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Importance and Application of Exercise Rehabilitation after PCI in Elderly Patients with Coronary Heart Disease

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Abstract: Focusing on exercise rehabilitation for elderly patients with coronary artery disease after coronary angiography, this paper systematically analyzes the multifaceted significance of exercise rehabilitation in restoring physical function, improving mental health, and enhancing quality of life. The paper explores the mechanisms and clinical effects of rehabilitation modalities, including aerobic exercise to promote collateral circulation and cardiac function, resistance training to improve lipid profile by increasing muscle mass, flexibility training to prevent joint stiffness, and balance training to reduce the risk of falls. Key findings emphasize that exercise rehabilitation can promote the aerobic metabolism of myocardium, increase myocardial oxygen uptake, enhance myocardial contractility, improve cardiac pumping function, improve cardiac function, significantly reduce cardiovascular events and postoperative complications, and improve patients' quality of life. Meanwhile, early exercise rehabilitation has a positive impact on patients' psychological state through neurobiological mechanisms, improves psychological comfort, reduces anxiety and depression, and improves the negative psychological state of patients after coronary heart disease surgery. The study provides both theoretical frameworks and practical guidance for integrating scientific exercise programs into post-PCI rehabilitation, emphasizing its role in achieving comprehensive physical and psychological recovery for elderly patients.

Keywords: Elderly coronary heart disease, Post-PCI, Exercise rehabilitation, Rehabilitation modalities, Importance.

1. Introduction

With the deepening aging of China's population, the incidence of coronary heart disease among the elderly has been increasing year by year [1]. Statistical data show that the prevalence of coronary heart disease in adults over 60 years old has exceeded 40%, and coronary heart disease is the leading cause of death in the elderly aged 50-74 and over 75 years old. Percutaneous coronary intervention (PCI) has become a key treatment to rapidly open occluded coronary arteries and restore myocardial blood supply. Although PCI can effectively relieve acute myocardial ischemia, it cannot completely solve the problems, such as decreased quality of life and exercise tolerance of patients after PCI

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surgery. At the same time, elderly patients often have multiple underlying diseases such as diabetes and hypertension, which can complicate the progression of coronary heart disease in the elderly and lead to geriatric syndromes. Coronary heart disease, complications, and geriatric syndromes interact with each other, increasing the disease burden of coronary heart disease in the elderly, exacerbating age-related decline in physical function, and resulting in poor prognosis. Therefore, it is extremely important to develop exercise rehabilitation programs for elderly patients. Scientifically tailored exercise programs not only accelerate physical recovery by improving myocardial contractility and vascular elasticity but are also the cornerstone of improving quality of life and extending survival. Numerous studies have shown that elderly patients participating in structured exercise rehabilitation after PCI have a 26% reduction in cardiovascular mortality compared to patients who did not receive intervention [2].

This article systematically explores the multi-dimensional importance of exercise rehabilitation, spanning its impacts on cardiovascular function, mental health, and complication prevention. By dissecting the mechanisms of aerobic exercise, resistance training, flexibility exercises, and balance training, it aims to clarify how integrated rehabilitation modalities address the specific needs of elderly patients—from mitigating myocardial ischemia through collateral circulation development to alleviating psychological stress via neuroendocrine regulation. The research further provides evidence-based guidance for clinical practice, emphasizing the necessity of personalized exercise protocols in post-PCI care for the elderly.

2. Effects of exercise rehabilitation on cardiovascular function and metabolic indices in elderly patients after percutaneous coronary intervention for coronary heart disease

Elderly coronary heart disease patients post-PCI often present with compromised cardiac function, including reduced left ventricular ejection fraction (LVEF) and impaired diastolic filling, alongside vascular fragility characterized by endothelial dysfunction and reduced arterial compliance [3]. This physiological vulnerability necessitates targeted interventions, with exercise rehabilitation emerging as a non-pharmacological strategy to remodel the cardiovascular system. Aerobic exercise programs, when prescribed at 60-70% of age-predicted heart rate reserve, initiate a cascade of adaptive responses. Walking for 30 minutes daily, for example, stimulates the release of vascular endothelial growth factor (VEGF) and nitric oxide, promoting collateral vessel dilation and neovascularization. This process creates a "biological bypass," increasing coronary collateral flow by 40-60% in studies. When the main coronary arteries are partially occluded, these collateral networks maintain myocardial oxygen supply, reducing ischemic burden by up to 35%. Concurrently, aerobic training enhances myocardial contractility through mitochondrial biogenesis and improved calcium handling, leading to a 10-15% increase in LVEF within 12 weeks of consistent exercise. Elderly patients who engage in swimming or cycling show improved cardiac reserve, with peak oxygen uptake (VO_2peak) increasing by 12-18%, a metric strongly associated with reduced mortality. Resistance training, though ostensibly a musculoskeletal intervention, exerts profound cardiovascular benefits via metabolic modulation. Using resistance bands or 2-5 kg dumbbells in 2-3 sets of 10-15 repetitions, elderly patients can increase lean muscle mass by 8-12% over 16 weeks. This muscle hypertrophy enhances insulin-mediated glucose uptake by 25-30%, lowering fasting blood glucose and reducing the risk of diabetic cardiomyopathy. Mechanistically, increased muscle mass upregulates lipoprotein lipase activity, facilitating triglyceride clearance and reducing low-density lipoprotein cholesterol (LDL-C) by 18-22%. Clinical registries demonstrate that elderly post-PCI patients adhering to resistance training protocols experience a 25-30% reduction in major adverse cardiovascular events (MACE), with incident myocardial infarction rates dropping by 28%

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compared to sedentary controls. The synergy of aerobic and resistance modalities creates a comprehensive cardiovascular repair strategy. Aerobics directly improves myocardial perfusion and pump function, while resistance exercise addresses metabolic comorbidities that drive cardiac workload. This dual approach not only restores physiological function but also mitigates the atherosclerotic process, making exercise rehabilitation an indispensable component of post-PCI care for older adults. Clinicians are increasingly integrating these modalities into personalized programs, monitoring parameters like heart rate variability and blood pressure response to ensure safety and optimize therapeutic gains.

3. The positive impact of exercise rehabilitation on the mental health of elderly patients

PCI surgery brings the dual burden of physical trauma and psychological stress to elderly patients. Studies have shown that the elderly are prone to clinically significant anxiety or depression after PCI [4]. This psychological loss stems from multiple factors: the fear of surgical recurrence, concerns about functional decline, and the emotional impact of facing death. These mental health issues not only undermine the quality of life but are also associated with a 2-3 3-times increased risk of cardiovascular events, highlighting the urgency of integrating psychological rehabilitation. Exercise rehabilitation emerged as a neurobiological intervention to coordinate the release of key neurotransmitters. During aerobic exercise, the hypothalamic-pituitary axis triggers the secretion of endorphins. Endorphins bind to central opioid receptors, reducing pain perception by 40-60% and weakening the stress response. Meanwhile, the dopaminergic pathways in the substantia nigra are activated, and the synaptic dopamine level increases by 25-30% - this neurotransmitter regulates the brain's reward circuit, enhancing pleasure and motivation. Neuroimaging studies have shown that 12 weeks of regular exercise can increase the volume of the hippocampus by 2-3% and reverse stress-induced atrophy associated with depression. The influence of exercise patterns on their psychological benefits is different. Gentle practices like Tai Chi, accompanied by slow movements of shifting the center of gravity and concentrated breathing, can induce a meditative state, reducing cortisol levels by 15-20%. In a randomized trial, elderly patients after PCI practiced Baduanjin (a traditional qigong) for 8 weeks, and their anxiety scores decreased by 38% compared with the control group. Fad-paced activities, such as square dancing, accompanied by rhythmic music and teamwork, create a sense of joy through synchronized movements, prompting participants to report a 50% higher positive impact score. Equally important is the social framework provided by the practice. Community-based rehabilitation groups usually meet 2 to 3 times a week, providing organized interaction opportunities. Elderly patients may withdraw from the surgery due to physical limitations and rebuild social connections by sharing their exercise experiences. Participating in group exercise programs can improve self-identity. Peer support in these groups cultivates a sense of belonging, while collective goal setting enhances self-efficacy. This integration of "mind-body-social" exercise rehabilitation addresses the overall needs of elderly patients. By integrating neurochemical regulation, physical activation and social engagement, it can not only serve as a "healing ointment for the soul" but also act as a strategic intervention to disrupt the cycle of psychological distress and cardiovascular risk. Clinicians are increasingly advocating for exercise prescriptions that are targeted at mental health, recognizing that in this group of people, emotional recovery is as important as physical rehabilitation.

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4. The value of multiple rehabilitation types in reducing complications

Elderly patients undergoing PCI treatment for coronary heart disease have an increased risk of complications if they sit for a long time. Long-term inactivity can lead to muscle atrophy at a rate of 1-2% per week, joint stiffness, and limitation of the range of motion by up to 30%, increasing the risk of deep vein thrombosis (DVT) by 2-3 times [5]. Sports rehabilitation programs address these issues in targeted ways, each aimed at alleviating specific complications. Flexibility training, which includes dynamic range of motion exercises and static stretching, is crucial for maintaining joint health. Neck rotation (repeating 10 to 15 times a day) can prevent cervical stiffness that hinders head movement, while lateral bending of the waist and leg stretching can maintain the flexibility of the lumbar vertebrae and knee joints. Balance training, such as standing on one leg and walking from heel to toe, is aimed at age-related proprioceptive decline. Postoperative weakness after PCI exacerbated this decline, and the risk of falls in sedentary elderly patients increased by 40%. Performing balance exercises on a stability pad can enhance neuromuscular coordination and reduce fall-related fractures by 35-40% by improving posture control. Aerobic exercise, such as brisk walking for 30 minutes, five days a week, can increase blood flow velocity by 20-25%, reduce blood viscosity and the incidence of DVT, while resistance exercise can increase muscle mass by 10-15%, improve insulin sensitivity and reduce constipation [6]. The latter is crucial because tension during defecation can increase intra-abdominal pressure by 40 to 60 mmHg, temporarily increasing the burden on the heart. Overall, these approaches form a comprehensive strategy to minimize postoperative morbidity and restore functional independence.

5. Types of exercise rehabilitation and their effects

5.1. Aerobic exercise

Aerobic exercise is the core component of active exercise rehabilitation, which can increase the diameter, elasticity and blood supply performance of coronary arteries and improve endothelial function, thus improving the cardiac function of patients with coronary heart disease [7]. In 2020, the European Association of Preventive Cardiology (EAPC) recommended that patients with coronary heart disease choose aerobic exercise types such as walking, jogging, swimming, rowing, cycling, climbing stairs, and dancing. For patients with severe heart disease, individualized traditional exercise training is recommended as a method of aerobic exercise (e.g., Tai Chi, Baduanjin, and Wuqiuquan), and the intensity of the exercise needs to be determined based on parameters such as exercise load testing stratified by the patient's goals, personal preferences and risk.

5.2. Strength training

With aging, significant structural and functional changes occur in human muscles, including a decrease in muscle fibers, a reduction in muscle weight, a decline in muscle metabolic capacity, an increase in fat content, and a decrease in bone density. This series of changes ultimately leads to a reduction in muscle strength. When this strength reduction reaches a certain level, it affects the normal mobility of the elderly, and the body's functional level is also affected by mobility, which may ultimately lead to adverse changes in the health status of the elderly. In terms of the composition of physical fitness in the elderly, strength is an important component. Strength training for the elderly has obvious positive effects on enhancing the body's athletic ability, preventing

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muscle atrophy, and reducing frailty. In addition, strength training can also produce certain cognitive benefits, especially executive function.

Strength training can be carried out under the guidance of a doctor, including grip strength training, suspension training, knee joint, ankle joint, quadriceps femoris, grip training, leg strength, hip muscles, trunk muscle strength, and oral muscle training. In daily life, it can also be carried out through physical activities such as labor, brisk walking, running, jumping, cycling, and mountain climbing. It can also be done with the help of equipment, such as dumbbells, treadmills, resistance bands, Swiss balls, kettlebells and barbells.

5.3. Balance training

Balance dysfunction is common in the elderly, and age-related physiological function decline, comorbidities, and polypharmacy can all affect the balance function of the elderly [8]. Adding balance training to routine cardiac rehabilitation can improve patient prognosis. In daily life, the elderly can perform balance training through Tai Chi, single-leg standing exercises, and other programs, which can not only prevent falls but also enhance physical coordination and play a role in safeguarding daily life safety [9].

6. Guarantee measures for the effectiveness of exercise rehabilitation

6.1. Construction of a comprehensive evaluation system

Elderly patients with coronary heart disease are assessed for their physical health status, i.e., general condition assessment and functional assessment. General condition assessment includes current medical history, past medical history, medication history, physical examination, imaging examination, laboratory examination, static cardiac function assessment, and nutritional status assessment. Functional assessment includes cardiac function assessment (commonly used methods of cardiac function assessment include the New York Heart Association (NYHA) functional classification, Killip's classification of acute myocardial infarction, Forrest's hemodynamic classification, Weber's classification, and the Canadian Cardiovascular Society (CCS) classification of angina pectoris, etc.), pulmonary function assessment (usually using lung volume testing, pulmonary ventilation function testing, and may also include Smoking cessation status assessment. If the patient has dyspnea, this may be assessed using the Borg Dyspnea Scale, modified Medical Research Council (mMRC) dyspnea questionnaire, etc.), exercise risk assessment (exercise electrocardiogram loading test, cardiopulmonary exercise test (CPET), 6-minute walk test (6MWT), etc.), assessment of motor function (muscular strength, muscular endurance), and assessment of balance and mobility), frailty assessment (using the FRAIL scale), fall risk assessment and lifestyle habits assessment [10].

6.2. Construction of a dynamic monitoring system and knowledge education and psychological support

Dynamic monitoring of heart rate (40-70% of maximum heart rate reserve), blood pressure and ECG in elderly patients with coronary artery disease and subjective assessment applying the Borg scale. Evaluate and optimize the exercise rehabilitation program every 4-6 weeks. A team of exercise rehabilitation professionals is also formed to help with the post-rehabilitation and follow-up of elderly patients. In addition, education on exercise knowledge, risk prevention, exercise rehabilitation compliance and importance is provided through one-on-one instruction, group

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training, and popular science materials. Timely alleviate the negative emotions of patients and enhance the confidence of elderly patients in rehabilitation.

7. Conclusion

Exercise rehabilitation for elderly patients with coronary heart disease post-PCI embodies multifaceted clinical value that cannot be substituted. Clinical evidence shows that systematic exercise programs combining aerobic training, resistance exercise, flexibility, and balance training can reduce the risk of major adverse cardiovascular events (MACE) by 30%-40% in this population. Aerobic activities like brisk walking or swimming promote collateral circulation development, acting as a "natural bypass" to maintain myocardial blood supply when coronary arteries are compromised. Resistance training, meanwhile, enhances muscle mass by 15%-20%, improving insulin sensitivity and reducing low-density lipoprotein cholesterol levels by approximately 25%. Flexibility and balance exercises play equally critical roles—static stretching prevents joint contractures that impede daily activities, while single-leg standing drills reduce fall risks by 40%, a vital benefit given the high fracture morbidity in elderly populations. Beyond physical rehabilitation, exercise acts as a neurobiological regulator, increasing endorphin secretion to alleviate 35%-50% of postoperative anxiety and depression symptoms. The social interaction inherent in group exercise programs further mitigates feelings of isolation, with participation rates in community-based rehabilitation correlating with a 2.3-fold improvement in quality of life scores. Notably, integrated rehabilitation modalities also address secondary complications: aerobic exercise lowers blood viscosity to reduce deep vein thrombosis risk, while resistance training enhances gastrointestinal motility to prevent constipation-induced cardiac stress. To maximize these benefits, clinical practice should prioritize evidence-based exercise prescriptions tailored to age-related physiological declines. This requires collaborative efforts from cardiologists, rehabilitation specialists, and geriatricians to design programs with precise intensity monitoring. By embedding exercise rehabilitation into standard post-PCI care pathways, healthcare systems can facilitate not only physical recovery but also psychological resilience, enabling elderly patients to reclaim functional independence and quality of life.

Authors contribution

All the authors contributed equally and their names were listed in alphabetical order.

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