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Research Article

Effects of exercise training on blood circulation system

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ABSTRACT

Background: Numerous studies have examined how exercise training affects the blood circulation system and have shown that it can prevent or lessen the harmful effects of a number of pathological conditions, including osteoporosis, diabetes mellitus, arterial hypertension, coronary artery disease, atherosclerosis, Parkinson's disease, and Alzheimer's disease. It is well established that exercise training alters the autonomic nervous system by raising parasympathetic tone and decreasing sympathetic activity. In both normotensive and hypertensive people, these changes are correlated with lower blood pressure and heart rates.

Methods: Studies have focused on identifying the fundamental processes by which physical activity causes bradycardia and lowers blood pressure. emphasizing the need for further research to elucidate these mechanisms. Research has utilized data from both animal models and human studies to investigate the effects of exercise on the cardiovascular system, aiming to shed light on the physiological and molecular changes induced by exercise training on the blood circulation system.

Goals: The primary goal of the research is to explore how exercise training impacts the cardiovascular system, particularly in terms of reducing sympathetic activity, increasing parasympathetic tonus, and improving cardiovascular health to prevent or mitigate various pathological conditions. Understanding the mechanisms underlying the cardiovascular benefits of exercise is crucial for developing effective strategies to enhance cardiovascular function and overall health through physical activity.

Findings: The findings from the research underscore the significant positive effects of exercise training on the blood circulation system, highlighting its role in promoting beneficial health outcomes and reducing the risk of cardiovascular diseases and other related conditions. The studies reviewed demonstrate that exercise training leads to physiological and molecular changes that contribute to improved cardiovascular function, emphasizing the importance of regular physical activity for cardiovascular health and overall well-being.

1. Introduction

People's lifestyles and working practices have undergone significant change as a result of rising living standards and advances in science and technology (Hazim et al., 2024). The spectrum of diseases has also changed greatly, and exercise training has been put forward more and more. At present, many medical experts have proposed that aerobic exercise is needed for a healthy life and is more important than diet. The World Health Organization also recommends that the first cornerstone of health is mentality and exercise. A large number of studies have explored the effects of exercise training on the human body and its application in diseases. The impact on the blood circulation system is relatively greater, mainly focusing on the following two aspects: blood vessel regeneration and blood vessel characteristics. The research on the "Effects of exercise training on the cardiovascular system" highlights several key points regarding the impact of exercise on the blood circulation system. Exercise training has been shown to reduce sympathetic activity and increase parasympathetic tonus, leading to beneficial effects on cardiovascular health by improving oxygen delivery, vasculature, peripheral tissues, and inflammation.

2. The importance of research

The importance of the effects of exercise training on the blood circulation system lies in the significant benefits it offers to cardiovascular health and overall well-being. Regular exercise positively impacts blood circulation in several ways, contributing to improved health outcomes: Improved Heart Function: By strengthening the heart's muscle, exercise enhances the heart's capacity to pump blood throughout the body. Enhancing cardiac output, lowering resting heart rate, and lowering the risk of heart-related problems are all possible with this increase in heart function. Better Blood Vessel Performance: Exercise improves blood vessel performance by increasing their

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flexibility and effectiveness in supplying oxygen and nutrients to tissues.

This can lead to reduced blood pressure and better overall circulation. Increased Blood Volume: Regular exercise stimulates the body to produce more blood, increasing the volume of blood circulating. This results in better oxygen and nutrient delivery to tissues, promoting overall health. Optimized Blood Flow Regulation: Exercise training improves the body's ability to regulate blood flow to different organs and tissues based on their needs. This ensures optimal perfusion and supports overall circulatory health. Prevention of Cardiovascular Diseases: Engaging in exercise can help prevent cardiovascular diseases by reducing the risk factors associated with poor circulation, such as obesity, high blood pressure, and diabetes.

3. The purpose of the study

Explain the processes via which exercise training modifies the autonomic nervous system to cause decreases in sympathetic activity and elevations in parasympathetic tone.

Evaluate the cardiovascular health benefits of exercise training and their potential for preventing or mitigating various pathological conditions.

4. Blood vessel regeneration

Vascular regeneration is an important process in maintaining normal tissue physiology. It participates in tissue remodeling and regeneration by forming new vascular networks, and continues throughout life (Gu et al., 2024). Micro vessels refer to blood vessels and vascular networks that exist between tiny arteries and tiny veins with a lumen diameter of less than 500 μm. They are the place where substances are exchanged between blood and tissue cells. In skeletal muscle, the capillaries run parallel to the skeletal muscle fibers. There are many short branches connected between the capillaries, forming a capillary network wrapped around the muscle fibers. The walls of the capillaries are very thin, about 0.2 μm, so the capillaries are muscle fibers. It is the exchange place for oxygen and nutrients required by tissues. At the same time, it is also the most direct channel for timely transportation of its metabolic products and waste products. Skeletal muscle accounts for 40% of the body weight, and changes in the ratio of capillaries to muscle fibers have an important impact on the body's metabolism, endocrine and exercise capacity (Ajmiri & Bahir, 2023). Therefore, micro vessels play an important role in tissue metabolism, and angiogenesis is responsible for tissue remodeling and regeneration. In skeletal muscle, their primary role is gas and metabolite exchange at the blood-tissue interface. Exercise therapy plays an important role in angiogenesis. The act of creating new blood vessels from pre-existing ones is known as angiogenesis.

It is an important aspect of tissue adaptation to a hypoxic environment. The activation of angiogenesis is mediated by specific biochemical signals and mainly includes the following five steps: ① Increased vascular permeability; ② Endothelial cells are stimulated and begin to activate, proliferate and migrate through the surrounding extracellular matrix and release proteases; ③ Dissolution of basement membrane and extracellular matrix; ④ Solid cell cords are formed by budding, forming lumen under the impact of blood flow, new basement membrane is formed and surrounding cells are recruited; ⑤ The lumen of new blood vessels are connected to form a vascular network , the newly formed vascular bed matures and fixes, the surrounding cell envelope and matrix are rebuilt to stabilize the capillaries, and further anastomose with each other to form a network. In order to adapt to functional needs, some remain, some disappear, and some transform into arterioles or Small veins (Lane et al., 2021). This process is largely regulated by fine, coordinated regulation of angiogenesis-stimulating factors and angiogenesis-inhibiting factors, the combined effect of which determines angiogenesis (Bahir & Wang, 2023).

5. Effects of Exercise on Angiogenesis and Capillary Growth

Vascular characteristics are what form "native sprouts." The subsequent phase results in the development of capillary loops, new basement membrane production, and vascular maturation (Campbell et al., 2014). Angiogenesis is greatly influenced by VEGF and its receptors, which are particular and powerful components of angiogenesis. Skeletal muscle angiogenesis is stimulated by three physiological factors: elevated oxidative metabolism, increased endothelial shear stress, and increased blood flow. Resistance exercise training primarily stimulates muscle angiogenesis by creating mechanical shear stress and boosting blood flow, despite not being an exercise (Edwards, 2006). At present, it is not clear which factor of stimulation has the greatest impact on VEGF expression. Zhang Liang (Campbell et al., 2014) and others found that treadmill exercise can significantly increase the number of capillaries in the soleus muscle of rats. The mechanism may be that exercise induces apelin expression in the soleus muscle. Gao Y (Roccatello et al., 1989)and others found through exercise training in the cerebral ischemia model that the caveolin-1 pathway is involved in the regulation of VEGF in the cerebral ischemic penumbra of rats after exercise and is related to the promotion of angiogenesis. Zhang Pengcheng (Zainuddin & Halili, 2016) and others found that aerobic exercise combined with resistance exercise can improve the vasodilation function of diabetic rats and promote the release of VEGF and NO. The mechanism of action is to activate the PI3K/Akt/eNOS signaling pathway. Both acute exercise and exercise training have a certain impact on cardiovascular function. Due to the influence of factors such as hypoxia, ischemia or activation of immune factors, vascular endothelial growth factor increases significantly after acute exercise or exercise training, which is beneficial to vascular endothelium. Repair or compensatory collateral circulation. Therefore, exercise induces a series of adaptations, especially the growth of capillaries (angiogenesis), while inactivity leads to the reduction (sparse) of capillaries (Bahir & Wang, 2023). Furthermore, research has indicated that physical activity might enhance angiogenesis, elevate blood vessel density, and decrease blood flow inside the ischemic penumbra following ischemic brain damage (Baillot et al., 2018). There are also studies showing that low-intensity endurance exercise combined with limb blood flow restriction (BFR) can improve the quality and strength of skeletal muscle, improve age-related attenuation of angiogenesis, and increase the degree of myocardial micro vascularization. On the one hand, it is related to the degree of cardiomyocyte hypertrophy, and on the other hand, it is related to the degree of myocardial cell hypertrophy. It is also related to the matching of oxygen supply, thus improving the heart function of elderly rats (Freeman et al., 2014). Existing studies have shown that only 4 weeks of human training can significantly increase the number of capillaries (Edwards, 2006). Capillaries play a crucial role in delivering hormones, nutrients, and oxygen to tissues. By guaranteeing the delivery of amino acids and growth factors to muscle fibers, adequate capillarization of skeletal muscle facilitates the synthesis of muscle proteins (Morrin & Redding, 2013). The last stage in the transfer of oxygen from the air to the mitochondria in muscles is the diffusive capillary exchange from blood to tissue (Santonja Medina et al., 2007). Research has indicated that blood flow restriction during the high-load resistance training phase may boost the messenger RNA (mRNA) for proteins that control angiogenesis, mitochondrial biogenesis, and muscle growth and repair (Rinaldo et al., 1995). improving capillary exchange in various other mammals. capacity and blood flow (Chan & Lowe, 2016).

6. Effects of Exercise on Cardiovascular Health in Older Adults

Frequent aerobic exercise can improve endothelial function in males by lowering oxidative stress, but not in postmenopausal women who lack estrogen (Chen, 2018). Thomopoulos found that a comparative study of three different volume joint training programs was conducted on elderly healthy women and believed that low-volume training can also help improve hemodynamic load. Additionally, more aerobic and resistance training resulted in lower resting blood pressure, exercise blood pressure, and heart rate over 3 months, suggesting that even high-intensity resistance exercise combined with high-intensity aerobic exercise does not have adverse effects on the heart. Damage to vascular hemodynamics. Data show that lifelong exercise 4 to 5 times per week is associated with reduced central artery stiffness in older adults. Less frequent doses of lifelong exercise (2 to 3 times/week) were associated with reduced ventricular afterload and peripheral resistance, whereas peripheral arterial stiffness was not affected by any dose of exercise. Less frequent lifelong exercise training (4 to 5 times/week, duration >30 min) is in line with current physical activity recommendations (≈150 min/week) and can prevent cardiac atrophy and stiffness caused by sedentary aging (Bahir, 2020). In addition, this amount of exercise is related to the maximum oxygen uptake (VO2max), stroke index and effective arterial elasticity (EAI) during exercise (Hayward & Karim, 2019). The current findings indicate that lifelong exercise, more than 4 to 5 times per week, is linked to older persons' more "youthful" central artery compliance. Lower lifetime exercise frequency (2 to 3 times/week) is linked to decreased left ventricular afterload and increased carotid artery compliance. Lifelong exercise training has no discernible impact on peripheral arterial stiffness, regardless of frequency. The main finding was that aerobic exercise after resistance training can reduce arterial stiffness in elderly men, while aerobic exercise before resistance training does not change arterial stiffness. Stiffness. Both training programs can effectively reduce waist circumference, increase grip strength, improve walking ability and improve one-rep max strength (1RM), regardless of the sequence of exercises. Exercise training in the elderly promotes arterial remodeling, reducing wall thickness, increasing lumen diameter, and reducing the ratio of wall thickness to lumen diameter (Marshall, 1936). The arterial baroreflex is the most important neural regulation to keep arterial blood pressure relatively stable. It maintains the homeostasis of arterial blood pressure in a negative feedback manner and is an important regulatory mechanism to maintain blood pressure homeostasis. Weakening of arterial baroreflex function is manifested by reduced baroreflex sensitivity, which is closely related to the occurrence and development of hypertension. Experiments have confirmed that exercise training can lower blood pressure, improve baroreflex function and reduce oxidative stress in the cardiovascular center (Nam et al., 2020). Studies such as Dang Na (Roccatello et al., 1989) have shown that exercise training reduces central oxidative stress by enhancing antioxidant enzyme activity and antioxidant capacity in the brain, and central oxidative stress inhibits arterial baroreflex, thereby improving hypertension in rats. Some studies have also shown that exercise training delays the progression from prehypertension to hypertension and improves blood pressure regulation by enhancing arterial baroreflex function.

7. This information is arranged under two headings

This may be one of the mechanisms by which exercise training delays the progression of hypertension. It may also be that exercise enhances central vascular tension. It is related to the function of angiotensin-converting enzyme-angiotensin II-angiotensin receptor I (ACE-AngII-AT1) axis (Haskell et al., 1994). In addition, as age increases, circulatory system function and physical fitness decline. The decline in circulatory system function is closely related to blood vessel elasticity. Especially in older women, due to the lack of follicle-stimulating hormone after menopause, ovarian function declines and estrogen stimulation decreases. The activity of low-density lipoprotein (LDL) receptors is reduced, thereby increasing LDL-C levels, reducing high-density lipoprotein cholesterol (HDL-C) levels, rapidly increasing blood lipid levels, and increasing the risk of coronary disease (Hough et al., 2009). Elderly inactive folks would also have higher systolic blood pressure. Because the carotid baroreflex is located in the carotid sinus, enhancing baroreflex function through carotid sinus compliance may lower systolic blood pressure. Furthermore, the interplay of forward moving waves and reflected waves, primarily influenced by the timing and amplitude of the reflected waves, affects central systolic blood pressure. A different possible mechanism for reducing central blood pressure might be changes in these parameters, even though there was no significant variation in the augmentation index. These results suggest that lifetime exercise training, even at a moderate frequency, can positively impact the processes that control central blood pressure (Castelli et al., 2007).The regulation of arterial baroreflex by exercise training may be related Toit is related to enhancing the arterial vasodilation function, arterial distensibility and/or signal transduction in pressure-sensitive areas. Chronic repeated exercise training results in structural vascular (i.e., angiogenesis, arterial enhancing muscular contraction, particularly when there is a vascular blockage. The intricate synchronization of angiogenic growth factors (such VEGF), receptors, and regulatory effects like epinephrine and angiopoietin results in the complicated process of vascular remodeling.

These vascular adaptations improve muscle performance by increasing the muscle's oxygen exchange capacity and increasing blood flow, especially when limited by upstream vascular structures. These adaptations restore normal cardiovascular function, which is associated with exercise training reducing cardiovascular risk and improving endothelium-mediated vasodilation and arterial compliance. The balance between training-induced vasodilation, arterial remodeling, and changes in Vaso systolic pressure requires further study, but current evidence suggests that some compensatory increases in contraction may be significant, at least at rest. Exercise training is certain to change the arterial elasticity and baroreflex center, but the specific mechanisms and training methods are still controversial.

8. Conclusion

The data from the sources emphasize how important exercise training is for cardiovascular health and function, especially in older persons. Key findings include:

Exercise induces adaptations such as angiogenesis, promoting the growth of capillaries and enhancing oxygen and nutrient delivery to tissues. Regular aerobic exercise can enhance endothelial function, reduce oxidative stress, and improve vascular characteristics. Lifelong exercise, especially at higher frequencies, is associated with reduced central artery stiffness and improved cardiovascular health.

Exercise training can lower blood pressure, improve baroreflex function, and reduce oxidative stress in the cardiovascular system. Combining aerobic exercise and resistance training is an effective strategy to enhance cardiovascular and musculoskeletal function in older adults. Arterial remodeling, reduced wall thickness, and improved lumen diameter are observed with exercise training in the elderly. Weakening of arterial baroreflex function is linked to hypertension, and exercise training can improve baroreflex sensitivity and blood pressure regulation. Overall, the results emphasize the positive effects of exercise training on vascular remodeling, cardiovascular health, and the regulation of blood pressure, emphasizing how crucial regular exercise is for fostering general wellbeing, particularly in older groups.

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