

The Impact of Resistance Training on Cardiovascular Diseases in Middle-aged and Elderly Individuals

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Abstract: As China gradually enters an aging society, the health conditions of the middle-aged and elderly are not optimistic, especially the cardiovascular diseases among them are particularly prominent. With the increase of age, the cardiovascular system of the middle-aged and elderly will undergo degenerative changes, which may lead to a series of problems such as arteriosclerosis, elevated systolic blood pressure, and decreased cardiac output. Resistance training has the effect of reducing the risk of cardiovascular diseases for the middle-aged and elderly. Resistance exercise has a good effect on reducing cardiovascular risk factors, alleviating chronic inflammatory responses, and improving lipid abnormalities in the middle-aged and elderly population. This article explores the effects of resistance training on the prevention of cardiovascular disease risks in the middle-aged and elderly from two aspects: the improvement mechanism of cardiovascular structure and function and the regulation mechanism of metabolism and inflammation. It indicates that scientific and reasonable cardiac rehabilitation resistance training methods can improve the cardiac function of the middle-aged and elderly, inhibit the decline of muscle strength, and improve the quality of life, thereby enabling the middle-aged and elderly to enjoy a better quality of life. If the middle-aged and elderly can incorporate safe and effective resistance training into their daily lives, it will be of great significance for improving the quality of life of the elderly, reducing the risk coefficient of cardiovascular system diseases, and alleviating the burden of social elderly care.

Keywords: Resistance training, middle-aged and elderly people, Cardiovascular, Exercise prescription

1. Introduction

China has the largest elderly population in the world and is also one of the countries with the fastest aging rate. By the end of 2024, the population aged 60 and above was 310.31 million, accounting for 22.0% of the total population, among which the population aged 65 and above was 220.23 million, accounting for 15.6% of the total population [1]. Compared with 2014, both the number and proportion of the elderly population have increased rapidly. The health condition of middle-aged and elderly people is not optimistic, especially the problem of cardiovascular diseases among them is particularly prominent. In 2019, the "China Cardiovascular Health and Disease Report" showed that the incidence of cardiovascular diseases (CVD) has been continuously rising, with about 330 million existing patients, including 240 million with hypertension and 11 million with coronary heart disease [2]. In the past, surgery and drugs were mainly used to treat cardiovascular disease patients in China.

In recent years, with the development of cardiac rehabilitation, more and more people have begun to pay attention to the promoting effect of exercise on cardiovascular health.

Studies have shown that resistance exercise can stimulate skeletal muscles, increase the number of capillaries, improve blood circulation, increase blood oxygen content, and improve heart structure; it can increase peripheral vascular resistance sharply in a short time, slightly increase cardiac output, and enhance the heart's pumping capacity; it can reduce cardiac stiffness, enhance ventricular diastolic compliance, inhibit myocardial cell apoptosis [3]. Therefore, resistance training can be used as an effective exercise method for the prevention and treatment of cardiovascular diseases and can be used as a supplement to drug treatment to enhance the comprehensive intervention effect. Previous studies have shown that long-term and systematic aerobic training has a good effect on improving cardiopulmonary endurance and preventing cardiovascular diseases [4], but there are relatively few studies on the prevention of cardiovascular diseases through resistance training.

Therefore, this paper conducts research on the impact of resistance training on the prevention of cardiovascular diseases in middle-aged and elderly people, summarizes and sorts out the effects of resistance training on the prevention of cardiovascular diseases in middle-aged and elderly people, and proposes exercise prescriptions and suggestions for resistance training in middle-aged and elderly people, with the aim of promoting the popularization and development of resistance training for the prevention of cardiovascular diseases among middle-aged and elderly people, thereby improving the cardiovascular health of middle-aged and elderly people and achieving the goal of preventing diseases before they occur and building a healthy China in the context of an aging society.

2. Research on the prevention of cardiovascular diseases through exercise

2.1. Characteristics of cardiovascular system decline in middle-aged and elderly people

2.1.1. Changes in heart structure and function

The functional level of middle-aged and elderly people declines with age. Regarding the heart, the left ventricular wall thickens, the number of myocardial cells decreases, and their volume increases in middle-aged and elderly people. The interstitial fibrous tissue of the myocardium proliferates, weakening the heart's contractility and gradually reducing the cardiac output. The heart valves gradually calcify, thicken, and harden, leading to valve stenosis or insufficiency, which affects normal blood flow in the heart. The cells in the sinoatrial node and atrioventricular node, as well as other conduction tissues, gradually decrease, while fibrous tissue increases, resulting in a decline in cardiac contractility, a reduction in stroke volume, and a decrease in ejection fraction. At the same time, during diastole, the filling capacity of the ventricles also decreases, and arrhythmias and cardiac arrest are more likely to occur during intense exercise [5].

2.1.2. Changes in blood vessels

In terms of blood vessels, the elastic fibers in the vessel walls of middle-aged and elderly people decrease, while the collagen fibers increase, reducing vascular elasticity and making them harder. At the same time, the intima of the vessels thickens, and lipid deposits form atherosclerotic plaques, leading to vessel narrowing and affecting blood supply. Due to arteriosclerosis and changes in the reactivity of vascular smooth muscle cells to vasoactive substances, peripheral vascular resistance increases, blood pressure rises, and the burden on the heart increases.

2.1.3. Cardiovascular and pulmonary system

The degenerative changes in the cardiovascular and pulmonary systems mainly manifest in two pathways: pulmonary circulation and systemic circulation. In pulmonary circulation, the alveolar walls of middle-aged and elderly people become thinner, lung elasticity decreases, pulmonary ventilation volume reduces, and the oxygen exchange function of the lungs weakens, with efficiency decreasing. During exercise, this is manifested as an increase in respiratory rate but a decrease in respiratory depth, making hypoxia more likely to occur. In systemic circulation, due to weakened cardiovascular function, the efficiency of oxygen transport decreases, the oxygen-carrying capacity of red blood cells weakens, and the ability of tissues to take up and utilize oxygen also decreases, with metabolism slowing down. During exercise, this can lead to muscle weakness, dizziness, chest tightness, and other conditions [6].

2.2. Comparison of effects of different exercise methods

Long-term aerobic exercise can effectively enhance the function of the cardiovascular and pulmonary systems, making the coronary arteries wider, increasing the content of elastic fibers in the vessel walls, and thereby effectively improving the heart's pumping and transporting capacity. It also continuously enhances the muscle strength of the respiratory muscles and the elastic fibers of the alveolar walls, thereby effectively increasing the potential ventilation capacity of the lungs to meet the oxygen supply requirements during aerobic metabolism [7]. Strength training (resistance training) can increase muscle mass, improve basal metabolic rate, enhance insulin sensitivity, and reduce the risk of diabetes. Moderate resistance training can regulate blood pressure by improving vascular endothelial function [8]. High-intensity interval training (HIIT), which alternates between short periods of high-intensity and low-intensity exercise, can achieve similar effects to aerobic exercise in a shorter time, efficiently enhancing aerobic capacity and cardiovascular endurance [9]. It stimulates the secretion of nitric oxide, improves vascular elasticity, and promotes vasodilation. Flexibility training reduces cortisol levels through deep breathing and meditation, lowers sympathetic nerve excitability, and reduces stress-induced hypertension. At the same time, slow movements combined with breathing regulation promote peripheral blood circulation [10].

3. Effect of resistance training on cardiovascular health in middle-aged and older adults

3.1. Directly improve cardiovascular structure and function

Resistance training stimulates cardiomyocyte protein synthesis (mTOR pathway activation) through stress loading, enhancing contractility but maintaining ventricular cavity volume (unlike pathological hypertrophy). By up-regulating the activity of the SERCA2a protein, it can accelerate the recovery of calcium ions and alleviate senile diastolic dysfunction. Long-term training reduces resting heart rate and sympathetic excitability, increases heart rate variability (HRV), and reduces the risk of arrhythmias. Long-term resistance training decreases NO-mediated vasodilation and peripheral resistance, which can reduce systolic blood pressure by 5 to 8 mmHg and diastolic blood pressure by 3 to 5 mmHg in the long term. Increased blood flow to the muscles promotes renal sodium excretion, which indirectly decreases blood volume. The elasticity of collagen in the blood vessel wall is increased, and the ability to buffer blood pressure fluctuations is enhanced, reducing the risk of orthostatic hypotension.

3.2. Metabolism and inflammation regulation

3.2.1. Body metabolism

In terms of regulation of lipid metabolism, when muscles contract, ATP consumption increases, the AMP/ATP ratio increases, and AMPK is activated. Resistance training stimulates the release of lipoprotein lipase (LPL) from skeletal muscle and adipose tissue, accelerates the hydrolysis of triglycerides in chylomicrons and VLDL, and reduces blood TG levels. High-density lipoprotein (HDL) transports peripheral tissue cholesterol to the liver through ABCA1 receptors for metabolism, and resistance training improves HDL function by reducing visceral fat. In terms of glucose metabolism regulation, resistance training activates the PI3K/Akt pathway, promotes insulin receptor substrate (IRS) phosphorylation, drives GLUT4 transport to the cell membrane, and increases muscle uptake of glucose. Muscle contraction directly stimulates GLUT4 translocation through AMPK and Ca²⁺/calmodulin kinase (CaMK) signaling, improving insulin sensitivity. Resistance training inhibits gluconeogenesis by decreasing hepatic phosphoenolpyruvate carboxykinase (PEPCK) and glucose-6-phosphatase (G6Pase) expression. At the same time, glycogen synthase (GS) activity increases, which promotes the conversion of glucose into glycogen storage and reduces free blood glucose. In terms of hormone and adipokine regulation, resistance training reduces visceral fat, reduces the volume of fat cells, and promotes adiponectin secretion. Adiponectin enhances fatty acid oxidation and insulin sensitivity by activating the AMPK and PAR- α pathways.

3.2.2. Inflammation regulation

Resistance training reduces its ability to activate NF- κ B by reducing oxidative stress (ROS \downarrow) and advanced glycation end products (AGEs \downarrow). Up-regulate the expression of I κ B α (NF- κ B inhibitor) and prevent NF- κ B nuclear translocation, thereby reducing the expression of pro-inflammatory factor genes such as TNF- α , IL-6 and IL-1 β , Resistance training inhibits NLRP3 inflammasome assembly, reduces the release of IL-1 β and IL-18, and inhibits the pro-inflammatory signaling pathway by reducing risk signal molecules such as ATP and uric acid. Resistance training promotes the secretion of anti-inflammatory factors, and after regular training, IL-6 turns into an anti-inflammatory effect by inhibiting TNF- α and activating IL-10. Resistance training promotes IL-10 secretion by regulatory T cells (Tregs) and inhibits M1-type polarization in macrophages. Visceral fat reduction is associated with decreased macrophage infiltration of adipose tissue, conversion of M1 type (pro-inflammatory) to M2 type (anti-inflammatory), and increased secretion of IL-10 and adiponectin. Resistance training strengthens the TRX system, repairs oxidative damage proteins, boosts the immune system, and maintains cellular redox balance.

4. Key precautions for resistance training in middle-aged and elderly people (safety and effect)

4.1. Training intensity and time

It is recommended to use moderate intensity (60%-70% 1RM) to avoid sudden increases in blood pressure caused by heavy weight. Combined with variant training, the muscles are continuously stimulated by changing the angle of movement (e.g., incline press), speed (e.g., slow eccentric), or tool (e.g., dumbbell changing kettlebells).

4.2. Training format

Warm-up activities for more than 10 minutes before the start of each training session. Acceptable warm-up activities include some dynamic stretching and low- to moderate-intensity training. The

selection of movements needs to be combined with functionality: (1) multi-joint compound movements, such as seated chest presses, elastic band rowing, modified squats, and improved daily activities. (2) Unilateral training, such as one-leg hip bridges and Bulgarian split-leg squats, to improve balance and prevent falls. During training, breath-holding actions should not be taken to avoid difficulty in venous blood return, insufficient blood supply to the heart and brain, and abnormal increase in blood pressure.

4.3. Medical supervision of special populations

Patients with coronary heart disease and heart failure need to develop a personalized plan under the guidance of the cardiac rehabilitation team to avoid overload. Monitor blood pressure before and after training and avoid high-intensity training when blood pressure is not controlled (e.g., >160/100 mmHg). Patients with chronic obstructive pulmonary disease (COPD) will have their oxygen saturation (SpO₂) at high intensity, which may lead to adverse events of hypoxemia [11]. Therefore, for patients with common diseases in old age, an individualized exercise plan should be developed to reduce the risk of resistance exercise.

Conduct health screening and risk assessment before exercise to identify elderly patients with unstable conditions and clarify the risk level; the patient's basic condition is monitored by wearing a portable device during exercise. Exhaustive resistance exercises, which increase blood pressure, heart rate, and cardiac output, should be avoided when setting exercise intensity [12]; for patients with low heart rate and high myocardial perfusion pressure, resistance exercise is more conducive to balancing myocardial oxygen supply and demand than a high proportion of aerobic exercise, and the proportion of resistance exercise can be appropriately increased in the arrangement of exercise [13].

5. Conclusion

The formulation of a resistance training prescription is more complex than aerobic endurance training, and there are many load factors involved in exercise, including the control of exercise intensity, time, frequency, number of sets, number of repetitions, interval time and other factors. The American College of Sports Medicine (ACSM) and the American Heart Association (AHA) recommend resistance training 2-3 times per week in sets of 2-4 at 60%-80% 1RM in sets of 8-12. The resistance training intensity of the healthy elderly population is controlled at 20%-50% 1RM. 10-15 reps per set. For resistance training in the elderly population, attention should be paid to strengthening monitoring during exercise to prevent the occurrence of sports injuries, attention should be paid to the control of movement and breathing rhythm, and blood pressure should be minimized due to breath-holding [14].

Resistance training has a positive effect on improving cardiovascular structure, promoting metabolism, being anti-inflammatory and reducing risk factors for cardiovascular disease in middle-aged and older adults. Meta-analyses have demonstrated that progressive resistance training increases upper body strength and aerobic capacity in adults with coronary artery disease [15]. There are various forms of resistance training, such as isokinetic muscle strength testers, dumbbells, elastic bands, push-ups, supine crunches, half squats, etc. The results of a four-week intervention by the cardiac rehabilitation (CR) team in China using elastic bands in 42 elderly people in the community showed that elastic bands can effectively improve muscle strength and endurance in the elderly, and can be used as an ideal program for community or family cardiac rehabilitation [16]. KATO et al. [17] focused on the effects of CR on exercise capacity, inflammatory state, and cardiac function after catheter ablation in patients with persistent atrial fibrillation (AF), and found that CR resistance training improved the exercise capacity, systemic inflammatory status, and left ventricular systolic function of 61 subjects after cycling, treadmill walking, and equipment-based strength training (rowing, leg extension, leg curl, hip abduction, and leg compression). and does not increase the risk of

recurrence of AF [18]. Therefore, it is of great significance for middle-aged and elderly people to improve the quality of life, reduce the risk coefficient of cardiovascular system diseases, and reduce the burden of social pension through safe and effective resistance training.

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