
Impact of Exercise Interventions on Elderly Heart Failure: Evaluating Aerobic, Resistance, and Combined Approaches

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Abstract

In recent years, the number of elderly individuals has continued to rise, particularly in China, where aging has become a serious issue. Common symptoms of aging, such as hypertension, heart disease, and osteoporosis, are increasingly prevalent. Heart failure, a complication of heart disease, primarily affects the elderly and can severely impact their quality of life, even posing life-threatening risks. This study explores the impact of exercise interventions on the treatment and rehabilitation of heart failure in the elderly, aiming to provide more comprehensive and effective evidence. Keywords such as "exercise," "aerobic exercise," "resistance exercise," "combined exercise," "heart failure," and "elderly" were entered into databases like HowNet, Wanfang, VIP, PubMed, and Embase to select and summarize representative articles. The results indicate that all three types of exercise interventions positively affect elderly heart failure, though the degree of positive impact and improvement in related physical indicators vary. Targeted exercise interventions should be based on the type and severity of heart failure in the elderly. Aerobic exercise is recommended for patients with mild conditions, while resistance exercise is suitable for those with severe heart failure and muscle weakness. Combined exercise depends on concurrent symptoms, such as respiratory failure and the inability to stand. Further study is needed to better understand the relationship between exercise types and rehabilitation outcomes. Developing individualized intervention programs based on disease severity and overall physical condition is crucial. Additionally, educating and training healthcare professionals on implementing effective exercise intervention programs for elderly patients with heart failure is essential.

Keywords: *Senior Citizens; Heart Failure; Sports*

A. Introduction

The aging population is a global phenomenon, with China experiencing one of the most rapid increases in the number of elderly individuals. This demographic shift has brought about a surge in age-related health issues, particularly cardiovascular diseases such as hypertension, heart disease, and osteoporosis. Among these, heart failure stands out as a significant complication that predominantly affects the elderly, posing serious risks to their quality of life and overall health. Heart failure, a chronic and progressive condition, results in the heart's inability to pump sufficient blood to meet the body's needs. This condition not only diminishes physical capacity but also leads to various debilitating symptoms, such as shortness of breath, fatigue, and fluid retention. Consequently, managing heart failure in the elderly requires comprehensive and multifaceted approaches to improve their functional status and quality of life.

Cardiovascular and cerebrovascular problems have always been a concern of the country and society. In China, aging is increasingly aggravating, the life expectancy of the population is

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gradually extended, and the co-occurrence of cardiovascular and cerebrovascular diseases is gradually highlighted. According to the calculation and statistics of China Cardiovascular Health and Disease Report 2020 released by the National Cardiovascular Disease Center, the number of people suffering from cardiovascular diseases in China is about 330 million, of which about 8.9 million are patients with heart failure. Moreover, the number of heart failure patients has doubled every year. Today, there are more than 11 million heart failure patients. In the elderly over 70 years old, one in ten people dies. Studies have shown that the mortality rate in five years after the diagnosis of chronic heart failure is as high as 50%. Heart failure is one of the five fatal causes of cardiovascular disease in China at present, and it brings heavy economic burden to patients and their families (Xu, et al., 2019). According to the release by the National Health and Family Planning Commission's Health Development Study Center in 2018, China's heart failure treatment costs amounted to 13.642 billion yuan, while the total expenditure of the basic medical insurance fund for the treatment of cardiovascular and cerebrovascular diseases amounted to 331.243 billion yuan, of which heart failure reached 7.865 billion yuan, with the cost mainly concentrated in the elderly. According to 2018 data, 17.88% of the elderly over the age of 60 spent 6.755 billion yuan on cardiovascular and cerebrovascular diseases (Chai, et. all., 2021). Exercise intervention has a positive effect on heart failure in the elderly. Exercise can improve blood pump function, peak heart rate and ventricular diastolic function of patients with heart failure, and improve the symptoms, functional performance and health-related quality of life of elderly patients with systolic heart failure (Fu, et. all., 2016). However, most of the studies are only limited to one type of exercise for the intervention of heart failure, and it is not clear which type of exercise has the best effect on heart failure. Through collecting the relevant literature both in China and abroad, this paper summarizes the effects of aerobic exercise, resistive exercise and combined exercise on heart failure in the elderly, and discusses the best exercise for the intervention of heart failure in the elderly.

Exercise interventions have emerged as a promising strategy in the treatment and rehabilitation of heart failure. Regular physical activity is known to confer numerous cardiovascular benefits, including improved heart function, enhanced muscle strength, and better overall endurance. However, the type and intensity of exercise suitable for elderly patients with heart failure can vary significantly based on the severity of their condition and associated comorbidities. This study aims to explore the impact of different exercise interventions—specifically aerobic exercise, resistance exercise, and combined exercise—on the treatment and rehabilitation of elderly patients with heart failure. By conducting a thorough review of literature sourced from databases such as HowNet, Wanfang, VIP, PubMed, and Embase, this study seeks to provide comprehensive evidence on the effectiveness of these exercise modalities. The findings will help develop targeted exercise programs tailored to the specific needs of elderly heart failure patients, ultimately enhancing their rehabilitation outcomes and overall well-being.

The results of this study are expected to offer valuable insights into the optimal exercise strategies for elderly individuals with heart failure, guiding healthcare professionals in implementing effective and individualized intervention programs. Additionally, this study underscores the importance of educating and training healthcare providers on the implementation of exercise interventions, thereby improving the standard of care for this vulnerable population.

B. Methods

This study utilizes a qualitative descriptive literature review design to investigate the impact of various exercise interventions on the treatment and rehabilitation of elderly patients with heart failure. A systematic search was conducted across multiple academic databases, including HowNet, Wanfang, VIP, PubMed, and Embase. The search employed keywords such as "exercise," "aerobic exercise," "resistance exercise," "combined exercise," "heart failure," and

"elderly" to identify relevant studies. To be included in the review, studies had to meet specific criteria: they must focus on elderly patients (aged 60 and above) with heart failure, investigate the effects of aerobic, resistance, or combined exercise interventions, be published in peer-reviewed journals, and be available in English or Chinese. The initial search results were screened by reviewing titles and abstracts to exclude irrelevant studies. Full texts of the remaining articles were then examined to ensure they met the inclusion criteria. Data collection involved extracting detailed information from each study, including author(s) and year of publication, study population characteristics (such as sample size, age, and severity of heart failure), type of exercise intervention (aerobic, resistance, or combined), duration and frequency of the exercise program, measured outcomes (like cardiovascular health, muscle strength, and quality of life), and key findings and conclusions.

The data was analyzed using thematic analysis. This process began with familiarization, where the studyrs read and re-read the selected articles to gain an in-depth understanding of their content. Next, key themes and patterns related to the effects of different exercise interventions on elderly heart failure patients were identified and labeled through a coding process. These codes were then grouped into broader themes to synthesize findings across different studies, focusing on types of exercise interventions, their specific benefits, and considerations for implementation in elderly populations with heart failure. Finally, the themes were summarized to provide a coherent narrative of the existing evidence, highlighting the impact of aerobic, resistance, and combined exercises on the health and rehabilitation outcomes of elderly heart failure patients.

This method aims to produce a comprehensive understanding of how various exercise interventions can be effectively utilized to enhance the health and quality of life of elderly individuals suffering from heart failure. The findings from this study are intended to guide healthcare professionals in designing and implementing effective, tailored exercise programs for this vulnerable population..

C. Findings and Discussion

1. *Heart Failure in the Elderly: Causes, Types, and Pathophysiology*

Complexities of Heart Failure

Heart failure is a complex disorder caused by abnormal changes in heart structure and function for various reasons, resulting in ventricular contraction and/or relaxation dysfunction, mainly manifested as decreased exercise tolerance and fluid retention. To put it simply, under the normal condition of venous return, the decrease in cardiac output and increase in ventricular filling pressure due to their own cardiac damage cause insufficient blood perfusion of tissues and congestion of pulmonary and/or systemic circulation. Heart failure can be divided into heart failure with decreased ejection fraction and heart failure with preserved ejection fraction according to pathophysiological and clinical characteristics, also known as systolic heart failure and diastolic heart failure. On this basis, it can be divided into acute heart failure and chronic heart failure according to the time, speed and severity of the disease. Acute heart failure is generally the deterioration of chronic heart failure or it is caused by sudden myocardial damage and sudden aggravation of heart load. Acute left heart failure is the most common, and chronic heart failure refers to that the original patient has chronic heart disease, and the ventricles are gradually damaged for various reasons, followed by heart failure symptoms, which is a slow process (Cheng, 2001).

Causes of Heart Failure in the Elderly

The causes of heart failure in the elderly are complex, with primary and secondary causes. Diseases of primary myocardial contraction and relaxation, such as myocarditis, cardiomyopathy, myocardial infarction and myocardial fibrosis. Dilated cardiomyopathy is characterized by decreased systolic function. The main manifestation of hypertrophic cardiomyopathy in the early stage is impaired myocardial diastolic function, while in the late stage it is often combined with myocardial systolic dysfunction. Restrictive cardiomyopathy refers to the limitation of ventricular filling, which makes the heart unable to relax effectively. Secondary causes mainly include hypertension, valvular heart disease, hyperthyroidism, chronic anemia, etc. Data suggest that hypertension is the most common cause of heart failure in the elderly, with about 75% of patients having progressive hypertension [1]. Therefore, attention must be paid to the prevention and treatment of hypertension in the elderly to prevent the occurrence and progression of heart failure in the elderly (Zhang & Yu, 2010).

Causes of Heart Failure in The Elderly

Respiratory tract infection is the main cause of heart failure in the elderly, followed by myocardial hypoxia and ischemia, arrhythmia, anemia and excessive labor resulting in fatigue, emotional excitement, as well as intravenous infusion or blood transfusion too fast, renal failure, etc. According to statistics, 9% of the elderly with pneumonia due to respiratory tract infection died of heart failure, mainly because the body generation level is higher at the time of infection, leading to accelerated heart rate, rapid increase in body oxygen consumption, and increase in catecholamine hormones in the body. It increases the heart load and myocardial damage, and after infection there will be a large amount of release of endotoxin, resulting in abnormal myocardial contraction and thus heart failure. The reason for heart failure caused by myocardial ischemia is due to the decline in coronary artery reserve function of the elderly. During heart activity, it causes the decline in myocardial contractility caused by myocardial ischemia, leading to heart failure. Tachyarrhythmia is the most common cause of heart failure in the elderly due to arrhythmia (Cheng, 2001).

The Common Types of Heart Failure in the Elderly

1. According to the speed of disease, can be divided into acute heart failure and chronic heart failure. 2. It can be divided into left heart failure, right heart failure and whole heart failure according to the site of occurrence. Left ventricular systolic dysfunction heart failure is the most common type of heart failure and is caused by the weakened contractile emptying ability caused by myocardial contractility. The main manifestations are enlargement of left ventricular cavity, enlargement of left ventricular volume at the end of systole and reduction of left ventricular ejection fraction. 3. Left ventricular diastolic dysfunction Heart failure refers to the condition that the left ventricular systolic function is normal, the myocardium is obviously hypertrophic, the left ventricular diameter is normal, the left atrium is enlarged, and the left ventricular filling rate and filling amount are decreased, or the filling amount is normal, but the left ventricular filling pressure is abnormally increased. 4. Refractory congestive heart failure refers to that if the symptoms and signs of heart failure remain unchanged for a long time or progressive aggravate after appropriate etiological treatment and conventional anti-heart failure treatment, it is called refractory heart failure.

2. The Effect of Different Training Programs on Heart Failure in The Elderly

Aerobic Exercise on The Elderly Heart Failure

Aerobic exercise is a kind of exercise mode that carries out aerobic oxidation energy supply for a long time under low intensity. Many studies have shown that aerobic exercise has a good effect on heart failure in the elderly, and it can alleviate and improve various intervention indicators of the disease. It has been reported that aerobic exercise is considered to be the safest

and most effective strategy to improve the clinical symptoms of chronic heart failure [8]. Hwang (Hwang, Chien & Wu, 2010) once used medium aerobic intensity training to conduct a 16-week exercise experiment for the elderly patients with chronic heart failure. The patients received one-hour exercise each time, and forty minutes of formal exercise covered treadmill walking and Schwinn cycle power measurement. The previous exercise amount was 40% to 50% of the heart reserve. With the increased tolerance to exercise, the heart reserve was gradually increased to 60%. After 16 weeks of exercise, the final result showed that the body function indexes of the elderly patients with heart failure and the six-minute walking distance were significantly improved compared with those before the experiment. Brubaker (Brubaker, et. al., 2020) conducted high-intensity aerobic exercise for four weeks in nine patients with ejection fraction-preserved heart failure. No major cardiovascular events or musculoskeletal injuries occurred during the exercise, and finally the peak oxygen uptake of patients and left ventricular diastolic dysfunction were improved. At the same time, he proposed that high-intensity intermittent training seemed to be safe and well-tolerated. In patients with ejection fraction-preserved heart failure, high-intensity intermittent training seemed to be better than medium-intensity aerobic training.

Aerobic Exercise on Neurohumoral Effects

The occurrence and development of heart failure are closely related to the changes of neurohumoral balance, because the sympathetic nerves and renin-angiotensin-aldosterone system are activated due to the effects of decreased cardiac output and organ perfusion of the body, which increases myocardial contraction, heart rate and vasoconstriction, and increases extracellular fluid volume. However, persistent neurohumoral excitability leads to deterioration of myocardial function, causing inflammatory reactions, end organ damage, and skeletal muscle disorders, thereby resulting in deterioration of locomotor ability and further progression of heart failure.

The specific mechanism of sympathetic nerve excitation in CHF is still unclear. At present, it is generally believed that the main causes are the increase in central nervous system such as anterior sympathetic neuron discharge and the changes of excitatory membrane receptors (Gao, L., et al., 2008). Many studies have shown that the increase of oxidative stress is the main regulator of central sympathetic nerve excitation (Gao, L., et al. 2004). The imbalance between the production of reactive oxygen species and antioxidant protection mechanisms in CHF leads to the accumulation of ROS, which leads to oxidative stress. The increase of oxidative stress in presympathetic neurons may change the activities of multiple ion channels and promote the excitability of neurons (Chan & Chan, 2012), aerobic exercise rehabilitation inhibits the activation of systemic sympathetic nervous system in CHF and promotes the functional recovery of cardiac sympathetic nerve. Studies have shown that aerobic exercise promotes the reuptake of norepinephrine (NE) and recovers the NE release from the sympathetic nerve endings by up-regulating the expression of norepinephrine transporter in cardiac sympathetic neurons. Or by up-regulating β 1- adrenergic receptor (β 1-AR) and tyrosine hydroxylase and down-regulating the expression of G protein-coupled receptor kinase 2 gene, β 1-AR can be brought back to functional coupling (re-sensitization), and the sympathetic activity of the heart can be enhanced and that of the whole body can be inhibited so as to maintain the heart function and delay the progression of CHF (Li, at. al., 2015). In addition, the levels of angiotensin and progesterone can be maintained. The balance between AngII and AG1-7 is crucial in the regulation of sympathetic excitability. Aerobic rehabilitation improves the balance between AT1R and AngII type 2 receptors by regulating the expression of AngII type 1 receptor (AT1R) in the hypothalamic PVN, and blocks the further activation of RAAS. As a result, the levels of AngII, aldosterone, vasopressin and atrial natriuretic peptide are decreased, thereby reducing cardiac load and benefiting the rehabilitation of CHF.

Effects of Aerobic Exercise on Myocardium

The specific mechanism of the beneficial effects of aerobic exercise rehabilitation on myocardium of CHF is mainly related to various inflammatory and immune mechanisms that affect myocardial remodeling, according to the current research results, in addition to the aforementioned effects of aerobic exercise on neurohumoral regulation. Myocardial remodeling is an important cause for the development of chronic heart failure. Myocardial remodeling is mainly closely related to myocardial hypertrophy, myocardial fibrosis and apoptosis, which eventually leads to the decline of cardiac function.

Studies have shown that aerobic exercise rehabilitation can improve the systolic and diastolic function of mice with heart failure and partially reduce the degree of left ventricular dilatation and myocardial hypertrophy, and the specific mechanism is related to the protective effect of β_3 -AR-nNOS-NO pathway and the alleviation of myocardial oxidative stress (Wang, et al., 2017), aerobic exercise increases the expression of β_3 -adrenergic receptor (β_3 -AR). Neuronal nitric oxide synthase (nNOS) is activated to produce NO, thereby reducing the degree of myocardial hypertrophy and alleviating myocardial remodeling, thereby improving left ventricular function and delaying the progression of heart failure. In addition, aerobic exercise rehabilitation can reduce myocardial ROS content and increase myocardial SOD level, thereby reducing myocardial oxidative stress damage and improving cardiac function, which is conducive to the rehabilitation of CHF.

Myocardial fibrosis caused by excessive deposition of extracellular matrix in CHF plays an important role in myocardial remodeling (Segura, Frazier & Buja (2014)) Research has confirmed that TGF- β , tissue inhibitors of metalloproteinases (TIMP-1) and matrix metalloproteinase (Matrix metalloproteinase, MMP-1) and other signaling molecules to regulate the metabolic reaction of collagen, and the abnormal TGF- β /TIMP-1/MMP-1 signaling pathway will cause collagen deposition and fibrosis [17] research shows that exercise, especially medium- and low-intensity aerobic exercise, can regulate the dynamic balance of MMP-1/TIMP-1, reduce collagen deposition and reduce myocardial fibrosis by inhibiting TGF- β overexpression, and has a beneficial effect on the collagen content and spatial ordering and interaction of collagen, thereby inhibiting CHF myocardial remodeling, improving cardiac function and patients' life quality, and delaying the progression of heart failure (Kwak, et al., 2011; Zhen & Li, 2015).

Therefore, aerobic exercise rehabilitation is likely to reduce myocardial hypertrophy through β_3 -AR-nNOS-NO pathway, reduce collagen deposition through TGF- β /TIMP-1/MMP-1 signaling pathway, and reduce myocardial fibrosis, and reduce myocardial damage and apoptosis through the irisin /ROS/ uncoupling protein 2 pathway, etc., thereby reducing the degree of myocardial remodeling, improving cardiac function, and delaying the progression of heart failure.

Effects of Aerobic Exercise on Skeletal Muscle

Skeletal muscle is the largest reservoir of protein in the body, and maintaining its normal function is crucial for the movement and respiratory function of the human body. Skeletal muscle dysfunction leads to movement limitation and daily activity damage in patients with CHF. Evidences Adams, et al., (2017) show that muscle atrophy in skeletal muscle of patients with CHF is mainly related to various pathophysiological mechanisms such as inflammation, hormone changes, oxidative stress, autophagy, and apoptosis. The decrease in cardiac output and systemic congestion in CHF leads to a decrease in food intake and exercise capacity, promotes the release of inflammatory factors, increases sympathetic excitability, and affects the secretion of muscle-related hormones. These factors together act on the muscle tissue, causing the decline of skeletal muscle growth factors, increased oxidative damage, enhanced the activity of ubiquitin-proteasome system (ups), induced autophagy and apoptosis, and led to the imbalance of protein synthesis and degradation, leading to skeletal muscle atrophy. The specific mechanism

of aerobic exercise rehabilitation on CHF skeletal muscle is still unclear, but it may be related to reducing inflammation, oxidative stress and energy metabolism, and improving the balance between the synthesis and degradation of muscle proteins. The following describes the mechanisms related to inflammation and immunity.

The effect of aerobic exercise rehabilitation on CHF skeletal muscle is related to its efficacy in promoting skeletal muscle regeneration and improving the balance between protein synthesis and degradation in skeletal muscle, in addition to reducing muscle sympathetic nerve activity and vasoconstriction, and improving oxidative stress and inflammatory reaction. Studies (Antunes-Correa, et al., 2020) have confirmed that aerobic exercise rehabilitation up-regulates the level of microRNA-1 and reduces the expression of PTEN protein, which is beneficial to the up-regulation of rapamycin target protein (mTOR) to stimulate the increase in p-AKT protein synthesis, and the reduction in the inhibition of PI3K/AKT/mTOR pathway to help improve the anabolism/catabolism balance. Elevated microRNA-1 levels also reduced 4(histone deacetylase 4,HDAC4), promoted myoblast differentiation, and caused the expression of myocyte enhancer factor 2C, MEF2c), myogenic differentiation factor D (Myogenic differentiation factor D, Myod) and follistatin (Follicstatin, FS) expressions are increased, and then activate the myogenic pathway mTOR/MyoD/microRNA-1/HDAC4/FS to stimulate skeletal muscle myogenic fusion, and promote the regeneration of skeletal muscle, thus improving exercise intolerance caused by CHF skeletal muscle lesions and conducive to CHF rehabilitation.

Anti-Inflammatory Effect of Aerobic Exercise

Inflammatory factors are one of the main indicators for the progression and prognosis of chronic heart failure. In the early stage of CHF, plasma inflammatory factors were elevated, such as major pro-inflammatory cytokines [such as tumor necrosis factor, TNF)] and chemokines (such as macrophage chemoattractant protein -1). First, the activation of inflammatory factors increases oxidative stress through the activation of inducible nitric oxide synthase (iNOS), inhibits the release of sarcoplasmic reticulum Ca^{2+} and the expression of phosphorylated proteins, promotes cardiomyocyte apoptosis and myocardial remodeling, and affects myocardial systolic and diastolic function, thereby accelerating the progression of CHF. Second, the increase of inflammatory factors will also lead to endothelial dysfunction by increasing the production of ROS, endothelial cell apoptosis and increasing the expression of endothelial cell adhesion molecule (Crimi, et al., 2009). In addition, high levels of inflammatory factors have adverse effects on skeletal muscle contraction and metabolism by promoting oxidative stress and skeletal muscle cell apoptosis, reducing the expression of insulin-like growth factor-1 (IGF-1), and inducing impaired expression of iNOS in aerobic metabolism through inhibition of peroxynitrite and cytochrome C oxidase, and thus, persistently increased levels of inflammatory factors lead to muscle catabolism and consumption.

Aerobic exercise rehabilitation has an anti-inflammatory effect on patients with heart failure. Aerobic exercise has been proved to reduce the circulating levels of pro-inflammatory cytokines and other pro-inflammatory markers in the population (Wang & Zhang, 2016). After patients with CHF receive aerobic exercise rehabilitation treatment, inflammatory factors such as TNF- α and IL-6 will be decreased in the body to reduce the inflammatory response, the activation and oxidative stress of iNOS, myocardial apoptosis and myocardial remodeling, and improve cardiac function. At the same time, it can reduce ROS production, endothelial cell apoptosis and significantly reduce endothelial cell function markers Endocan and Syndecan-4, improving cardiac endothelial cell function and contributing to the rehabilitation of CHF. In addition 17(T helper cell 17,Th17) are significantly increased and regulatory T cell,Treg) are significantly decreased in patients with CHF, suggesting that the Th17/Treg imbalance may play a role in the pathogenesis of CHF (Li, et al., 2010). Th17 and Treg are new discovered CD4⁺T

cell subsets in recent years. Among them, Th17 plays a pro-inflammatory role, while Treg plays an immunosuppressive role. They play an important role in maintaining the immune balance of inflammation. Transforming growth factor- β (TGF- β) and IL-6 are the key cytokines that induce the initial CD4+T cells to differentiate into Th17 (Wang & Shen, 2010). The differentiation, development and function of Treg are also regulated by a variety of cytokines. Under the joint action of IL-2 and TGF- β , fork head/winged helix transcription factor 3 (FOXP3) is activated via STAT5 pathway, thereby regulating the differentiation process of Treg. A number of experimental studies Chen, Z., et al. (2018) have revealed that Th17 was significantly increased and Treg was significantly decreased in CHF rat models and patients, and the levels of cytokines IL-6, IL-17, and TNF- α were significantly increased, but TGF- β level was significantly decreased. After 12 weeks of aerobic exercise training, the ratio of Th17/Treg was significantly decreased, as well as the levels of IL-17, IL-6 and TNF- α , while TGF- β was increased. The left ventricular ejection fraction (LVEF) was also significantly higher than that in the untrained group. The results showed that aerobic exercise could improve the imbalance of Th17/Treg in heart failure and regulate the inflammatory immune response, thereby improving cardiac function and facilitating the rehabilitation of CHF.

Resistance Training on The Influence of Heart Failure in the Elderly

For the elderly, once they reach a higher age, their muscle strength will be severely decreased and it is even difficult to stand. In this case, it is somewhat difficult to do aerobic exercise. Most elderly patients with chronic heart failure are accompanied by peripheral muscle weakness, and muscle strength has been reported as a predictor of long-term survival for patients with chronic heart failure. Therefore, in recent years, many scholars have begun to study the effect of anti-resistance training on heart failure in the elderly. Compared with aerobic exercise, anti-resistance training exerts lower pressure on the heart. Some studies have also confirmed the safety of anti-resistance exercise and proposed that muscle strength can significantly improve the reduction rate of peripheral resistance of blood vessels, resulting in improved afterload on the heart, proving the effectiveness of long-term resistance training (Giuliano, et. al., 2017). Catherine Giuliano (Angadi, et. al., 2015) mentioned in a systematic evaluation that cardiac rehabilitation still focuses on aerobic or intensive training, and the evidence supporting resistance training as an effective independent treatment is limited. Previous reports have said that compared with aerobic training, anti-resistance training has little effect on increasing the peak oxygen uptake of patients with heart failure, but the anti-resistance training has greatly improved the strength and endurance of skeletal muscle. Some researchers believe that resistance training may be a suitable alternative for many patients who do not have enough ability to tolerate aerobic exercise, such as the elderly or patients with more severe heart failure. Resistance training has good effects on muscle strength (1RM), aerobic capacity (measured by VO₂ peak and/or 6-minute walk distance), and quality of life, so it may also be a suitable choice for patients with heart failure. Lovell et al. (2009) found after 16 weeks of strength training that resistance training could significantly improve the cardiovascular function of older men and claimed that resistance training could not only increase muscle strength and hypertrophy, but also provide significant cardiovascular benefits for the elderly.

Resistance training is conducive to improving cardiac function in patients with CHF. Patients with CHF are prone to fatigue and dyspnea due to the decline of cardiac function, which has seriously affected the quality of life and exercise tolerance of patients. Hu, et al. (2020) The improvements in LVEF, LVED, NYHA cardiac function classification, BNP and 6MWD of patients in the observation group were superior to those in the control group 12 months after discharge ($P < 0.05$), suggesting that long-term regular anti-resistance training could improve cardiac function of patients with CHF. In the aspect of ventricular remodeling, Luo et al. (2014) found that three months of exercise training for patients with CHF could improve their LVEF and exercise tolerance, but the improvement of left ventricular remodeling was not significant.

Zhou et al. (2013) found that six weeks of rehabilitation training could improve the 6MWD and cardiac function of patients with CHF, but there was no significant difference in BNP level ($P>0.05$). In this study, the levels of LVED and BNP in the observation group were significantly lower than those in the control group ($P<0.05$), which might be related to the patient's persistent exercise for 12 months. The increase of BNP in CHF patients is due to the continuous ventricular secretion caused by the increased ventricular wall tension. If the intervention time is not enough and the effect of ventricular remodeling is not significant, the improvement of BNP is not significant. Therefore, cardiac rehabilitation exercise needs long-term and gradual exercise to achieve the effect of anti-ventricular remodeling.

Resistance training is conducive to reducing the readmission rate and medical expenses of patients with CHF. CHF patients are repeatedly hospitalized due to their repeatedly aggravating conditions, which not only increases the medical burden, but also increases the mental pressure of patients and their families, resulting in a decline in the quality of life of patients and an increase in the risk of death. Therefore, cardiac rehabilitation after discharge in patients with CHF is of positive significance. This study showed that the times of re-hospitalization and the per capita cost of hospitalization for heart failure in patients of the observation group within 12 months after discharge were significantly lower than those of the control group ($P<0.05$). It indicated that resistance training could reduce readmission rate and hospitalization expenses of patients with CHF. Resistance exercise with elastic belt is beneficial to improving the compliance of cardiac rehabilitation. According to their research, Yang Xianjun et al. (2015) held that only safe, effective and patient-compliant rehabilitation exercise can achieve the best curative effect. In this study, only one patient in the observation group dropped out of the study due to moving out of the city, and all other patients were able to complete the resistance training as required. Because elastic belt was used for training in this study, the elastic belt model or intensity of exercise load could be dynamically adjusted. Elastic belt training movements are easy to learn and various in forms, and there are no too many requirements for venues and sports equipment. Patients can practice indoors and outdoors without being affected by the weather, making patients' compliance in rehabilitation training high.

Galvao et al. found that after 12 weeks of high-strength and high-resistance training, the torque of thigh muscles and knee extensor muscle of aged men was significantly increased. Later, it was found that even if low-intensity resistance exercise was not performed regularly or only, its promoting effect on torque increase of knee extensor still existed. Fiatarone et al. confirmed that resistance training could not only improve the muscle quality and strength of the elderly, but also increase the walking speed. Candow et al.[33] It was reported that 22 weeks of resistance training (3 times a week) in healthy elderly (60–71 years old) could increase local muscle volume and enhance the strength of the upper and lower limbs. Williams et al (2016) Studies have shown that resistance training can directly improve the ultrasonic structure and neuromuscular function of skeletal muscle in patients with heart failure, rather than simply increasing muscle volume. Therefore, anti-resistance training can effectively improve the muscle quality and endurance of patients with myasthenia gravis, and enhance physical function.

Effect of Combined Training on Heart Failure in the Elderly

Giulia No et al. (2019) compared the effects of three different kinds of training on heart failure. The experimental tests were conducted with simple aerobic, aerobic and anti-resistance training, as well as aerobic anti-resistance inspiratory muscle combination training. The main test indexes were the changes of peak oxygen consumption, left ventricular end-diastolic diameter and left ventricular end-systolic diameter. The secondary indexes included the assessment of walking distance and quality of life, as well as the perception of dyspnea and the functions of limbs and respiratory muscles. The results of the study showed that each type of exercise improved the indexes differently. The aerobic exercise was better when the pathological

changes of muscle fibers were not obvious, but the aerobic peak value increased more. The left ventricular end diastolic diameter was improved. The combined training had the largest reduction in the left ventricular end systolic diameter. The aerobic anti-resistance training was better than the aerobic training alone in improving the vascular diastolic function and inflammation in patients with heart failure. The combined training was better than the aerobic training in walking distance and quality of life. Walking distance is better than aerobic anti-resistance training, combined exercise improves cardiopulmonary index more and cardiopulmonary exercise lasts longer, aerobic training response is improved, diaphragm is improved, so as to weaken the dyspnea of patients with heart failure and improve the metabolic ability of skeletal muscle. Therefore, inspiratory muscle training and anti-resistance training seem to play a key role in improving the performance of inspiratory muscle and dyspnea, and increasing the muscle strength of limbs to further improve the quality of life and promote activities of daily living, respectively, which indicates that both models are ideal candidates for aerobic training, especially when the inspiratory and limb muscle functions of patients with chronic heart failure decrease.

Laoutaris et al. (2020) performed intermittent muscle exercise for eight weeks twice a week for nine patients with heart failure with decreased ejection fraction over the age of 60. The intermittent muscle exercise adopted low-weight and high-repeatability exercises (the combination of moderate intensity aerobic and anti-resistance training). The study found that the peak oxygen uptake of elderly patients was increased, the efficiency of muscle voluntary contraction was increased, the muscle strength was improved, the muscle endurance and aerobic capacity was improved. He stressed that intermittent muscle training may provide more beneficial exercise options for older patients with heart failure with reduced ejection fraction, especially those with significant impaired aerobic capacity and strength.

Researchers such as Caminitia (2022) compared 24-week hydrotherapy and combined endurance training for patients with reduced sexual heart failure with individual endurance training, and the study found that the combined training more effectively improved exercise tolerance and central hemodynamics, maximum exercise capacity, maximum oxygen uptake, and 6 MWT walking distance.

Yuds et al. (2022) performed aerobic and anaerobic combined training three times a week for 12 weeks, covering upper and lower limb strength training, aerobic dance, resistance training and relaxation training. There are two types of sports: resistance training (starting from 10 repetitions, with the increase in resistance and repetition times alternately) and aerobic exercise (starting from one group, lasting for 5 minutes, and increasing by three groups at most, and then increasing by 1 kg. The results showed that after intervention, the elderly patients with heart failure not only improved in muscle strength, but also showed an improvement trend in mental state and health-related quality of life.

Giuliano[8] explored the combined effects of intermittent training and intermittent and strength training on heart failure in the elderly. The intermittent circulation training group received a training plan lasting for 40 minutes, while the combined training group received 20 minutes of intermittent training and 20 minutes of strength training, including the quadriceps, hamstring, biceps and shoulder muscles. Each limb was trained in three groups with 10 to 12 repetitions. Each group rested for 30 seconds, and the experimental results showed that both groups had improved motor ability, and the combined training had significantly improved vascular reactivity, thereby improving patients' motor ability and quality of life, and enhancing endothelial dysfunction. It was also the first time that the combined strength and intermittent training had affected vascular reactivity. Resistance strength training was a simple, safe and effective alternative training for patients with heart failure, which could be used as a supplement to intermittent training to improve motor ability and vascular reactivity.

D. Conclusion

The rising number of elderly individuals, particularly in China, has brought significant attention to age-related health issues, with heart failure emerging as a critical concern due to its severe impact on quality of life and potential life-threatening risks. This study has explored the effects of different exercise interventions—namely aerobic, resistance, and combined exercises—on the treatment and rehabilitation of elderly patients with heart failure. The findings indicate that all three types of exercise interventions have positive effects on elderly heart failure patients, although the degree of impact and improvement in physical indicators vary depending on the type and severity of heart failure.

Specifically, aerobic exercise is beneficial for patients with mild heart failure, resistance exercise is suitable for those with severe heart failure and muscle weakness, and combined exercise is recommended based on concurrent symptoms such as respiratory failure and the inability to stand. These results underscore the importance of tailored exercise interventions that consider the specific needs and conditions of elderly patients with heart failure. Further study is necessary to deepen the understanding of the relationship between different types of exercise and rehabilitation outcomes. Additionally, developing individualized intervention programs based on disease severity and overall physical condition is crucial. Educating and training healthcare professionals to implement effective exercise intervention programs for elderly heart failure patients is essential to enhance their rehabilitation and quality of life.

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