Thorac Res Pract. 2023; 24(6): 298-303 DOI: 10.5152/ThoracResPract.2023.23036

Original Article

Does Telerehabilitation for Coronavirus Disease 2019 Patients Discharged with Oxygen Shorten the Time of Weaning from Oxygen?

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Cite this article as: Deniz S, Yılmaz C, Süneçli O, Kuru Akyol E. Does telerehabilitation for coronavirus disease 2019 patients discharged with oxygen shorten the time of weaning from oxygen? *Thorac Res Pract.* 2023;24(6):298-303.

Abstract

OBJECTIVE: Early pulmonary rehabilitation (PR) and acute and post-acute mobilization with telemonitoring and telerehabilitation (TR) have been recommended for coronavirus disease 2019 (COVID-19) patients. We aimed to compare the duration of weaning from oxygen in patients with hypoxemic COVID-19 who received PR and those who did not.

MATERIAL AND METHODS: This study was designed as a quasi-experimental study and was conducted on patients discharged with oxygen supplementation between December 2021 and May 2022. They were compared with patients who received PR and those who did not in terms of the duration of oxygen use.

RESULTS: A total of 61 patients (9 women in each group) completed the study. The mean age was 65 ± 12. Thirty patients underwent PR (group 1) and the remaining 31 patients were classified as control group (group 2). When the groups were compared in terms of duration of oxygen use, patients who performed PR were statistically significant shorter duration than those who did not (P = .012). In addition, PR improved their quality of life compared to group 2.

CONCLUSION: It was concluded that although PR has many indications, it is also effective, feasible, and safe in prolonged infections and it was thought that TR may also be effective as supervised PR.

KEYWORDS: COVID-19, pulmonary rehabilitation, telerehabilitation, oxygen supplementation, quality of life

Received: *March 31, 2023* ***Accepted:*** *August 14, 2023* ***Publication Date:*** *October 27, 2023*

INTRODUCTION

In December 2019, 27 cases of pneumonia of unknown origin were detected in Hubei.[1] With the number of infected people and severe pneumonia cases increasing, the World Health Organization (WHO) officially declared a pandemic in February 2020. Since then, different variants of severe acute respiratory syndrome coronavirus 2 (SARS-CoV) have been defined by the WHO.[2] Compared with patients infected with the alpha or delta variants, omicron patients were hospitalized significantly less often, required less intense respiratory support, and had a shorter length of stay.[3] National ensemble predicts that the number of daily coronavirus disease 2019 (COVID-19) hospital admissions will decrease.[4]

Studies have shown that oxygen support at discharge is safe and reduces mortality and hospital readmission in patients with hypoxemic COVID-19.[5,6] The use of modern technology has allowed us to facilitate discharge in patients with mild-to-moderate disease in a safe and appropriate manner in COVID-19.[7] Early pulmonary rehabilitation (PR) and mobilization in the acute and post-acute phase with telemonitoring and telerehabilitation (TR) have been recommended for COVID-19 patients.[8,9] Many recommendations regarding PR have been reported in the literature; however, these are not based on the experience of COVID-19 patients, so there is a need for an individualized approach and the use of behavior change strategies.[9]

In this study, we aimed to investigate the effect of TR on the duration of weaning from oxygen in hypoxic COVID-19 patients discharged with oxygen supplementation. The primary endpoint was to compare the duration of weaning from oxygen, and the secondary endpoint was to examine the change in quality of life.

MATERIALS AND METHODS

Study Design and Participants

This study was designed as a quasi-experimental study and was conducted in patients discharged with oxygen supplementation between December 2021 and May 2022. The study was approved by the Institutional Review Board

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for Human Studies and Ethics Committee of University of Health Science Turkey, Dr Suat Seren Chest Diseases and Thoracic Surgery Research and Training Hospital (Approval Acceptance Number: 2020-KAEK-139) and was conducted in accordance with the tenets of the Declaration of Helsinki. Written informed consent was obtained from each patient.

We studied 127 patients who were hospitalized with hypoxemic COVID-19 (non-intensive care unit setting), of whom 15 patients did not give consent and 39 patients were excluded because they had concomitant respiratory diseases. These diagnoses were obtained from the hospital information management system and verified by patient self-report. In addition, 9 patients with other comorbidities were excluded (rheumatoid arthritis n = 1, pregnancy n = 1, uncontrolled hypertension n = 2, uncontrolled diabetes mellitus n = 2, cardiac arrhythmia n = 1, orthopedic disability n = 1, neurological disorders n = 1). These patients were assessed and verified by the relevant department. One patient was unable to complete the program due to unwillingness. Two patients were lost to follow-up due to relocation. Sixty-one hypoxemic patients with COVID-19 who were deemed clinically suitable to be discharged with oxygen supplementation were included. Patients were allocated 1:1 and divided into 2 groups: the intervention group (group 1) and the control group (group 2).

Inclusion Criteria

1. Patients >18 years of age with COVID polymerase chain reaction (PCR) (+) and radiologically compatible with COVID-19 pneumonia.
2. Patients discharged with oxygen supplementation.
3. Those able to communicate remotely.

Exclusion Criteria

1. Pregnancy or lactation.
2. Concomitant diseases (Chronic obstructive pulmonary disease [COPD] group B, C, D, uncontrolled or severe asthma, other respiratory diseases, cancer, immunological disorders, concomitant other infection diseases).
3. Orthopedic, neurological conditions that preclude participation in an exercise program.
4. History of unstable cardiovascular conditions such as cardiac arrhythmia, uncontrolled hypertension (HT), pulmonary hypertension, and uncontrolled diabetes mellitus (DM).
5. Thrombotic diseases.

Procedures

Demographic characteristics, comorbidities, and medical history were recorded in detail. Patients were examined for all systems. If any problem was identified during the examination, the relevant department was consulted. Blood samples were taken from each patient (liver and kidney function tests, glucose, D-dimer, ferritin, C-reactive protein, and blood cell count).

Health-related quality of life (HRQOL): This was assessed using the nationally validated version of the St George's Respiratory Questionnaire (SGRQ). The Hospital Anxiety and Depression Scale (HADs) was used to assess anxiety and depression separately. The Modified Medical Research Council (mMRC) dyspnea scale was used to assess the perception of dyspnea. All questions and assessments were carried out by a pulmonologist and all patients were assessed before and after PR.

Oxygen saturation follow-up: National Health Service guidelines suggest that unless there is a suspicion of CO_2 retention, arterial gases are not required and patients can be monitored using continuous peripheral arterial oxygen saturation (SpO_2).[10] At discharge, it was recommended that patients be monitored with daily pulse oximetry (PO) on their own. After discharge, patients were followed up by daily telephone calls to discuss their condition. If the patient was able to walk for 30 minutes without supplemental oxygen with an SpO_2 above 90%, it was recommended to wean them off oxygen during the day; if the SpO_2 was stable above 92% during the day at rest, the patients were called in for an arterial blood gas analysis (ABGa) in the hospital.

Arterial blood gas analysis: This was performed at rest on 100 μL of arterial blood taken from the radial artery (Nova Biomedical Critical Care Xpress, Waltham, Mass, USA). If SpO_2 was greater than 92% at rest on ABGa, the patient was completely weaned from oxygen. All interventions and assessments were reviewed by a pulmonologist.

Pulmonary Rehabilitation

Patients were informed about PR and trained by a physiotherapist and a specialist in physical and rehabilitation medicine at discharge; however, PR was not delivered in the hospital. Pulmonary rehabilitation consisted of treatment, education, self-management intervention, patient interview, exercise, and maintenance program. Home COVID-19 maintenance treatment and education with self-management interventions were provided. Patient education was provided with a booklet, healthy lifestyle education, family encouragement, and social activities. Patients were called by a physiotherapist at least twice a week to discuss the frequency and intensity of the exercises and to give motivational speeches about continuing the exercises. Patients were followed until they stopped using oxygen or completed the 8-week PR period. Pulmonary rehabilitation included breathing exercises (slow inhalation and exhalation through the nose and mouth, respectively, pursed-lip breathing, and diaphragmatic breathing), peripheral muscle training including lower and upper limb strength (initially warm-up, bed exercises, then low-intensity exercise, aerobic exercise, and stretching), bronchial hygiene techniques (postural drainage, and percussion), and secretion clearance. Warm-up exercises include shoulder shrugs and circles, side bends, knee lifts, ankle taps, and circles. Fitness exercises included marching on the spot, step-ups, walking, and jogging. Physical

MAIN POINTS

- We have shown that telerehabilitation (TR) can be implemented in post-infection conditions such as coronavirus disease 2019 and that TR can be as effective as pulmonary rehabilitation.
- Telerehabilitation is cost-effective and feasible.
- In particular, patients who had difficulties in transport to a hospital because of general health situations or socioeconomic problems are logical candidates for TR.

exercise was performed as aerobic exercise (low intensity, short duration, 3-5 sessions/week, 20-30 minutes per session). Strength training started with a reduced load and was repeated in the target muscle group 8-12 times, 1-3 sets/time, with 2 minutes rest between sets, at least 3 sessions/week for up to 8 weeks, depending on the patient's condition. The load was increased by 5%-10% each week. In addition, balance training (hands-free balance training, posture, flexibility, and rhythmic breathing) and activities of daily living (mobilization, dressing, undressing, toileting, and bathing) were recommended to be performed under supervision as much as possible. The program to be followed was completely individualized according to the patient's condition. Patients were encouraged to continue with the exercise program.

Statistical Analysis

Data were analyzed using IBM Statistical Package for Social Sciences (SPSS) Statistics (IBM Corp., Armonk, NY, USA). Group comparisons were made using a non-parametric test and, where appropriate, a *t*-test. Median (minimum, maximum) as well as mean ± SD and interquartile range (IQR) (Q1 and Q3) are presented for all variables. Repeated measures analysis of variance (ANOVA) and Mann–Whitney *U* test (comparison of post-pre values) were used to determine differences between groups for parametric and non-parametric tests, respectively. The duration of oxygen weaning in patients was assessed using the Kaplan–Meier method. For all statistical comparisons, the significance level was set at $\alpha = 0.05$ (probability of a type 1 error) and 2-sided. A *P*-value <.05 was considered statistically significant.

Table 1. Demographic Data of the Patients

	PR (+)		PR (−)		
Variables	**Mean ± SD**	**Median (minimum, maximum)**	**Mean ± SD**	**Median (minimum, maximum)**	***P***
Age*	63 ± 12	64 (35, 89)	67 ± 12	70 (39, 89)	.165
Gender (female)	62 ± 11	64 (37, 88)	68 ± 14	70 (35, 81)	.112
Smoking*	34 ± 21	40 (39, 89)	40 ± 18	40 (5, 80)	.401
PR duration	24 ± 13	21 (10, 60)			NA
Use of O_2 (days)	28.7 ± 21.9	21 (10, 90)	41.1 ± 26.6	30 (15, 90)	NA
mMRC	3 ± 1	4 (2, 4)	4 ± 0	4 (3, 4)	.054
HADa*	7.9 ± 5.1	7.5 (1, 19)	9.6 ± 5.8	9 (1, 21)	.239
HADd	7.7 ± 4.6	6 (2, 16)	10 ± 6.3	8 (2, 21)	.210
Symptom	20.3 ± 19.4	19.7 (0, 56.3)	23.3 ± 23.2	21.3 (0, 88)	.678
Activity	79.7 ± 16.9	82.5 (47.3, 100)	82.4 ± 12.6	86.3 (55.1, 100)	.813
Impact	43.6 ± 15.6	39.8 (20.8, 78.6)	45.8 ± 14.2	46.4 (18.2, 80.5)	.248
Total*	50.5 ± 14.2	48.1 (28, 79)	53.2 ± 12.8	54.3 (29, 79)	.454
AST*	27 ± 12	26 (7, 53)	22 ± 13	18 (9, 71)	.188
ALT	64 ± 47	43 (8, 178)	32 ± 28.5	23 (9, 143)	**.001**
Urea	47 ± 17	43 (18, 88)	56 ± 32	51 (16, 158)	.327
Creatinine*	0.82 ± 0.25	0.8 (0.4, 1.3)	0.9 ± 0.28	0.8 (0.4, 1.6)	.226
Ferritin	518 ± 387	411 (16, 1799)	480 ± 458	318 (70, 2299)	.363
D-dimer	952 ± 786	720 (259, 4369)	1421 ± 959	1100 (404, 4500)	**.013**
CRP	4.4 ± 4.0	3.4 (0.2, 14.3)	3.7 ± 4.3	2.1 (0.1, 17.2)	.427
WBC (×10^3)	10.7 ± 4.0	9.4 (5.0, 19.5)	10.6 ± 3.7	11 (4.8, 21.5)	.971
Hemoglobin*	12.3 ± 1.4	12.7 (8.3, 14.9)	12.2 ± 2.3	12 (8.8, 18.5)	.863
Hematocrit*	36.4 ± 4.1	37 (28, 44)	36.7 ± 6.9	36 (22, 54)	.876
Neutrophil (×10^3)*	8.8 ± 3.9	8.0 (1.8, 17.0)	8.4 ± 3.4	8.1 (4.2, 19.4)	.754
Lymphocyte (×10^3)	1.2 ± 0.8	1.2 (0.3, 3.8)	1.2 ± 0.5	1.2 (0.3, 2.3)	.670
pO_2	51 ± 4	52 (40, 58)	49 ± 6	51 (33, 59)	.453
pCO_2	36 ± 5	35 (29, 48)	40 ± 9	37 (26, 72)	.145
SpO_2	87 ± 3	87 (76, 92)	84 ± 6	86 (61, 93)	.182
HCO_3*	26 ± 3	26 (20, 33)	28 ± 5	27 (20, 43)	.360

*Normal distribution, if variables were fitted normal distribution, the means of variables were compared, if not, the medians of variables were compared. Statistically significant results are given in bold.HADa and d, hospital anxiety and depression; mMRC, Modified Medical Research Council Dyspnea Scale.

RESULTS

A total of 61 patients (9 women in each group) completed the study (1 patient who was unable to complete the program and 2 patients who were lost to follow-up were 67, 71, and 63 years old, respectively). The mean age was 65 ± 12. Thirty patients were performed PR (group 1) and the remaining 31 patients were classified as group 2. Significance was not found in terms of smoking history between groups [smokers, non-smokers, and ex-smokers (P = .963). The patients' comorbidities were similar in each group (P = .489). There was no significance in terms of basic demographic data of the patients and is presented in Table 1.

Patients who received PR improved their HRQOL. While significant changes were observed in the impact, activity, and total SGRQ domains, no significance was detected in the mMRC and HAD assessments (Table 2, Figure 1).

When the groups were compared in terms of duration of oxygen use, patients who performed PR were statistically significantly shorter than those who did not (Figure 2).

DISCUSSION

The results of the study provide the benefits of exercise interventions delivered by TR for recently discharged from hospital with oxygen supplementation in hypoxemic patients with COVID-19. Patients who received TR improved their quality of life and were weaned oxygen off in a statistically significantly shorter time compared to patients who did not receive TR.

A randomized controlled trial (RCT) of 120 patients showed the superiority of TR over no rehabilitation for 6 minute walking test (6MWD), lower limb muscle strength, and HRQOL.[11] In our study, TR resulted in an improvement in patients' quality of life. Cardiorespiratory exercise is dependent on adequate oxygen transport by the respiratory and circulatory systems and efficient use of oxygen. Skeletal muscle, like all tissues, requires a constant supply of oxygen at a rate that keeps pace with changing metabolic demands. These needs increase proportionally with increasing exercise intensity.[12] Although we did not measure muscle strength and exercise capacity, the fact that oxygen saturation improved in the PR-treated

Table 2. Comparison of Variables Before and After Pulmonary Rehabilitation

	PR (+)		PR (–)		
Variables	**Mean**	**Median (Q1, Q3)**	**Mean**	**Median (Q1, Q3)**	***P***
mMRC	−1.6	−2 (−2, −1)	−1.19	−1 (−2, −1)	.109
HADa	−3.83	−3 (−5, −1)	−3.9	−3 (−7, 0)	.794
HADd	−3.77	−3 (−5, −2)	−4.1	−3 (−7, −1)	.664
Symptom	−5.5	−1.9 (−10, 0)	0.1	0 (−6, 0.6)	.086
Activity*	−28.9	−25.4 (−44, −18)	−17.7	−17 (−26, −4)	**.039**
Impact*	−24.8	−22 (−31, −15)	−12.5	−13 (−20, −6)	**.002**
Total*	−23.3	−23 (−31, −15)	−12.2	−13.7 (−21, −2)	**.001**
AST	−8.9	−4 (−17, 0)	−4.5	−2 (−7, 1)	.083
ALT	−37.8	−28 (−49, −9)	−16	−7 (−20, −2)	**.005**
Urea	−18.7	−19 (−30, −8)	−16.8	−9 (−27, −2)	.296
Creatinine	−0.01	0 (−0.1, 0.1)	−0.02	0 (−0.1, 0.1)	.100
Ferritin	−314	196 (−461, −107)	−134	−95 (−271, −11)	.051
D-dimer	22	33 (−237, 378)	−174	−118 (−896, 268)	.180
CRP	−2.7	−1.6 (−5.4, −0.1)	−1	−0.4 (−1.6, −0.3)	.061
WBC (×10^3)*	−2.3	−1.8 (−4.8, −0.4)	−1.7	−1.5 (−4.7, −0.1)	.571
Hemoglobin*	0.14	0.5 (−0.5, 1)	−0.07	−0.1 (−0.7, 1)	.578
Hematocrit	1.23	2 (−1, 3)	0.59	0 (−2, 4)	.400
Neutrophil (×10^3)*	−3.4	−3.6 (−5.6, −0.8)	−1.99	−1.8 (−4.6, 0.2)	.143
Lymphocyte (×10^3)	0.8	0.7 (0.4, 1.1)	0.34	0.3 (−0.2, 0.7)	**.031**
pO_2*	22.48	23.5 (14.1, 29.6)	14.7	14.5 (5.4, 19.6)	**.016**
pCO_2	−0.08	−0.65 (−3.2, 3)	−1.24	0 (−5, 5)	.902
SpO_2*	7.67	7.9 (5.3, 10.1)	7.54	6.1 (3, 11.7)	.933
HCO_3*	−1.77	−2.4 (−4.8, 1)	−2.77	−1.5 (−5, 0.5)	.709

*Normal distribution, if variables were fitted normal distribution, the means of variables were compared, if not, the medians of variables were compared.Statistically significant results are given in bold. HADa and d, hospital anxiety and depression; mMRC. Modified Medical Research Council Dyspnea Scale.

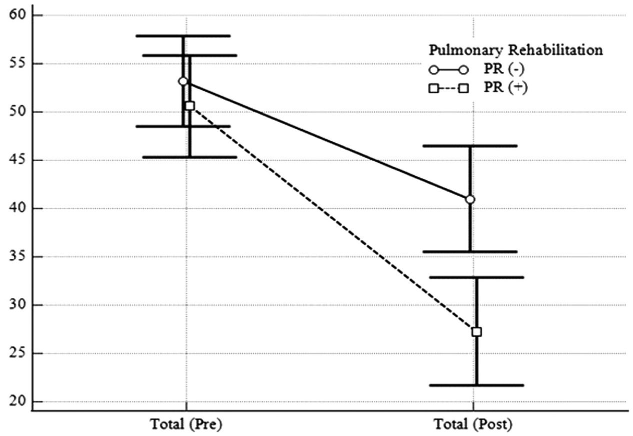

Figure 1. Comparison of St George's Respiratory Questionnaire total values between groups.

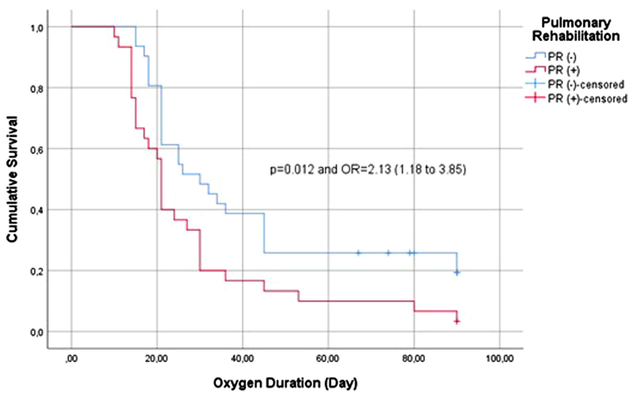

Figure 2. Comparison of duration of weaning off oxygen between groups.

patients in a shorter period of time may indirectly translate into improved exercise capacity and muscle strength.

With pandemic situations, technology has become an integral part of our lives. Telerehabilitation, which is a part of technology, is promising and cost-effective, and it facilitates patient participation in PR. In addition, TR may be safe and feasible, and it leads to a reduction in the need for conventional PR; furthermore, TR should be considered during the COVID-19 pandemic in COPD.[13] Meanwhile, TR has also been performed in patients with COVID-19. A review showed that TR influences physical activity and positive clinical outcomes and is similar to conventional PR in patients with COVID-19.[14]

An RCT, consisting of a small sample size, was carried out on 36 patients with COVID-19 in the acute stage, with only 1 week of TR. The 6-minute walk test, multidimensional dyspnea-12, 30-second sit-to-stand test, and Borg scale were evaluated. It was found that all 3 variables changed significantly in favor of the intervention group.[15] Compared to our study, we delivered TR varying between 1 and 8 weeks. Similarly, only 1 week of TR was effective, safe, and feasible as in the study and it paved the way for weaning from oxygen in our study. Patients in our study also improved their quality of life. In addition, patients who were weaned off oxygen for a shorter time showed a greater improvement in HRQOL, as expected. Telerehabilitation can improve exercise capacity, dyspnea, and HRQOL and does not significantly increase adverse events.[16] We did not observe any adverse events in our patients until the end of the study in each group.

A study conducted in patients with COPD, 12 weeks, 2 sessions per week, outpatient PR, showed that oxygen uptake, oxygen pulse (mL/beat), and work rate increased significantly in favor of the interventional group, but the oxygen saturation of the patients did not change compared to before and after PR (pre- and post-SpO_2 93.9%-94%).[17] Another study performed in a similar population showed that participants significantly improved oxygen saturation and exercise capacity (6MWT).[18] Although participants had different diagnoses, PR improved oxygen saturation and HRQOL in patients with COVID-19 in our study.

A case report showed that a patient with post-acute COVID-19, 80 years old, reported improvement in gait speed, exercise capacity, and oxygen saturation after PR. The patient's oxygen saturation was 88% on the first day and reached 98% after 10 days of PR.[19] Similarly, the earliest weaning time from oxygen was 10 days in group 1 and 15 days in group 2.

Patients with COVID-19 can suffer from various dysfunctions such as impaired lung function, physical deconditioning, muscle weakness, delirium, and other cognitive impairments.[20] Previously defined in patients with COPD, PR improves dyspnea, health status, and exercise tolerance.[21] Telerehabilitation is recommended for patients with COVID-19 to reduce viral spread, but there is little information on how best to do this in these patients.[22] Our study showed that TR improved the quality of life and oxygenation in patients with COVID-19 as in patients with COPD.

CONCLUSION

It was concluded that although PR has many indications, it is also effective, feasible, and safe in prolonged infections and it was thought that TR may be also effective as supervised PR.

Ethics Committee Approval: The study was approved by the Institutional Review Board for Human Studies and Ethics Committee of University of Health Science Turkey, Dr Suat Seren Chest Diseases and Thoracic Surgery Research and Training Hospital (Approval Acceptance Number: 2020-KAEK-139) and was conducted in accordance with the principles of the Declaration of Helsinki.

Informed Consent: Informed consent was obtained from all individual participants included in the study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – S.D.; Design – S.D.; Data Collection and/or Processing – S.D., C.Y., E.K.A., O.S.; Analysis and/or Interpretation – S.D.; Literature Search – C.Y., E.K.A., O.S.; Writing Manuscript – S.D.; Critical Review – S.D.

Declaration of Interests: The authors have no conflict of interest to declare.

Funding: This study received no funding.

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