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Fatigue Exercise to Regulate the Heart Rate of Parasympathetic Nerve in Normal and Obese Rats

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Abstract: Peripheral nerve injury is very easy to lead to the central nervous system pathways of the human body produce significant changes, and sports training in promoting the recovery of the motor function after the central nerve injury plays a specific role in promoting. The purpose of this study was to investigate the effects of fatigue exercise on parasympathetic heart rate regulation in normal and obese rats. In the experimental study in this paper, normal rats were taken as experimental objects, and the reflex sensitivity of various nerve and heart rate functions was observed under the moderate intensity for 14 weeks as the research indicators, and the difference between the exercise group and the experimental control rats was compared to make a determination. The experimental data in this paper showed that systolic blood pressure (SBP) and diastolic blood pressure (DBP) did not change significantly in the aerobic training group compared with the quiet control group and the fatigue training group, but heart rate (HR) significantly decreased ($P<0.05$), and the peak left indoor pressure (LVSP) and the maximum rate of left indoor pressure rise (±dP/DT Max) were significantly increased ($P<0.05$). The expression of left ventricular cholinergic nerve and M2 receptor was significantly up-regulated ($P<0.05$). The experimental results showed that compared with the control group, the rats in the exercise group had hypertrophy of myocardium, increased cardiac pump strength, sympathetic arterial pressure reflex sensitivity and vagal nerve mediated arterial pressure reflex sensitivity. What is affected in this response is variability in cardiac sympathetic tone and increased variability in cardiac vagal tone. Long-term aerobic exercise can improve the capacity of cardiovascular autonomic regulation, which can make the coordination and conflict between sympathetic and parasympathetic nerves set up a new balance relationship at a higher level of function.

1. Introduction

The incidence of obesity is increasing every year, and it is estimated that by 2030, there will be

1.12 billion obese people in the world. Obesity is not only a disease, but also the cause of many chronic diseases. Obesity is the number one disease affecting human health today. Human health today. Obesity is usually associated with overweight and hyperlipidemia. Most of the current treatments for obesity focus on drugs, diet management and exercise regulation. However, research shows that long-term use of drugs can cause toxicity and side effects, as well as definitely increase the financial pressure on patients. Data suggest that dietary restriction has a role in the prevention and treatment of obesity, but the role is unclear. Nowadays, aerobic exercise is regarded as the most effective way to lose weight, and it is attracting more and more attention from professionals and scholars at home and abroad. This study attempts to observe the effects of aerobic exercise combined with diet regulation on weight and blood lipid of nutritionally obese rats, so as to provide correct experimental reference value for the rational treatment of obesity.

Peripheral nerve injury is one of the most common disorders in surgical clinics. The common causes include trauma, firearms injuries, and ischemic injuries, the most common being trauma [1]. On average, more than half a million patients a year have peripheral nerve injuries due to trauma, or 2.8% of the total. Compared with the incidence of tumors and cardiovascular diseases, the incidence of peripheral nerve injury is low, but the disability rate is high and the prognosis is poor. Patients with peripheral nerve injury may have sensory, motor or autonomic nerve dysfunction in the innervation region, which seriously affects people's quality of life [2]. Partial paresthesia is one of the conditions in which peripheral nerve damage occurs. Partial paresthesia can lead to deep sensory deficits, the inability to distinguish limb position and movement direction, leading to sensory ataxia. In clinical practice, a variety of methods (such as drugs, acupuncture, physical therapy and cell therapy) are commonly used to treat peripheral nerve injury, but they are not effective. Therefore, how to propose the method of motor function recovery after peripheral nerve injury has become a key issue in medical research.

Grossman et al. found through research that obesity can be an independent risk factor for the development of cardiovascular diseases, and the increase of cardiovascular diseases is closely related to the degree of obesity [3]. Echocardiography is mainly due to increased left ventricular diameter, thickened left ventricular wall and diaphragm, and increased left ventricular mass index, as it can affect the heart structure and function of obese patients and impair left ventricular function. Zarich et al. found a strong relationship between obesity and the development of heart failure [4]. In severely obese patients, chronic volume overload increases pressure and compensatory thickening of the left ventricular wall, leading to the development of cardiomyopathy characterized by left ventricular dilatation. Overweight or left ventricular systolic function in patients with mild obesity echocardiographic parameters have no obvious change, moderately obese patients show a compensatory increase left ventricular systolic function and diastolic function is reduced, there are many obese and overweight people of the echocardiography test researches on the change of left ventricular diastolic function, but few studies have effects on left ventricular systolic function.

During the exercise phase, parasympathetic function is inhibited and sympathetic activity leads to an increase in the center rate of the exercise process; however, parasympathetic function is stimulated again after exercise, which leads to a decrease in the heart rate during the recovery period. Reasonable exercise may lower your heart rate when you are quiet, but there are many reasons for this. According to the findings of the research on exercise ability, the treadmill exercise model of rats with different exercise intensity was established to study the influencing factors of different exercise intensity on the regulating function of heart rate of rats' vegetal nerves.

The experimental data in this paper showed that systolic blood pressure (SBP) and diastolic blood pressure (DBP) did not change significantly in the aerobic training group compared with the quiet control group and the fatigue training group, but the heart rate (HR) significantly decreased (P <0.05), and the peak left indoor pressure (LVSP) and maximum rate of left indoor pressure rise (±dP/ DT Max) significantly increased (P <0.05) in the aerobic training group. Sports training can be applied in clinical peripheral nerve injury with special clinical application value because they are part of sensory loss in peripheral nerve injury. Medical research on sports training after peripheral nerve injury can be used in clinical practice, and medical references are provided for rehabilitation therapy.

2. Research Methods of the Influence of Exercise on Rats

2.1. Obesity and Its Epidemiology

Obesity is a chronic metabolic disease that may be caused by excessive accumulation of fat in the body [5]. The prevalence and death rates of obesity continue to increase in both developing and developed countries, making it a global epidemic threatening human health. Statistics show that from 1998 to 2009, the prevalence of overweight/obesity in Chinese adults increased from 13.4% to 26.4%, and the prevalence of abdominal obesity increased from 18.5% to 37.6%. From the overall data, the obesity rate in China has increased significantly, while the local growth rate has greatly accelerated. Figures from the National Health and Nutrition Examination Survey (NHANES) show that adult obesity rates have increased every year for the past 30 years. In 2007-2008 alone, some 68% of the overweight or obese population (34% of them obese) was determined by race, age, sex and socioeconomic status. Contrary to this trend, the socioeconomic status gap in obesity rates may be narrowing, according to experimental data. Low-calorie and high-calorie foods usually supplement the energy needs of the human body, resulting in less physical exercise and a higher obesity rate [6]. This indicates that obesity is no longer a "wealth disease" and its development mainly depends on the imbalance between energy intake and energy consumption. The increase of abdominal/visceral obesity is closely related to the increase of TG and LDL and the decrease of HDL in the body.

2.2. Effects of Exercise on Rat Heart

Although the phenomenon of cardiovascular adaptive exercise is widely recognized, the research results are very different due to different exercise methods, exercise intensity and exercise time. It can be used as the theoretical reference material for the impact of exercise on cardiovascular activities, but practical guidance is not very important [7]. Regular exercise for a long time can lead to adaptive hypertrophy of the heart in rats, but the symptoms of cardiac hypertrophy vary with exercise methods. Even among rats of the same breed, there may be individual differences in motor ability. In the experiment studied in this paper, the maximum movement speed test method studied by the researchers was used as a reference before the exercise training of rats. Maximum speed test, the test with the interval of 2 d to 3 times, the maximum speed of each rat was considered the maximum value of the three test values, for each test in rats, the calculation of each rat was 85% - 90%, 50% 60%, 65% 70%, 30% 40% determine the speed of the rat, although the maximum speed may not be completely consistent, but the intensity of the exercise intensity will be in the corresponding movement within the scope of the study show that both high intensity exercise and moderate intensity exercise, the study can effectively reduce the body weight of rats, and this is mainly due to weight loss, This is achieved by reducing the amount of body fat [8]. The heart index of rats was significantly increased in the high-intensity exercise, suggesting that high-intensity exercise training can lead to moderate-intensity exercise training. However, morphological HE staining and Masson staining showed that moderate and high intensity exercise training affected the myocardial structure of rats. No significant change or fibrosis was observed in the serum CRP test, showing two things: the effect of exercise training on the heart of rats irreversibly inflammatory damage. The results of this study differ from previous results [9]. In this experiment, the differences of heart rate regulation due to exercise mode, exercise intensity and exercise time in normal rats were studied.

2.3. Experimental Animal Model

Obesity is caused by the long-term intake of excessive energy, which has greatly exceeded the body's energy consumption. Too much energy in the body will be converted into fat, and too much accumulation will lead to nutritional disorders [10]. Obesity is a public health problem that the scientific community attaches great importance to, and there are various ways to lose weight. Restricting diets is one of the most common ways to lose weight. Researchers found that simple diets have some effects on weight loss, but the final effect is not obvious. Aerobic exercise is considered the most basic and robust way to lose weight and researchers believe that cardiovascular interventions are effective in preventing obesity and its complications. A number of studies have suggested that exercise intervention is one of the effective ways to prevent obesity. Relevant data show that aerobic exercise can not only achieve the purpose of weight loss and fitness, but also can reduce and eliminate the complications caused by nutritional obesity. A literature review found that exercise alone was not the most effective way to lose weight. Since the research reports on the effectiveness of diet management or aerobic exercise in the treatment of obesity at home and abroad are not completely consistent, this paper introduces the methods of diet management combined with aerobic exercise in the treatment of obesity in normal rats, hoping to put forward some effective opinions on relevant theories. Since many studies have proved that two indicators of body weight and blood lipid can be used to detect obesity, this study will observe the changes of body weight and blood lipid in nutritionally obese rats, establish normal or obese rat models, and prove the influence of diet regulation and aerobic exercise on obesity.

2.4. Effects of High-Intensity Fatigue Training on Cardiac Function and Parasympathetic Nerve and Its Physiological Mechanism Analysis

During high-intensity, high-load exercise, where blood flows to areas of frequent movement, such as the trunk and limbs, gravity collects blood into the capillaries around the body, reducing blood flow and myocardial volume. Transient cerebral ischemia and hypoxia. The heart is sensitive to blood. Previous studies have shown that ischemia can damage cardiomyocytes and collagen fibers. However, there have been few reports of intense exercise training of the cholinergic nerves of the heart and its main receptor. Clinical studies have shown that ischemic heart disease is associated with decreased parasympathetic activity, and about one-third of ischemic heart disease is associated with decreased parasympathetic activity. In addition, one third of patients in the acute phase, such as unstable angina and acute myocardial infarction, further reduced parasympathetic activity in the heart. Studies have shown that parasympathetic activity can be used as a major reference index. The continuous decrease of parasympathetic activity indicates the continuous recurrence of ischemia, while the increase of parasympathetic activity indicates the improvement of ischemia [11-12].

Many scholars pay attention to sports training and cardiac parasympathetic nerve regulation about contact, studies have shown that moderate intensity of training load can improve HRV parameters related to the parasympathetic nerve, and high load trainees rhythm of the heart is low, even in the absence of the overload training, parasympathetic control HRV parameters also competitive, even if there is no fatigue sex also failed to return to the quiet control. In a related study, increasing the intensity of an athlete's training load from medium to final intensity reduced HRV and stress-reflex sensitivity after 20 days. In other words, sympathetic activity is increased, parasympathetic activity is decreased, and autonomic balance is supplied by the original parasympathetic nerve. The experiment proved that sympathetic nerve transformation is dominant, high intensity, high intensity training changed the cardiovascular automatic regulation system, the regulation from parasympathetic nerve to sympathetic nerve regulation.

2.5. Weight Loss and Cardiovascular Disease

According to research, reducing body fat accumulation rather than muscle mass is associated with a significantly lower mortality rate than losing weight without a systematic approach. Blind weight loss has potential side effects and may accelerate cardiovascular disease progression and prognosis. Lifestyle interventions such as exercise interventions and calorie restriction are non-drug treatments and have been incorporated into rehabilitation training for cardiovascular disease weight loss, according to the study. This intervention significantly reduced the incidence of metabolic syndrome. A study of 530 obese patients who received exercise training and restricted a high-calorie diet showed that overweight and obese people lost weight, reduced blood sugar and lipids, and significantly improved risk factors for coronary heart disease and reduced mortality. A study of 1,500 patients with coronary heart disease showed that a six-month diet program that actively lost weight reduced the risk of coronary heart disease within four years. However, the obesity and CARDIOVASCULAR disease weight loss paradox has been reported to be limited to patients with coronary heart disease who lose weight (which is associated with being overweight or obese). Fat loss in obese/overweight patients can prevent and reverse obesity-related cardiovascular disease. Weight loss and normalization are not the only goals, but weight loss is needed to improve the risk factors for cardiovascular disease associated with obesity. Losing weight can not only increase human metabolism in new cities, but also have beneficial effects on cardiovascular disease through a variety of mechanisms.

3. Cardiac Parasympathetic Heart Rate Regulation Function Experiment in Rats

3.1. Establishment of Animal Movement Model

36 male SD rats (purchased from the experimental animal Center of the Medical College for testing), 3months old, weight 232±13g, national standard rodent dry feed as food, room temperature 18-23℃, humidity 40-60%. The animals were randomly divided into three groups: normal control group, aerobic training group and fatigue training group. Use a step-up treadmill, repurchase the animal to adjust to eating, and begin training a week later. The initial speed is 20m/min and the time is 20minutes. The motion reference training model has changed slightly. In the quiet control group, the rats lived in normal conditions in cages and did not exercise. The aerobic training group trained at a speed of 20m/min 5 days a week to maintain a constant exercise speed. Increase your exercise time by 5 minutes every 2days. Increasing the time to 60minutes per day increased the incline by 5%, and then did not increase the time until the training was over. The fatigue training group trained 6 days a week with an initial speed of 20m/min.

3.2. Experimental Steps

The day after exercise training, the hemodynamics of the entire animal were tested. In the hemodynamic study, 8 rats were collected from each group using a polysomnograph. After weight measurement, we administered abdominal anesthesia to the rats, then separated the right common carotid artery, intubated the right carotid artery and left ventricle, and measured systolic and diastolic blood pressure of the artery. After stabilization for 5 minutes, left ventricular pressure, left ventricular diastolic pressure and maximum left ventricular peak heart rate were measured.

3.3. Sampling and Preparation of Experimental Specimens

After completing the hemodynamic examination of the rats, the hearts were quickly removed and washed with phosphate buffer solution (PBS) of 4℃ 0.01mmol/L. After the water was absorbed by the filter paper, the hearts were weighed and placed. Use ophthalmic scissors, ophthalmic forceps, and double-sided blades to separate and open the ventricles. After weighing, they were placed in a 4℃ environment, fixed with 10% formaldehyde solution for 24 hours, and rinsed overnight with running water. A left ventricular paraffin was inserted and Leica RM2 162 paraffin sectioning machine was cut into 6 m (for receptor measurement). The remaining left ventricle was placed in tissue blocks containing 30% sucrose, embedded in OCT, and sectioned with a Leica CM21900 constant-cold slicer (for neuromeasurement) at 20m. The slices were then preserved at 20℃ for future use.

3.4. Intervention Plan of Aerobic Exercise

In the exercise program of obese SD rats, moderate intensity aerobic exercise treadmill training was selected. The load was set at 17m/min, 45min/day, and the slope was 5°, which was approximately equivalent to 50% maximal oxygen uptake of rats. Train six days a week, take one day off, and train for eight weeks.

3.5. Collection of Experimental Samples and Measurement of Indicators

At the end of the experiment, the rats fasted overnight for 10h, were anesthetized with excessive pentobarbital sodium (40mg/kg body weight), weighed by an electronic scale, and blood was taken from their eyes. The blood was centrifuged in a TGL-16 desktop high-speed centrifuge, and the serum was extracted and stored in a -80℃ refrigerator. Total cholesterol (TC), triglyceride (TG) and low-density lipoprotein (LDL-C) were detected by an ultraviolet spectrophotometer.

4. Discussion of Rat Experiment

4.1. Changes of Heart Rate and Neuromodulation in Rats

(1)Arterial pressure reflex sensitivity (BRS) refers to the changes in blood pressure (BP) Δ cause changes in heart rate (Δ HR) the sensitivity of the calculation for the Δ HR/Δ BP. A classic BRS test can cause changes in blood pressure by physical or pharmacological means and observe corresponding changes in heart rate, but changes in blood pressure caused by conventional methods are usually normal. The Baroreflex mechanism beyond the range of physiological changes may be significantly different from normal physiological conditions, affecting the accuracy of the study results. In this study, we used postural changes in normal rats as a means of inducing blood pressure fluctuations, which is a natural response, and since BRS is measured in the normal physiological range, it is possible to really assess the bottom cardiovascular stress reflex under stable conditions. Sensitivity. At the end of the observation period, systolic blood pressure, diastolic blood pressure and mean arterial blood pressure in the motion-tail group showed no significant difference from the control group (P>0.05), but the heart rate difference was statistically significant (P<0.05). The experimental results are shown in Table 1 and Figure 1:

Table 1. Caudal artery blood pressure and pulse of rats in each group in awake and quiet state

Grouping	Number of animals	SBP/mmHg	DBP/mmHg	MBP/mmHg	HR/next min-1
Control group	14	132.8±10.3	85.2±16.2	122.0±12.5	420.0±41.4
Test group	14	134.6±14.2	86.4±19.1	115.4±22.3	387.9±43.2

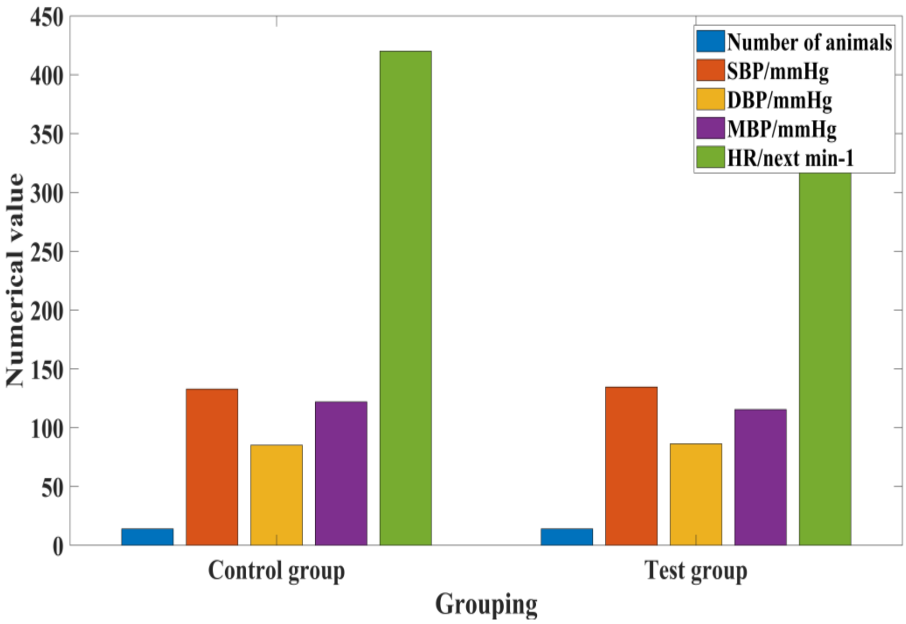

Figure 1. Caudal artery blood pressure and pulse of rats in each group in awake and quiet state

(2)In the experimental study, this paper respectively using rats "pressure reflection index" and "pressure reflection index" to evaluate the vagus nerve and sympathetic nerve function, and use the "pressure reflection" to fuzzy in sports training, not just only calculation to determine the overall sensitivity, pressure reflex sympathetic and parasympathetic nervous degree of different nature or effects of different defects. Differences between absolute and relative values must also be taken into account when calculating arterial pressure reflex sensitivity over a 14-week period. Otherwise, different conclusions will be drawn. The results showed that the absolute and relative values of the "pressure reflex index" in the exercise group were significantly higher than those in the control group. The absolute value of "pressure reflex index" was obviously lower than that of the control group, but there was no significant difference between the two groups. Long-term participation in aerobic exercise increased and enhanced sympathetic stress response, but had little effect on inactivating the sensitivity of parasympathetic stress response. At the end of the experimental observation period, the TF, VLF, HF and VLFnorm of the exercise group were higher than those of the control group, with statistically significant differences (P <0.05), but there were two LF/HF. There was no significant difference between the experimental group and the control group (P> 0.05). Detailed data are shown in Table 2 and Figure 2:

Table 2. Comparison of heart rate variability (HRV) of rats in each group

Group	Number of animals	TF/ms^2	VLF/ms^2	LF/ms^2	HF/ms^2	LF/HF
Control group	14	0.72±0.14	0.14±0.06	0.11±0.07	0.41±0.11	0.27±0.06
Sports Group	14	0.87±0.23	0.23±0.07	0.15±0.07	0.53±0.08	0.22±0.07

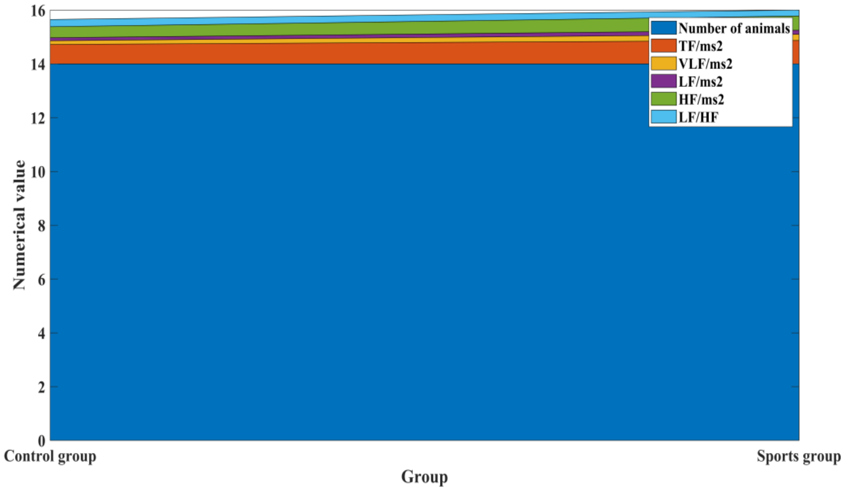

Figure 2. Comparison of heart rate variability (HRV) of rats in each group

4.2. Experimental Comparison of the Two Groups of Rats

(1) Since two indexes of weight and blood lipid of rats can be used to detect obesity, in this study, we observed the changes in weight and blood lipid of nutritionally obese SD rats, which led to dietary restriction and aerobic stress, showing the impact of exercise on obesity. The results showed that the body weight, TC, TG and LDL-C levels in the rat model group were significantly higher than those in the control group, and the difference was statistically significant (P <0.05). High-energy diet led to SD rats and hyperlipidemia. Dietary management and aerobic exercise were used to intervene in SD rats. As a result, the weight and lipid levels of SD rats in the exercise-controlled diet group and the exercise-controlled group were significantly lower than those in the obese group. However, the weight and lipid levels of the exercise control group were significantly lower than that of the exercise group, with statistically significant differences (P <0.05). Therefore, it can be concluded that aerobic exercise can improve the weight and lipid levels of nutritionally obese SD rats, but the comprehensive effect of diet management and aerobic exercise is better. The comparison of important results of the two groups of experiments is shown in Figure 3:

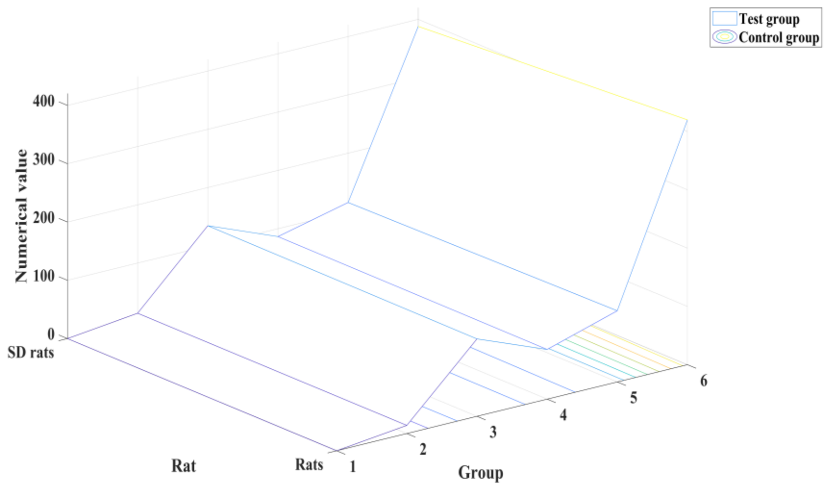

Figure 3. Comparison of the significance of the two groups of experiments

(2)The peripheral nerve function indexes of the experimental group and the control group were lower than those of the sham operation group (P<0.05). 7 days after surgery, the peroneal nerve data index was the lowest in the control group, and then gradually increased, but still lower than the preoperative level (P<0.05). The peroneal nerve functional index value of the experimental group recovered better than that of the control group after 21 and 28 days, and the difference was statistically significant (P<0.05), as shown in Figure 4. The experimental results showed that when the dorsal root ganglion excision can cause extensive motor dysfunction, the motor training of rats plays an important role in promoting motor coordination and recovery.

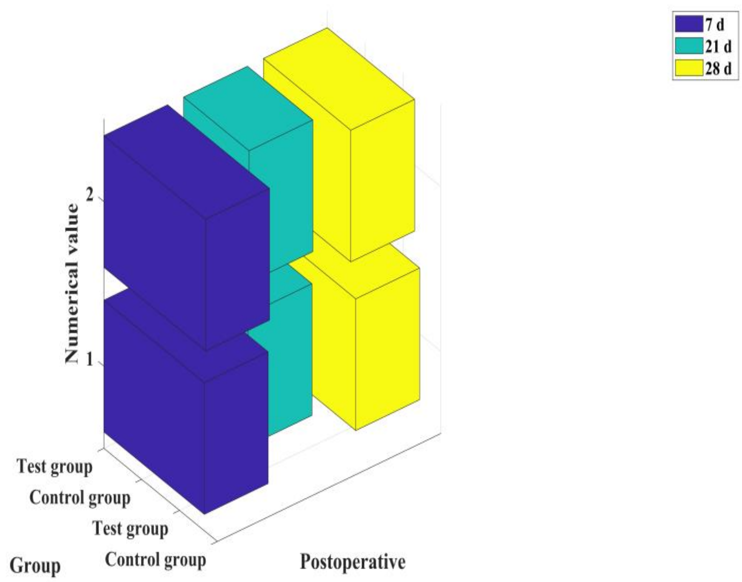

Figure 4. Comparison of exercise training for coordination of movement and recovery of motor function

5. Conclusion

(1) The effect on heart rate regulation varies with exercise methods, but the effect is still unclear. At the same time, exercise training can also cause hypertonic and inflammatory responses in the heart, which can also lead to changes in autonomic nervous system heartbeat and blood pressure control. Under the influence of exercise training, the sympathetic nerve and vagus nerve heart rate control function changes. The experimental analysis of several weeks showed that moderate intensity exercise and high intensity exercise training did not significantly affect the quiet heart rate of rats, but regulated the function of vagus nerve fibers, and effectively inhibited the ability of normal rats vagus nerve to control the heart rate. Known intracardiac regulatory pathway proteins and interventional proteins that have no regulatory function and do not affect the downstream vagus nerve may exist in unknown areas requiring further investigation.

(2) In this study on the regulation of parasympathetic heart rate by fatigue exercise in normal and obese rats, similar changes were observed in rats in the moderate intensity swimming group. That is, the heart weight index of exercise group was significantly higher than that of control group ($P < 0.01$), indicating that exercise group showed cardiac hypertrophy. In addition, the heart rate of the exercise group was significantly lower than that of the control group at rest and under anesthesia. There was no significant difference in blood pressure (CBP, DIastolic, and mean arterial pressure) between the calm and quiet states. The above results indicated that after 14 weeks of moderate intensity swimming training, the cardiac function of the exercise group rats was significantly improved. The improvement of cardiac function in the exercise group was related to the structural changes caused by myocardial hypertrophy and was closely related to the improvement of autonomic nerve control function. In the aerobic group, the rat heart developed structural and functional fitness. The myocardium showed birth hypertrophy, quiet heart rate decreased, systolic force and diastolic function increased. In the aerobic exercise group, the sympathetic mediated arterial pressure reflex sensitivity was increased, and the cardiovascular autonomic control function was significantly enhanced. The arterial pressure reflex sensitivity was not affected by the vascular nerve, but the sympathetic and vagal tone changes were increased. It has been suggested that both the sympathetic and vagus nerves enhance cardiovascular regulation and achieve balance at higher levels of function, and that such balance restores cardiovascular health and is a mechanism for aerobic exercise.

(3) Frequency domain method was used to analyze and compare the differences of HRV parameters between motion and quiet control. The experimental results showed that the difference of TF, VLF, HF and VLFnorm in the exercise group was significantly higher than that in the quiet control group ($P < 0.05$), but the difference of LF/HF was not statistically significant ($P > 0.05$), and the long-term existence was observed in the exercise time. The results showed that aerobic exercise could increase the overall variability of heart rate (TF) and vagal tone (HF). Increased sympathetic tone variation (VLF and LF increase). In this study, it was found that the cardiac dysfunction in the exercise and training group of rats could be caused by myocardial ischemia caused by fatigue training, which would lead to parasympathetic nervous dysfunction. The loss of parasympathetic nerve exacerbates myocardial ischemia, thus forming a vicious circle. The balance of sympathetic nerve reduces the nerve's ability to regulate the heart in rats, thus weakening the function of the heart.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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