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ORIGINAL

EFFECT OF OPTIMIZED COMPREHENSIVE EXERCISE PRESCRIPTION ON REHABILITATION, CARDIOPULMONARY FUNCTION AND SHORT-TERM PROGNOSIS OF PATIENTS WITH ACUTE EXACERBATION OF CHRONIC OBSTRUCTIVE PULMONARY DISEASE

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ABSTRACT

Background: An acute exacerbation of chronic obstructive pulmonary disease (AECOPD) is difficult to achieve satisfactory results only with general drug therapy in clinic. The optimized comprehensive exercise prescription is a scientific intervention that has been used in the past in the care of chronic patients. However, the effectiveness of this intervention in patients with AECOPD has been rarely reported. **Objective:** To explore the effect of optimized comprehensive exercise prescription on rehabilitation effect, cardiopulmonary function, and short-term prognosis of patients with AECOPD. **Methods:** During February 2019 to August 2022, 140 patients with AECOPD cured in our hospital were randomly classified into control group (n=70) and study group (n=70). A routine intervention was provided to the control group, while a comprehensive exercise prescription intervention was provided to the study group. The efficacy of the different interventions, pulmonary function, life quality, severity of dyspnea, improvement of exercise ability and blood gas analysis were compared. **Results:** In the control and study groups, the total effective rate was 65.71% and 90.00% respectively. A better intervention efficacy was observed in the study group (P<0.05). The forced expiratory volume in the first second (FEV1), the expiratory flow at forced exhalation of 25%/75% vital capacity (FEF25%-75%) and the percentage of forced expiratory volume in 1 second to forced vital capacity (FEV1/FVC) in the study group after the different interventions were higher (P<0.05). After the intervention, the St. George respiratory questionnaire (SGRQ) of patients lessened, and the SGRQ scores in the study group were lower (P<0.05). After the intervention, the dyspnea score lessened, and the dyspnea score of the study group was lower (P<0.05). After the intervention, the 6-minute walking distance (6MWD) of patients elevated, and the 6MWD in the study group was higher (P<0.05). After the intervention, the arterial partial pressure of oxygen (PaO2) elevated and the arterial partial pressure of carbon dioxide (PaCO2) lessened. The PaCO2 in the study group was lower, and PaO2 was higher (P<0.05). **Conclusion:** Optimized comprehensive exercise prescription can remarkably improve the exercise ability and life quality of patients with acute exacerbation of stable chronic obstructive pulmonary disease. In the meanwhile, it can also enhance the cardiopulmonary function of patients, improve short-term prognosis, and achieve good rehabilitation outcomes.

KEYWORDS: Optimized comprehensive exercise prescription; Chronic obstructive pulmonary disease; Acute exacerbation; Rehabilitation effect; Cardiopulmonary function; Short-term prognosis

1. INTRODUCTION

An acute exacerbation of chronic obstructive pulmonary disease (AECOPD) refers to the sudden worsening of symptoms during the course of chronic obstructive pulmonary disease (COPD). It is characterized by the deterioration of respiratory symptoms beyond the level of daily changes, such as dyspnea, cough, expectoration, and other symptoms appear in a short time, sputum volume increase or purulent, and may be accompanied by obvious inflammatory reaction (Ritchie & Wedzicha, 2020). Acute episodes and existing complications can affect the progression and severity of the disease. According to the 2013 Global Burden of Disease report, chronic obstructive pulmonary disease (COPD) is ranked as the third leading cause of death globally. Each year, approximately 3 million people die from COPD, of which more than 31.3% are in China, and after 2030, more than 4.5 million people will die each year from COPD and related complications. Approximately 100 million people in China are diagnosed with COPD, which accounts for 7% of the total population (Duffy & Criner, 2019). The frequency of acute exacerbations in patients with COPD ranges from 0.5 to 3.5 times per year, and approximately one third of patients hospitalized with AECOPD are readmitted for a relapse within 2 months of discharge (Halpin et al., 2021). Frequent acute exacerbation will lead to a sharp decline in pulmonary function of COPD patients, thus aggravating symptoms and seriously affecting the life quality of patients. Furthermore, it can also cause damage to extra-pulmonary organs during acute exacerbations, such as skeletal muscle weakness. Skeletal muscle incompetence can affect the patient's mobility and exercise endurance, so creating a vicious circle. Some scholars have put forward that patients with AECOPD will have skeletal muscle incompetence problems due to lack of scientific and effective exercise, which will aggravate the condition of AECOPD and directly increase the readmission rate and mortality of patients (Araújo et al., 2022; Riley & Sciurba, 2019). The investigation found that patients with AECOPD have a high risk of death, with the risk of death reaching more than 20% within one year and the mortality rate rising to about 55% within five years (Martí et al., 2020). At the same time, patients with AECOPD will further increase their hospitalization and treatment costs due to recurrent disease, systemic inflammatory reaction, lessened living ability and other reasons, which will increase the socio-economic burden (Cassady & Reed, 2019). By 2020, the disease economic burden of COPD patients in China will rise to the first place of medical expenses (Brennan et al., 2022). Thus, academic circles have begun to focus on comprehensively strengthening research into AECOPD treatment and rehabilitation. Currently, there are many clinical treatments for AECOPD. The European Respiratory Society (ERS) and the American Thoracic Society (ATS) have jointly developed guidelines for the management of COPD known as the ERS/ATS guidelines. These guidelines provide a standardized approach to the treatment of AECOPD (Riley & Sciurba, 2019). Patients with AECOPD can alleviate the symptoms of infection and dyspnea to a certain extent through antibiotics, hormones, noninvasive auxiliary ventilation, but patients with AECOPD who stay in bed for a long time cannot solve their own skeletal muscle dysfunction and muscle mass decline with drugs and noninvasive mechanical ventilation.

In 2007, the American College of Physicians (ACP), the American College of Chest Physicians (ACCP) and ERS/ATS jointly recommended that lung development should be considered if a patient has dyspnea, limitation of motion or a predicted value of the first second forced expiration (FEV1%pre>50%) (Akman et al., 2023; MacLeod et al., 2021; Polachini et al., 2022). In recent years, the concepts related to exercise prescription and pulmonary rehabilitation have also been applied to patients with COPD, where exercise interventions can help improve lung function and immune function in COPD patients (Mathioudakis et al., 2020; Torres-Sánchez et al., 2018). At present, a small number of preliminary clinical studies abroad have shown that exercise can effectively improve the oxygen carrying capacity of patients with AECOPD, reduce postoperative complications, shorten hospital stay, reduce the risk of lung infection, relieve anxiety and depression, and improve the life quality (Brennan et al., 2022; Martínez-Gestoso et al., 2021; Prosper et al., 2023). This study inspired an attempt to improve the rehabilitation outcome, cardiorespiratory fitness, and short-term prognosis of patients with AECOPD with an optimized comprehensive exercise prescription. Currently, there are fewer studies on optimizing comprehensive exercise prescription for patients with AECOPD in China. It is necessary to further study the effect of optimized comprehensive exercise prescription on patients with AECOPD, in order to fully demonstrate the application value of this intervention and lay a theoretical foundation for its popularization and application. The main participants of this study have multidisciplinary practical or educational experience in nursing, rehabilitation medicine, clinical medicine, sports medicine, and sports medicine. The researchers therefore have strengths in movement demonstration, correction of poor patient movements, exercise training process control, musculoskeletal biomechanical protection measures, and health education. This study is an attempt to present a summary of experiences in optimizing the implementation of comprehensive exercise prescription, and to provide a greater basis for the popularization and application of relevant techniques by clinical practitioners, exercise prescribers and sports health workers.

2. Patients and methods

2.1 Research flow chart

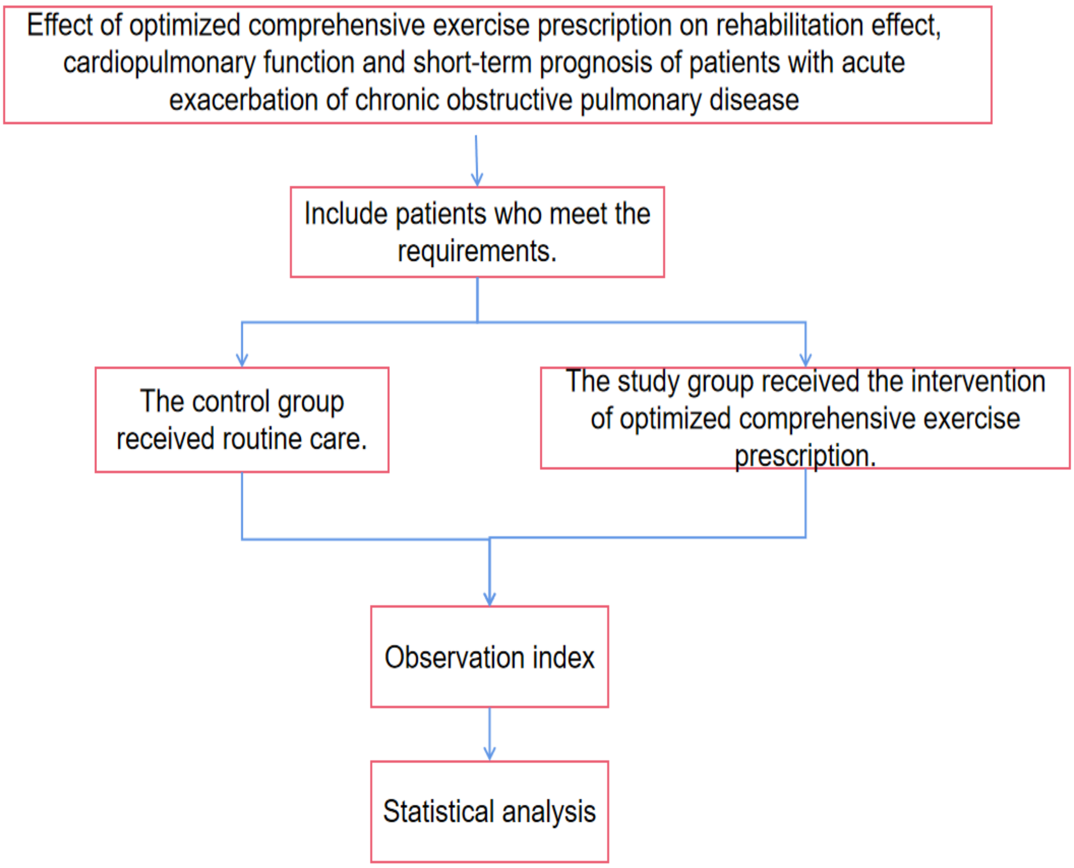

Figure 1: Flow chart of this research

2.2 General information

During February 2019 to August 2022, 140 patients with AECOPD cured in our hospital were randomly classified into control group (n=70) and study group (n=70). A routine intervention was provided to the control group, while a comprehensive exercise prescription intervention was provided to the study group. In the control group, the age of the patients ranged from 56 to 74 years (mean=60.38 ±3.56) years, including 48 males and 22 females.

The course of disease was from 8 to14 years (average course = 11.38 ±2.93) years. The body mass index (BMI) was from 17.30 to 28.10kg/m^2 (mean=23.11 ±2.14) kg/m^2. In the study group, the age of the patients was 54 to 76 years old (mean=60.86 ±3.41) years old, including 45 males and 25 females. The duration of the disease ranged from 7.5 to 15 years (mean=11.78±2.52) years. The BMI ranged from 17.22 to 28.17kg/m^2 (average =23.15±2.17) kg/m^2. No remarkable difference was found in the general data (P>0.05). Informed consent forms were signed by all patients for this study, which was approved by our hospital's Medical Ethics Council.

Inclusion criteria: (1) all the patients were diagnosed with COPD and were in acute exacerbation, and the diagnostic criteria were referred to the relevant literature (Staub et al., 2019); (2) the patients could walk independently; (3) the patients were 50-80 years old; (4) prior to enrollment, the patient had not participated in any form of pulmonary rehabilitation; (5) the patients had a clear consciousness and could clearly express their wishes to answer the questions; (6) all the patients voluntarily participated in lung rehabilitation training.

Exclusion criteria: (1) patients with hemodynamic instability (such as acute left heart failure, intractable hypotension, malignant arrhythmia, unstable angina pectoris, history of acute myocardial infarction within a month); (2) patients with other systemic diseases, like severe liver and kidney dysfunction, malignant tumors, motor system and neuromuscular diseases; (3) patient in severe respiratory failure requiring ventilator; (4) there were serious cognitive and mental disorders. Calculation formula of sample size:

$$n_1 = \frac{\left[z_{\alpha/2}\sqrt{p(1-p)(1+c)/c} + Z_\beta\sqrt{p_1(1-p_1)+p_2(1-p_2)/c}\right]^2}{(p_1-p_2)^2}$$

The bilateral α is 0.05, β is 0.2, the intervention effect (total effective rate) is taken as the effect index. The parameters are set as P1=0.96, P2=0.77. After calculation, the sample size of each group was 63 cases (dropout rate= 10%). The two groups each included about 70 patients, a total of 140 patients.

2.3 Treatment methods

The control group received routine intervention. (1) According to the consensus of Chinese experts in diagnosis and treatment of AECOPD (2017) (Gu et al., 2022), the medication given included the administration of bronchodilators, hormones, antibiotics, anti-asthmatic agents, expectorants and other drugs.

(2) Administration of oxygen by nasal cannula with an oxygen flow rate of 1L/min-2L/min for more than 15 hours a day.

(3) Psychological intervention: to understand the reasons for the patient's anxiety, so that the patient would be convinced and reassured, eliminating the patient's pessimism and increasing the patient's understanding of and confidence in the disease.

(4) Nutritional support: a diet was given enough calories, high quality protein and high fat.

(5) Health education: the education covered the basics of the disease, effective methods of sputum removal, dietary guidance, smoking cessation, and introduced the content and role of rehabilitation.

(6) Respiratory muscle training: the patient was instructed to contract the lips and breathe in and out in a ratio of 1:2, trained 3-4 times a day for 10-15 minutes each time.

(7) Patients were required to get out of bed every day, but the time and intensity of activity were not required.

Based on the control group, the study group received the intervention of optimized comprehensive exercise prescription. The specific measures are as follows. According to the intensity calculation formula in the Pulmonary Rehabilitation Toolkit provided by the Australian Lung Foundation: (6 minutes walking distance + 6) x prescription time. An exercise prescription was developed and the patient was instructed in exercise training for a minimum of 10 days of intervention from the second day of admission to the day of discharge. (1) Forms of exercise included walking exercises, referencing everyday walking movements and swinging your arms as much as possible. (2) Exercise intensity: Using the 6-minute walking distance test (6MWD), the patient's 6-minute walking distance was measured strictly. The exercise intensity was calculated according to the formula in the Lung Rehabilitation Kit provided by the Australian Lung Foundation: (6-minute walking distance / 6) × prescription time walking distance = 6-minute walking distance + 6-minute walking distance = 1-minute walking distance x 30-minute walking distance =

1-minute walking distance x 20-minute walking distance =-1-minute walking distance x 10-minute walking distance. Throughout the walking training, the patient was unable to achieve the same walking speed as the 6-minute walk test. Therefore, the prescribed exercise intensity was set at 80% of the calculated distance of the 6-minute walk. (3) Exercise time was 08:00 a.m. and 15:00 p.m. twice a day. (4) Duration of exercise: the training should be started at 80% of the 10-minute walking distance as the exercise intensity. If the patient could tolerate it, the patient was encouraged to extend the training time until he could hold it for 30 minutes until he was discharged.

2.4 Observation index

2.4.1 Evaluation of intervention effect

After 4 weeks of intervention, the effect of the intervention was assessed. The patient's discomfort was remarkably improved, cough and asthma disappeared, lung auscultation showed a reduction in croup, cardiac function classification improved by 2 grades compared to pre-treatment and lung auscultation showed a reduction in croup; and cardiac function elevated by 1 grade was effective. No remarkable improvement was found in patients' symptoms, and no remarkable change in cardiac function and pulmonary auscultation was invalid. Total effective rate = (number of markedly effective cases + effective cases) / total number of cases × 100%.

2.4.2 Pulmonary function test

The lung function test was carried out by the medical staff specialized in the lung function room using the test method recommended by the German pulmonary function instrument (Germany) according to the ATS/ERS guidelines. The evaluation was carried out before and 4 weeks after the intervention.

The test procedure was as follows: the subject was instructed to sit up straight and practice breathing hard according to the instructor's instructions. After the subject had correctly mastered the breathing action, a nose clip and mouth bite were attached after ensuring that the mouth and nose were not leaking, start breathing. Subjects were required to inhale quickly and forcefully, and exhale forcefully, quickly and without interruption until they exhaled completely, usually at least for more than 6 seconds complete at least 3 tests after a short rest. The test indicators included FVC, FEV1, FEF25%-75%, and calculated the percentage of FEV1/FVC.

2.4.3 Life quality questionnaire

Before and 4 weeks after exercise intervention, St George's Breathing Questionnaire (SGRQ) was adopted to assess the life quality of patients (Lo et al., 2020). There are 50 questions in SGRQ questionnaire, which can be classified into three items including symptoms, activities, and influences. The completed questionnaire was entered into the SGRQ scoring software (developed by the Department of Respiratory Medicine, China Union Medical College, Chinese version) and weighted according to the different items selected by the patient to generate a final SGRQ total score and three sub-scores. The score ranges from 0 to 100, and as the score rises, the quality of life of the patient becomes worse.

2.4.4 Dyspnea questionnaire

The modified Medical Research Council (mMRC) was adopted to assess the subjective breathing of COPD patients before and 4 weeks after the intervention (Munari et al., 2021). mMRC adopts a scale of 5 (0-4). A score of 0 indicated little dyspnea and a score of 4 indicated severe dyspnea. Specific test levels and scoring criteria, a score of 0 means that the patient only feels breathless during strenuous exercise; a score of 1 means that the patient feels breathless when rushing or walking uphill; a score of 2 means that the patient needs to stop breathing when slower than their peers or when engaging in the same intensity of activity; a score of 3 means that the patient stops breathing after every 100 meters or after walking on level ground for a few minutes; a score of 4 means that the patient has to stay at home or suffers from shortness of breath.

2.4.5 Athletic ability

The exercise ability of both groups was evaluated before and 4 weeks after intervention, and the 6-minute walking distance was used as the evaluation index of exercise ability. The specific test methods and matters needing attention were strictly in accordance with the 6MWT guidelines issued by the American Thoracic Association in 2002. The test site was a 30-meter-long horizontal corridor in the ward, marked every 5 meters, and turned to place obvious signs, so that the subjects could try their best to walk as fast as they can. At the end of the test, the subjects immediately stopped and marked by the testers, and then the testers calculated the distance the subjects walked in 6 minutes and did not speak during the walk.

Normative language (hold for 1 minute if you are doing well) must be used as a reminder during the experiment, but no other encouraging language (or body language). At least two tests should be conducted, and the one with the longest walking distance should be taken as the result. The distance walked was accurately measured according to the distance markers on the ground. The total distance walked was calculated, rounded off to the nearest metre and finally recorded on the registration form.

2.4.6 Blood gas analysis index

Arterial blood samples were collected without oxygen inhalation, and arterial PaO2 and partial PaCO2 were measured by blood gas analyzer before and 4 weeks after intervention.

2.5 Statistical analysis

The data were analyzed and processed by SPSS24.0 statistical software. A ($\bar{x}$±s) symbol is used to indicate measurements with a normal distribution or approximate normal distribution. Comparing the two groups was done using paired t-tests, while comparing the two groups separately using independent sample t-tests. The n (%) was adopted to represent the counting data, and χ 2 test was adopted. $P<0.05$ was the differences were statistically remarkable.

3. Results

3.1 Comparison of intervention effect

The study group exhibited a total effective rate of 90.00%, with 38 cases showing marked effectiveness, 25 cases showing effectiveness, and 7 cases showing ineffectiveness. In comparison, the control group had a total effective rate of 65.71%, with 23 cases showing marked effectiveness, 23 cases showing effectiveness, and 24 cases showing ineffectiveness. An improved intervention effect was observed in the study group ($P<0.05$). In Fig.2, you can see all data results.

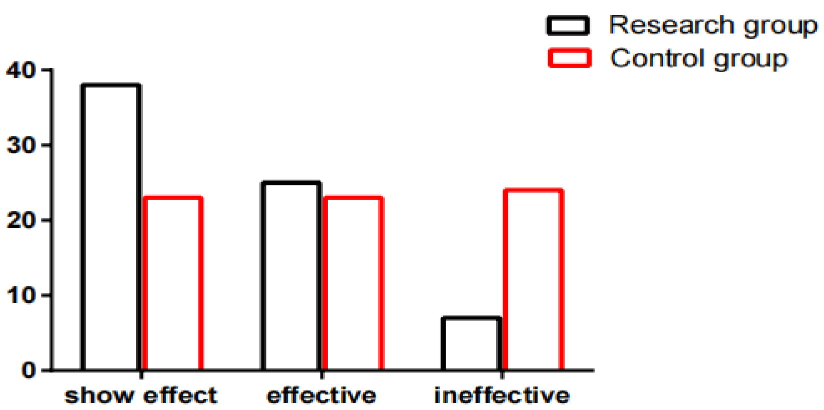

Figure. 2: Comparison of intervention effects

3.2 Comparison of pulmonary function

No remarkable difference was found in lung function before intervention ($P>0.05$). After the intervention, the lung function was improved. The FEV1, FEF25%-75% and FEV1/FVC in the study group were higher ($P<0.05$). In Table 2, you can see all data result.

Table 2: The pulmonary function indexes［$\bar{x}$±s，%］

GROUP	N	FEV1（%）		FEF25%-75%		FEV1/FVC（%）	
		BEFORE INTERVENTION	AFTER INTERVENTION	BEFORE INTERVENTION	AFTER INTERVENTION	BEFORE INTERVENTION	AFTER INTERVENTION
C GROUP	70	29.48±5.93	28.48±4.31	46.69±5.34	49.18±5.91*	63.19±5.91	62.18±5.29
R GROUP	70	29.18±5.44	35.48±5.91*	46.68±4.78	54.18±3.81*	63.58±5.53	69.38±4.38*
T		0.311	8.006	0.011	5.949	0.403	8.771
P		＞0.05	＜0.01	＞0.05	＜0.01	＞0.05	＜0.01

Note: ** compared with the same group before intervention (P<0.05).*

3.2 SGRQ score comparison

No remarkable difference was found in SGRQ score before intervention (P>0.05). After the intervention, the SGRQ scores of patients lessened, and the SGRQ scores in the study group were lower (P<0.05). In Table 3, you can see all data results.

Table 3: The SGRQ scores between the two groups［$\bar{x}$±s，points］

GROUP	N	BEFORE INTERVENTION	AFTER INTERVENTION
C GROUP	70	54.58±3.91	43.19±5.76*
R GROUP	70	54.62±4.83	38.48±4.91*
T		0.053	5.206
P		＞0.05	＜0.01

Note: ** compared with the same group before intervention (P<0.05).*

3.3 Comparison of dyspnea score

No remarkable difference was found in dyspnea score before intervention (P > 0.05). After the intervention, the dyspnea score lessened, and the dyspnea score of the study group was lower (P<0.05). In Table 4, you can see all data results.

Table 4: The dyspnea scores［$\bar{x}$±s，points］

GROUP	N	BEFORE INTERVENTION	AFTER INTERVENTION
C GROUP	70	3.49±0.31	2.48±0.43*
R GROUP	70	3.48±0.36	1.58±0.42*
T		0.176	12.527
P		＞0.05	＜0.01

Note: ** compared with the same group before intervention (P<0.05).*

3.4 Comparison of 6MWD

Compared with 6MWD, no remarkable difference was found before intervention (P>0.05). After the intervention, the 6MWD of patients elevated, and the 6MWD in the study group was higher (P<0.05). In Table 5, you can see all data results.

Table 5: The results of 6MWD［$\bar{x}$±s，m］

GROUP	N	BEFORE INTERVENTION	AFTER INTERVENTION
C GROUP	70	104.85±12.83	203.85±14.98*
R GROUP	70	105.39±11.73	289.49±32.18*
T		0.259	20.185
P		＞0.05	＜0.01

Note: ** compared with the same group before intervention (P<0.05).*

3.5 Comparison of arterial blood gas analysis

No remarkable difference was found in arterial blood gas analysis before intervention (P>0.05). After the intervention, PaO2 elevated and PaCO2 lessened. PaCO2 in the study group was lower, and PaO2 was higher (P<0.05). In Table 6, you can see all data results.

Table 6: The results of arterial blood gas analysis before treatment［$\bar{x}$±s，mmHg］

GROUP	N	PAO2		PACO2	
		BEFORE INTERVENTION	AFTER INTERVENTION	BEFORE INTERVENTION	AFTER INTERVENTION
C GROUP	70	55.19±5.93	64.93±2.84*	56.69±2.84	45.69±4.43*
R GROUP	70	55.48±5.18	76.18±3.91*	56.48±2.33	38.58±3.81*
T		0.308	19.477	0.478	10.180
P		＞0.05	＜0.01	＞0.05	＜0.01

Note: ** compared with the same group before intervention (P < 0.05).*

4. Discussion

As the development of COPD proceeds, AECOPD marks the onset of acute respiratory symptoms that exceed daily changes in respiratory symptoms. The number of acute exacerbations in COPD patients is 0.5 - 3.5 times per year (Huebner et al., 2022). Frequent acute exacerbations in patients with COPD can result in not only a drastic decline in lung function but also nutritional imbalances and reduced skeletal muscle strength. Even if patients with AECOPD receive conventional drug treatment, it is very difficult to improve lung function and life quality in a short time, and even if they can be successfully improved (Hoult et al., 2022). A few of clinical practices have proved that early lung rehabilitation can benefit patients with acute exacerbation of COPD (Cole & Smith, 2020; Pépin et al., 2022; Staub et al., 2019). Exercise therapy, as the core of lung rehabilitation, has attracted more and more attention in the acute exacerbation of COPD.

Pulmonary rehabilitation programs have become crucial when treating COPD, and exercise intensity has been identified as a key factor in their effectiveness (López-López et al., 2021). Due to the limitation of AECOPD patients' own diseases and the decline of exercise endurance, what intensity of exercise training they can withstand is still controversial at present, so choosing appropriate exercise intensity in early exercise rehabilitation has become the key to exercise training in the acute exacerbation of COPD (Kichloo et al., 2019). The pulmonary rehabilitation therapy has gradually come into people's attention in China, it is used in patients with stable COPD. There are few studies on early rehabilitation in acute exacerbation and early discharge after acute exacerbation, but foreign scholars have studied this field for a long time (Crisafulli et al., 2020; Martí et al., 2020). Early pulmonary rehabilitation in patients with AECOPD can prevent the deterioration of skeletal muscle function, enhance exercise endurance and daily activity ability, and improve lung function and life quality (Bräunlich et al., 2022; Lancaster et al., 2021). The main intervention methods of early rehabilitation are exercise training, breathing training, neuro-myoelectric stimulation, ultrashort wave therapy, health education, nutrition intervention, psychological support and counseling and so on.

Aerobic and resistance exercises are the main forms of exercise training in pulmonary rehabilitation, with lower limb exercises comprising a significant portion of this training. The American Lung Rehabilitation Guide points out that lower limb exercise training is a necessary content of COPD rehabilitation. Walking training is recommended to be the most accessible to patients because it is simple and well tolerated (Al-Hasan & Al-Jaghbeer, 2020). The optimized comprehensive exercise prescription is respected by most patients because it can repeat exercise in a short time, rhythmic and planned movements to achieve the improvement effect of general physical training on heart, lung, and exercise ability. Cardiopulmonary function is not only an important indicator of cardiovascular health, the improvement of this index also contributes to the improvement of the whole circulatory system to lessen the risk of chronic diseases, alleviate the related symptoms of patients with chronic diseases (Al-Hasan & Al-Jaghbeer, 2020).

In order to achieve better results when preventing and treating chronic diseases, the formulation of the optimized comprehensive exercise prescription training program needs to be jointly formulated by medical and sports professionals. The basic training for optimizing the comprehensive exercise prescription is to adapt the appropriate amount, intensity and intervals of exercise for patients with different underlying conditions (Studer et al., 2022). The optimized comprehensive exercise prescription generally requires rest or low-intensity exercise in the middle of the exercise, the whole training process takes a short time, and there are preparatory activities and relaxation activities after the end of exercise (Lawless et al., 2022). Clinically, the application of optimized comprehensive exercise prescription puts more emphasis on safety and patients' own feelings and can individualize the exercise mode and intensity according to the course and symptoms of patients with different basic conditions. in order to obtain the best curative effect (Spies et al., 2021). Our results suggest that A better intervention efficacy was observed in the study group.

The FEV1, FEF25%-75% and FEV1/FVC in the study group were higher. The SGRQ score in the study group was lower. Compared with the dyspnea score, the dyspnea score in the study group was lower. The 6MWD of the study group was higher. In addition, PaCO2 in the study group was lower and PaO2 was higher. After a period of individual walking exercise, the improvement in dyspnea scores and SGRQ scores in the study group was better, indicating that the optimized comprehensive exercise prescription training can remarkably enhance the physiological function of patients with acute exacerbation of COPD, achieve good rehabilitation results and help improve the short-term prognosis of patients.

The prescription designed in this study includes respiratory muscle training, endurance training and anti-resistance exercise, which is in line with the prescription scheme of lung rehabilitation exercise and the recommendation of the American Association of Sports Medicine (ACSM) guidelines. The intervention of optimized comprehensive exercise prescription adopted in this study can also avoid sports injury and aggravate the condition of patients caused by overload exercise, which is secure and feasible (Brown & Braman, 2020). For patients with acute exacerbation of COPD, early low-intensity exercise training can effectively improve the patient's exercise endurance, high-intensity endurance training can effectively improve the range of physiological function, and more beneficial.

Patients with acute exacerbations of COPD are advised to undertake pulmonary rehabilitation training as early as possible. High intensity endurance training can be appropriate as physical tolerance improves (Chan & Lim, 2019). During the whole training period, oxygen inhalation was allowed and carried out under the supervision and guidance of doctors. Meanwhile, the heart rate, blood oxygen saturation and dyspnea were closely monitored to ensure the safety and effectiveness of the training process (Golpe et al., 2022).

5. Conclusion

In summary, the optimized comprehensive exercise prescription not only remarkably improved exercise capacity in patients with acute exacerbations of stable COPD, but also improved cardiopulmonary function and short-term prognosis. It is suggested that multi-regional, multi-center and large sample studies can be conducted in future studies.

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