Society/European Respiratory Society policy statement: enhancing implementation, use, and delivery of pulmonary rehabilitation. *Am J Respir Crit Care Med.* 2015;**192**(11):1373-86. doi: 10.1164/rccm.201510-1966ST. [PubMed: 26623686].
30. Wuytack F, Devane D, Stovold E, McDonnell M, Casey M, McDonnell TJ, et al. Comparison of outpatient and home-based exercise training programmes for COPD: a systematic review and meta-analysis. *Respirology*. 2018;**23**(3):272-83. doi: 10.1111/resp.13224. [PubMed: 29194864].
31. Uzzaman MN, Agarwal D, Chan SC, Engkasan JP, Habib GM, Hanafi NS, et al. Effectiveness of home-based pulmonary rehabilitation: systematic review and meta-analysis. *Eur Respir Rev.* 2022;**31**(165):220076. doi: 10.1183/16000617.0076-2022. [PubMed: 36130789].
32. Nolan CM, Kaliaraju D, Jones SE, Patel S, Barker R, Walsh JA, et al. Home versus outpatient pulmonary rehabilitation in COPD: a propensity-matched cohort study. *Thorax*. 2019;**74**(10):996-8. doi: 10.1136/thoraxjnl-2018-212765. [PubMed: 31278173].
33. Mendes de Oliveira JC, Leitão Filho S, Fernando S, Malosa Sampaio LM, Negrinho de Oliveira AC, Hirata RP, et al. Outpatient vs. home-based pulmonary rehabilitation in COPD: a randomized controlled trial. *Multidiscip Respir Med*. 2010;**5**(6):1-8. doi: 10.1186/2049-6958-5-6-401. [PubMed: 22958267].
34. Vilarinho R, Serra L, Coxo R, Carvalho J, Esteves C, Montes AM, et al. Effects of a home-based pulmonary rehabilitation program in patients with chronic obstructive pulmonary disease in GOLD B Group: A Pilot Study. *Healthcare (Basel).* 2021;**9**(5):538. doi: 10.3390/healthcare9050538. [PubMed: 34064453]
35. José A, Holland AE, de Oliveira CS, Selman JP, de Castro RA, Athanazio RA, et al. Does home-based pulmonary rehabilitation

improve functional capacity, peripheral muscle strength and quality of life in patients with bronchiectasis compared to standard care?. *Braz J Phys Ther.* 2017;**21**(6):473-80. doi: 10.1016/j.bjpt.2017.06.021. [PubMed: 28869119].