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Original Article

Pulmonary rehabilitation training for improving pulmonary function and exercise tolerance in patients with stable chronic obstructive pulmonary disease

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Abstract: Objective: To investigate the effect of pulmonary rehabilitation training on pulmonary function and exercise tolerance in patients with stable chronic obstructive pulmonary disease (COPD). Methods: By a random number table method, 90 patients with COPD admitted to our hospital from January 2019 to January 2020 were divided into three groups: the control group (conventional treatment), the observation group A (conventional treatment + pulmonary rehabilitation training three times a week) and the observation group B (conventional treatment + pulmonary rehabilitation training five times a week), with 30 patients in each group. The pulmonary function, exercise tolerance (the 6-min walking distance (6MWD)), sleep quality (Pittsburgh Sleep Quality Index (PSQI)) and quality of life (generic quality of life inventory-74 (GQOLI-74)) before and after intervention were compared among the three groups. Also, the satisfaction rate was recorded in all groups. Results: After 6 months of intervention, the FEV_1%, FVC% and FEV_1/FVC as well as the GQOLI-74 scores increased significantly, while the PSQI scores decreased markedly in all groups as compared to those before intervention; the index levels and GQOLI-74 scores were significantly higher, and PSQI scores were markedly lower in the observation group B than in the other two groups (all $P<0.05$). After 3 and 6 months of intervention, the 6MWDs of the three groups were significantly increased compared with those before intervention, and the 6MWD was significantly longer in the observation group B than in the other two groups ($P<0.05$). Moreover, the satisfaction rate was significantly higher in observation group B than in the other two groups ($P<0.05$). Conclusion: For patients with stable COPD, pulmonary rehabilitation training based on drug therapy can improve the pulmonary function, exercise tolerance, sleep quality and quality of life more effectively than drug treatment alone. What's more, the therapeutic effect of training five times a week is significantly better than that of training three times a week.

Keywords: Chronic obstructive pulmonary disease, stable phase, pulmonary rehabilitation training, pulmonary function, exercise tolerance

Introduction

Chronic obstructive pulmonary disease (COPD) is a common and frequently-occurring disease, which greatly endangers human health. The incidence of COPD is gradually increasing under the influence of air pollution, dust, smoking and other factors. Generally, COPD is characterized by cough, expectoration, chest tightness, and shortness of breath. In severe cases, respiratory failure may even occur, seriously affecting the patients' quality of life (QoL) [1]. Pulmonary rehabilitation is the main intervention for COPD in addition to drug therapy, exerting certain favorable effects on the respiratory function [2]. O'Donnell et al. reported that decreased cardiopulmonary function in COPD patients could directly affect the exercise capacity, while appropriate exercise training could ameliorate cardiopulmonary function and exercise tolerance [3].

The core of pulmonary rehabilitation is both respiratory and exercise training which aims to reduce acute symptoms and the frequency of acute attacks, as well as promote the recovery of pulmonary function and exercise tolerance [4]. Pulmonary rehabilitation training has be-

come one of the main methods for non-drug treatment of respiratory diseases, with advantages of economy, convenience, less adverse reactions and easy operations. However, for COPD patients, there is no uniform standard concerning the start, duration and frequency of pulmonary rehabilitation training. Some scholars believe that as long as the pulmonary rehabilitation training is within a tolerable range, higher frequency delivers better outcomes. On the contrary, some scholars argue that there is no significant improvement in pulmonary function with an increase in the frequency of training [5, 6]. Therefore, we herein explored the effect of different frequencies of pulmonary rehabilitation training on the pulmonary function of COPD patients, aiming to provide a reference for clinical pulmonary rehabilitation of COPD patients.

Materials and methods

General data

We enrolled 90 patients with COPD who were admitted to our hospital from January 2019 to January 2020 by using a random number table for this prospective study. All patients were divided into the control group (conventional treatment), the observation group A (conventional treatment + pulmonary rehabilitation training three times a week) and the observation group B (conventional treatment + pulmonary rehabilitation therapy five times a week), with 30 patients in each group.

Inclusion and exclusion criteria

Patients aged 35-75 years were included if they were diagnosed with COPD according to the Guidelines for the Diagnosis and Treatment of Chronic Obstructive Pulmonary Disease [7]; were able to be discharged under stable conditions; and cooperated well with this study. In addition, patients were excluded if they additionally had lung cancer or other severe diseases of the respiratory system; were unable to participate in the 6-min walking test (6MWT); or were accompanied by severe cardiovascular and cerebrovascular diseases, mental diseases or other severe diseases. All patients gave their signed informed consent and the study was approved by the Ethics Committee of our hospital.

Methods

The control group received conventional drug treatment (e.g., anti-infection medication, antiasthmatics and expectorants) with atomization inhalation of budesonide, and underwent low-flow oxygen inhalation for 14 days if necessary.

Observation group A was given pulmonary rehabilitation training, i.e., pursed-lip breathing, abdominal breathing, and abdominal resistance training three times a week in addition to the conventional drug treatment [8, 9]. As to pursed-lip breathing, the patients were instructed to select a comfortable sitting position, inhale forcefully through the nose for 2-3 s, and hold their breath for about 2 s. Subsequently, the patients were guided to pucker their lips and exhale through their pursed lips for 4-5 s. The whole process was repeated for 15-20 min/each day. As to abdominal breathing, the patients were instructed to maintain a half-lying posture with knees bent and hands gently placed on the upper abdomen. With each breath, the hands on the stomach remained immobile and moved upward and downward accordingly. The whole process was also repeated for 15-20 min daily. As to abdominal resistance training, the patients were in a supine position with a sandbag on the abdomen that moved upward and downward with inspiration and expiration, which was repeated for 5 min/time. The weight of sandbag can be increased appropriately according to patient ability, and routine low-flow oxygen therapy was performed for 1 hour before and after the abdominal resistance training. The rehabilitation training above was conducted once every other day, three times a week, for a total of 6 months.

Observation group B was given pulmonary rehabilitation training five times a week in addition to conventional drug treatment. The training in observation group B was the same as that in the observation group A, except for the training frequency (5 times a week for 6 months).

Outcome measures

Main outcomes: Pulmonary function: Forced expiratory volume in one-second percent (FEV_1%) and forced vital capacity percent

Table 1. General data (n, $\bar{x}$ ± sd)

	Control group (n=30)	Observation group A (n=30)	Observation group B (n=30)	χ^2/F	P
Gender (n)				1.165	0.559
Male	17	14	18		
Female	13	16	12		
Age (year)	45.5±5.4	46.3±6.3	45.8±5.9	0.142	0.868
BMI (kg/m^2)	24.03±1.11	23.77±1.20	24.20±1.32	0.956	0.388
Course of disease (d)	3.33±1.04	3.56±1.28	3.30±1.11	0.461	0.632
Pulmonary function grading (n)				1.900	0.387
II	18	14	19		
III	12	16	11		
Underlying diseases (n)				2.262	0.273
Diabetes	3	5	3		
Hypertension	6	4	7		
Hyperlipidemia	2	2	3		

(FVC%) were measured by a pulmonary function instrument (Guangzhou Aoxun Instruments Co., Ltd., China) after 6 months of intervention, and the FEV_1/FVC ratio was calculated.

Exercise tolerance: The 6-min walking distance (6MWD) was measured before intervention, 1 month, 3 months and 6 months after intervention by using the 6MWT [10].

Secondary outcomes: Sleep Quality: The sleep quality was assessed by Pittsburgh Sleep Quality Index (PSQI) after 6 months of intervention [11]. In scoring PSQI, seven components were included, namely, sleep quality, sleep efficiency, sleep medication, sleep duration, sleep disturbance, sleep latency and daytime sleep dysfunction. The total score ranged from 0-21 points (each item was scored 0 to 3 points), with lower scores revealing better sleep quality.

QoL: The QoL after 6 months of intervention was evaluated by the generic quality of life inventory-74 (GQOLI-74), which incorporated 4 dimensions [12]. In scoring GQOLI-74, material life score ranged from 16-80 points, and social, physical, and psychological function score ranged from 20-100 points. The total score was 76-380 points, with higher scores indicating a better QoL.

Satisfaction with care: The patient satisfaction was evaluated by a self-made satisfaction questionnaire of our hospital, which was graded as satisfied, basically satisfied and dissatisfied. Satisfaction with care = (satisfied + basically satisfied) cases/total number of cases * 100%.

Statistical analysis

Data analyses were conducted with SPSS 20.0 software. Chi-square test (χ^2 test) was adopted for enumeration data expressed as percentage (n/%). The measurement data were expressed as mean ± standard deviation ($\bar{x}$ ± sd). Independent sample t-test was applied for the comparison among the three groups, and paired samples t-test was used for the comparison before and after intervention. *P*-values less than 0.05 were considered significant.

Results

General data

There was no significant difference in general data such as gender, age, body mass index among the three groups, suggesting the three groups were comparable (P>0.05), as shown in **Table 1**.

Comparison of pulmonary function

After 6 months of intervention, the FEV_1%, FVC% and FEV_1/FVC were significantly increased in all groups as compared to those before intervention. The index levels were significantly higher in observation group B than in the other two groups, and higher in observation group A than in the control group (all P<0.05). See **Table 2**.

Table 2. Comparison of pulmonary function ($\bar{x}$ ± sd)

Group	Time	FEV_1%	FVC%	FEV_1/FVC
Control group (n=30)	Before intervention	52.30±3.98	56.50±4.07	54.44±4.76
	6 months after intervention	54.88±3.64*	58.77±3.74*	56.97±4.60*
Observation group A (n=30)	Before intervention	52.10±4.22	56.44±4.85	54.76±4.67
	6 months after intervention	56.73±3.05*,#	61.20±4.58*,#	59.90±5.55*,#
Observation group B (n=30)	Before intervention	52.74±3.32	56.80±4.05	55.03±5.07
	6 months after intervention	58.99±3.49*,#,&	64.40±3.35*,#,&	62.85±5.36*,#,&

Note: Compared with pre-intervention, *P<0.05; compared with the control group, #P<0.05; compared with the observation group A, &P<0.05. FEV_1: Forced expiratory volume in one-second; FVC: forced vital capacity.

Table 3. Comparison of 6MWD before and after intervention ($\bar{x}$ ± sd, m)

Group	Before intervention	1 month after intervention	3 months after intervention	6 months after intervention
Control group (n=30)	35.59±4.49	36.24±3.85	37.44±5.04*	38.77±5.76*
Observation group A (n=30)	36.11±4.29	37.15±4.77	39.58±5.40*,#	40.06±4.85*,#
Observation group B (n=30)	35.96±4.84	37.35±4.40	41.96±4.40*,#,&	43.38±5.40*,#,&

Note: Compared with pre-intervention, *P<0.05; compared with the control group, #P<0.05; compared with the observation group A, &P<0.05. 6MWD: 6-min walking distance.

Table 4. Comparison of PSQI before and after intervention ($\bar{x}$ ± sd, points)

Group	Before intervention	6 months after intervention
Control group (n=30)	16.49±2.99	14.33±3.02*
Observation group A (n=30)	16.84±3.03	12.09±2.66*,#
Observation group B (n=30)	16.38±2.37	10.11±2.05*,#,&

Note: Compared with pre-intervention, *P<0.05; compared with the control group, #P<0.05; compared with the observation group A, &P<0.05. PSQI: Pittsburgh Sleep Quality Index.

Table 5. Comparison of GQOLI-74 before and after intervention ($\bar{x}$ ± sd, points)

Group	Before intervention	6 months after intervention
Control group (n=30)	192.03±20.02	210.02±23.38*
Observation group A (n=30)	194.38±24.38	224.48±20.93*,#
Observation group B (n=30)	193.47±19.94	250.05±23.37*,#,&

Note: Compared with pre-intervention, *P<0.05; compared with the control group, #P<0.05; compared with the observation group A, &P<0.05. GQOLI-74: generic quality of life inventory-74.

Comparison of exercise tolerance (6MWD)

No significant difference was identified in 6MWD among the three groups at 1 month after intervention and before intervention (P>0.05). After 3 and 6 months of intervention, the 6MWDs of the three groups were significantly increased as compared to those before intervention. The 6MWD was significantly longer in observation group B than in the other two groups, and longer in observation group A than in the control group (all P<0.05). See **Table 3**.

Comparison of sleep quality (PSQI score)

After 6 months of intervention, the PSQI scores of the three groups were reduced as compared to those before intervention. The PSQI scores were significantly lower in observation group B than in the other two groups, and lower in observation group A than in the control group (all P<0.05). See **Table 4**.

Comparison of QoL (GQOLI-74 score)

After 6 months of intervention, the GQOLI-74 scores of the three groups were increased as compared to those before intervention. The GQOLI-74 scores of observation group B were significantly higher than in the other two groups, and higher in observation group A than in the control group (all P<0.05). See **Table 5**.

Comparison of satisfaction with care

The rate of patient satisfaction in observation group B (86.67%) was significantly higher than

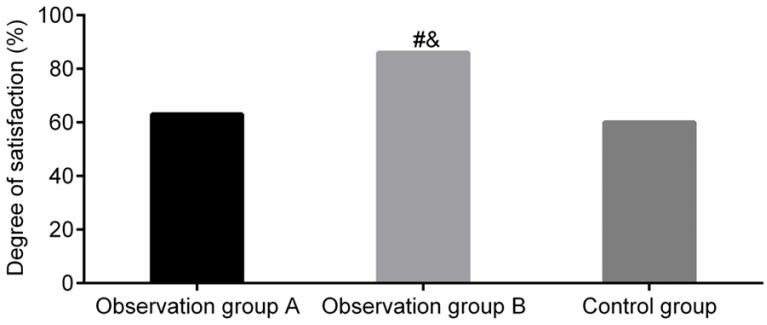

Figure 1. Comparison of Satisfaction with care. Compared with the control group, #P<0.05; compared with the observation group A, &P<0.05.

that in observation group A and in the control group (63.33% and 60.00% respectively, P<0.05). However, no significant difference was revealed in the satisfaction rate between observation group A and the control group (P>0.05). See **Figure 1**.

Discussion

COPD patients may be accompanied by obvious airflow limitation and dysfunction of pulmonary ventilation, present with significant cough, expectoration, asthma and other symptoms. For those with COPD, decreased exercise capacity over a long period leads to skeletal muscle atrophy, and decreased oxygen uptake capacity, which tends to induce hypoxemia and hypercapnia, endangering the lives of patients' [13]. Besides drug therapy, reasonable pulmonary rehabilitation interventions have significant clinical significance in facilitating the ability of skeletal muscle to take up oxygen and alleviating symptoms such as dyspnea [14].

COPD patients have long-term hypoxia due to pulmonary ventilation dysfunction and decreased saturation, which results in decreased exercise tolerance. For predicting the QoL and death of COPD patients, exercise tolerance is a valid indicator [15]. In our study, after 6-month intervention, the FEV_1%, FVC%, FEV_1/FVC and 6MWDs in the three groups were significantly increased as compared to those before intervention; the improvement was significantly greater in observation group B than in the other two groups, and greater in observation group A than in the control group. The results suggest that pulmonary rehabilitation training based on drug therapy for patients with stable COPD is more effective in enhancing their pulmonary function and exercise tolerance. Also, the treatment outcome is better when patients exercise five times a week instead of three times a week. Langer et al. identified that 6MWD was significantly increased in COPD patients after long-term pulmonary rehabilitation training [16]. However, the results of studies on the effect of pulmonary rehabilitation on the pulmonary function are still not uniform. For example, Armstrong et al. concluded that after pulmonary rehabilitation training, although FEV_1%, FVC% and other pulmonary functions were improved to a certain extent, the effect was not obvious. Hence, it has been pointed out that pulmonary rehabilitation training only plays an auxiliary role to drug intervention [17]. Nevertheless, most scholars have considered that pulmonary rehabilitation training can significantly improve the pulmonary function of patients with chronic lung disease [18, 19].

Furthermore, COPD patients have an expiratory airflow limitation that progresses irreversibly, and dyspnea that affects daily life and work. Sleep disturbance is a common comorbidity of COPD. This is mainly because symptoms such as chest tightness and dyspnea make patients have difficulty in falling asleep, with reduced sleep quality and efficiency [20, 21]. In this study, after the 6-month intervention, the PSQI scores decreased and GQOLI-74 scores increased in all groups as compared to those before intervention; while observation group B showed greater changes in the PSQI and GQOLI-74 scores than the other two groups, and observation group A revealed a better result than the control group. The results indicate that pulmonary rehabilitation training based on drug therapy can improve the sleep quality and QoL of patients with stable COPD more effectively than drug treatment alone, and the treatment outcome is better when patients exercise five times a week instead of three times a week. Similarly, Pehlivan et al. also found that appropriately increasing the frequency of pulmonary rehabilitation training contributes to the improvement of QoL in COPD patients [22].

However, there are still some limitations in our study. This research was from a single-center

with a limited sample size. The effect of training times and frequency on the pulmonary function and exercise tolerance of patients with COPD still needs to be confirmed by multi-center studies with larger sample sizes in the future.

To sum up, pulmonary rehabilitation training based on drug therapy can deliver a better treatment outcome in patients with stable COPD than drug therapy alone regarding the pulmonary function, exercise tolerance, and sleep quality and QoL, with higher frequency (five times/week) delivering better therapeutic results.

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Disclosure of conflict of interest

None.

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