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Effect of progressive muscle relaxation as an add-on to pulmonary telerehabilitation in discharged patients with COVID-19: A randomised controlled trial

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ABSTRACT

Background: and purpose: Most patients with coronavirus disease 2019 (COVID-19) experience persistent physical and psychological symptoms. This study aimed to investigate the effects of pulmonary telerehabilitation (PTR) combined with progressive muscle relaxation (PMR) on the physical and psychological outcomes of discharged patients with COVID-19.

Materials and methods: This randomised, assessor-blinded, parallel-group study was conducted in hospitals affiliated with Qom University of Medical Sciences between May and October 2021. Discharged COVID-19 patients aged 18–65 years were randomly assigned to two groups of 26 patients each. The experimental group underwent PTR and PMR for six weeks, while the comparison group received PTR alone. Primary (functional capacity) and secondary (dyspnoea, anxiety, depression, fatigue, sleep quality, and quality of life) outcomes were evaluated at baseline and after six weeks.

Results: The experimental group showed significantly higher sleep quality ($P = 0.001$, 95% confidence interval [CI]: 1.20–4.09) and significantly lower fatigue ($P = 0.041$, 95% CI: 4.79–5.25) and anxiety ($P = 0.001$, 95% CI: 1.21–4.47) than the comparison group. No between-group differences were observed in terms of other outcomes ($P > 0.05$).

Conclusion: PTR coupled with PMR was more effective for promoting sleep quality and alleviating anxiety and fatigue than PTR alone.

1. Introduction

Coronavirus disease 2019 (COVID-19) was initially reported in Wuhan, China, but quickly spread worldwide, triggering a global pandemic [1]. Patients with COVID-19 show great diversity in symptom severity; while the majority of patients are asymptomatic or develop only mild influenza-like symptoms, hospitalisation is required in cases with severe symptoms [2,3]. The majority of discharged patients with COVID-19 experience persistent physical and psychological symptoms, including dyspnoea, fatigue, anxiety, depression, decreased functional capacity, and poor sleep quality [4–6], which can cause deconditioning and a lower quality of life [7]. Therefore, providing appropriate interventions to treat persistent symptoms and prevent complications in these patients after discharge is crucial [8].

Pulmonary rehabilitation is an effective intervention for preventing deterioration of pulmonary and physical functions [9,10]. Social distancing policies adopted during the COVID-19 pandemic to reduce the spread of the infection have restricted access to outpatient rehabilitation programs for patients with COVID-19. Therefore, telerehabilitation was recommended for patients with COVID-19 [11,12]. A recent randomised controlled trial showed that pulmonary rehabilitation is effective for improving respiratory function, quality of life, and anxiety in patients with COVID-19 [13]; nevertheless, given older adults as the target population, the results cannot be generalized to all age

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groups. The effects of pulmonary rehabilitation on sleep quality and fatigue, the most prevalent symptoms in patients with COVID-19, have not been investigated.

Recent studies have shown that including complementary intervention to conventional care can improve psychological symptoms in patients with COVID-19 [14,15]. Liu et al. [16] found that progressive muscle relaxation (PMR) reduced anxiety and improved sleep quality in patients hospitalised with COVID-19. The PMR is a simple self-management and systematic relaxation technique that can achieve deep relaxation. Research has shown that PMR reduces fatigue and depression and improves sleep quality in chronic obstructive pulmonary disease (COPD) [17–19]. Indeed, a previous prospective cohort study recommended the use of interventions to alleviate both physical and psychological symptoms of COVID-19 [20], which can be achieved using PMR coupled with pulmonary telerehabilitation (PTR).

Given the limited data on the effects of interventions on persistent post-discharge symptoms in COVID-19, further studies are required to evaluate the efficacy of complementary interventions on symptoms [21]. To the best of our knowledge, the effects of PTR coupled with PMR on post-discharge outcomes have not yet been investigated in patients with COVID-19. This study was therefore conducted to investigate the effects of PMR coupled with PTR on functional capacity, anxiety, depression, fatigue, dyspnoea, quality of life and sleep quality compared to PTR alone, in discharged patients with COVID-19.

2. Materials and methods

2.1. Trial design and setting

This study was an assessor-blinded randomised controlled trial with two parallel treatment arms, conducted in hospitals affiliated with the Qom University of Medical Sciences, Qom, Iran, between May 2021 and October 2021. The study was performed in accordance with the Consolidated Standards of Reporting Trials (CONSORT 2010) guidelines [22].

2.2. Participants

Participants were selected from hospitals affiliated with Qom University of Medical Sciences by screening the hospital database. The inclusion criteria were age 18–65 years, COVID-19 confirmed by polymerase chain reaction (PCR) test, one day after discharge from the hospital and access to the Internet and video call. The exclusion criteria were pregnancy, re-hospitalisation, history of stroke, multiple sclerosis, chronic pulmonary and kidney conditions, uncontrolled diabetes or hypertension, cardiovascular diseases including uncontrolled arrhythmias, and severe neurological disorders such as Guillain-Barre syndrome.

2.3. Randomisation

Permuted-block randomisation with a block size of four was performed to randomly assign eligible participants to an experimental group receiving both PTR and PMR, and a comparison group receiving only PTR [23]. The blocks were randomly stacked using a Google random number generator. Random allocation was performed by an individual blinded to the grouping and the randomisation list was placed in sealed envelopes.

2.4. Blinding

The outcome assessor was blinded, unaware of the study objectives, and was not informed of the group assignment.

2.5. Intervention

The exercises were taught to the experimental and comparison groups in one face-to-face session. The participants were advised to perform the exercises at home for six weeks and received descriptions and videos of each exercise through WhatsApp messenger. Two sessions per week were conducted under the supervision of a physiotherapist via video call [13,24]. Both groups performed PTR exercises once a day for five days per week [25,26]. In the experimental group, PMR exercises were performed twice a day (morning and night) for five days a week [16,17,27]. In both groups, patient adherence was assessed using daily text messages.

2.5.1. Comparison group

The six-week training program in the comparison group comprised breathing exercises, such as diaphragmatic breathing, pursed lip breathing, chest expansion, and deep breathing with arm movement. These exercises were performed in three sets of ten repetitions each. Strength training for large muscles included squats, standing heel-rise, shoulder abduction, shoulder flexion, shoulder horizontal adduction and extension, and elbow flexion and extension. Three sets of strength exercises were performed with a 2-min rest between sets of ten repetitions. The upper limb exercises began with an external load. The external load for each muscle group was ten repetitions maximum and progressively increased by 5–10% per week [28]. Aerobic exercises included walking and upper-limb exercises. The six-week daily aerobic exercises with a rest interval, if needed, began at 10 min and increased to 30 min depending on the patient's tolerance [29]. The intensity of these exercises was determined based on the Borg scale (moderate-intensity score: 3–4). Moreover, the speed of walking and upper limb aerobic exercises increased according to this scale over six weeks [30,31].

2.5.2. Experimental group

PMR and PTR were performed in the experimental group. PMR lasted 15–20 min based on the modified Jacobson's method proposed by Bernstein [27]. The techniques, including contraction and relaxation of the 16 main muscle groups, were explained to the patients, who were placed in a supine position and were asked to focus on a single muscle group. Contraction of each muscle group was performed for 5–7 s and the patients were asked to focus on the feeling of contraction, and on muscle relaxation for 30–40 s. Each muscle group contracted during deep inhalation, and relaxed during exhalation. All the muscle groups, i.e., the right and left hands and forearms, right and left biceps, upper and lower sections of the face, neck, back, abdomen, right and left thighs, right and left ankles, and feet, were contracted and relaxed in all sessions [18,19,27].

2.6. Outcome measures

The primary outcome was functional capacity, while secondary outcomes included dyspnoea, fatigue, sleep quality, depression, anxiety, quality of life, and health status. Outcomes were evaluated before and after the six-week intervention. Variables such as functional capacity, dyspnoea, and fatigue were also evaluated at the end of two weeks.

The 6-min walk test (6 MWT) was performed face-to-face according to the guidelines of the European Respiratory Society and the American Thoracic Society to evaluate functional capacity. The test was conducted at the Physiotherapy Department of the Qom University of Medical Sciences hospitals in a straight corridor with a hard surface. The participants wore comfortable clothes, performed no exercise during the 2 h preceding the test, and sat on a chair near the test site 10 min before beginning the test [32]. The beginning and the end of the 15-m route were marked. The patients were then asked to stand and assume a position on the starting line. As the participants began to walk, an electronic timer set at 6 min was started. In case of inability to continue for 6 min or severe dyspnoea, they were asked to sit on the chair and the timer

was stopped. SpO_2 and heart rate were monitored before and after the test using a fingertip pulse oximeter (Yimi Life, Model:YM101). The total distance walked in meters was recorded [33]. Furthermore, dyspnoea was measured at the end of the 6 MWT using the Borg scale (0–10) [34].

The Persian version of the Fatigue Severity Scale (FSS) was used to assess fatigue. The FSS is a nine-item scale. The items are scored on a scale of 0–7, with a total score ranging from 9 to 63. The higher the score, the higher the fatigue severity [35]. The validity of the fatigue severity scale was confirmed in Iran, and its test-retest reliability coefficient was calculated as 0.78–0.95 [36]. The Pittsburgh Sleep Quality Index (PSQI) was used to assess sleep quality. The PSQI is a 19-item index. The items are scored on a scale of 0–3, with a total score ranging from 0 to 21; the higher the score, the more severe the sleep disorder [37]. Moghadam et al. [38] evaluated the validity and reliability of this index and confirmed the psychometric properties of the Persian version of the PSQI by calculating Cronbach's alpha of 0.77. The Hospital Anxiety and Depression Scale (HADS) was used to evaluate anxiety (seven items) and depression (seven items). The HADS is a 14-item scale. The items are scored on a four-point scale of 0–3, yielding a total score of 0–21, with higher scores indicating worse depression and anxiety [39]. The validity and internal consistency of the Persian version of this self-reported rating scale were previously confirmed in an Iranian population [40]. The 36-item Short-Form Health Survey (SF-36) was used to evaluate the quality of life. SF-36 is a 36-item questionnaire with eight subscales. The subscales include physical functioning, physical role, bodily pain, general health, vitality, social functioning, emotional role, and mental health. The total score of this questionnaire ranges from 0 to 100, with lower scores denoting lower quality of life [41]. Investigating the internal consistency (reliability) of the Persian version of the SF-36, Montazeri et al. [42] confirmed the reliability of all dimensions of this questionnaire by calculating a Cronbach's alpha of 0.77–0.90 except for vitality, which had a Cronbach's alpha of 0.65. Health status was evaluated using the 50-item St. George's Respiratory Questionnaire (SGRQ), which comprises three components, including symptoms, activity, and impacts (on daily life). The possible score on this questionnaire ranges from 0 to 100, with higher scores indicating greater restrictions [43]. Fallah-Tafti et al. [44] previously measured the validity and reliability of the Persian version of this questionnaire in patients with COPD and calculated a Cronbach's alpha of 0.93 for the entire questionnaire. All self-reported assessment tools, i.e., FSS, PSQI, HADS, SF-36, and SGRQ were sent as Google forms to the participants via WhatsApp messenger at the assessment time points and completed by the participants in online sessions under the supervision of an evaluator.

2.7. Statistical analysis

2.7.1. Sample size calculation

A priori sample size per group was calculated as 26 based on the data from a previously published RCT with 6 MWT as the primary outcome [13], and a test power of 80%, alpha of 5%, and an effect size of 0.71 for between-group differences using G*power software version 3.0.10. Considering a dropout rate of 10%, the sample size was set to 58 (29 per group).

2.7.2. Data analysis

Statistical analysis were performed using SPSS-19 with the significance level set at $P < 0.05$. The Shapiro–Wilk test was used to investigate normality, and Levene's test was used to assess variance homogeneity. As the data were normally distributed, parametric measures were used. The independent *t*-test was used to investigate between-group differences at baseline and at the end of the 6th week, while the paired *t*-test was used to examine within-group differences. In addition, repeated measures analysis of variance (ANOVA) (two groups, three times) was conducted to examine within- and between-group differences for the variables that were assessed three times (fatigue, 6 MWT, and dyspnoea). The post-hoc Bonferroni test was used to investigate the significant group × time interactions. The between-group effect sizes (ES) were calculated using Cohen's d. The ES was considered small ($d = 0.20$), medium ($d = 0.50$), or large ($d = 0.80$) [45].

2.8. Ethical considerations

This study was registered in the International Database of Clinical Trials (clinicaltrials.gov) (NCT04741282) and approved by the Research Ethics Committee of the Iran University of Medical Sciences, Tehran, Iran (IR.IUMS.REC.1399.1119). All participants were briefed on the intervention, assured of their right to withdraw from the study at their own discretion and of the confidentiality of their information through coding the questionnaires, and then asked to sign consent forms. The comparison group underwent PMR after the completion of the study.

3. Results

Patients were enrolled between May 2021 and August 2021; 107 discharged patients with COVID-19 were assessed for eligibility, of whom 43 did not meet the inclusion criteria and six declined to participate. In total, 58 patients with COVID-19 were included after hospital discharge. Of these, 52 completed the intervention. Two patients withdrew from each group before completing all sessions. One patient was excluded from the comparison group due to re-hospitalisation, and one in the experimental group due to relocation to another city. This information is presented in the CONSORT flow diagram (Fig. 1).

3.1. Baseline characteristics

Table 1 shows the demographic and clinical characteristics of the patients at baseline, suggesting no differences in any variable between the groups.

3.2. Functional capacity

The six-week intervention was found to significantly increase the distance walked in the 6 MWT in the experimental and comparison groups ($P < 0.001$); nevertheless, statistically insignificant differences were observed between the groups ($P = 0.96$) (Table 2). The between-group effect size was small after the intervention ($ES < 0.2$).

3.3. Dyspnoea

Dyspnoea significantly decreased after the intervention in both groups according to the Borg dyspnoea scale ($P < 0.001$); however, statistically insignificant differences were observed between the groups ($p = 0.812$) (Table 2). The between-group effect size was small after the intervention ($ES < 0.2$).

3.4. Fatigue

The fatigue severity scale showed significant reductions in fatigue in both the groups ($P < 0.001$). Post-intervention fatigue was less severe in the experimental group than that in the comparison group ($P = 0.041$). The between-group effect sizes were medium to large at two weeks ($ES = 0.635$) and six weeks ($ES = 0.792$) after the baseline assessment. Significant group × time interactions were also observed for fatigue severity ($P = 0.005$) (Table 2). Repeated-measures ANOVA revealed significant within-group differences in the experimental group between baseline and two weeks ($P = 0.003$), and between baseline and six weeks ($P < 0.001$). Despite the insignificant differences between baseline and two weeks later in the comparison group ($P = 0.999$), the baseline was significantly different from six weeks later ($P = 0.043$) (Fig. 2). Table 2 presents the within-group and between-group differences in the

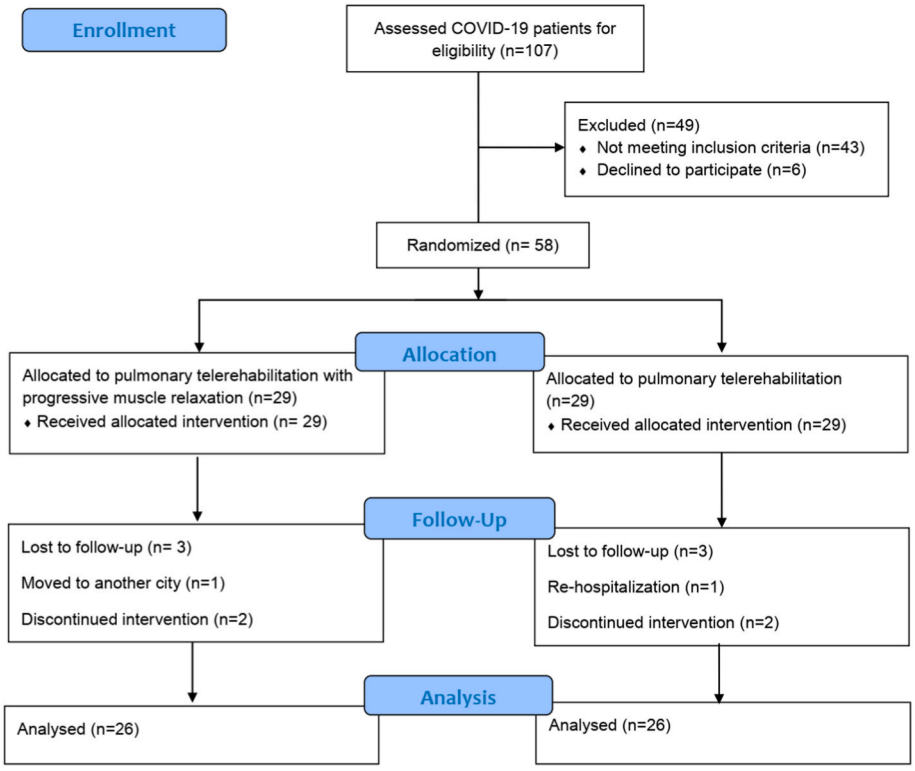

Fig. 1. CONSORT flow diagram of the study.

Table 1
Baseline characteristics of discharged patients with COVID-19 in the experimental and the comparison groups.

Characteristics	Comparison group (n = 26)	Experimental group (n = 26)	P-value
Sex (female)	13 (50%)	11 (42.3%)	[a]0.578
Height (cm)	169.34 ± 7.99	172.23 ± 9.58	[b]0.244
Weight (kg)	75.76 ± 9.75	78.53 ± 12.23	[b]0.371
BMI (kg/cm^2)	26.50 ± 3.64	26.39 ± 2.81	[b]0.796
Age (years)	44.19 ± 8.4	46.00 ± 11.26	[b]0.514
Duration of hospitalisation (day)	8.80 ± 4.11	9.15 ± 3.62	[b]0.749
CT scan feature of lung lesion			[a]0.532
Multiple lobes	18 (69%)	20 (76%)	
Single lobe	8 (31%)	6 (24%)	

Data are expressed as mean ± standard deviation, or numbers (%).
[b] Independent *t*-test.
[a] Chi-square test; BMI: body mass index; CT scan: computed tomography scan.

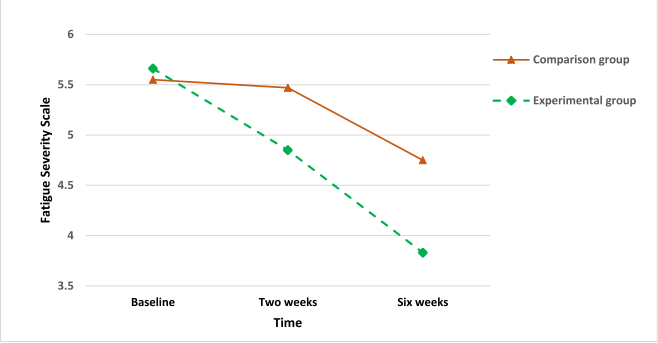

Fig. 2. Comparison of the fatigue severity scale score before the intervention, and at two and six weeks after, between the experimental and comparison groups using repeated measures ANOVA with the Bonferroni post-hoc test.

Table 2
Comparison of functional capacity, dyspnoea, and fatigue within and between the two groups of patients with COVID-19 before and after two and six weeks of intervention using repeated measures ANOVA.

Outcomes	Groups	Time period			P-value			95% CI	
		Baseline	Second week	Sixth week	Group* time	Time	Group	Lower limit	Upper limit
6 MWT	Comparison	290.96 ± 137.76	467.96 ± 122.21	520.69 ± 96.35	0.335	<0.001*	0.960	394.89	456.62
	Experimental	272.26 ± 142.79	468.11 ± 118.06	534.53 ± 93.29					
Dyspnoea Borg scale	Comparison	4.23 ± 1.96	1.98 ± 1.11	0.84 ± 1.02	0.523	<0.001*	0.812	2.06	2.71
	Experimental	4.46 ± 1.65	1.84 ± 1.12	0.98 ± 0.87					
FSS	Comparison	5.55 ± 1.07	5.47 ± 1.01	4.75 ± 1.41	0.005*	<0.001*	0.041*	4.70	5.25
	Experimental	5.66 ± 0.95	4.85 ± 0.94	3.83 ± 0.84					

Data are expressed as mean ± standard deviation; 6 MWT: 6-min walk test; FSS: Fatigue Severity Scale; CI: confidence interval; * significant differences, $P < 0.05$.

variables assessed three times using repeated-measures ANOVA.

3.5. Sleep quality

Significant improvements were observed in the experimental ($P < 0.001$) and comparison ($P = 0.007$) groups. Moreover, these improvements were significantly greater in the experimental group than in the comparison group ($P = 0.001$) (Table 3).

3.6. Anxiety and depression

Significant reductions were found in the post-intervention HADS scores in terms of anxiety ($P < 0.001$) and depression in the experimental ($P < 0.001$) and comparison ($P = 0.02$) groups. Statistically significant between-group differences were observed only in terms of anxiety, with the experimental group receiving a significantly lower score ($P = 0.001$) (Table 3).

3.7. Quality of life

Statistically significant within-group differences were observed in the SF-36 total score and the mental and physical subscales of the SF-36 in both groups ($P < 0.001$). However, no between-group differences were observed for these outcomes (Table 3). In addition, no between-group differences were found in terms of physical functioning, physical role, bodily pain, general health, vitality, social functioning, emotional role, and mental health as the eight health domains of this questionnaire ($P > 0.05$).

3.8. Health status

The SGRQ suggested statistically significant post-intervention improvements in health status in both the groups ($P < 0.001$). No between-group differences were observed in this regard ($P = 0.784$). In addition, significant improvements in symptoms, activity, and impacts as subscales of this questionnaire ($P < 0.001$) were found in both groups (Table 3). Table 3 presents the between-group differences in the

Table 3
Comparison of sleep quality, depression, anxiety, quality of life and health status between the two groups before and after the intervention using an independent sample *t*-test.

Outcomes	Groups	Time period		Between-group mean difference post-intervention	Independent-test (P-value)	Effect size (Cohen's d)	95% CI	
		Baseline	Sixth week				Lower limit	Upper limit
PSQI	Comparison	7.92 ± 4.04	6.76 ± 3.19	2.653	0.001*	1.03	1.21	4.08
	Experimental	7.19 ± 3.04	4.11 ± 1.75					
HADS	Comparison	14.61 ± 6.99	11.53 ± 7.14	3.653	0.033*	0.06	0.29	7.00
	Experimental	13.76 ± 4.65	7.88 ± 4.63					
Anxiety	Comparison	7.50 ± 3.48	5.80 ± 3.54	2.846	0.001*	0.97	1.22	4.46
	Experimental	6.80 ± 3.00	2.96 ± 2.08					
Depression	Comparison	7.15 ± 3.98	5.73 ± 3.74	0.961	0.327	0.28	−0.99	2.91
	Experimental	7.11 ± 2.93	4.76 ± 3.12					
SGRQ	Comparison	55.67 ± 12.40	23.03 ± 12.99	−0.943	0.784	0.07	−7.81	5.92
	Experimental	60.11 ± 11.16	23.97 ± 11.64					
Symptoms	Comparison	59.59 ± 19.69	23.70 ± 16.13	−1.939	0.656	0.12	−10.63	6.75
	Experimental	60.88 ± 19.14	25.64 ± 15.06					
Activity	Comparison	68.13 ± 15.65	37.56 ± 22.51	−2.059	0.709	0.10	−13.08	8.96
	Experimental	75.09 ± 11.62	39.62 ± 16.63					
Impacts	Comparison	48.62 ± 17.48	14.89 ± 10.42	−0.494	0.870	0.03	−6.54	5.55
	Experimental	51.51 ± 15.93	14.39 ± 14.89					
SF-36	Comparison	33.11 ± 11.32	64.92 ± 15.03	−0.153	0.969	0.04	−8.09	7.78
	Experimental	30.42 ± 9.75	65.57 ± 13.42					
Mental status	Comparison	35.61 ± 11.59	61.92 ± 16.11	−1.50	0.717	0.10	−9.78	6.78
	Experimental	34.26 ± 12.53	63.42 ± 13.49					
Physical status	Comparison	34.53 ± 16.99	65.69 ± 15.75	−0.807	0.830	0.05	−8.75	7.13
	Experimental	30.15 ± 11.70	66.50 ± 12.59					

Data are expressed as mean ± standard deviation; PSQI: Pittsburgh Sleep Quality Index; HADS: Hospital Anxiety and Depression Scale; SGRQ: St. George Respiratory Questionnaire; SF-36: 36-item Short-Form Health Survey; * Significant differences, $P < 0.05$.

variables assessed using the independent *t*-test before and six weeks after intervention.

4. Discussion

This randomised controlled trial investigated the effects of PTR combined with PMR on post-discharge complications in patients with COVID-19. The findings of this study showed that supplementing PTR with PMR did not affect the functional capacity. However, compared with PTR alone, this combination was found to significantly improve sleep quality and decrease fatigue and anxiety in patients with COVID-19 after their discharge. Despite the previously reported negative effects of fatigue on functional capacity [46–48], the present study showed no differences in functional capacity between the two groups. This finding is consistent with the results obtained by Cortes-Telles et al. [49], who reported insignificant differences in pulmonary function and 6 MWT between patients with COVID-19 with or without fatigue. It is worth noting that the fatigue severity obtained in the present study was lower in the experimental group than in the comparison group.

Although the aetiology remains unclear, it is known that fatigue is complicated and multifactorial in terms of its mechanism [50]. No distinct immunological findings associated with fatigue have been observed in patients with COVID-19. Therefore, non-pharmacological interventions are recommended to treat fatigue in these patients [51]. Kentson et al. [52] showed that fatigue has a more significant relationship with psychological factors than physiological factors in COPD. Given that stress is a reported risk factor for fatigue after acute infections [53], and that fatigue is correlated with sleep quality [54], we postulate that PMR lowers fatigue by affecting anxiety and sleep quality. PMR can trigger psychophysical relaxation by reducing sympathetic nervous system activity and preventing the side effects of stress and anxiety [55]. Park et al. [56] found that PMR decreased heart and respiratory rates, systolic and diastolic blood pressure, and salivary cortisol levels, which could explain the effect of PMR on anxiety in the present study. The present findings are consistent with those reported by Liu et al. [16] and Xiao et al. [57], who found that 5- and 7- day PMR reduced anxiety and improved sleep quality compared to routine care in patients with COVID-19. In these studies, the target population comprised hospitalised patients with COVID-19. However, in the current study, the effect of PMR was investigated in patients with COVID-19 who were discharged from the hospital. Lolak et al. [58] found that adding PMR to 8-week centre-based pulmonary rehabilitation did not yield additional benefits in terms of decreasing depression and anxiety in patients with COPD, which is consistent with the present findings in terms of depression symptoms. The discrepancy in the results of studies on anxiety could be explained by the differences in telerehabilitation and centre-based pulmonary rehabilitation procedures. A recent review conducted on COPD revealed that the HADS anxiety score showed a greater improvement in telerehabilitation compared with centre-based pulmonary rehabilitation [59]. The present results are consistent with a study by Chegeni et al. [17], who found that an 8-week PMR decreased the FSS score and certain subscale scores of the PSQI in patients with COPD.

The present study evaluated quality of life using the SF-36 and found no significant differences between the groups in the total and individual dimension scores of this questionnaire. Pulmonary rehabilitation appears to have adequate effects on the quality of life [13,60,61]; hence, PMR cannot reveal further statistical and clinical improvements. The effectiveness of PTR on clinical improvement could not be elucidated with the present findings, as PTR was performed in both groups; nevertheless, statistically significant changes in all outcomes were observed in both groups after the intervention, which is consistent with the results of a randomised controlled trial, suggesting that respiratory rehabilitation improves functional capacity and quality of life and relieves anxiety in patients with COVID-19 [13]. Retrospective and cohort studies also suggest that comprehensive pulmonary rehabilitation improves functional capacity and alleviates respiratory symptoms and fatigue in these patients [20,24,62]. Functional limitations in COVID-19 are associated with deconditioning, loss of skeletal and respiratory muscle strentgh, decreased respiratory capacity, increased breathing effort and inadequate gas exchange [6,63,64]. Pulmonary rehabilitation can improve respiratory function, gas exchange and muscle strentgh in patients with COVID-19 [13,65,66].

The present study's limitations include failure to investigate factors such as psychological conditions, diet, family support, and the home environment. These factors may have affected the outcomes. Moreover, this study did not determine the long-term effects by performing a follow-up; therefore, follow-up data collection is recommended in future studies. This study was conducted on patients with COVID-19 after hospital discharge; thus the results cannot be generalized to a group of non-hospitalised patients with persistent symptoms after COVID-19. This study did not include a group that only received progressive muscle relaxation. Moreover, only patients with COVID-19 who had access to the Internet were included in this study.

5. Conclusion

Compared with PTR alone, the combination of PTR and PMR more effectively promoted sleep quality and alleviated anxiety and fatigue. Considering that most patients with COVID-19 are not hospitalised, it is recommended that future research be conducted to investigate the treatment effects in non-hospitalised and symptomatic patients with COVID-19.

Author statement

Arghavan Hajibashi: Conceptualization, Investigation, Data curation, Writing-Original draft, Writing-Reviewing and Editing. **Javad Sarrafzadeh:** Conceptualization, Supervision, Visualization, Validation, Writing-Reviewing and Editing. **Ali Amiri:** Conceptualization, Supervision, Validation, Data curation, Resources, Writing-Reviewing and Editing. **Reza Salehi**: Conceptualization, Formal analysis, Methodology, Writing-Reviewing and Editing. **Behnoosh Vasaghi-Gharamaleki**: Conceptualization, Project administration, Writing-Reviewing and Editing. All the authors approved the final version of the manuscript for submission.

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Declaration of competing interest

The authors declare that they have no competing interests.

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