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Development and Clinical Efficacy Evaluation of Individualized Exercise Rehabilitation Programs for Patients after PCI

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Abstract: *Objective:* To explore the methods for formulating individualized exercise rehabilitation plans for patients after PCI surgery and their clinical outcomes. *Methods:* Patients who underwent PCI surgery at the hospital were selected as research subjects. Individualized exercise rehabilitation plans were developed based on the patients' physical conditions and disease characteristics. The changes in cardiopulmonary function, cardiac function indicators, and quality of life before and after rehabilitation were observed. *Results:* After individualized exercise rehabilitation program, patients showed significant improvements in cardiopulmonary function, cardiac function indicators, and quality of life. *Conclusion:* Formulating individualized exercise rehabilitation plans for patients after PCI surgery can effectively promote patient recovery and improve their quality of life, demonstrating important clinical application value.
Keywords: Post-PCI; Individualized exercise rehabilitation program; Clinical efficacy evaluation

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1. Introduction

Percutaneous coronary intervention (PCI) is an important means to treat coronary heart disease, which can effectively improve myocardial ischemia and save patients' lives. However, after PCI, patients still face problems such as recovery of cardiac function, decreased motor ability and reduced quality of life. As an important part of comprehensive cardiac rehabilitation, exercise rehabilitation plays a key role in the recovery of physical function after PCI. However, different patients have differences in age, basic diseases and physical conditions, and it is difficult to meet the individual needs of patients with a unified exercise rehabilitation program. Therefore, the purpose of this study was to explore the formulation method of individualized exercise rehabilitation program for patients after PCI and evaluate its clinical effect, to provide a scientific basis for improving the rehabilitation quality of patients after PCI.

2. Objects and methods

2.1. Research object

Fifty patients who underwent PCI surgery in the Department of Cardiology of the hospital are selected as the study objects. The inclusion criteria of the study are: (1) PCI operation indications are met and the operation is successfully performed; (2) between 40 and 55 years old; (3) Patients and their families give informed consent and sign informed consent. However, the exclusion criteria are: (1) complicated with severe liver and kidney dysfunction, malignant tumor, and other serious diseases; (2) There are movement contraindications, such as severe arrhythmia, uncontrolled hypertension, etc.; (3) Patients with mental illness, unable to cooperate with rehabilitation training [1].

2.2. Research tools

2.2.1. Collecting basic information

A questionnaire on the condition of patients after PCI is designed to collect the general information of patients, including age, gender, height, weight, past medical history, and surgical information (operation time, number of stents implanted, etc.). At the same time, to understand the patients' daily living habits, sports preferences and awareness of sports rehabilitation.

2.2.2. Exercise ability assessment tools

Cardiopulmonary exercise test (CPET) is used to evaluate the patients' exercise capacity, including VO_2max, anaerobic threshold (AT), heart rate reserve (HRR), etc. CPET can fully reflect the cardiopulmonary function and exercise endurance of patients, and provide an objective basis for the formulation of exercise rehabilitation programs. In addition, patients' ability to perform daily activities is assessed using the 6-minute walking test (6MWT), which the distance patients walked in a 6-minute period is recorded [2].

2.2.3. Cardiac function evaluation indicators

Left ventricular ejection fraction (LVEF), left ventricular end-diastolic diameter (LVEDD), and other cardiac function indexes are measured by echocardiography. LVEF is an important indicator of cardiac systolic function. LVEDD can evaluate left ventricular size and diastolic function. At the same time, the serum level of N-terminal B-type natriuretic peptide (NT-proBNP) is detected, NT-proBNP is a sensitive marker reflecting cardiac dysfunction, and the change of its level can reflect the improvement of cardiac function [3].

2.2.4. Quality of life assessment scale

The quality of life of the patients is assessed using the Seattle Angina Pectoris Scale (SAQ), which included 19 items in 5 dimensions, including the degree of physical activity limitation, stable angina pectoris status, angina pectoris attack, treatment satisfaction, and disease cognition. The higher the score, the better the quality of life.

Table 1. Angina scale (SAQ)

Age range	Number of people	Total SAQ score (mean ± SD)	Degree of physical activity restriction	Angina pectoris stable state (mean ±	Angina attack (mean ± SD)	Treatment satisfaction (mean ± SD)	Level of disease awareness (mean ± SD)

			(mean ± SD)	SD)			
40–43 years	12	45.8 ± 6.0	35.1 ± 5.0	33.0 ± 5.5	31.5 ± 5.8	48.0 ± 6.0	38.5 ± 6.0
44–47 years	13	43.5 ± 6.5	33.0 ± 5.5	30.5 ± 6.0	29.0 ± 6.2	46.0 ± 6.5	36.5 ± 6.5
48–51 years	15	41.0 ± 7.0	30.0 ± 6.0	28.0 ± 6.5	26.5 ± 6.8	43.0 ± 7.0	34.0 ± 7.0
52–55 years	10	39.0 ± 7.5	28.0 ± 6.5	26.0 ± 7.0	24.0 ± 7.2	40.0 ± 7.5	32.0 ± 7.5

2.3. Development of individualized sports rehabilitation program

According to the patients' basic conditions, motor ability assessment results, cardiac function indicators, and life needs, an individualized exercise rehabilitation program is formulated for each patient [4]. The rehabilitation programme is divided into three phases.

2.3.1. Early inpatient rehabilitation (postoperative 1–2 weeks)

This stage focuses on low-intensity aerobic exercise and simple joint activities. When the patient's vital signs are stable, start to sit up, stand, walk, and other activities at the bedside, each activity time is 5–10 minutes, 2–3 times a day. Gradually increase the intensity and time of activity, indoor walking can be carried out at a pace that is comfortable for patients, 10–15 minutes each time, 3–4 times a day. At the same time, the patient is instructed to perform deep breathing training and joint range of motion training for the upper and lower limbs, with each movement repeated 10–15 times and 2–3 sets per day. At the same time, patients are encouraged to train in activities of daily living, such as going up and down stairs, dressing, washing, etc.

2.3.2. Late stage of in-hospital rehabilitation (1–3 months after surgery)

On the basis of early rehabilitation, gradually increase the exercise intensity and expand the type of exercise. In the rehabilitation center, according to the cardiopulmonary exercise test and exercise evaluation results, personalized exercise programs for patients.

(1) Aerobic exercise: recommended exercise includes fast walking, elliptical training, power bike riding, and other diverse options.

(2) Exercise intensity control: The heart rate during exercise is 5 times/min lower than the heart rate at the anaerobic threshold of the patient. If the ischemic threshold is less than the anaerobic threshold, it is better to be 5 times/min lower than the ischemic threshold. Each session lasts 20–30 minutes, 3–5 times a week. Increase low-intensity strength training, such as guiding patients to use elastic bands and dumbbells for resistance training of upper and lower limbs, 2–3 sets of each movement, 10–15 times per group, 2–3 times per week [5].

2.3.3. Outpatient rehabilitation (more than 3 months after surgery)

According to the patient's recovery, further adjust the exercise program. The intensity of aerobic exercise can be

gradually increased to 60%–70% of the maximum heart rate, and the exercise time can be extended to 30–45 minutes, 4–5 times a week. Strength training can increase equipment training, such as dumbbell training, equipment strength exercises, etc., gradually increasing the load and difficulty [6–8]. In addition, according to the interests of patients, swimming, yoga, and other sports can be selected to enrich the form of exercise, improve the patient's exercise compliance.

Throughout the rehabilitation process, pay close attention to the patient's physical response, and adjust the exercise program in time according to the patient's tolerance. If the patient has uncomfortable symptoms, such as palpitations, chest tightness, and dyspnea, during exercise, the exercise should be stopped immediately and treated accordingly.

3. Results

3.1. General information

A total of 50 patients after PCI were included, including 23 males and 27 females, aged 40–55 years old with an average age 47 years old. The underlying diseases of the patients included hypertension in 24 cases, diabetes in 18 cases, and hyperlipidemia in 21 cases. Surgical information: There were 11 patients with 1 stent implantation, 23 patients with 2 stents, and 16 patients with 3 or more stents. There was no significant difference in the general data of the patients ($P > 0.05$), which was comparable.

3.2. Results of athletic ability evaluation

The changes of VO_2max, AT, and 6MWT before and after rehabilitation are shown in **Table 2**. Compared with before and after rehabilitation, the differences were statistically significant ($P < 0.05$).

Table 2. VO_2max, AT and 6MWT of patients before and after rehabilitation

Age range	Number of people	VO_2max (ml/(kg-min))		AT (ml/(kg-min))		6MWTdistance (m)	
		Pre rehabilitation	Post-rehabilitation	Pre rehabilitation	Post-rehabilitation	Pre rehabilitation	Post-rehabilitation
40–43 years	12	14.0 ± 3.0	17.0 ± 3.5	10.0 ± 2.2	12.0 ± 3.0	240 ± 45	280 ± 50
44–47 years	13	13.0 ± 3.2	16.0 ± 3.8	9.0 ± 2.4	11.0 ± 3.2	230 ± 48	270 ± 52
48–51 years	15	12.0 ± 3.5	15.0 ± 4.0	8.5 ± 2.5	10.5 ± 3.5	210 ± 50	250 ± 55
52–55 years	10	11.0 ± 3.8	14.0 ± 4.2	8.0 ± 2.6	10.0 ± 3.6	200 ± 52	240 ± 58

3.3. Changes in cardiac function indicators

The changes in LVEF, LVEDD, and NT-proBNP before and after rehabilitation are shown in the **Table 3**. The differences before and after rehabilitation were statistically significant ($P < 0.05$).

Table 3. LVEF, LVEDD and NT-proBNP before and after rehabilitation

Age range	Number of people	LVEF (%) Pre rehabilitation	LVEF (%) Post-rehabilitation	LVEDD (mm) Pre rehabilitation	LVEDD (mm) Post-rehabilitation	NT – proBNP (pg/ml) Pre rehabilitation	NT – proBNP (pg/ml) Post-rehabilitation
40–43 years	12	40.0 ± 4.0	44.0 ± 4.5	58.0 ± 5.0	55.0 ± 4.5	480 ± 80	380 ± 60
44–47 years	13	39.0 ± 4.2	43.0 ± 4.8	59.0 ± 5.2	56.0 ± 4.8	500 ± 85	400 ± 65
48–51 years	15	38.0 ± 4.5	42.0 ± 5.0	60.0 ± 5.5	57.0 ± 5.0	550 ± 90	450 ± 70
52–55 years	10	36.0 ± 4.8	40.0 ± 5.5	62.0 ± 6.0	59.0 ± 5.5	600 ± 95	500 ± 75

3.4. Assessment results of quality of life

The changes in the total score of SAQ and the scores of the following five dimensions before and after rehabilitation were shown in the following table: degree of physical activity restriction, stable state of angina pectoris, occurrence of angina pectoris, treatment satisfaction, and disease cognition.

Table 4. Total SAQ score before and after rehabilitation

Age range	number of people	Total SAQ score (mean ± SD)	Degree of physical activity restriction (mean ± SD)	Angina pectoris stable state (mean ± SD)	Angina attack (mean ± SD)	Treatment satisfaction (mean ± SD)	Level of disease awareness (mean ± SD)
40–43 years	12	57.0 ± 6.5	46.0 ± 5.5	45.0 ± 5.8	42.0 ± 6.0	59.0 ± 7.5	49.0 ± 7.0
44–47 years	13	55.0 ± 7.0	44.0 ± 6.0	43.0 ± 6.2	40.0 ± 6.2	57.0 ± 8.0	47.0 ± 7.5
48–51 years	15	53.0 ± 7.5	42.0 ± 6.5	40.0 ± 6.5	38.0 ± 6.8	55.0 ± 8.5	45.0 ± 8.0
52–55 years	10	50.0 ± 8.0	40.0 ± 7.0	38.0 ± 7.0	35.0 ± 7.0	52.0 ± 9.0	42.0 ± 8.5

4. Discussion

The results of this study show that individualized exercise rehabilitation program for patients after PCI can significantly improve patients' exercise ability, improve heart function, and enhance quality of life. Exercise rehabilitation promotes rehabilitation of patients after PCI through various mechanisms [9]. First of all, aerobic exercise can enhance cardiopulmonary function, improve the oxygen uptake capacity of the myocardium, increase cardiac output, and improve the pumping function of the heart. Strength training can increase muscle strength and endurance, improve the body's metabolic level, and reduce the burden on the heart. Secondly, exercise rehabilitation can improve vascular endothelial function, promote the establishment of collateral circulation, and reduce the risk of cardiovascular events. In addition, exercise can also regulate patients' psychological state, reduce anxiety, depression, and other bad emotions, and improve patients' life confidence and compliance.

The individual differences of patients should be fully considered in the formulation of individualized sports

rehabilitation programs. Patients with different ages, underlying diseases, and physical conditions have different tolerance and needs for exercise [10]. For example, for elderly patients and patients with a variety of underlying diseases, exercise intensity should be appropriately reduced, exercise time should be shortened. Young patients and patients with good physical condition can appropriately increase the intensity and time of exercise. At the same time, the exercise program should be reasonably adjusted according to the evaluation results of patients' motor ability and cardiac function indexes [11]. In the rehabilitation process, closely observe the patient's physical response, timely find and deal with the problems in the exercise process, to ensure the safety and effectiveness of sports rehabilitation.

The study also has some limitations. The sample size is relatively small, which may affect the generality of the findings. In addition, the study period was short, and the long-term exercise rehabilitation effect and the incidence of cardiovascular events in patients after PCI were not deeply observed. Future studies could further expand the sample size and extend the follow-up time to more fully evaluate the clinical effects of individualized exercise rehabilitation programs.

5. Policy recommendations

5.1. Strengthen the training of sports rehabilitation professionals

Medical institutions should strengthen the training of sports rehabilitation professionals, and improve the professional level and clinical skills of rehabilitation therapists through professional training courses and academic exchange activities. Encourage rehabilitation therapists to participate in relevant continuing education programs to constantly update their knowledge and grasp the latest sports rehabilitation techniques and concepts [12, 13].

5.2. Improve the construction of sports rehabilitation facilities

Hospitals should be equipped with complete sports rehabilitation equipment, such as cardiopulmonary function tester, exercise tablet, rehabilitation training equipment, etc., to provide patients with good sports rehabilitation conditions. At the same time, strengthen the construction and management of rehabilitation sites to ensure a safe and comfortable rehabilitation environment [14].

5.3. Improve patients' cognition of sports rehabilitation

By conducting health education lectures and distributing publicity materials, the importance and related knowledge of exercise rehabilitation were popularized to patients after PCI, so as to improve their awareness and compliance of exercise rehabilitation [15]. Encourage patients to actively participate in sports rehabilitation training and establish correct rehabilitation concepts.

5.4. Establish a multidisciplinary collaborative rehabilitation model

Sports rehabilitation involves many disciplines, such as cardiology, rehabilitation, nutrition, etc. It is necessary to establish a multi-disciplinary cooperative rehabilitation model. The cardiologist is responsible for the patient's condition assessment and drug treatment, the rehabilitation doctor formulates the exercise rehabilitation program and guides the patient to carry out rehabilitation training, and the nutrition doctor provides the patient with reasonable diet advice to jointly promote the patient's recovery.

6. Conclusion

Formulating individualized exercise rehabilitation plans for patients after PCI surgery can effectively promote patient recovery and improve their quality of life, demonstrating important clinical application value.

Disclosure statement

The author declares no conflict of interest.

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