FİZİKSEL TIP VE REHABİLİTASYON BİLİMLERİ DERGİSİ
Journal of Physical Medicine and Rehabilitation Sciences

ORIGINAL RESEARCH ORİJİNAL ARAŞTIRMA

DOI: 10.31609/jpmrs.2023-99394

Cardiopulmonary Rehabilitation Versus Home-Based Exercise Program for Post-Acute COVID-19 Symptoms

Postakut COVID-19 Semptomlarında Kardiyopulmoner Rehabilitasyon ve Ev Temelli Egzersiz Programının Karşılaştırılması

Fulya BAKILAN[a], İsmail Güneş GÖKMEN[b], Burcu ORTANCA[a], Anıl UÇAN[c], Emine EYİGÜN[d], Fezan MUTLU[e], Hatice Merve GÖKMEN[b], Ayşe EKİM[b]

[a]Eskişehir Osmangazi University Faculty of Medicine, Department of Physical Medicine and Rehabilitation, Eskişehir, Türkiye
[b]Eskişehir City Hospital, Clinic of Physical Medicine and Rehabilitation, Eskişehir, Türkiye
[c]Eskişehir City Hospital, Clinic of Internal Medicine, Eskişehir, Türkiye
[d]Eskişehir City Hospital, Unit of Nursing, Eskişehir, Türkiye
[e]Eskişehir Osmangazi University Faculty of Medicine, Department of Biostatistics, Eskişehir, Türkiye

ABSTRACT Objective: The need for cardiopulmonary rehabilitation (CPR) for post-acute coronavirus disease-2019 (COVID-19) symptoms such as dyspnea and fatigue is known. However, rehabilitation units cannot handle all post-acute COVID-19 patients also this would be a huge economic burden. This study aimed to compare the effect of CPR and home-based exercise programs on exercise endurance and quality of life in post-acute COVID-19 patients. **Material and Methods:** This retrospective study was conducted with the records of 88 post-acute COVID-19 patients who received CPR (n=45) or home exercise programs (n=43). Both programs included aerobic, breathing, and flexibility exercises (CPR: three or four days per week for a total of 20 sessions, home exercise program: three or four days per week over a period of six weeks). The results of the six-minute walk test (6MWT) were used for exercise endurance as a primary outcome measure. Borg-dyspnea/fatigue, the visual analog scale (VAS) for pain, and the Short Form-36 (SF-36) were used as secondary outcome measures. All before and after primary and secondary outcome measurements were recorded. **Results:** Borg-dyspnea (p=0.004), fatigue (p=0.001), VAS-pain (p=0.034), SF-36: physical function (p=0.023), physical role (p=0.049), emotional role (p=0.038), bodily pain (p=0.021) energy (p=0.001) showed more improvement in CPR group than home exercise program group. However, improvements in the 6MWT were similar in both groups(p=0.266). **Conclusion:** Considering that both CPR and home-based exercise programs showed similar effects on exercise endurance, we believe home exercise programs which are also safe and cost-effective could be an alternative to CPR programs.

Keywords: COVID-19; dyspnea; rehabilitation; quality of life

ÖZET Amaç: Dispne ve nefes darlığı gibi post-akut koronavirüs hastalığı-2019 [coronavirus disease-2019 (COVID-19)] semptomlarında, kardiyopulmoner rehabilitasyon (KPR) ihtiyacı bilinmektedir. Ancak rehabilitasyon ünitelerinin kapasiteleri tüm post-akut COVID-19 hastalarını üstlenmeye yetmemektedir ayrıca bu da ekonomi üzerinde büyük bir yüktür. Bu çalışmanın amacı, KPR ve ev egzersiz programının, post-akut COVID-19 hastalarında egzersiz dayanıklılığı ve yaşam kalitesi üzerine etkileri kıyaslamaktır. **Gereç ve Yöntemler:** Bu retrospektif çalışma, hastanede (n=45) KPR uygulanan ve ev egzersiz programı verilen (n=43) toplam 88 post-akut COVID-19 hastanın dosya kayıtları ile yürütülmüştür. Her iki program da aerobik, solunum ve fleksibilite egzersizlerini içeriyordu (KPR: haftada 3 veya 4 gün, toplam 20 seans, ev egzersiz programı: haftada 3 veya 4 gün, 6 hafta boyunca). Egzersiz dayanıklılığı ölçümü için primer veri olarak 6 dakika yürüme testi (6DYT) kullanıldı. Sekonder veri olarak Borg-dispne/yorgunluk, ağrı için görsel analog skala [visual analogue scale (VAS)] ve Kısa Form-36 (KF-36) kullanıldı. Tüm tedavi öncesi ve sonrası primer ve sekonder veriler kayıt altına alındı. **Bulgular:** KPR grubunda, ev egzersiz programı grubuna göre Borg-dispne (p=0,004), yorgunluk (p=0,001), VAS-ağrı (p=0,034), KF-36: fiziksel fonksiyon (p=0,023), fiziksel rol (p=0,049), emosyonel rol (p=0,038), beden ağrısı (p=0,021), enerji (p=0,001) değerlerindeki gelişmeler daha fazla idi. Ancak 6DYT değerindeki gelişmeler her iki grupta benzerdi (p=0,266). **Sonuç:** KPR ve ev egzersiz programlarının egzersiz enduransı üzerine benzer etkileri göz önüne alındığında, hem güvenli hem de uygun maliyetli olan ev egzersiz programlarının, hastane temelli KPR programlarına alternatif olabileceği kanısındayız.

Anahtar Kelimeler: COVID-19; dispne; rehabilitasyon; yaşam kalitesi

TO CITE THIS ARTICLE:
Bakılan F, Gökmen İG, Ortanva B, Uçan A, Eyigün E, Mutlu F, Gökmen HM, Ekim A. Cardiopulmonary Rehabilitation Versus Home-Based Exercise Program for Post-Acute COVID-19 Symptoms. Turkiye Klinikleri Journal of Physical Medicine and Rehabilitation Sciences. 2024;27(2):105-13.

Correspondence: Fulya BAKILAN
Eskişehir Osmangazi University Faculty of Medicine, Department of Physical Medicine and Rehabilitation, Eskişehir, Türkiye
E-mail: fulyabakilan@gmail.com

Peer review under responsibility of Journal of Physical Medicine and Rehabilitation Science.

Received: 01 Sep 2023 ***Received in revised form:*** 18 Mar 2024 ***Accepted:*** 18 Mar 2024 ***Available online:*** 21 Mar 2024

Many individuals recovering from coronavirus disease-2019 (COVID-19) experience fatigue, dyspnea, muscle weakness, exercise intolerance, and decreased quality of life.[1] Rehabilitation programs, including pulmonary rehabilitation and physical therapy, are often recommended to help individuals regain their strength and cardiopulmonary capacity.[2-8]

In previous studies, cardiopulmonary rehabilitation (CPR) programs were found effective in improving exercise capacity in the post-acute COVID-19 period. In a recent study, Szarvas et al. reported that a CPR program improved the quality of life, respiratory functions, complaints, and clinical status of post COVID-19 patients.[9] Barbara et al. reported that aerobic and resistance exercises improved not only cardiopulmonary functions but also musculoskeletal functions in patients with COVID-19.[10] Furthermore, both Al Chikhanie et al. and Spielmanns et al. reported that pulmonary rehabilitation was more effective in post-acute COVID-19 patients than in patients with other pulmonary diseases.[11,12]

There are many advantages to interventions conducted in rehabilitation units, including the ability to monitor patients and the intensity of exercise, greater supervision, motivation, and social interaction. However, rehabilitation units cannot handle all post-acute COVID-19 patients and this would also be a huge economic burden. Moreover, physical distancing makes it harder for rehabilitation programs in groups. On the other hand, home-based exercise programs such as exergames and telerehabilitation have been reported to make similar improvements in exercise endurance in many various diseases.[8,13,14]

We hypothesized that home-based exercise programs could be an alternative to hospital-based CPR, given that they are cheap, easy, and safe methods to fight the long-term effects of COVID-19.

The purpose of this study was to compare the effect of CPR and home-based exercise programs on exercise endurance, dyspnea, fatigue, pain, and health-related quality of life in post-acute COVID-19 patients.

MATERIAL AND METHODS

STUDY DESIGN AND PARTICIPANTS

This retrospective cohort study was carried out using the treatment records of 118 post-acute COVID-19 patients who were referred to the physical medicine and rehabilitation (PMR) outpatient clinic with dyspnea, fatigue, and myalgia and had a home exercise program or a hospital-based CPR program between January and June 2021. Records of all patients who met inclusion and exclusion criteria were evaluated.

Inclusion Criteria:

- Being 18 years or older,
- Having COVID-19 treatment (home quarantine/hospital/intensive care unit) according to a positive polymerase chain reaction (PCR) test in a nasopharyngeal + oropharyngeal swab or chest computed tomography (CT),
- Disease duration: At least 6 weeks after COVID-19 infection,
- Patients whose symptoms began after COVID-19 infection,
- Participating in a home-based exercise program (for 6 weeks) or hospital-based CPR (for 12-20 sessions) due to post-acute COVID-19 symptoms (fatigue, myalgia, dyspnea) between “January and June 2021”,

Exclusion Criteria:

- Patients who had both a negative PCR test and chest CT,
- Patients without pre and post-treatment records [for the six-minute walk test (6MWT), Borg scales, Visual Analog Scale-pain (VAS-pain), and short form-36 (SF-36)],
- Acute COVID-19 patients (patients whose symptoms had started less than one month previous),
- Patients who left the hospital-based rehabilitation program before the end of 12 sessions,
- Patients who did not come for follow-up after a home-based exercise program,
- The patients who did not do home-based exercises regularly were also excluded.

MEASUREMENTS

The patients were divided into two groups according to having hospital-based CPR or home-based exercises. All patients were evaluated in terms of the 6MWT as the main outcome measure and for Borg dyspnea/fatigue, VAS-pain, and quality of life as secondary outcome measures before treatment and after the treatment which ends in the 6th week.

A detailed anamnesis was recorded including age, gender, body mass index, education, employment, chronic diseases (diabetes mellitus, hypertension, chronic obstructive pulmonary disease, cardiac disease, cancer, rheumatological disease etc.), smoking, place of treatment (home quarantine, hospital, intensive care unit), duration of treatment in hospital, the number of months since the onset of COVID-19 symptoms and the usage of anticoagulants and treatment drugs such as hydroxychloroquine and favipiravir.

The admission symptoms to PMR outpatient clinics were recorded as myalgia, chest pain, fatigue, dyspnea, and cough. Myalgia was accepted as pain in more than one region (shoulder girdle, arm, thigh, lower leg).

The laboratory values and the presence of the chest CT findings of the patients were recorded. Laboratory values were recorded for hemoglobin, leucocyte, lymphocyte, platelet, C-reactive protein, erythrocyte sedimentation rate, ferritin, and D-dimer in acute COVID-19 infection. The typical findings of the chest CTs were: bilateral, multifocal, peripheral ground glass opacities with/without consolidation, including fissures close to visceral pleural surfaces. The COVID-19 Reporting and Data System (CO-RADS) was used for chest CTs. CO-RADS assigns scores from 1 to 5 (1: very low suspicion of COVID-19, 5: very high suspicion of COVID-19).[15]

Exercise endurance was evaluated with the 6MWT. The test was applied one day before treatment and one day after the treatment under the supervision of a PMR specialist. All patients walked along a 30-meter-long corridor without obstacles at their normal walking speed. They were permitted to rest or sit, then the test went on until it reached maximum. This test was recorded in meters (m).[16] Peripheral oxygen saturation was measured with pulse oximetry, heart rate (beat per minute), systolic/diastolic blood pressure (mmHg), respiratory rate, and the Borg scale were also measured before and after 6MWT for perceived dyspnea (scale range from 0 to 10) and muscle fatigue (scale range from 6 to 20: higher values show more severe symptoms).[17]

The VAS-pain was used to measure general body musculoskeletal pain, which was assessed from 0 (no pain) to 10 (worst possible pain).[18]

A quality-of-life assessment was performed using the SF-36, which has 36 items regarding physical function, physical role, emotional role, energy, bodily pain, mental health, general health, and social function. The scale ranges from 0 (poor health) to 100 (perfect health).[19]

TREATMENT PROTOCOLS

Exercise protocols for both home based exercise programs and hospital-based CPR were determined by two PMR specialists who were experienced in CPR. The protocols consisted of aerobic, breathing and flexibility exercises.

The protocol for hospital-based CPR was for three or four days a week for a total of 20 sessions, with each session lasting from 50 to 60 minutes. The CPR consisted of aerobic, breathing, and flexibility exercises. The aerobic exercise program consisted of five minutes of warm-up, then 30 minutes on a treadmill, cycle or arm ergometer, and five minutes of warm-down at the end. Aerobic exercise intensity was derived from 6MWT.[20] Patients were monitored during exercise with a pulse oximeter and the exercise was stopped when symptoms were limited (Borg dyspnea score ≥7).[21] Breathing exercises consisted of five to10 minutes of pursed lip and abdominal breathing, secretion mobilization, and thoracic expansion exercises. Flexibility exercises consisted of five to ten minutes of stretching and range of motion exercises for both upper and lower extremities and the spine.

The patients in home-based CPR group were given a written guide for exercises and also instructed in breathing, flexibility, and aerobic exercises by a PMR specialist. Aerobic exercise intensity was also derived from 6MWT.[20] Walking program involved

walking three or four days a week for 40 minutes each day for a period of six weeks. The flexibility and breathing exercises were the same as for hospital-based CPR and lasted for five to ten minutes each. In addition, the patients were required to fill in a chart showing the dates and duration of their exercise to assess their compliance with the program.

This study was conducted according to the Helsinki Declaration. Ethical approval was received from the Eskişehir Osmangazi University Non-invasive Clinical Research Ethics Committee (date: March 16, 21; decision number: 12).

STATISTICAL ANALYSIS

The distribution of each continuous variable was analyzed using the Shapiro-Wilk test. Normally distributed variables were found using the unpaired t-test and are expressed as mean ± standard deviation (SD). Non-normally distributed variables were found using the Mann Whitney U and Wilcoxon Signed Ranks Test and are expressed as median value (25-75%). Mann Whitney U test and t-test were used for intergroup comparisons. Wilcoxon Signed Ranks Test was used for intragroup comparisons. Categorical variables were compared using chi-square statistics and are presented as numbers and percentages. A p-value < 0.05 was considered significant. All analyses were performed using the G*Power softwarepackage (version 3.1.9.4) (Franz Faul, Universität Kiel, Düsseldorf, Germany).

RESULTS

The files of 88 post-acute COVID-19 patients (50 females, 28 males) (mean age 52.4±12.3) who met inclusion criteria, were recorded and divided into two groups according to whether they had participated in a hospital-based (n=45) or home-based exercise program (n=43) (Figure 1).

All patients could walk. The median number of sessions in the hospital-based CPR group was: 19 (15-20).

In all 88 patients who were referred to PMR Clinic, the rate of fatigue was 89%, of dyspnea 68%, of myalgia 63%, of cough 37%, and of chest pain 21%. A comparison of baseline characteristics showed that the rate of cough and dyspnea at admission to PMR clinic was different between the groups. The rate of cough (p=0.010), and dyspnea (p=0.048) were higher in the hospital-based CPR group (Table 1).

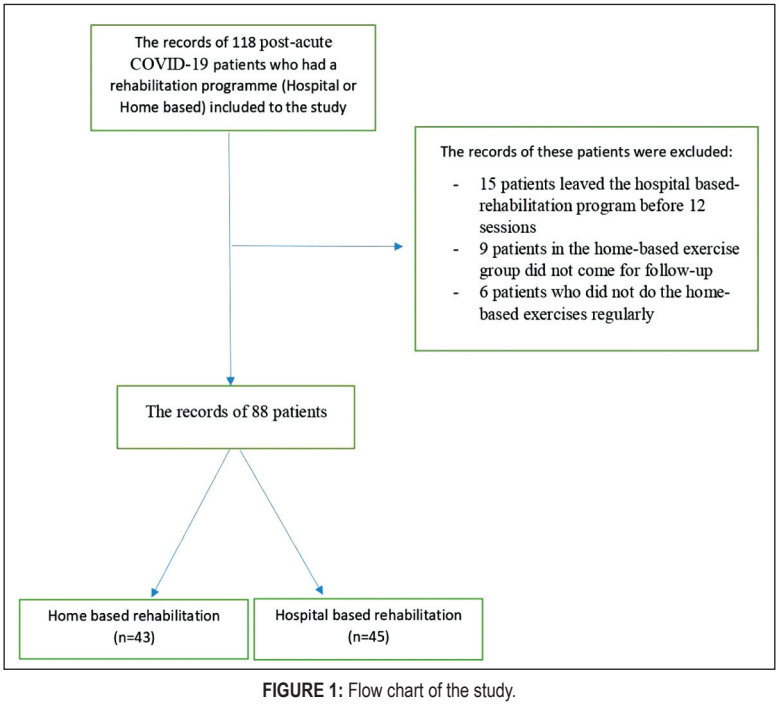

FIGURE 1: Flow chart of the study.

Patients were evaluated in terms of 6MWT and the Borg scales. The baseline characteristics of the outcome measures were similar between groups. The home-based exercise group showed improvement in oxygen saturation (p=0.015), 6MWT in meters (p=0.002), and Borg dyspnea scores (p=0.020). The hospital-based CPR group showed an improvement in heart rate (p=0.047), 6MWT in meters (p<0.001), Borg dyspnea (p<0.001), and Borg fatigue (p<0.001) scores. Comparison of groups showed that Borg dyspnea (p=0.004) and fatigue (p=0.001) scores showed more improvement in the hospital-based CPR group than in the home-based exercise group; however, the improvements in 6MWT were similar (p=0.266) (Table 2).

Patients were evaluated in terms of VAS-pain and the SF-36. The baseline values were similar between the groups. VAS-pain scores showed an improvement in both groups (home-based exercise: p=0.013, rehabilitation: p<0.001). However, the final VAS-pain scores (p=0.034) were lower in the hospital-based CPR group than in the home-based exercise group, although the basal VAS-pain scores (p=0.435) were similar. While half of SF-36 parameters showed an improvement in the home-based exercise group (physical function: p>0.001, physical role: p=0.004, emotional role: p=0.017, social function: p=0.010), all of SF-36 parameters (all: p<0.001) showed an improvement in the hospital-based CPR group. Comparison of the groups with regard to SF-36 showed that physical function (p=0.023), physical role (p=0.049), emotional role (p=0.038), bodily pain (p=0.021) and energy (p=0.001) showed more improvement in the hospital-based CPR group than in the home-based exercise group (Table 3).

DISCUSSION

To the best of our knowledge, this is the first study that compares the effect of CPR and home-based exercise programs in post-acute COVID-19 patients. Both programs were found to affect exercise endurance, pain, dyspnea, and quality of life in post-acute COVID-19 patients who had persistent symptoms for more than four weeks. Short-term CPR in the hospital improved pain, dyspnea, fatigue, and quality of life more than the six-week home-based

TABLE 1: Comparison of baseline characteristics between groups.

	Home based exercise (n=43) median (25-75%)	Hospital based CPR (n=45) median (25-75%)	p value
Age (years)	51 (41-63)	51 (45-64)	0.455
Gender (female/male) n (%)	26 (60)/17 (40)	24 (53)/21 (47)	0.329
BMI (kg/m²)	29.38 (26.21-33.05)	28 (26.38-31.72)	0.535
Smoking n (%)	5 (12)	1 (0.02)	0.106
Chronic diseases n (%)	22 (51.1)	31 (68.8)	0.115
Duration of treatment in hospital (days)	10 (8.75-15.25)	12 (10-18.75)	0.294
Treatment place n (%)			0.123
Home quarantine	21 (49)	15 (33)	
Hospital service	18 (42)	19 (42)	
Intensive care unit	4 (9)	11 (25)	
Presence of COVID-19 findings in chest CT (positive/negative) n (%)	25 (58)	36 (80)	0.782
Disease duration (months)	3 (1.8-4)	3 (2-6)	0.674
Symptoms n (%)			
Cough	10 (23.2)	23 (51.1)	**0.010**
Dyspnea	25 (58.1)	35 (77.7)	**0.048**
Chest pain	9 (20.9)	10 (22.2)	0.883
Fatigue	37 (86)	42 (93.3)	0.259
Myalgia	27 (62.7)	29 (64.4)	0.872

CPR: Cardiopulmonary rehabilitation; BMI: Body mass index; CT: Computed tomography.

TABLE 2: Inter and intragroup comparison of Borg dyspnea and fatigue scales, and the 6 minutes walking test.

	Home-based exercise (n=43) median (25-75%)	Hospital based CPR (n=45) median (25-75%)	p value
Basal oxygen saturation (%)	96 (95-97)	96 (95-97)	0.992
Final oxygen saturation (%)	96 (95.5-97)	96 (96-97)	0.778
p value	**0.015**	0.162	
Basal heart rate (bpm)	86 (80.5-95)	89 (77.50-98)	0.689
Final heart rate (bpm)	86 (78.5-93)	85 (74-92)	0.406
p value	0.961	**0.047**	
Basal systolic blood pressure (mmHg)	130 (116-141)	130 (120-135)	0.551
Final systolic blood pressure (mmHg)	125 (117-135)	125 (115-140)	0.937
p value	0.709	0.236	
Basal diastolic blood pressure (mmHg)	80 (75-85)	80 (75-85)	0.934
Final diastolic blood pressure (mmHg)	78 (70-85)	80 (70-85)	0.979
p value	0.308	0.173	
Basal 6MWT (meters)	439 (326-524)	426 (348-489)	0.891
Final 6MWT (meters)	471 (351-526)	471 (435-540)	0.266
p value	**0.002**	**<0.001**	
End-Basal Borg dyspnea score (n)	3 (1.75-4)	2 (0.87-3)	0.248
End-Final Borg dyspnea score (n)	2 (0.5-4)	1 (0-2)	**0.004**
p value	**0.020**	**<0.001**	
End-Basal Borg fatigue score (n)	11 (8.75-13)	11 (9-13)	0.498
End-Final Borg fatigue score (n)	11 (8-13)	7 (6-9)	**0.001**
p value	0.246	**<0.001**	

CPR: Cardiopulmonary rehabilitation; bpm: Beats per minute; 6MWT: The 6 minutes walking test.

CPR; however, a comparison of groups showed that both treatment programs had similar effects on exercise endurance.

Exercise training programs (aerobic and resistance interventions) are known to be effective in post-COVID-19 patients after hospital discharge.[22] Barbara et al. investigated the result of an 8-week exercise rehabilitation program which includes both aerobic and resistance exercises and reported increased cardiopulmonary and musculoskeletal functions in patients with COVID-19.[10] A randomized controlled study in China evaluated the effect of six weeks of pulmonary rehabilitation in elderly patients who were discharged from hospital after COVID-19 infection. Similar to our study's results, exercise endurance was assessed using 6MWT and significant improvements were reported in the intervention group.[4] Another recent paper in Italy found significant improvements in 6MWT with 20-30 days of inpatient pulmonary rehabilitation.[22] Moreover, another study in Germany compared the results of mild/moderate and severe/critical COVID-19 patients after three weeks of inpatient pulmonary rehabilitation. The 6MWT change was reported as 48 meters in the mild/moderate group, while in severe/critical patients the change was 124 meters.[5] Examining the baseline 6MWT scores, our study population consisted of mostly mild/moderate COVID-19 patients. Our 6MWT change was 45 meters in the hospital-based CPR group: this change is consistent with the German study.[5] Huang et al. reported a median 6MWT of 495 meters, without any intervention, six months after hospital discharge in 1,733 COVID-19 patients.[5] Our patients in both the home-based exercise and hospital rehabilitation groups reached a nearly comparable value of 6MWT with programs of only approximately six weeks duration.

Fatigue and dyspnea were the most reported symptoms in post-acute COVID-19 patients in the literature, leading to a decrease in quality of life.[24] Similar to our results, studies conducted before the COVID-19 pandemic showed the efficacy of pul-

TABLE 3: Inter and intragroup comparison of visual analog scale-pain and Short-Form 36.

		Home based exercise (n=43) median (25-75%)	Hospital based CPR (n=45) median (25-75%)	p value
Basal VAS-pain (n)		4 (2-5)	5 (2-6)	0.435
Final VAS-pain (n)		2.5 (1-5)	2 (0-3)	**0.034**
p value		**0.013**	**<0.001**	
SF-36 subgroups (n)				
Physical function	Basal	67.50 (33.75-85)	60 (37.50-70)	0.133
	Final	70 (50-95)	85 (72.5-95)	**0.023**
	p value	**<0.001**	**<0.001**	
Physical role	Basal	50 (0-100)	50 (0-75)	0.168
	Final	100 (25-100)	100 (75-100)	**0.049**
	p value	**0.004**	**<0.001**	
Emotional role	Basal	66.70 (0-100)	33.33 (0-66.66)	0.074
	Final	100 (33.30-100)	100 (66.66-100)	**0.038**
	p value	**0.017**	**<0.001**	
Bodily pain	Basal	67.50 (45-100)	67.50 (55-77.50)	0.516
	Final	77.5 (55-100)	90 (77.50-100)	**0.021**
	p value	0.258	**<0.001**	
Energy	Basal	40 (27.50-55)	40 (27.50-50)	0.838
	Final	42.50 (25-56.25)	60 (50-70)	**0.001**
	p value	0.155	**<0.001**	
Mental health	Basal	64 (48-73)	56 (48-68)	0.215
	Final	68 (48-76)	68 (54-76)	0.433
	p value	0.362	**<0.001**	
General health	Basal	55 (40-65)	45 (38.5-60)	0.152
	Final	60 (40-65)	60 (45-70)	0.240
	p value	0.283	**<0.001**	
Social function	Basal	62.50 (50-100)	50 (37.5-75)	0.109
	Final	87.5 (50-100)	100 (75-100)	0.073
	p value	**0.010**	**<0.001**	

CPR: Cardiopulmonary rehabilitation; VAS: Visual analog scale; SF-36: Short form-36.

monary rehabilitation on quality of life in many other diseases.[25] In previous studies, quality of life was investigated and conflicting results were reported: the Chinese study reported significant improvements in quality of life after six weeks of pulmonary rehabilitation in COVID-19 patients; however, the German study found no improvement in both quality of life and Borg dyspnea after three weeks of pulmonary rehabilitation.[4,5] Different from the German study, significant improvements in quality of life and Borg dyspnea were seen in both study groups in the current study; however, the improvement in the hospital-based CPR group was more significant. The duration of rehabilitation was approximately six weeks in both our study and the Chinese study, while it was only three weeks in the German study.[4,6] We believe that the differences between these studies can be explained by the duration of rehabilitation.

The effect of various exercises on pain relief has been shown in many previous studies.[26] Exercise is the core of CPR. Similar to our study, the Chinese study found that there was pain relief after six weeks of pulmonary rehabilitation.[4] We attribute the pain relief seen in our and the Chinese studies to the exercises carried out. Indeed, there was greater pain relief in the hospital-based CPR group than in the home-based group, as with quality of life. Moreover, fatigue improved only in the hospital-based CPR group. The efficacy of the exercises is affected by the time and place they occur and their intensity. At six weeks

after follow-up, the patients were required to provide an exercise chart with the dates and duration of the exercises they had done; however, we were not able to know whether they had engaged in the exercises with as much intensity as had been recommended. In the hospital-based CPR group, on the other hand, the intensity of the exercises was under professional supervision.

In a study that evaluated home-based exercise training in post-COVID-19 patients, Dalbosco-Salas et al. reported the effect of home-based exercise training which consists of warm-up for 5 minutes, breathing exercises for 3 minutes, aerobic and/or strength exercises for 20-30 minutes, and stretching for 5 minutes.[27] Similar to our results, physical capacity, quality of life, and symptoms were found to be improved. The methodologies of all the above studies are different from ours. None of them compared the efficacy of a home-based exercise program with a hospital-based cardiopulmonary program.

The conditions during the pandemic have been different from previous times. The high number of post-COVID-19 patients, the limited capacity of rehabilitation units, the risk of re-infection during travel to these units, the inability to carry rehabilitation programs in groups due to physical distancing and economic circumstances force us to find simple, safe, and low-cost strategies for COVID-19 patients who have persistent symptoms. For this reason, the current study compared home- and hospital-based rehabilitation programs. The main disadvantage of home-based exercise programs is that they are difficult to follow up and that it is hard to evaluate exercise compliance, as was the case in our study: 13% of our patients did not come to follow-up, while 16% of them did not engage in regular exercise. This disadvantage could be solved with hybrid approaches, virtual reality, and telerehabilitation programs and patient compliance could be increased.[27] Further long-term follow-up studies are needed to evaluate the efficacy of hybrid approaches and telerehabilitation programs on post-acute COVID-19 symptoms.

LIMITATIONS OF THE STUDY

The main limitation of our study is the lack of a randomized control group due to ethical problems. The other limitations are the retrospective design and the fact that spirometry was not evaluated because the pandemic has limited its use. The strengths of our study are: 1) to the best of our knowledge, it is the first study that compares home-based exercise and hospital-based CPR in post-acute COVID-19 patients; and 2) the baseline characteristics of all outcome measures were similar, which makes comparing post-treatment outcomes more reliable.

CONCLUSION

In conclusion, both home-based exercises and hospital-based CPR had similar effects on exercise endurance, we believe that home-based CPR programs could be an alternative to hospital-based programs during the ongoing COVID-19 pandemic.

Acknowledgment

English control was supported by David Duffy, who is an English native-speaker translator in Polen Translation Co. All of the authors declare that there is no conflict of interest.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

REFERENCES

1. Pavli A, Theodoridou M, Maltezou HC. Post-COVID syndrome: incidence, clinical spectrum, and challenges for primary healthcare professionals. Arch Med Res. 2021;52:575-81. [Crossref] [PubMed] [PMC]
2. Ceravolo MG, de Sire A, Andrenelli E, et al. Systematic rapid "living" review on rehabilitation needs due to COVID-19: update to March 31st, 2020. Eur J Phys Rehabil Med. 2020;56:347-53. Update in: Eur J Phys Rehabil Med. 2020;56:354-60. Update in: Eur J Phys Rehabil Med. 2020;56:508-14. [Crossref] [PubMed]
3. Liu K, Zhang W, Yang Y, et al. Respiratory rehabilitation in elderly patients with COVID-19: A randomized controlled study. Complement Ther Clin Pract. 2020;39:101166. [Crossref] [PubMed] [PMC]
4. Hermann M, Pekacka-Egli AM, Witassek F, et al. Feasibility and efficacy of cardiopulmonary rehabilitation after COVID-19. Am J Phys Med Rehabil. 2020;99:865-9. [Crossref] [PubMed] [PMC]
5. Gloeckl R, Leitl D, Jarosch I, et al. Benefits of pulmonary rehabilitation in COVID-19: a prospective observational cohort study. ERJ Open Res. 2021;7:00108-2021. [Crossref] [PubMed] [PMC]
6. Udina C, Ars J, Morandi A, et al. Rehabilitation in adult post-COVID-19 patients in post-acute care with Therapeutic Exercise. J Frailty Aging. 2021;10:297-300. [Crossref] [PubMed] [PMC]
7. Betschart M, Rezek S, Unger I, et al. Feasibility of an outpatient training program after COVID-19. Int J Environ Res Public Health. 2021;18:3978. [Crossref] [PubMed] [PMC]
8. Marchionni N, Fattirolli F, Fumagalli S, et al. Improved exercise tolerance and quality of life with cardiac rehabilitation of older patients after myocardial infarction: results of a randomized, controlled trial. Circulation. 2003;107:2201-6. [Crossref] [PubMed]
9. Szarvas Z, Fekete M, Horvath R, et al. Cardiopulmonary rehabilitation programme improves physical health and quality of life in post-COVID syndrome. Ann Palliat Med. 2023;12:548-60. [Crossref] [PubMed]
10. Barbara C, Clavario P, De Marzo V, et al. Effects of exercise rehabilitation in patients with long coronavirus disease 2019. Eur J Prev Cardiol. 2022;29:e258-e60. [Crossref] [PubMed] [PMC]
11. Al Chikhanie Y, Veale D, Schoeffler M, et al. Effectiveness of pulmonary rehabilitation in COVID-19 respiratory failure patients post-ICU. Respir Physiol Neurobiol. 2021;287:103639. [Crossref] [PubMed] [PMC]
12. Spielmanns M, Pekacka-Egli AM, Schoendorf S, et al. Effects of a comprehensive pulmonary rehabilitation in severe post-COVID-19 patients. Int J Environ Res Public Health. 2021;18:2695. [Crossref] [PubMed] [PMC]
13. Blair J, Corrigall H, Angus NJ, et al. Home versus hospital-based cardiac rehabilitation: a systematic review. Rural Remote Health. 2011;11:1532. [Crossref] [PubMed]
14. Besnier F, Gayda M, Nigam A, et al. Cardiac rehabilitation during quarantine in COVID-19 pandemic: challenges for center-based programs. Arch Phys Med Rehabil. 2020;101:1835-8. [Crossref] [PubMed] [PMC]
15. Prokop M, van Everdingen W, van Rees Vellinga T, et al; COVID-19 Standardized Reporting Working Group of the Dutch Radiological Society. CO-RADS: A Categorical CT Assessment Scheme for Patients Suspected of Having COVID-19-Definition and Evaluation. Radiology. 2020;296:E97-E104. [Crossref] [PubMed] [PMC]
16. ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories. ATS statement: guidelines for the six-minute walk test. Am J Respir Crit Care Med. 2002;166:111-7. Erratum in: Am J Respir Crit Care Med. 2016;193:1185. [Crossref] [PubMed]
17. Borg GA. Psychophysical bases of perceived exertion. Med Sci Sports Exerc. 1982;14:377-81. [Crossref] [PubMed]
18. Gallagher EJ, Liebman M, Bijur PE. Prospective validation of clinically important changes in pain severity measured on a visual analog scale. Ann Emerg Med. 2001;38:633-8. [Crossref] [PubMed]
19. Kocyigit H, Aydemir O, Fisek G, et al. [Validity and reliability of Turkish version of short form 36: a study of patients with rheumatoid disorder]. J Drug Ther. 1999;12:102-6. [Link]
20. Deschenes M, Garber CE. Chapter 7. General Principles of Exercise Prescription. In: Pescatello LS, Riebe D, Thompson PD. (Eds.). ACSM's guidelines for exercise testing and prescription. Lippincott Williams & Wilkins; 2014. p:173.
21. Kurtaiş Aytür Y, Füsun Köseoglu B, Özyemişci Taşkıran Ö, et al. Pulmonary rehabilitation principles in SARS-COV-2 infection (COVID-19): The revised guideline for the acute, subacute, and post-COVID-19 rehabilitation. Turk J Phys Med Rehabil. 2021;67:129-45. [Crossref] [PubMed] [PMC]
22. Zampogna E, Paneroni M, Belli S, et al. Pulmonary rehabilitation in patients recovering from COVID-19. Respiration. 2021;100:416-22. [Crossref] [PubMed] [PMC]
23. Huang C, Huang L, Wang Y, et al. 6-month consequences of COVID-19 in patients discharged from hospital: a cohort study. Lancet. 2021;397:220-32. [PubMed] [PMC]
24. Cabrera Martimbianco AL, Pacheco RL, Bagattini ÂM, et al. Frequency, signs and symptoms, and criteria adopted for long COVID-19: A systematic review. Int J Clin Pract. 2021;75:e14357. [Crossref] [PubMed] [PMC]
25. Reina-Gutiérrez S, Torres-Costoso A, Martínez-Vizcaíno V, et al. Effectiveness of pulmonary rehabilitation in interstitial lung disease, including coronavirus diseases: a systematic review and meta-analysis. Arch Phys Med Rehabil. 2021;102:1989-97.e3. [Crossref] [PubMed] [PMC]
26. Ouellet P, Lafrance S, Pizzi A, et al. Region-specific exercises vs general exercises in the management of spinal and peripheral musculoskeletal disorders: a systematic review with meta-analyses of randomized controlled trials. Arch Phys Med Rehabil. 2021;102:2201-18. [Crossref] [PubMed]
27. Dalbosco-Salas M, Torres-Castro R, Rojas Leyton A, et al. Effectiveness of a primary care telerehabilitation program for post-COVID-19 patients: a feasibility study. J Clin Med. 2021;10:4428. [Crossref] [PubMed] [PMC]