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The Effect of Home-Based Pulmonary Rehabilitation Lung Function Indices and Quality of Life in Patients with Chronic Obstructive Pulmonary Disease: A Randomized Clinical Trial

Mohammad Soleimani Arfa [1], Neda Sanaie[2], Malihe Nasiri [3], Seyed Mohammad Javad Ghazavi Dozein[1], Fariba Borhani [2*]

Abstract

Background: Chronic obstructive pulmonary disease (COPD) is a major cause of death in both developed and developing countries. Pulmonary rehabilitation aimed at controlling the symptoms in patients with COPD. Nurses play a crucial role in implementing home rehabilitation.

Aim: This study was performed with aim to determine the effect of home-based pulmonary rehabilitation on lung function indices and quality of life in patients with chronic obstructive pulmonary disease.

Method: This randomized clinical trial study was conducted on 60 COPD participants. The research units were randomly assigned to the intervention and control groups**.** Before and 8 weeks after the intervention, the participants filled out the questionnaires of severity of dyspnea, exercise capacity and quality of life. The intervention group received the home-based Pulmonary Rehabilitation program, four 20 to 30-minute sessions. Pulmonary rehabilitation consisted of three parts: warming up, aerobic exercises (often including walking) and strength exercises. The data was finally analyzed using SPSS statistical software (version 20) and chi-square, independent t, and paired t tests. $p<0.05$ was considered significant.

Results: No significant difference was found between the two groups before the intervention in terms of demographic characteristics, pulmonary function, dyspnea severity and quality of life ($p>0.05$). After the intervention, the dyspnea severity decreased in the intervention group (4.96 to 3.90) compared to control group (5.56 to 5.46) ($p<0.001$) and pulmonary function improved in the intervention group (324.63 to 349.46, respectively) compared to control group (286.36 to 287.33) ($p<0.001$). Moreover, quality of life increased in the intervention group (34.16 to 39.30) compared to the control group (35.10 and 35.43) ($p<0.0001$).

Implications for Practice: Home-based pulmonary rehabilitation improves lung function and quality of life in COPD patients. The findings of the present research can be suggested to the policymakers and nursing managers in order to improve care for pulmonary chronic obstructive disease patients.

Keywords: Home-based pulmonary rehabilitation, Quality of life, Chronic obstructive pulmonary disease

1. Student Research Committee, School of Nursing and Midwifery, Shahid Beheshti University of Medical Sciences, Tehran, Iran
2. Department of Medical Surgical Nursing, School of Nursing and Midwifery, Shahid Beheshti University of Medical Sciences, Tehran, Iran
3. Department of Pediatric Nursing, School of Nursing and Midwifery, Shahid Beheshti University of Medical Sciences, Tehran, Iran

* Corresponding Author Email: faribaborhani@msn.com

Introduction

Chronic lung diseases encompass a range of conditions such as Chronic Obstructive Pulmonary Disease (COPD), bronchiectasis, and pulmonary fibrosis, among which COPD is one of the most significant lung diseases leading to disability and mortality (1). Its prevalence is increasing in developing and developed countries (2). Currently, 300 million people worldwide suffer from chronic obstructive pulmonary disease (COPD), and in the past three decades, its prevalence, morbidity, and mortality rates have increased. Annually, between 100,000 to 150,000 deaths worldwide are reported due to this disease (3). According to the estimates by the Global Initiative for Chronic Obstructive Lung Disease (GOLD), COPD will rise from the fifth to the third leading cause of death globally by 2025 (4).

The most common symptom in individuals with chronic obstructive pulmonary disease (COPD) is breath, which inevitably leads to severe skeletal muscle atrophy, social isolation, and detrimental psychological effects. As a result, it is not surprising that reducing this distressing symptom has emerged as a primary goal emphasized in the guidelines (5). Although participants with COPD experience low quality of life, certain factors such as depression, physical inactivity, shortness of breath, and lack of social support negatively impact their quality of life (6). The goal is to maintain the highest level of independence and performance in society (7).

Since there is no definitive treatment for COPD, current therapeutic measures are often aimed to control the symptoms and avoid exposure to harmful environments (8). Pulmonary rehabilitation is a multifaceted approach that combines education and exercise to impact participants' activity levels, symptoms, and complaints (9). The goals of pulmonary rehabilitation are to reduce disease symptoms, restore and enhance functional capacity, increase participation in daily activities, and encourage independency. Pulmonary rehabilitation reduces lung hyperinflation and increases inspiratory capacity, both of which help decrease breathlessness during exertion. Additionally, exercise improves muscle performance, which delays fatigue and increases activity tolerance. In the meantime, self-management and behavior modification are among the main topics of educational components (10). Rehabilitation can be delivered through several models like Tele rehabilitation, Web-based rehabilitation, Home-based Pulmonary Rehabilitation, Primary care Pulmonary Rehabilitation, Breathlessness rehabilitation, and Community Pulmonary Rehabilitation. Based on a systematic review, home rehabilitation programs are superior to center-based programs for the elderly in terms of joining exercise program (11). Home interventions are more cost-effective than hospital treatments, and also the patient is at home and close to family members (3).

According to the World Health Organization (WHO), nurses are active members of the rehabilitation team (12). The traditional nursing model emphasized fulfilling participant’s basic needs, keeping them in a passive role. Modern nursing has shifted toward encouraging patients to actively participate in their own care. This involves not only providing assistance but also educating and empowering patients to achieve care-related goals on their own. This approach aligns with rehabilitation principles, aiming to support individuals with disabilities in gaining independency and enhancing their quality of life. Nurses are essential in every phase and type of rehabilitation care (13). Since participants' adherence to hospital rehabilitation programs is low (14), therefore, the present study was performed with aim to determine the effect of home-based pulmonary rehabilitation on lung function indices and quality of life in patients with chronic obstructive pulmonary disease. It is hoped that the research results will be able to introduce an effective method for improving pulmonary indicators, increasing daily life activities, and consequently enhancing the health and quality of life of these participants, by focusing on non-drug, low-cost, and non-invasive methods.

Methods

This randomized clinical trial study was conducted in 2024 at Shahid Beheshti University of Medical Sciences and its affiliated hospitals (Imam Hossein Hospital and Masih Daneshvari Hospital), Iran. The Pocock’s formula was used to estimate the sample size by considering $\alpha=0.05$, power=0.90, and the effect size of (d)=0.20, indicating the minimum required sample size of 26 individuals per group (15). To account for an anticipated dropout rate of 15%, the final calculation resulted in 30 individuals per group, amounting to a total of 60 participants. Notably, there was no attrition during the study, resulting in all 60 participants being included in the analysis phase (Figure 1).

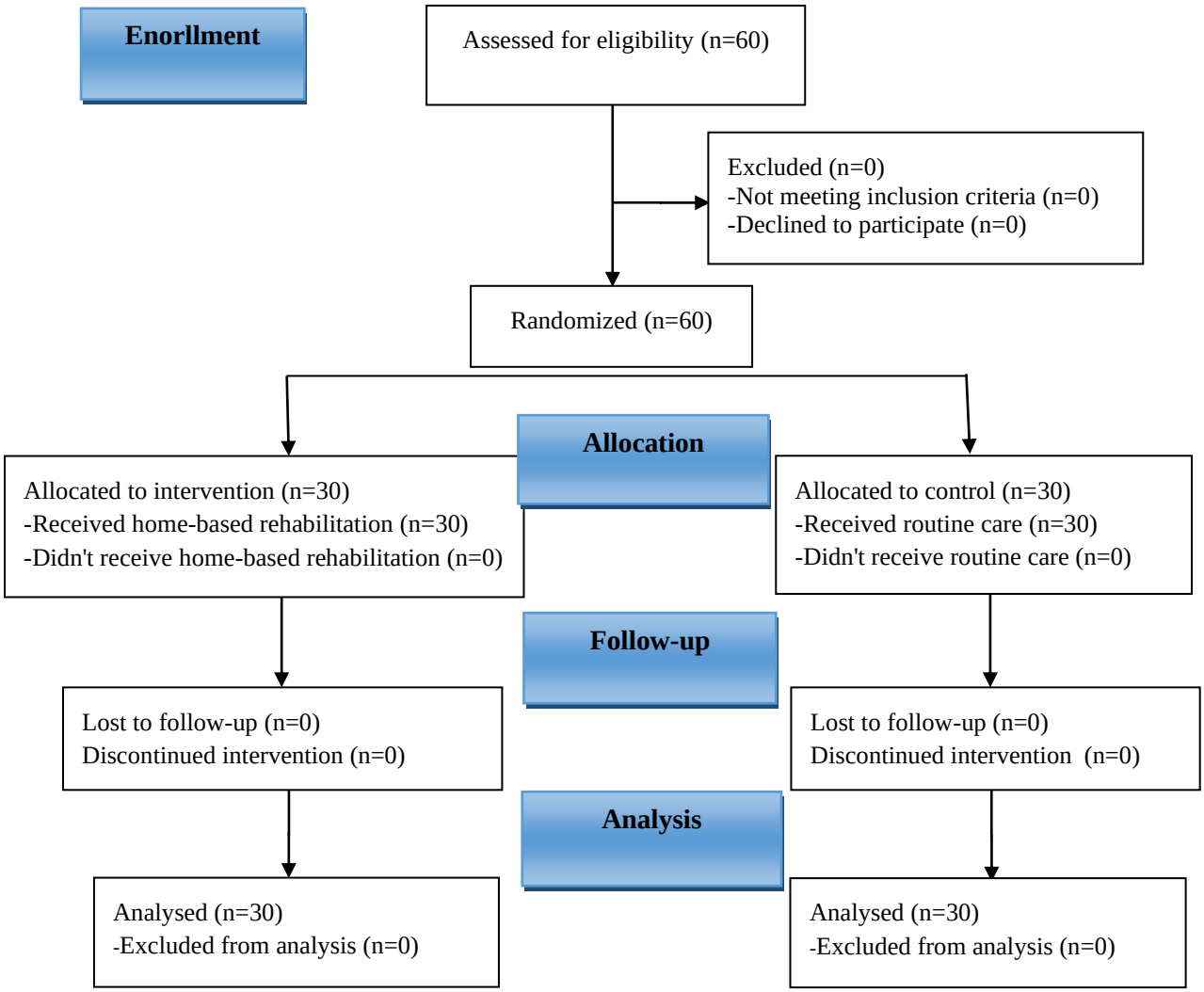

Figure 1. Flowchart of the effect of home-based pulmonary rehabilitation in patients with COPD

The inclusion criteria were age range of 18-75 years and experiencing chronic obstructive pulmonary disease, with a minimum of three months having elapsed since the diagnosis. The exclusion criteria were: the presence of recognized physical and mental health conditions that impact quality of life, such as those requiring dialysis or related psychological concerns, including depression and schizophrenia, necessitating medication or specific treatment protocols (as reported by participants themselves). Additionally, individuals who have missed two or more follow-up sessions did not engage in any further educational programs during the study. Moreover, individuals who required readmission upon entering the acute phase of the illness, as well as those with auditory, visual, or tactile impairments, or individuals unable to communicate in Persian were not included.

The tools used in this study were the demographic information questionnaire, Short Form Chronic Respiratory Questionnaire (SF-CRQ), Modified Borg Scale (MBS), and Six-Minute Walk Test (6MWT). Demographic information questionnaire encompassed inquiries regarding age, gender, economic status, educational background, occupation, duration of illness, hospitalization history, and underlying medical conditions.

Short Form Chronic Respiratory Questionnaire (SF-CRQ) is a quality of life questionnaire designed to assess the impact of chronic respiratory diseases, like COPD, on a patient's life. It is the first time this questionnaire has been used in Iran. The questionnaire evaluates four key domains: fatigue, shortness of breath, control over life, and emotional functioning. It comprises eight questions rated on a 7-point Likert scale, with a higher score signifying enhanced functioning in each domain. Each domain's score ranges from 1 to 7, leading to a cumulative score spanning from 1 to 56. Tsai and colleagues

assessed the validity and reliability of this questionnaire in participants with chronic obstructive pulmonary disease, yielding a Cronbach's alpha coefficient of 0.82 (16). Charalambous and Molassiotis also applied this questionnaire to lung cancer participants, with initial reliability measured at a Cronbach's alpha coefficient of 0.88, which increased to 0.91 after one month (17). In this study, Cronbach's alpha coefficient was used to measure internal consistency and it was 0.87.

Modified Borg Scale (MBS) is a validated numerical tool, designed to assess the level of dyspnea experienced by patients during physical exertion. Typically utilized during the six-minute walk test, the MBS is administered in a single trial and monitored alongside objective indicators of exercise intensity in healthy individuals. Consequently, it has been adopted for application in chronic lung disease. The scale begins at zero, indicating no breathing difficulties, and progresses to ten, which denotes maximal shortness of breath. In a study conducted by Banerjee et al. (2017), the validity and reliability of the MBS were substantiated, with a Cronbach's alpha of 0.81 (18). Furthermore, another investigation by Reychler et al. in 2021 reported an Intraclass correlation coefficient (ICC) of 0.79, signifying the commendable reliability of this instrument (19). In the current study, the reliability of the scale was evaluated, yielding a Cronbach's alpha value of 0.81.

Six-Minute Walk Test (6MWT) is utilized to assess the distance an individual can walk on a level surface over six minutes. This method serves as an effective measure of the physiological responses of various body systems during exercise, including the respiratory and cardiovascular systems, blood circulation, and muscular function. The goal is to cover the maximum distance within six minutes at a pace that is comfortable for the individual. Since this test simulates walking in daily life, it provides a more accurate representation of the individual's performance level compared to more intensive exercise recording the distance covered in six minutes to establish a score; and re-measure pulse rate, blood pressure, blood oxygen levels, and respiration rate post-test. In the study conducted by Jalili and Nazem (2017), the validity and reliability of the 6-minute walk test were confirmed, with a Cronbach's alpha of 0.75 indicating strong internal consistency for this questionnaire (20). Additionally, Holland and colleagues utilized this test in patients with pulmonary fibrosis, yielding an ICC of 0.96 over an eight-week period, which corresponds with the duration in the current research (21).To assess the reliability of the test, the test-retest method was used with an interval of 48 hours. The ICC for the test results was reported to be 0.93.

At first, two hospitals were randomly selected from five teaching hospitals providing services in respiratory disorders and the necessary permissions for entry were obtained. Initially, the objectives of the study and the method of conducting the study were explained to the patients and written consent was obtained. The selection of each center for the type of intervention was done with concealment. In such a way that six envelopes were selected and the name of the hospital and the group was written inside each envelope. From these opaque envelopes, two envelopes were selected and according to the above division, the type of intervention in each hospital was determined. Each participant was placed in a group based on the place of service, including the intervention group (A) and the control training group (B). Demographic information was collected prior to their participation. The Borg dyspnea scale and the SF-CRQ quality of life questionnaires were obtained by the researcher, who provided explanations of the questions and response options to the participants. The procedure for conducting the six-minute walk test received approval from the heads of the physiotherapy departments at both hospitals. This test was carried out by marking a designated path with cones in the hospital corridors or open spaces. Upon entering the study, each participant was assigned to either the test or control groups. In the subsequent phase, participants in the test group participated in a home pulmonary rehabilitation program consisting of four in-person sessions, each lasting 20 to 30 minutes, which involved face-to-face participant education based on the content of an instructional booklet. The control group only received the standard clinical interventions consisting of hospital educations and rehabilitations.

A comprehensive booklet was developed concerning the pulmonary rehabilitation program, encompassing education on disease introduction, medication usage, nutrition, and suitable activities, based on the Australian Lung Association's 2020 guidelines and a thorough literature review. This educational material was specifically crafted for validation of the content directed at participants in the test group during the monitoring and follow-up phase, and for participants in the control group at the end of the study. It was reviewed by five specialists (three faculty members from the School of Nursing with teaching and clinical experience of respiratory patients, a pulmonologist, and a

physiotherapist). Following their confirmation of the scientific accuracy of the content, the booklet was shared with three individuals diagnosed with COPD who were not part of the study to evaluate its fluency and comprehensiveness. The review process addressed various aspects, such as comprehensibility, fluency, necessity, and the relevance of the material from the participants' perspective. Subsequently, the booklet was reviewed by three specialists, whose comments and corrections were duly implemented.

The final booklet is organized into five sections: Introduction, Medication Plan, Dietary Plan, Care Plan, and Pulmonary Rehabilitation. The first section provides an overview of the disease, including its underlying factors, general symptoms, and signs. Recognizing the critical role of proper medication use in managing the disease can significantly affect participants' activity levels and adherence to the rehabilitation program. The second section focuses on the participants' medication regimen. This section educates participants on various medication types and their side effects, with significant emphasis on the correct usage of different inhaler devices and appropriate storage of medications, supplemented by face-to-face training on the inhalers.

The dietary program outlined in the next section addresses the significant impact of nutrition and weight management on mobility and fatigue in participants. It highlights the importance of maintaining a healthy diet and recommends weight loss strategies for those who are overweight. The care education section stresses the importance of smoking cessation and daily practices such as airway clearance, along with oxygen use and therapy as needed. Collectively, these components prepare participants for an effective rehabilitation program, detailed in the final section, which outlines its benefits and is based on exercises recommended by the Australian Lung Association. Training related to this section is conducted through in-person sessions encompassing movements and precautions.

The rehabilitation exercises consist of three main parts. The first part includes warming up, featuring stretching exercises, such as shoulder rotations and side stretches. In the subsequent stage, participants are encouraged to engage in daily walking for 20 minutes at a moderate pace, or to utilize a stationary bike if available. The final segment focuses on strength exercises, taught using 1-kilogram weights, encompassing movements such as bicep curls and sit-to-stand exercises, aimed to increase the strength and endurance of various muscles to enhance overall activity tolerance. The goal is to train participants four to five times a week, with each session lasting 20 to 30 minutes, starting with shorter sessions of approximately 10 minutes. Participants are advised to incorporate either aerobic exercises or strength training daily, also addressing potential risks associated with exercise.

Participants and their companions during sessions are provided with educational materials regarding disease introduction, dietary precautions, medication plan and care strategies, including instructions on the use of various inhalation devices and identification of signs indicative of disease exacerbation. The pulmonary rehabilitation program emphasizes on walking as a common aerobic exercise, alongside demonstrations of strength movements performed in front of participants and their companions, as detailed in the provided booklet. Supplemental information and precautions were shared using images and content on a social media platform. The educational content was delivered both verbally and through practical exercises according to a predetermined schedule. Throughout the study, the researcher was in contact with participants via a designated messaging application, providing summaries of the educational program and addressing any questions.

Upon completion of the intervention, lung function was re-evaluated. Quality of life and dyspnea questionnaires were completed for both the control and test groups. Statistical analysis was performed using SPSS software (version 20). The normality of the data was first assessed and since the normal distribution of data, the effectiveness of the home pulmonary rehabilitation was analyzed using paired test and independent t-test. $p<0.05$ was considered significant.

Ethical Consideration

The study was approved by the Joint Organizational Ethics Committee of Shahid Beheshti School of Nursing and Midwifery, Tehran, Iran (ethical code: IR.SBMU.PHARMACY.REC1402.113) and was registered in the Iranian Registry of Clinical Trials (IRCT20231126060183N1). The researcher explained the purpose and method of conducting the research to the relevant officials. In all stages of the research, the ethical considerations such as obtaining informed consent, information confidentiality and the possibility of withdrawing from the study at each stage was taken into account.

Results

The results of Fisher's exact test and independent t-test showed no significant difference between the two groups regarding the demographic characteristics, suggesting that the demographics profiles of both groups were homogeneous ($p<0.05$) (Table 1).

Table 1: Demographic characteristics of participants in both groups

Variable	Intervention N (%)	Control N (%)	Test result	*p*-value
Age (Mean±SD)	64.10±11.18	63.20±13.45	t =0.470	0.640
Sex				
Male	17(56.7)	19(63.3)	χ^2=0.278	0.792
Female	13(43.3)	11(36.7)		
Marital Status				
Single	28(33.3)	8(26.7)	χ^2=2.095	0.385
Married	20(66.7)	22(73.3)		
History of hospitalization				
Yes	23(76.7)	21(70)	χ^2=0.341	0.771
No	7(23.3)	9(30)		
Underlying diseases				
Yes	19(63.3)	21(70)	χ^2=0.300	0.785
No	11(36.7)	9(30)		

Table 2: Mean of quality of life before and after the intervention

Quality of life dimensions		Before Mean±SD	After Mean±SD	Paired-samples t-test results		
Dyspnea	Intervention	8.46±1.45	10.83±1.45	t=-6.94	df=36	*p*<0.001
	Control	9.26±2.51	9.70±1.41	t=-1.45	df=39	*p*=0.157
Independent-samples t-test results		t=-1.50 *p*=0.137	t=3.68 *p*<0.001		-	
Fatigue	Intervention	8.40±1.40	9.50±1.38	t=-3.61	df=36	*p*=0.001
	Control	8.80±2.26	8.40±1.63	t=-0.76	df=39	*p*=0.444
Independent-samples t-test results		t=-0.82 *p*=0.414	t=2.87 *p*=0.007		-	
Emotional function	Intervention	9.56±1.07	1.13±1.04	t=-3.31	df=36	*p*=0.002
	Control	9.16±1.01	9.30±1.11	t=-1.68	df=39	*p*=0.103
Independent-samples t-test results		t=1.48 *p*=0.144	t=2.98 *p*=0.004		-	
Control	Intervention	7.73±1.36	8.83±1.08	t=-3.75	df=36	*p*=0.001
	Control	7.86±1.96	8.03±1.54	t=-1.22	df=39	*p*=0.231
Independent-samples t-test results		t=-0.30 *p*=0.761	t=2.32 *p*=0.024		-	
Total score of quality of life	Intervention	34.16±4.26	39.30±2.21	t=-7.69	df=36	*p*<0.001
	Control	35.10±6.39	35.43±2.94	t=-0.39	df=39	*p*=0.697
Independent-samples t-test results		t=-0.66 *p*=0.509	t=5.74 *p*<0.001		-	

The independent t-test indicated that the mean of the fatigue domain score, emotional functioning domain, control domain, shortness of breath domain, and overall quality of life score for participants prior to the intervention did not demonstrate a statistically significant difference in both the test and control groups. However, following the implementation of the rehabilitation program, the means across all dimensions, as well as the overall quality of life score, in the test group exhibited a statistically significant improvement compared to the control group. Furthermore, the results of the paired t-test indicated a significant difference in the overall quality of life score and its dimensions in the test group before and after the intervention. In contrast, the

control group did not show a significant difference before and after the intervention (Table 2).
As the results of the independent t-test showed, the mean of dyspnea severity prior to the intervention did not exhibit a statistically significant difference between the test and control groups. Following the intervention, the mean of dyspnea severity significantly improved in the test group compared to the control group. Furthermore, a comparison of the mean scores of dyspnea severity in the test group before and after the intervention, the paired t-test revealed a significant difference between the pre-test and the post-test. In contrast, no significant difference was observed in the control group between the pre-test and the post-test (Table 3).

Table 3: Changes in meann of dyspnea before and after the intervention

Variable		Before Mean±SD	After Mean± SD	Paired-samples t-test results	
Modified Borg Scale	Intervention	4.96±1.35	3.90±1.24	t=4.06	p<0.001
	Control	5.56±1.92	5.46±1.77	t=1.79	p=0.083
Independent-samples t-test results		t=-1.39 p=0.168	t=3.96 p<0.001	-	

The mean of heart rate, systolic blood pressure, diastolic blood pressure, respiratory rate, and arterial oxygen saturation at the end of the six-minute walk test before and after the intervention did not differ significantly between the two groups. Moreover, before the intervention, the mean distance covered at the end of the six-minute walk test in in the two groups did not show a statistically significant difference. However, this difference between the two groups was significant after the intervention. Comparison of the mean scores of the distance covered by participants before and after the intervention in the test group using the paired t-test indicated a significant difference between the pre-test and the post-test. But in the control group, this difference was not significant. The independent t-test showed that the mean changes in the distance score of participants in the test group were significantly higher than the control group (Table 4).

Table 4: Changes in mean of six-minute walk test before and after the intervention

Quality of life dimensions		Before Mean±SD	After Mean±SD	Paired-samples t-test results	
Covered distance	Intervention	324.63±95.04	349.46±84.75	t=-4.25	p<0.001
	Control	286.36±72.27	287.33±72.90	t=0.98	p=0.331
Independent-samples t-test results		t=-1.75 p=0.084	t=3.04 p=0.004	-	

Discussion

The results of the current research showed that home-based pulmonary rehabilitation has positive effects on COPD patients. The evaluation of dyspnea severity scores in patients before and after the intervention in the test group revealed a notable difference, whereas the control group showed no significant change in dyspnea severity scores between the pre-test and post-test. This indicates that the home pulmonary rehabilitation intervention has effectively diminished dyspnea severity in individuals with chronic obstructive pulmonary disease. Amini et al. (2019) found that following the intervention, there was a statistically significant difference in pulmonary function between the two groups, with the breathing exercises enhancing the participants' breathing techniques. It was recommended that these exercises be integrated into the pulmonary rehabilitation program for these patients (22). Additionally, a study performed in the Military Specialist Hospitals reported a significant improvement in atrial axygen saturation in the test group during the transition from the pre-test to the post-test. The researchers concluded that controlled breathing exercises can effectively enhance arterial oxygen saturation in patients with chronic obstructive pulmonary disease (23). The mentioned studies utilized controlled breathing exercises to enhance arterial oxygen saturation. However, in the current study, the researcher explored the combined effects of various methods and breathing exercises as part of home pulmonary rehabilitation, which contrasts with incentive spirometry exercises or simple pursed-lip breathing techniques.
In the current research, comparison of functional exercise capacity scores for participants in the test

group before and after the intervention revealed a significant improvement, contrasting with the control group, where no significant difference was observed between the pre-test and post-test scores. These findings indicate that the home pulmonary rehabilitation intervention effectively enhances the functional exercise capacity of participants with chronic obstructive pulmonary disease. Osadnik et al. conducted a study which demonstrated that pulmonary rehabilitation is associated with marked clinical improvements in exercise capacity and quality of life after program completion in adults with asthma (24). Similarly, Reis and colleagues conducted a study to assess the impact of exercise on pain and functional capacity in breast cancer patients, concluding that exercise significantly benefits pain management and functional capacity in this population (25). These researches incorporated controlled breathing exercises to improve arterial oxygen saturation. However, the present study uniquely examined the combined effects of various methods and breathing exercises within the framework of home pulmonary rehabilitation, distinguishing it from traditional breathing exercises, such as incentive spirometry or pursed-lip breathing.

According to the findings of the present study, comparison of quality of life scores in the test group before and after the intervention revealed a significant improvement from pre-test to post-test. Conversely, the control group exhibited no significant difference in their scores during the same timeframe. These findings suggest that home-based pulmonary rehabilitation is effective in enhancing the quality of life for participants with chronic obstructive pulmonary disease (COPD). Jokar and colleagues conducted a study in 2015 to determine the impact of home-based pulmonary rehabilitation on the quality of life and fatigue of participants with chronic obstructive pulmonary disease. Their conclusion indicated that the implementation of a home-based pulmonary rehabilitation program could effectively reduce fatigue in patients with COPD (26). Similarly, the study conducted by Zheng et al. in 2022 in China demonstrated that such exercises provide significant benefits in reducing fatigue among this population (27).

One of the limitations of this study is that the exercises were conducted without direct supervision, necessitating reliance on the participant's self-report to verify exercise adherence. Additionally, the absence of a unified messaging platform among participants presented challenges in following up the patients, as communication was conducted across multiple messaging platforms. The limitations didn't affect the study’s generalizability.

Implications for practice

The findings of the present study affirm the research hypothesis and demonstrate the effectiveness of home-based pulmonary rehabilitation interventions on pulmonary indicators, including the severity of dyspnea and the overall quality of life in patients with chronic obstructive pulmonary disease (COPD). This indicates that the implementation of this treatment plan, which is recognized as a simple, cost-effective, accessible, feasible, and beneficial non-pharmacological nursing intervention, can significantly reduce dyspnea severity and enhance pulmonary metrics and quality of life for COPD patients. Home-based rehabilitation represents a critical and advantageous intervention within the nursing profession, executed through an interdisciplinary and team-oriented approach. The application of such methods, particularly those that participants can perform independently at home, is vital for delivering effective nursing care, ensuring continuity of care, and managing potential challenges in care delivery. Consequently, the integration of these interventions into nursing practice appears to be of paramount importance. Future studies are recommended to be performed and use several months of follow-up or assess pulmonary capacities by spirometry in home-based pulmonary rehabilitation.

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Conflicts of interest

The authors declare that they have no competing interests.

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Authors' Contributions

Mohammad Soleimani Arfa contributed to the conception, design, data collection, data analysis and drafting the manuscript. Fariba Borhani performed conception, design, supervision of project, and revising the manuscript. Neda Sanaie conducted data collection and revising the manuscript. Malihe Nasiri contributed to data analysis and drafting the manuscript. All authors contributed to the writing of the article and discussed on the manuscript.

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