Swimming Increases the Level of Myocardial Autophagy in Spontaneously Hypertensive Rats

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Abstract: With the rapid development of China's economy, China's Engel coefficient has declined year by year. However, due to changes in dietary structure, the incidence of hypertension in China has increased year by year in recent years, and it has become smaller and smaller in age. Because high blood pressure can lead to a decline in the body function of patients, which seriously affects their quality of life, which makes the prevention and treatment of hypertension become urgent. The purpose of this paper is to investigate the improvement in swimming motility and the improvement of myocardial basal autophagy in spontaneously hypertensive rats. In this paper, the rat heart function test and autophagy markers were used to test the exercise group and the quiet group. The experimental results showed that the left ventricular end-diastolic pressure of the rats after swimming ($P<0.01$), left ventricular end-systolic pressure ($P<0.05$). It can be seen that long-term aerobic exercise may improve the myocardial structure and function of hypertensive rats by promoting the conversion of LC-I to LC3-II and the degradation of P62 and the increase of Beclin1.

Keywords: Aerobic Exercise, Spontaneous Hypertension, Myocardial Structure, Autophagy Level

1. Introduction

Hypertension is caused by a variety of factors, and elevated blood pressure is the main clinical manifestation of the disease, which afflicts approximately 20-50% of the world's population [1]. High blood pressure can cause changes in the function and structure of the heart and blood vessels, eventually leading to malfunctions. In addition, hypertension is likely to cause stroke, myocardial infarction, vascular disease and chronic kidney disease, and remains one of the leading causes of cardiovascular death [2]. According to statistics from epidemiological studies, it is estimated that by 2025, the number of global adult hypertension patients will increase by about 60% to 1.56 billion people [3]. Therefore, hypertension is an important global public health problem, and prevention, diagnosis, treatment, and control of hypertension are urgent. Blood Pressure (BP) is determined by Cardiac Output (CO) and Systemic Vascular Resistance (SVR), $BP = CO \times SVR$; therefore, cardiac output or peripheral resistance increases, can cause high blood pressure [4]. Although the mechanism of hypertension is relatively clear, the past 50 years of research on hypertension have failed to determine the specific pathogenesis of hypertension.

In recent years, exercise training has become an important intervention in the prevention and treatment of hypertension. Appropriate intensity exercise training can improve myocardial cell proliferation in myocardial infarction, promote myocardial cell proliferation, promote myocardial tissue neovascularization, increase myocardial blood perfusion, reduce local tissue inflammation and other mechanisms, to improve the left ventricular systolic and diastolic ability and protect the heart function [5]. Moreover, during exercise, it will promote venous return, prevent blood stasis in the veins, and reduce the formation of blood clots [6]. The regulation of cell whitening levels by exercise has also attracted people's attention. When intermittent aerobic exercise load and training volume are appropriate, exercise can degrade a series of proteins by means of increased levels of autophagy, such as cardiomyocytes and muscle cells. These proteins are caused by motor stimulation and cause protein synthesis or errors. The folded protein can provide certain energy and synthetic substrate for muscle fiber regeneration, and can inhibit the apoptosis of myocardial and muscle cells, so that the cell itself can maintain its stable state [7].

Venteclef and his team study reported the relationship between the abundance of epicardial adipose tissue (EAT) and the risk of cardiovascular disease, including atrial fibrillation (AF). However, its underlying mechanisms are still unclear. The aim of their study was to investigate the effects of the human EAT secretory genome on myocardial histology. Methods and Results EAT and subcutaneous fat (SAT) samples were analyzed and tested in 39 patients undergoing coronary artery bypass surgery. The fibrotic properties of the human fat storehouse were evaluated in an organic culture model of the rat atrium. The EAT secretion group induced

global fibrosis (interstitial and peripheral) of the rat atrium under organic culture conditions. Activin A is highly expressed in EAT compared to SAT and promotes atrial fibrosis, which is blocked by neutralizing antibodies. In addition, patients with low left ventricular function have elevated levels of activin A. In various parts of the human atrium and ventricular myocardium, fat and myocardial tissue are in intimate contact with fibrosis. They found that the secretory group of EAT promotes myocardial fibrosis by secreting a fatty fibrinolytic factor such as activin A [8]. Ghofrani and his team believed that endothelin, nitric oxide (NO) and prostacyclin (PGI2) pathways are involved in the pathogenesis of pulmonary hypertension (PAH). Although ET and NO are targeted early in the disease process, the current limitations of drug therapy (PGI2 or PGI2 analogs) for the PGI2 pathway result in their being unused or delayed. Selexipag is a novel oral selective agonist of the PGI2 (IP) receptor. Activation of IP receptors induces vasodilation in the pulmonary circulation and inhibits proliferation of vascular smooth muscle cells, which is a key factor in the pathogenesis of PAH. By combining oral administration with improved receptor selectivity, selexipag can achieve early combination therapy with a three-molecular approach to PAH and is expected to improve the daily and long-term clinical function and efficacy of PAH [9]. Mei and his team believed that autophagy is a highly conserved degradation process through which lysosomes degrade intracellular components, including soluble macromolecules (such as nucleic acids, proteins, carbohydrates and lipids) and dysfunctional organelles (Such as mitochondria, ribosomes, peroxisomes and endoplasmic reticulum). Autophagy is a protein complex that forms autophagosomes from autophagy-associated proteins (Atg), fuses with lysosomes to form autophagosomes, and its contents are degraded to provide energy for cell survival in response to environmental and cellular stress. Autophagy is an important player in cardiovascular diseases such as atherosclerosis, cardiac ischemia/reperfusion, cardiomyopathy, heart failure and hypertension. Autophagy interacts with reactive oxygen species produced in the endoplasmic reticulum and mitochondria and is particularly useful for cardiac ischemia, hypertension, and diabetes [10].

In this paper, we aimed to improve whether swimming can improve the level of myocardial autophagy in rats with spontaneous hypertension. The experiment compares the exercised and non-exercised rats through myocardial structure, cardiac function and myocardial self. The determination of the expression levels of phage-associated proteins and autophagy-related protein mRNA indicates that changes in myocardial basal autophagy play a role in aerobic exercise in improving myocardial function in spontaneously hypertensive rats.

2. Proposed Method

2.1. Autophagy

(1) Autophagy

Autophagy is a double-membrane packaging part of the cell membrane and organelle that is detached from the rough surface of the ribosome region. The protein composition needs to be degraded to form autophagy, and the lysosome fuses to form autophagolysin, which degrades the package contents. In order to achieve the metabolism of the cells themselves, some organelles need to be updated. Autophagy is a mechanism that maintains homeostasis during cell growth and development in vivo, primarily by the process by which cells use lysosomes to degrade macromolecules and damaged organelles. Moreover, autophagy is a life phenomenon that is now only found in eukaryotic cells [11].

(2) The way of autophagy

Cellular substances can be transported by different pathways to dissolve enzymes in the body. In different ways, we can classify autophagy into the following three types: The first one is large autophagy: mainly refers to the soluble enzyme source of retinal structure in human body. Soluble proteins and organelles in the cytoplasm are denatured, and autophagy is formed in a necrotic form, and is fused with lysosomes to degrade the packaging material. The second is small autophagy, the way of autophagy is that the longevity protein is directly encapsulated in the lysosomal membrane and degraded in the lysosome. The third way is through chaperone-mediated autophagy (CMA): intracellular proteins bind to the chaperone and are transported into the lysosomal cavity, which is digested by lysosomes in the lysosomal cavity. The substrate of CMA is a soluble protein molecule that is selective in protein clearance, while large autophagy and small autophagy have no apparent selectivity.

(3) Autophagy function

Physiological autophagy is the self-protection mechanism of cells. It is beneficial to the growth and development of cells, effectively protects cells from metabolic stress and oxidative damage, and plays an important role in cell stability, synthesis, degradation and recycling of cell products. However, excessive autophagy may result in metabolic stress, degradation of cellular components, and cell death. According to different forms, cell death can be divided into three types, namely apoptosis, autophagic cell death and necrosis. The deaths mentioned here may be accompanied by autophagy, which is a cell different from apoptosis and cell death and necrosis. Autophagy has a certain correlation with the two. For example, the balance between Bcl-2 and Bedim. The main functions of autophagy are as follows:

1) The role of the starvation reaction: In different organs (such as the liver) or cultured cells, the lack of amino acids leads to autophagy, autophagy breaks down macromolecules and produces intermediate metabolites required for catabolism and anabolism.

2) Play a role in normal cellular activities, which is responsible for the degradation of normal proteins during animal development, senescence, and differentiation to reconstitute cells.

(4) Regulation mechanism of autophagy-related genes

The level of autophagy in the cells is low in the basic state and is used to maintain the homeostasis of the internal environment. However, autophagy is significantly activated when cells are in a state of nutrient or insufficient energy (such as starvation), structural remodeling (such as when the body is in development), and removal of damaged organelles (such as oxidative stress, infection, and protein aggregation). To date, more than 30 specific genes associated with autophagy have been identified and named Autophagy associated with gene (Atg). Currently, five genes related to autophagy are of the utmost concern:

1) Autophagy-related gene Beclin1: also known as BECNI gene is one of the earliest autophagy genes found in mammals. Beclin1 is involved in the whole process of autophagy, especially in the initial stage of autophagosome formation. A key protein in induction.

2) Microtubule-associated protein l light chain 3 (LC3): 1 microtubule-associated protein light chain 3 is homologous to the yeast At98 gene in mammalian cells, and the microtubule-associated protein light chain 3 1 includes two main types I and II. The ubiquitin protein system modification process of LC3 in two samples: in the newly synthesized microtubule-associated protein light chain 3, it is transformed into a cytoplasmic protein type I microtubule-associated protein 1 light chain 3 by correlation cleavage and modification. Then, the I microtubule-associated protein light chain type 3 is transformed into the II microtubule-associated protein 1 light chain 3, and the pre-autophagy and autophagy are immersed in the surface orientation of the membrane by Atg5, and participate in the stretching and expansion process of the autophagosome. Therefore, many scholars have used II microtubule-associated protein 1 light chain 3 as a specific marker for autophagy activity. Autophagy activity is mainly determined by the ratio of light chain 3 of microtubule-associated protein 1 of type I and type II. If this ratio decreases, it indicates that the activity of white phagine decreases. If the ratio increases, it indicates that the activity of autophagy is increased.

3) Atg5 is a specific gene involved in autophagy in mammals. The occurrence of autophagy can be demonstrated by detecting its protein expression.

4) Atg7 is called ubiquitin-activating enzyme-like protein Atg7, which is a very important protein that plays a decisive role in the expansion and expansion of autophagosomes.

5) Atg9, a supermembrane vector, is an intracellular protein associated with autophagy. It is usually present in the cycle of autophagosomes and their surrounding structures.

2.2. Exercise and Autophagy

(1) Effects of exercise on autophagy of skeletal muscle cells

Exercise, as a newly defined stimulus, induces autophagy in cells. In some studies on humans, it has been found that endurance exercise can up-regulate the levels of related autophagy genes and protein expression in the lateral femoral muscle fibers. Cells and tissues are broken down by the stimulation of acute exercise, making it difficult to maintain their integrity. Changes in intracellular calcium homeostasis may activate intracellular proteases. By increasing the activity of active oxygen, lipid peroxidation and protein carbonylation increase the activity of mitochondria. Studies have shown that some factors related to exercise have an impact on cell function and activity. Autophagy is mainly through the damaged organelles to maintain and repair the health of the cells. Therefore, we also propose the following hypothesis that autophagy plays an important role in the maintenance of intracellular energy balance during and after exercise. Autophagy is an important mechanism for exercise to promote the health of the body. Long-term resistance exercise can enhance autophagy levels by increasing the levels of autophagy-related proteins Beclin1, Atg5, Atg12, and Atg7.

(2) Effects of exercise training on myocardial autophagy

Cardiomyocytes, also known as myocardial fibers, belong to a highly differentiated terminal cell. In general, autophagy can produce amino acids by degrading inactivated proteins, thereby providing a certain material basis to promote myocardial development and survival. Appropriate exercise training can cause good adaptive remodeling of myocardial tissue cells, promote autophagy, increase myocardial contractility, and play a protective role for myocardial fibers. Short-term exercise can cause apoptosis and activate autophagy of cardiomyocytes. Long-term exercise can reduce cardiomyocyte apoptosis and enhance autophagy activation. Exercise training with appropriate intensity enables the level of autophagy in cardiomyocytes to be regulated, the cell homeostasis to be effectively maintained, and apoptosis to be reduced.

(3) Effects of exercise training on autophagy-related genes in cardiomyocytes

Oxidative stress is produced in a hypoxic environment and stimulated by ischemia/reperfusion, thereby increasing Bedim activity and triggering autophagy in the cells. Some foreign scholars have found that when the

body's heart is exposed to oxygen and blood supply, it can enhance the occurrence of autophagy, thus avoiding the destruction of myocardial cells. Hypoxia-inducible factor HIF-1 induced BNIP3 expression and constitutive expression of Beclin-1 and Atg5 played a very important role, and it was also confirmed that in hypoxic environment, it can also cause autophagy in mitochondria. If the cells are in an oxygen-deficient environment for a long time, mitochondrial autophagy plays a role in preventing the cells from producing too much reactive oxygen species, and ultimately achieves the purpose of inhibiting cell death. If the body adapts to the movement in a hypoxic environment or a hypoxic environment, then the level of the autophagy-related gene Beclin1 will be increased to varying degrees, compared with the exercise adaptation and hypoxic environment adaptation under hypoxic conditions, the effect of exercise adaptation in the environment on the autophagy-related gene Beclin1 is more pronounced.

By inducing an animal model of low cardiac output heart failure, in the animal heart, not only the expression level of cellular white blood was increased, but also the expression level of Atg5 was decreased. Down-regulation of Atg5 expression levels can lead to a series of structural changes in the heart of the body, such as left ventricular enlargement, thickening of the ventricular wall, and decreased ventricular systolic and diastolic function.

2.3. Exercise and High Blood Pressure

The protection mechanism for exercise training for hypertensive patients mainly includes the following aspects:

(1) Exercise contributes to the formation of a good coronary collateral circulation system in the coronary arteries. It can increase myocardial blood supply and reserve to improve various functions of the heart, enhance the ability of the heart to exercise, help reduce heart rate, reduce aortic pressure and lower cholesterol.

(2) Moderate exercise training can improve the mitochondrial metabolism of hypertensive episodes. The heart is an energy-intensive organ with 90% of its energy coming from mitochondria. When myocardial infarction occurs, the morphology and function of mitochondria in the infarcted and non-infarcted regions are significantly abnormal, mainly due to decreased density of mitochondrial matrix, decreased activity of oxidative respiratory chain complex, and reduced composition of proteins and the number of DNA copies.

(3) Exercise training can improve the anti-oxidative stress of cardiomyocytes after hypertension. Complex and orderly oxidative stress and antioxidant stress systems are present in cells, and the balance between them maintains the normal physiological functions of the cells. When myocardial infarction, infarct area and infarct area, myocardial tissue is in high oxidative stress state, high level of reactive oxygen species (Reactive Oxygen Species, ROS) will not only directly destroy the plasma membrane and intracellular enzymes. When high blood pressure occurs in the body, exercise can inhibit the increase of infarcted superoxide anion and malondialdehyde, thereby reducing the level of oxidative stress in the heart after hypertension and reducing the cell death caused by hypertension or ischemia-reperfusion. Other studies have shown that after myocardial infarction hypertension, mitochondrial oxygen consumption rate decreased, H2O2 release increased, and exercise training can increase mitochondrial oxygen consumption rate and reduce H2O2 release. This suggests that the enhancement of antioxidant capacity after exercise training may also be an important mechanism for protecting the myocardium.

(4) Exercise training can regulate autophagy after hypertension. An increase in autophagosome formation or a decrease in the rate of degradation will result in the accumulation of autophagosomes and ultimately trigger an apoptotic pathway leading to cardiomyocyte death. At 2 weeks and 4 weeks after the onset of hypertension, exercise started at 30 minutes per day, 5 days a week, and 4 weeks of aerobic exercise, the proportion of LC3II/LC3I after hypertension was restored to the control level. The ratio of LC3II/LC3I was significantly negatively correlated with cardiac function.

(5) Exercise training can regulate the calcium homeostasis of cardiomyocytes after hypertension. To analyze the reasons, there are two main points: First, when the human body appears after hypertension, the active oxygen produced in the cardiomyocytes is reduced by exercise, and the reactive oxygen species downstream of cardiac troponin I is reduced (cardiac troponin I) Phosphorylation, probably due to increased SERCA and expression of PLB during exercise training, accelerates calcium and extracellular transport of cytoplasm to the sarcoplasmic reticulum.

2.4. Autophagy and Hypertension

In the acute phase and subacute phase, the autophagosome marker substance II microtubule-associated protein 1 light chain 3 and cathepsin D were up-regulated, and the expression of P62 was significantly decreased. It can be seen that the expression of autophagy in viable cardiomyocytes is significantly increased. At the same time, the level of autophagy expression in cardiomyocytes was significantly increased. It is important to note that in the marginal regions of hypertension, the level of autophagy is highest. When the myocardial infarction, the activity of cyclic adenosine activating protein kinase is enhanced, which in turn causes the autophagy pathway to be activated, leading to an increase in the level of autophagy, thereby allowing the cardiomyocytes

to survive? By detecting autocrine-associated gene Beclin1, it was found that the increase of the expression of the white-related gene Beclin1 also caused the activation of autophagy, but its effect on cardiomyocytes was to damage them.

The effects of autophagy on cells are both positive and negative. Usually, the level of autophagy in cardiomyocytes is very low. Autophagy levels increase ischemia reperfusion or heart failure. That is to say, under physiological or mild stress, autophagy of cardiomyocytes can maintain the homeostasis of the internal environment and play an active role in the size of the cardiomyocytes, the structure of the heart and the normal physiological functions of the heart. In the early stage of acute myocardial ischemia, autophagy of cardiomyocytes is enhanced and plays an active role in protecting heart function. The increase in autophagy in cardiomyocytes may have a negative effect during reperfusion. Therefore, autophagy plays an important role in ischemia and reperfusion after hypertension.

Ischemic phase: In the normal operation of the heart, the blood gradually decreases, resulting in a pathological state of reduced supply of dirty oxygen and a gradual decrease in myocardial energy metabolism, making it impossible to support the normal functioning of the heart. The blood supply to the heart is variable and always fluctuating, but this fluctuation can promote the supply and demand of the blood to a relatively balanced and stable state through the regulation of the body itself, thus ensuring the normal functioning of the heart function. Therefore, myocardial ischemia can be considered as a metabolite of cardiomyocytes caused by starvation and ischemia caused by hypoxia. Cardiomyocytes adapt to this state of undernutrition through autophagy and protect them in the heart. In the process of chronic myocardial ischemia, cardiomyocytes play a protective role in autophagy. Therefore, when myocardial hypoxia occurs, mitochondria are damaged by hypoxia stimulation, which can further reduce the synthesis of ATP, activate autophagy of cells, phagocytose cytoplasm and form autophagosomes, and fusion with lysosome to form white phagosome and reduce its content. During the degradation process, free fatty acids and amino acids are released, followed by synthesis of ATP through the tricarboxylic acid cycle to supplement the energy deficit caused by myocardial ischemia.

Reperfusion stage: Because of the sudden increase of blood perfusion, it will cause very serious damage to the body, and the increase of autophagy expression, one can obtain the necessary heat of the cells by degrading related proteins and organelles, making the cells stable. The state is maintained, reducing or eliminating the damage caused by reperfusion of the cells, and also causing endoplasmic reticulum stress in the cells, which in turn leads to cell death. When the heart is reconstituted, it immediately relieves the supply of oxygen and nutrients in the heart. Theoretically, autophagy is inhibited and decreased. However, through reperfusion, autophagy of cardiomyocytes will still be enhanced. The expression of the homologous gene Beclin1 of the yeast autophagy gene At96 showed a significant increase. Furthermore, apoptosis of cardiomyocytes increases with increasing levels of autophagy during reperfusion. In conclusion, autophagy plays a regulatory role in the ischemia and reperfusion phases of hypertension. We can take reasonable and effective methods to regulate autophagy, which may become a new direction for the rehabilitation of patients with hypertension.

Cardiomyocytes are cells with limited differentiation and regeneration. Autophagy may be one of the ways to promote cell material circulation and self-renewal. Therefore, cardiomyocyte autophagy plays an important role in maintaining cardiac function and vitality. Many studies have also confirmed that in many pathogenesis of heart disease, autophagy of cardiomyocytes is also involved. Normal autophagy can maintain the normal physiological balance of the cells. However, autophagy can be significantly increased as an adaptive response to stress under pathological conditions. Therefore, promoting the regeneration of cardiomyocytes is important for improving the remodeling of myocardial structures and enhancing cardiac function.

3. Experiments

3.1. Data Collection

In this study, 20 males with spontaneous hypertension were selected from 4 weeks old males and randomly divided into quiet group (SHR group) and exercise group (SE group). The exercise group uses a low-intensity swimming exercise, that is, no weight-bearing swimming exercise.

3.2. Experimental Design and Implementation

The rats started exercising one week after adaptive feeding. It is prescribed to exercise six days a week. During the first week of exercise, the rats swim for fifteen minutes on the first day and then increase for fifteen minutes each day until the sixth day of swimming is ninety minutes. Starting from the second week, exercise for six days a week, 90 minutes of swimming every day for 8 weeks. Twelve hours after the end of the last exercise, the left ventricular cannula was used to detect changes in cardiac function. HE staining and transmission electron microscopy were used to observe the structure of rat cardiomyocytes.

3.3. Experimental Methods

(1) Determination of cardiac function in rats

Rats were anesthetized with 3% pentobarbital sodium, and the right carotid artery was cannulated. The left ventricular pressure curve was recorded by a multi-function electrophysiological recorder (Powerlab/4 SP, AD Instruments, Australia). The left ventricular end-diastolic pressure was measured. (LVEDP) and left ventricular end-systolic pressure (LVSP), detecting myocardial function.

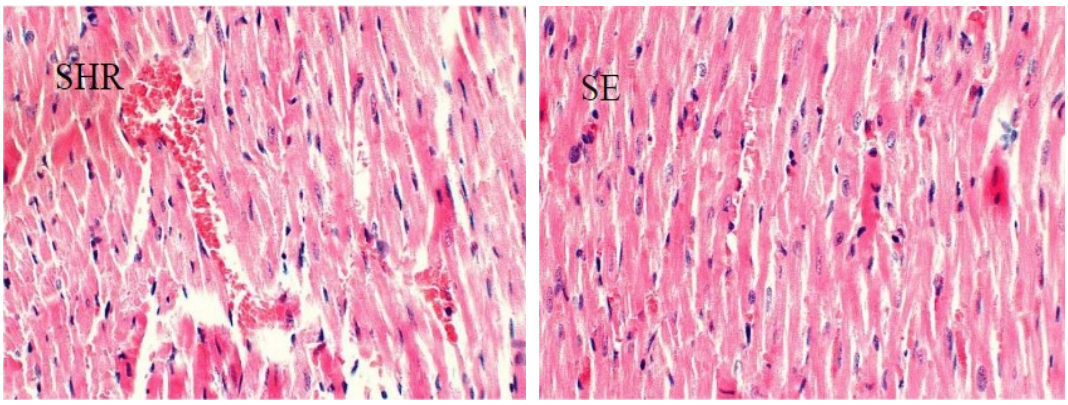
(2) Detection of autophagy markers

The protein was extracted from the myocardial tissue of the rat, the concentration of the protein was measured by the BCA method, and the amount of the sample was adjusted according to the quantitative result of the protein. The protein was separated by SDS-PAGE gel electrophoresis and transferred to PVDF membrane. 50 g/L skim milk powder was added dropwise at room temperature for one hour. After TBST washing, 1:1000 rabbit anti-rat LC3, Bec-lin1, p62 antibody were added. Incubate overnight at 4 degrees Celsius. After the next day washing, 1:1000 HRP-labeled goat anti-rabbit IgG was added and incubated for one hour at room temperature. Immunoblot chemiluminescence was used for semi-quantitative analysis using the AZUREC300 gel imaging system.

4. Discussion

4.1. Effects of Swimming on Myocardial Structure in Spontaneously Hypertensive Rats

In the SHR group, the myofibrils in the myocardial cells of the SHR group were disordered and replaced by proliferating mitochondria. The mitochondrial morphology was abnormal and the arrangement was irregular. Compared with the SHR group, the myocardial sarcolemlia of the SE group was clearer and mitochondria. Most are arranged in a compact manner. The results suggest that the ultrastructure of myocardial fibers in the SHR group is impaired, and swimming movement can reduce the damage of myocardial fiber structure [12]. The myocardial structures of the SHR and SE groups of rats are shown in Figure 1:



(a) myocardial structure in the SHR group (b) myocardial structure in the SE group

Figure 1. Myocardial structure of rats in SHR group and SE group

4.2. Effects of Exercise on Myocardial Function in Spontaneously Hypertensive Rats

The LVSP and LVEDP of the experimental rats were significantly increased ($P<0.01$). It is speculated that the blood pressure of the rats in the quiet group of 14 weeks old increased, and the heart function decreased. Compared with the quiet group, the LVSP and LVEDP in the exercise group decreased ($P<0.01$, $P<0.05$), indicating that swimming can improve the myocardial function of spontaneously hypertensive rats.The changes in rat autophagy-related proteins are shown in Figure 3:

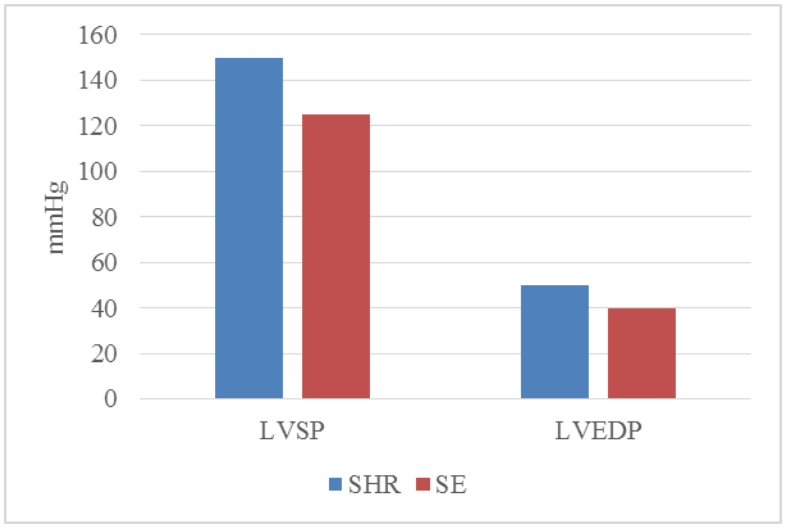


Figure 2. Rat hemodynamic changes

4.3. Effects of Exercise on the Expression of Autophagy-Related Proteins in Spontaneously Hypertensive Rats

The expressions of LC3-II, LC3-II/LC3-I and Beclin1 in SHR group were significantly decreased (P<0.05, P<0.01, P<0.01), and the expression of LC3-I was significantly increased (P<0.05). Compared with the SHR group, the expressions of LC3-II, LC3-II/LC3-I and Beclin1 in the SE group were significantly increased (P<0.01), and the expression of LC3-I was increased, but not obvious (P<0.05). >0.05). It was suggested that exercise increased the expression of LC3-II and the ratio of LC3-II/LC3-I and the expression of Beclin1 in SHR myocardium.The changes of autophagy-related proteins in rats are shown in the figure 3:

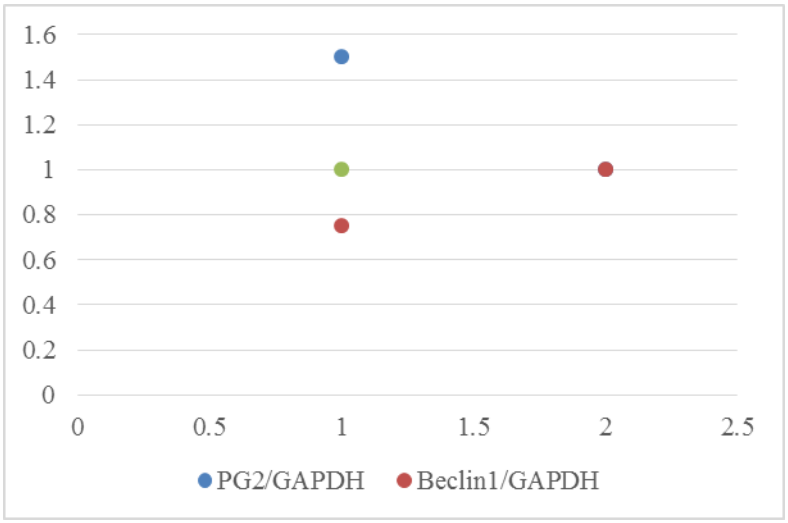


Figure 3. Changes in rat autophagy-related proteins

4.4. Changes in mRNA Transcription Levels of Autophagy-Related Genes in Rats

The p62 level in the SHR group was significantly higher (P<0.05). Compared with the SHR group, the expression of p62 mRNA in the SE group was significantly decreased (P<0.01). The mRNA level of related genes is shown in Figure 4 and Table 1:

Table 1. Related gene mRNA transcription level values

	LC3 mRNA	Beclin1 mRNA	p62 mRNA
SHR	0.01	0.075	0.028
SE	0.015	0.10	0.01

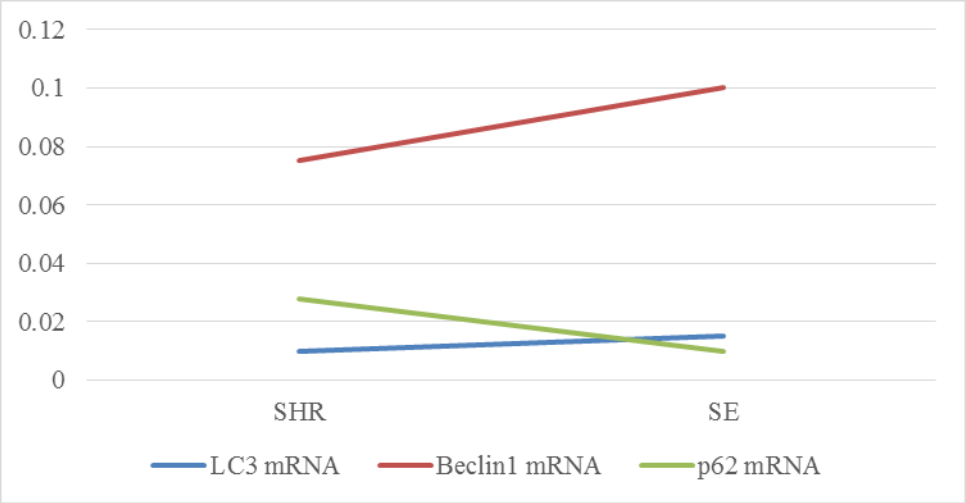


Figure 4. Changes in mRNA transcription levels of autophagy-related genes in rats

As can be seen from Table 1 and Figure 4, swimming exercise can reduce the expression level of p62 mRNA.

5. Conclusions

(1) Myocardial structural damage and decreased cardiac function in spontaneously hypertensive rats are associated with decreased levels of myocardial autophagy. Long-term swimming may improve the myocardial structure and function of spontaneously hypertensive rats by promoting the conversion of LC-I to LC3-II and the degradation of p62, the increase of Beclin1, increasing the level of myocardial autophagy.

(2) Leukocytes are common in normal cellular physiology and pathology, and they maintain balance in the body by removing excess or damaged organelles and proteins from the cells. However, insufficient and excessive autophagy can lead to the occurrence of related diseases. In an animal model of hypertension, autophagy can be detected to protect cardiomyocytes, which can increase the pressure of the endoplasmic reticulum and provide energy sources for other cells by digesting and degrading proteins and organelles. Therefore, it is clear that autophagy has a protective effect on the occurrence of hypertension.

(3) The basic level of autophagy can maintain the normal physiological balance of the cells, and autophagy in the pathological state can significantly improve the adaptive response to stress, so autophagy can be used as a factor in the treatment of hypertension. Therefore, it is particularly important to study the relationship between hypertension and autophagy. Appropriate exercise training can cause good adaptive remodeling of myocardial tissue cells, promote cell autophagy, increase myocardial contractile function, and play a protective role for myocardial fibrosis.

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