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*Original Article*

# The effects of cardiac exercise rehabilitation training on the cardiopulmonary function and quality of life in patients with chronic stable heart failure

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**Abstract:** Objective: To explore the effects of cardiac exercise rehabilitation training on the cardiopulmonary function and quality of life in patients with chronic stable heart failure. Methods: A prospective study was conducted on 84 patients with chronic stable heart failure who were admitted to the Department of Cardiology in our hospital from September 2018 to September 2019. They were randomly assigned to a control group and an observation group. The patients in the control group received conventional drug treatment, and the patients in the observation group received cardiac exercise rehabilitation training in addition to the conventional drug treatment. The cardiopulmonary exercise test (CPET) and 6-minute walking distance test results were recorded and compared between the two groups before and after the treatment. The patients' N-terminal pro-brain natriuretic peptide (NT pro-BNP) plasma levels were measured in the laboratory. Their quality of life was evaluated using the MOS item short from health survey (SF-36) rating scale. Results: After the treatment, the peak heart rate, ventilation/carbon dioxide slope ($VE/VCO_2$ slop), and NT pro-BNP levels of the two groups were all largely decreased compared to the levels before the treatment, and there were significant differences between the two groups ($P<0.05$). In addition, the patients' exercise tolerance (METs), volume peak oxygen ($VO_2$ peak) levels, SF-36 scores, 6-min walking distances, pulse oxygen levels, and anaerobic thresholds were all elevated through the treatment, and significant differences still existed between the two groups ($P<0.05$). Conclusion: Cardiac exercise rehabilitation training can improve the cardiopulmonary function and enhance both the exercise endurance and quality of life of patients with chronic stable heart failure to a certain extent.

**Keywords:** Chronic heart failure, cardiac exercise rehabilitation training, quality of life

## Introduction

The latest cardiovascular disease reports show that the morbidity and mortality of cardiovascular diseases are 7.7% and 98-100/10 million respectively, showing an increasing yearly trend [1]. Heart failure is the common late manifestation of various types of heart diseases (including cardiomyopathy, coronary heart disease, and heart valve disease), which are mainly manifested by a change in the cardiac ejection function and the reconstruction of the heart structure [2]. Since the beginning of the 21st century, the increasing incidences of chronic diseases such as hypertension, diabetes, and obesity further induce a higher yearly incidence of chronic heart failure [3]. According to the latest epidemiological surveys, heart failure has become a worldwide killer and shows a youthful trend. Therefore, it can be seen that heart failure is a significant disease threatening public health in China [4, 5].

Main manifestations of heart failure are cardiac filling and/or a reduction of ejection ability, both of which lead to a limitation of cardiac function. Also, heart failure is the late manifestation of heart disease, which not only affects patients' quality of life, it also seriously endangers the patients' lives. At present, the treatments for heart failure mainly include surgical heart transplantation and internal medical treatment [6, 7]. However, due to the limiting factors such as donor limitation, potential graft

rejection, and lifelong medication, heart transplantation cannot be accepted as the first-line treatment for heart failure. Thus, medical treatment is regarded as the first-line treatment method of heart failure because it can effectively improve the clinical symptoms (including chest tightness, shortness of breath, the gastrointestinal response, decreased exercise ability, etc.) of patients mainly through improving myocardial remodeling, reducing the incidence of malignant arrhythmia, decreasing the rate of myocardial oxygen consumption and relieving the myocardial burden, etc. [8, 9].

With the continuous improvement of the treatment for cardiovascular diseases, cardiac exercise rehabilitation is found to be helpful to improve cardiac function and balance the heart's risk factors, such as blood pressure, blood lipids, and blood sugar, ultimately improving patients' prognoses and quality of life. However, little research about cardiac exercise rehabilitation on chronic heart failure has been conducted until now [10, 11]. Based on this, our present study focuses on the effects of cardiac exercise rehabilitation training on the cardiopulmonary function and quality of life of patients with chronic stable heart failure, so as to provide a theoretical basis for improving the clinical treatment measures of heart failure and improving patients' quality of life.

## Materials and methods

### *Research objects*

A prospective study was conducted on 84 patients with chronic stable heart failure who were admitted to the Department of Cardiology in The Second Affiliated Hospital of Fujian Medical University from September 2018 to September 2019. These patients were randomly assigned to the control group or the observation group, with 42 cases in each group.

Inclusion criteria: (1) All the patients were diagnosed following the diagnostic criteria from *Diagnosis and Treatment of Chronic Heart Failure* of the American Heart Association [12]. (2) Patients aged 18-70. (3) Patients with cardiac function classes II-III. (4) Left ventricular ejection fraction (LVEF) <45% by transthoracic color Doppler echocardiography.

Exclusion criteria: (1) Patients suffering from coronary artery diseases or coronary syndrome. (2) Patients with a history of malignant arrhythmia or patients with an automatic defibrillation device. (3) Incomplete control of heart failure symptoms and hemodynamic instability. (4) Patients with the following basic diseases: aortic stenosis, hypertrophic obstructive cardiomyopathy, left ventricular thrombus. (5) Patients also suffering from major organ diseases such as liver and kidney dysfunction. (6) Patients also suffering from cancer.

Both groups of patients signed informed consent forms. The study was approved by the Ethics Committee of The Second Affiliated Hospital of Fujian Medical University.

### *Methods*

*Treatment methods:* After admission, the patients in the two groups were treated according to the relevant guideline recommendations [13]. At the same time, these following measures were administered to the patients depending on the situation: improve myocardial remodeling (Acertil, Servie (Tianjin) Pharmaceutical Co., Ltd, China), digitalis cardiotonic (Digoxin, Sanofi, France), β receptor blocker to reduce hypoxia consumption (Betaloc, AstraZeneca PLC, UK), diuretics to reduce the heart burden (hydrochlorothiazide tablets, Renhetang Pharmaceutical Co., Ltd., China), regular oxygen inhalation and electrocardiogram monitoring etc.

*Methods of cardiac rehabilitation training:* A personalized cardio rehabilitation exercise prescription was made according to the results of the cardiopulmonary exercise test combined with the results of the 6-min walking distance test, the N-terminal pro-brain natriuretic peptide (NT pro-BNP), and the left ventricular ejection fraction. The main activities included warm-up exercises, aerobic exercises, resistance exercises, and relaxation exercises [14].

Warm-up exercise: The main warm-up exercise was easy stretching with low oxygen consumption, lasting for 5 min. The main purpose of the warm-up exercise is to strengthen the adaptability of the cardiovascular system and the related joint activity, so as to prepare for the following sports training.

Aerobic exercise: Aerobic exercise is the core of the exercise training. The exercise intensity was evaluated according to each patient's heart

rate through the treadmill and fast walking, with a frequency of 3-5 times/week and 30-50 minutes/time. Target heart rate = (maximum heart rate - resting heart rate) * exercise intensity + resting heart rate. We started with half of the maximum intensity, up to 80%. The patients' degree of exercise fatigue is evaluated by referring to the Borg score, controlling it at 13-14 points.

Resistance exercise: The main resistance exercises were the dumbbell and the elastic band, with a frequency of three times per week. Each muscle group was trained two sets each session, 10-15 repetitions per set, with a rest of 2-3 minutes between sets. The Borg score was no more than 12 points.

Relaxation exercise: The relaxation exercise is mainly static stretching. Each part is maintained for about 15 s, but the longest is no more than 90 s. The intensity is based on no pain. The exercise involves 3-5 stretches for each muscle group, lasting for 3-5 min, and the patients can gradually extend the time according to their own conditions.

*Outcome measures*

*Main outcome measures:* Twelve weeks was taken as the node in our study. At the end of the study, the patients' cardiopulmonary functions were evaluated using the CPET cardiopulmonary exercise test system (Schiller104T, Switzerland). The gas exchange index, heart rate, blood pressure, electrocardiogram, and oxygen saturation were measured and recorded simultaneously. After the exercise test, the heart rate, ventilation/carbon dioxide slope ($VE/VCO_2$ slope), exercise tolerance (METs), volume peak oxygen ($VO_2$ peak), pulse oxygen and anaerobic threshold were all calculated [15].

*Secondary outcome measures*

The secondary outcome measures mainly include the following items. 1) Walking distance within 6 min: Record the patient's maximum walking distance within 6 minutes (the patients are accompanied by medical staff, so if the patient has chest distress or shortness of breath, the patient's ventricular arrhythmia is detected by telemetry electrocardiogram monitoring, so we can terminate the test immediately). 2) Serum NT pro-BNP levels: Fasting venous blood 6-8 mL was collected before and after the treatment in both groups and the serum (plasma) samples were obtained after centrifugation (3,000 r/min) for 10 min. NT pro-BNP was measured using a fluorescent immunoanalyzer (VIDAS 30, France). 3) SF-36 scores [16]: This survey consists of the following eight dimensions, including general health status, physiological function, social function, emotional function, physical pain, physiological function, mental health, energy. The higher the score is, the better the quality of life is. 4) Rate of re-hospitalization and the incidence of arrhythmia: The re-hospitalization rate and the incidence of arrhythmia of the two groups in the study period were calculated. Re-hospitalization rate = cases of re-hospitalization/total cases * 100%. Incidence of arrhythmia = cases of (atrial arrhythmia + ventricular arrhythmia)/total cases * 100%.

*Data analysis*

All the data were analyzed using SPSS 22.0 statistical analysis software. The measurement data was expressed as the mean ± standard deviation ($\bar{x}$ ± sd). Independent t-tests and paired t-tests were used for the intergroup comparisons and the intragroup comparisons, respectively. The enumeration data was expressed as the number of cases/percentage (n, %). A chi square test was employed to compare the groups and $\alpha$=0.05 was used as the inspection standard. $P<0.05$ indicated statistical significance.

## Results

*Comparison of the baseline data*

No significant differences were shown between the two groups in terms of gender, age, combined diseases (hypertension, hyperlipidemia, and diabetes), cardiac function grade, BMI or other general data ($P>0.05$). See **Table 1**.

*Comparison of the heart rate, $VE/VCO_2$ slop, METs, $VO_2$ peak, pulse oxygen, and anaerobic threshold before and after treatment*

After the treatment, the peak heart rate, the $VE/VCO_2$ slope, and the NT pro-BNP of the two groups were all largely decreased compared to their levels before the treatment, with a significant difference between the two groups

**Table 1.** Comparison of the baseline data

| Groups | Observation group | Control group | $t/x^2$ | P |
|---|---|---|---|---|
| Gender (Male/Female) | 24/18 | 27/15 | 0.449 | 0.503 |
| Age (year) | 56.8±5.1 | 56.1±4.8 | 0.648 | 0.519 |
| Hypertension | 21 | 17 | 0.768 | 0.381 |
| Hyperlipidemia | 11 | 9 | 0.203 | 0.652 |
| Diabetes | 13 | 10 | 0.539 | 0.625 |
| BMI ($Kg/m^2$) | 26.6±2.3 | 27.3±2.7 | 1.279 | 0.204 |
| Cardiac function | | | 0.191 | 0.662 |
| II grade | 19 | 21 | | |
| III grade | 23 | 21 | | |

Note: BMI: body mass index.

(P<0.05). In addition, the METs, $VO_2$ peak, SF-36 scores, 6 min walking distances, pulse oxygen and anaerobic threshold levels were all elevated throughout the treatment, and there were significant differences between the two groups (P<0.05). See **Table 2**.

*Comparison of the six-minute walking distance changes before and after the treatment*

No significant differences existed between the two groups in their six minute walking distances before the treatment (P>0.05). However, after treatment, the walking distance of the two groups both increased, but the observation group had a more significant increase (P<0.05). See **Figure 1**.

*Comparison of the serum NT pro-BNP levels before and after the treatment*

No significant difference existed in the serum NT pro-BNP levels between the two groups before the treatment (P>0.05). However, the serum NT pro-BNP levels in the two groups both decreased throughout the treatment, and the observation group had a more significant degree of decline (P<0.05). See **Figure 2**.

*Comparison of the re-hospitalization rates and the incidences of arrhythmia*

Re-hospitalization rate and the total incidences of arrhythmias (sinus tachycardia, ventricular premature beat) in the observation group were both much lower than they were in the control group (P<0.05), but no significant difference existed in the types of arrhythmias between the two groups (P>0.05). See **Table 3**.

*Comparison of the quality of life scores*

After the treatment, the quality of life scores in the observation group were much higher than the scores in the control group (P<0.05). The results suggest that cardiac rehabilitation training significantly improves patients' quality of life. See **Table 4**.

## Discussion

Some studies have shown that cardiac rehabilitation has an important application value in cardiovascular disease. The reports show that the sudden death rate of patients with acute myocardial infarction is halved within one year after cardiac rehabilitation training. However, due to the patients' poor compliance, the patients' uncertain treatment effects and their poor participation rate, the application of cardiac rehabilitation in the treatment of heart failure has not met the expectations. Therefore, it is of great clinical significance to explore the effects of cardiac rehabilitation training in patients with heart failure [17, 18].

Previous studies have shown that cardiopulmonary function and exercise ability are important indicators to evaluate the long-term prognosis of patients with heart failure, and are also predictors of death. Therefore, the above two indexes can also be used as reliable indexes to evaluate the cardiopulmonary function of patients after training [19]. Our results showed that the peak heart rate and the $VE/VCO_2$ slopes of the two groups were all largely decreased throughout the treatment, and there was a more significant decrease in the observation group. At the same time, the METs, $VO_2$ peak, pulse oxygen and anaerobic threshold were all elevated after the treatment, and the corresponding indexes in the observation group increased more significantly. The above results not only show the effectiveness of internal medicine comprehensive treatment, but also reflect the fact that cardiac exercise rehabilitation training can improve the clinical treatment effects of patients. It suggests that a finely designed exercise prescription can improve the

**Table 2.** Comparison of the cardiopulmonary function indexes before and after treatment

| Groups | Peak heart rate (times/min) | METs | $VO_2$ peak | $VE/VCO_2$ slop | Pulse oxygen | Anaerobic threshold (mL/(kg·min)) |
|---|---|---|---|---|---|---|
| Control group | | | | | | |
| Before | 118.2±11.1 | 4.2±0.6 | 16.3±4.2 | 32.8±6.1 | 95.1±2.1 | 10.77±1.9 |
| After | 113.6±11.8* | 4.7±0.7* | 17.0±2.9* | 29.2±4.2* | 95.4±2.0* | 11.02±2.0* |
| Observation group | | | | | | |
| Before | 125.6±10.3 | 4.1±0.7 | 16.2±2.4 | 33.1±6.7 | 95.3±1.9 | 11.17±1.8 |
| After | 108.7±12.4*,# | 6.8±0.8*,# | 20.0±3.0*,# | 27.1±2.9*,# | 96.5±2.5*,# | 13.47±2.3*,# |

Note: $VE/VCO_2$ slop: ventilation/carbon dioxide slope; METs: exercise tolerance; $VO_2$ peak: volume peak oxygen. Compared with the same group before treatment, *P<0.05; compared with the control group after treatment, #P<0.05.

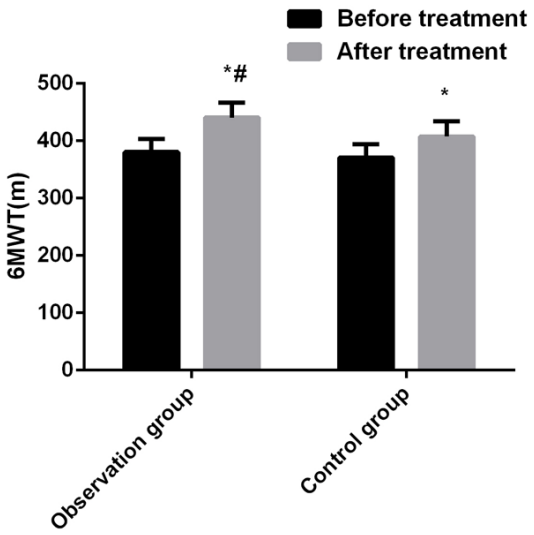


**Figure 1.** 6-minute walking test (6MWT). Compared with the same group before the treatment, *P<0.05; compared with the control group after the treatment, #P<0.05.

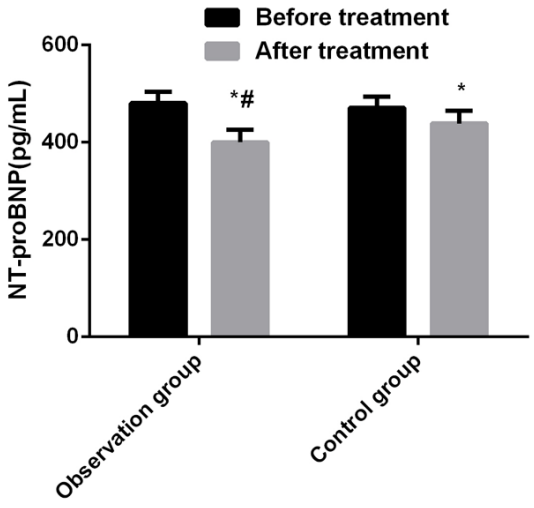


**Figure 2.** Comparison of the serum NT pro-BNP levels before and after the treatment. Compared with the same group before the treatment, *P<0.05; compared with the control group after the treatment, #P<0.05.

cardiopulmonary function, reduce the sympathetic nerve activity, improve the vagus nerve activity, maintain the balance of nerve function, and reduce patients' incidences of arrhythmia. Moreover, our study also shows that no significant difference exists in the types of arrhythmias between the two groups, and the total incidence of arrhythmias was lower in the observation group compared to the level in the control group, which is consistent with the previous research conclusions [20-22].

6MWT is the main simple and effective index to evaluate the change of heart function. Our results showed that the athletic ability of patients in the two groups both increased throughout the treatment, and the observation group had a more significant improvement. It can be seen that good rehabilitation exercise training helps to improve the athletic ability and the quality of life of patients, which is also consistent with previous similar research [23]. In addition, the NT pro-BNP in serum level is the most commonly used biochemical index in the current laboratory. Its change can directly reflect patients' heart function, and it is also the only objective index to evaluate heart function at present [24]. Similarly, our study showed that the NT pro-BNP levels of the two groups were both declined throughout the treatment, which proves the effectiveness of the treatment. At the same time, the more significant decline in the observation group further confirmed the conclusion that the cardiac rehabilitation training can improve the clinical treatment effect of heart failure [25].

**Table 3.** Comparison of the re-hospitalization rate and the incidence of arrhythmia

| Groups | Observation group (n=42) | Control group (n=42) | $\chi^2$ | P |
|---|---|---|---|---|
| Re-hospitalization rate (n, %) | 12 (28.6) | 24 (57.1) | 5.882 | 0.015 |
| Incidence of arrhythmias (n, %) | | | | |
| Sinus tachycardia | 3 (7.1) | 8 (19.0) | 2.615 | 0.106 |
| Ventricular premature beat | 7 (16.7) | 12 (28.6) | 1.710 | 0.192 |
| Total | 10 (23.8) | 20 (47.6) | 5.185 | 0.023 |

**Table 4.** Comparison of the SF-36 scores after the treatment

| Groups | Control group | Observation group | t | P |
|---|---|---|---|---|
| General health | 65.3±2.8 | 74.4±2.2 | 16.562 | <0.001 |
| Physiological function | 63.8±4.7 | 78.3±4.0 | 15.226 | <0.001 |
| Social function | 73. 6±3.8 | 82.9±3.4 | 11.820 | <0.001 |
| Emotional function | 63.7±5.2 | 78.4±4.8 | 13.462 | <0.001 |
| Somatic pain | 64.5±3.1 | 79. 9±4.0 | 19.722 | <0.001 |
| Physiological function | 69.1±4.8 | 77.8±5.4 | 7.804 | <0.001 |
| Mental health | 78.7±8.1 | 70.2±7.4 | 5.021 | <0.001 |
| Energy | 68.3±7.2 | 61.7±8.1 | 3.947 | <0.001 |

Note: SF-36: the MOS item short from health survey.

The quality of life score and the re-hospitalization rate are the most reliable indicators to evaluate the quality of the daily lives of patients after the treatment. Follow-up cardiac rehabilitation training improves the quality of daily life of the patients mainly by improving the patients' cardiopulmonary functions, reducing the re-hospitalization rate, and extending the walking distance [26]. Our results show that after the treatment, the patients' quality of life scores in the observation group were much higher than the scores in the control group, and the re-hospitalization rate was much lower than it was in the control group. Thus, it is confirmed that cardiac rehabilitation training can significantly improve the quality of life and reduce the re-hospitalization rate, which is consistent with the conclusion of previous foreign research [27].

However, the number of individuals in this study was relatively small, and only a single-center study was conducted. Thus, we still need a larger, multicenter sample and a prospective randomized controlled study to better identify the clinical effects of cardiac rehabilitation training. In addition, using more thorough laboratory indicators to comprehensively evaluate the clinical treatment effect will also be the focus of our further research.

In conclusion, our research confirmed that cardiac rehabilitation training can significantly improve the recovery of the cardiopulmonary indexes in patients with heart failure after treatment, improve their quality of life, reduce their re-hospitalization rate and assist in the treatment of chronic stable heart failure.

## Disclosure of conflict of interest

None.

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