Scholar Publishing Group
International Journal of Sports Technology
https://doi.org/10.38007/IJST.2021.020301
ISSN 2789-7141 Vol. 2, Issue 3: 1-12

Exercise on Heart Rate Regulation of Autonomic Nerve in Normal and Obese Rats

Mursaha Abstueri*

University of Delhi, Delhi, India

**corresponding author*

Keywords: Animal Movement Model, Autonomic Nerve Heart Rate, Regulatory Function, Obesity Research

Abstract: In recent years, the incidence rate of autonomic nerve dysfunction has increased significantly. This condition is manifested by the imbalance between sympathetic and parasympathetic nerves, which affects the physiological functions of the viscera. This paper mainly studies the effect of exercise on the heart rate regulation function of autonomic nerve in normal and obese rats. This paper mainly introduces the autonomic nervous system and the function of autonomic nerve in regulating heart rate. Forty eight healthy SD rats, half male and half female, weighing 100-150 g, were purchased from the animal experimental center of the municipal hospital. Rats were fed with normal diet for one week. Methods: 48 healthy SD rats were randomly divided into two groups: blank control group (n = 9) and obesity group (n = 36). The blank control group (group A) continued to feed with normal diet, while the experimental group (group B) was fed with high-fat diet. The results showed that: after 10 weeks of feeding with common diet, the average resting heart rate of rats in group A was 385.36bpmin, while that of rats in groups B1, B2 and B3 were 403.59bpmin, 415.68bpmin and 409.94bpmin respectively. After different time of exercise, the heart rate of B2 and B3 groups was 7.8% and 6.3% higher than that of B1 rats. The results showed that the heart rate regulation function of autonomic nerve was enhanced in group B2 after 1 hour of exercise, and decreased in group B3 after 2 hours of exercise. It is proved that exercise has an effect on the heart rate regulation function of autonomic nerve in rats. Moderate exercise can better improve the imbalance between parasympathetic nerve and sympathetic nerve in the heart of obese rats, promote nerve excitation, increase heart rate and improve heart rate variability.

1. Introduction

The autonomic nervous system plays an important role in the pathogenesis of organism or

functional disease. Vasovagal nerve has typical function, which is related to vascular inhibition and cardiac inhibition. Dysfunction of autonomic nervous system regulation will lead to dysfunction and imbalance of parasympathetic nervous system in autonomic nervous system, lead to cardiovascular, metabolic and endocrine disorders, bring arrhythmia, hypertension, hyperlipidemia, diabetes and other diseases, especially cardiovascular diseases, which will bring inconvenience to patients. The balance of parasympathetic nerve determines the function of sympathetic nerve.

Since nerve growth factor (NGF) can induce the collateral sprouting of noradrenergic sympathetic terminals, Walsh GS speculated that NGF may play a role in mediating the initiation of sympathetic axons into sensory ganglia. It was found for the first time that the level of NGF protein in trigeminal ganglion of adult transgenic mice was significantly higher than that of age-matched wild-type mice by using transgenic mouse lines overexpressing NGF in glial cells, and there were detectable expression levels of NGF mRNA in both ganglion and brainstem. In the trigeminal ganglion, a small number of sensory neurons showed NGF by immunohistochemical staining; the proportion of NGF positive neurons in transgenic mice was significantly higher [1]. Adrenergic activation and baroreflex dysfunction are common in essential hypertension, elderly hypertension, masked and white coat hypertension, resistant hypertension and obesity related hypertension. Whether this autonomic nervous behavior is specific to hypertension or can be detected in the early clinical stage of the disease, that is to say, the status of high normal blood pressure (BP) is still unclear to a large extent[2]. The increase of NaCl concentration in cerebrospinal fluid of patients with salt sensitive hypertension will increase sympathetic nerve activity (SNA). Stocker SD study explored the role of RVLM neurons in SNA and pressor response to cerebrospinal fluid hypernatremia. Intracerebroventricular infusion of 0.15 mol / L, 0.6 mol / L and 1.0 mol / L NaCl (5 L / 10 min) increased lumbar SNA, adrenal SNA and arterial blood pressure in a concentration dependent manner. Although visceral SNA did not change, renal SNA decreased[3]. Smith p g study explored the cell phenotype of sympathetic tissue during passage, and compared it with the cell phenotype of non-sympathetic region and smooth muscle target area. Tarsometatarsus and orbital muscles, the two main targets of orbital smooth muscle, contain a large number of synaptophysin immunoreactive nerves[4].

Neuroturin (NTN) is an important neurotrophic factor of parasympathetic nerve cells, which is particularly important for pelvic parasympathetic cells, because these neurons are vulnerable to injury in surgical operations such as prostatectomy. In order to solve this problem, wanigasekara y cultured isolated adult rat pelvic ganglion neurons and observed the structural changes after axotomy. The size of axotomy penile neurons without target source support was smaller than that of intact neurons. Studies on cultured adult pelvic ganglion neurons also showed that NTN stimulated the growth of somatic cells [5]. In order to reveal the brain region and transmitter system related to the regulation of pancreatic hormone secretion, RM combined specific vagotomy and sympathetic nerve transection with retrograde synaptic tracer pseudorabies virus (PRV) injection into the pancreas. After sympathetic or vagal transection, primary neurons appeared in the dorsal motor nucleus (DMV) and preganglionic spinal cord neurons (SPN), respectively. Careful observation of the survival time of the animals reveals the cell population that directly controls these DMV or SPN neurons. Compared with SPN neurons, the number of cells involved in DMV control is much more [6]. Berthoud h r injected the fluorescent lipophilic carbocyan dye DiI or dia into the dorsal motor nucleus of the vagus nerve and labeled the efferent preganglionic neurons of the vagus nerve anterogradely. Then, all neurons in the peripheral nervous system (outside the blood-brain barrier) were re stained in vivo by intraperitoneal injection of fluorogold (Co.). Under the guidance of ultraviolet and stereomicroscope, the anterior vertebral ganglia of the upper abdomen were identified and dissected in formalin fixed tissues, including many microganglia related to the periarterial plexus of the celiac artery and superior mesenteric artery [7]. More and more evidences

show that immune factors are involved in the pathogenesis of cardiac autonomic dysfunction in type 1 diabetes mellitus (DM). Muhr Becker D was used to evaluate the existence of autoantibodies against autonomic nerve tissue and its relationship with autonomic function test[8].

Forty eight healthy SD rats, half male and half female, weighing 100-150 g, were purchased from the animal experimental center of the municipal hospital. Rats were fed with normal diet for one week. Methods: 48 healthy SD rats were randomly divided into two groups: blank control group (n = 9) and obesity group (n = 36). The blank control group (group A) continued to feed with normal diet, while the experimental group (group B) was fed with high-fat diet. The control group was fed normally without exercise intervention. At the 8th week, the standard deviation of the number of rats in group B was 1.3 times larger than that in group A. Twenty seven obese rats were randomly divided into three groups: Group B1, group B2 and group B3. There were 9 rats in group B1, 9 rats in group B2, 9 rats in group B2, 9 rats in group B3, 9 rats in group B3, and 9 rats in group A. After different time of exercise, the heart rate of B2 and B3 groups was 7.8% and 6.3% higher than that of B1 rats. The results showed that the heart rate regulation function of autonomic nerve was enhanced in group B2 after 1 hour of exercise, and decreased in group B3 after 2 hours of exercise.

2. Autonomic Nervous System and Autonomic Nerve Heart Rate Regulation Function

2.1. Autonomic Nervous System

The autonomic nervous system is mainly composed of sympathetic nerve and parasympathetic nerve. It can regulate the activities of visceral and vascular smooth muscle, myocardium and glands, and also participate in endocrine regulation and metabolism of glucose, fat, water and electrolyte. Under normal or stress conditions, the autonomic nervous system can maintain the homeostasis of cardiovascular system, gastrointestinal tract and body temperature. The autonomic nervous system consists of preganglionic autonomic neurons, premotor neurons, afferent neurons, intermediate neurons connecting afferent signals and higher central nervous system [9].

The autonomic nervous system has the following characteristics: not under the control of will; the general internal organs will be subject to the dual control of sympathetic and parasympathetic nerves; the role of sympathetic and parasympathetic nerves on border irrigation is antagonistic, and the antagonistic effect is complementary; it has tension effect; it is regulated by emotion, such as the inhibition of digestive secretion caused by anxiety indigestion.

2.1.1. Sympathetic Nerve

Sympathetic ganglia regulate the whole heart, including sinoatrial node, atrioventricular node, atrioventricular muscle and ventricular muscle. Stimulation of sympathetic nerve can accelerate heart rate and make myocardium contract. At the same time, the conductive speed is accelerated and the conductive time is shortened. In contrast to the vagal effect, the stimulation of sympathetic nerve has a delay of about 5 seconds, then the heart rate gradually increases, and lasts 20 to 30 seconds after reaching steady state. There is an obvious correspondence between the variation of sympathetic nerve frequency and vagus nerve frequency.

2.1.2. Parasympathetic Nerve

The parasympathetic nerve that innervates the heart is also known as the vagus nerve. When the vagus nerve is excited, its postganglionic nerve endings release acetylcholine. This type of transporter binds to M-type cholinergic receptors on the myocardial cell membrane, slowing heart

rate, conduction and other inhibitory effects. The inhibition mechanism of acetylcholine is to increase the permeability of K channel on cell membrane and promote the outward flow of K. Once the outward flow of K increases, the absolute value of resting potential will be increased, the gap between resting potential and threshold potential will be widened, and the excitability of myocardium can be controlled. The increase of K outflow can also increase the absolute value of maximum repolarization potential, accelerate repolarization, and shorten the action potential time and refractory period. Acetylcholine has an inhibitory effect on the heart, because acetylcholine can reduce the autonomy of the sinus node, prolong the refractory period, slow down the conduction velocity of the excitation in the sinus node, and form sinus bradycardia; it can also shorten the refractory period of atrial muscle, accelerate the conduction velocity of excitation in the new chamber; inhibit the atrial node area and node area, delay or interrupt the atrioventricular conduction [10].

The parasympathetic activity of the heart originates from the central neurons, and the parasympathetic inhibition of the heart will disappear after cutting off the preganglionic fibers. The parasympathetic fibers of the heart are tense and rhythmic, which are synchronized with respiration, and are inhibited during inspiration.

The parasympathetic nerve mainly originates from the nucleus ambiguus (NA) of the nucleus vagus (dmnx). In addition, there are parasympathetic nerves in nucleus tractus solitarius, nucleus ambiguus, Na and dmnx. As the nuclei of various visceral motor neurons, the anatomical boundary of dmnx and Na is relatively vague, and the area of parasympathetic nerve aggregation is very small. It is very difficult to obtain the parasympathetic nerve which has functional activity and can be confirmed by retrograde activity in vivo.

2.2. Autonomic Nerve Heart Rate Regulation Function

2.2.1. Heart Rate Index

The resting heart rate is the heart rate per minute of the measured person in a steady state. The physiological parameters measured by resting heart rate are relatively simple with small deviation, and the resting heart rate is also related to life span [11].

Exercise heart rate is composed of exercise center rate and heart rate after exercise, that is, heart rate during exercise and heart rate after exercise. According to the recovery rate of heart rate, the coach can judge the adaptability and physical function of athletes. After the athletes finish the same training intensity, the heart rate of the tested athletes recovers slowly, indicating that the body function has not recovered, which is not suitable for this training. The heart rate of athletes returned to normal within 3 minutes after strong exercise load, which indicated that the athletes' physical function was in good condition.

Maximum heart rate. The heart rate increases with the increase of exercise intensity. When the exercise intensity reaches the limit, the heart rate cannot be increased. The maximum heart rate can be used as an indicator of exercise intensity. Generally speaking, the maximum heart rate will be equal to 220 minus the actual age.

Heart rate reserve, the difference between the maximum heart rate and the resting heart rate, can be used to calculate the target heart rate. The target heart rate will be higher than the reserve heart rate. Heart rate reserve is more in line with the true maximum oxygen uptake of athletes in sports.

2.2.2. Heart Rate Variability

Heart rate variability (HRV) is a small difference between successive heart beats, which is shown as irregular changes in the time of each cardiac cycle, and this change exists even when the heart

rate is relatively stable [12]. Abnormal heart rate variability is mainly manifested in the imbalance of autonomic nerve function. HRV is an indirect method to evaluate autonomic nerve function. HRV is the result of fine-tuning cardiovascular system through neurohumoral factors, and autonomic nerve activity can also be indirectly determined by HRV [13-14].

Under normal physiological conditions, the autonomic nervous system controls the rhythm of the heart and the dynamic balance of the autonomic nervous system through the antagonism of sympathetic and parasympathetic nerves[15]. If the balance is broken due to various reasons, it will lead to the dysfunction of sympathetic and parasympathetic nervous system and the change of heart rate, which is the physiological basis of HRV. Therefore, HRV reflects the activity of autonomic nerve, quantitatively evaluates the tension and balance of cardiac sympathetic nerve and parasympathetic nerve, and its effect on cardiovascular activity.

The analysis methods of HRV can be divided into linear dynamic analysis and nonlinear dynamic analysis. The linear dynamics analysis includes time domain analysis and frequency domain analysis evaluation. The main indexes of nonlinear dynamics analysis include stability index, regulation ability index and comprehensive evaluation index. HRV is mainly used to analyze the time-domain signal of HRV[16]. The frequency spectrum analysis method transforms the time series signal of RR interval into frequency domain through digital transformation, and forms the spectrum curve. This method can be used to analyze short-term HRV data. Under normal physiological conditions, the heart is not a simple periodic vibrator, but a complex heart rate adjustment process. In the time domain and frequency domain analysis methods, it can not fully reflect the small and short transient changes of heart cycle. Using nonlinear systems, we can understand the relationship between the transient changes of cardiac cycle and cardiac physiology and pathology. Both nonlinear and linear methods indicate that HRV is mainly dependent on heart rate. There was an inverse correlation between HRV and heart rate. Large HRV is associated with low heart rate, and vice versa.

2.3. Effect of Exercise on Obese People

Exercise has an impact on the blood lipid of obese people. During aerobic exercise, fat is decomposed as energy supply material, and fatty acids and triglycerides are consumed. Moderate intensity aerobic exercise can effectively improve blood lipid level. The way of exercise, the intensity of exercise, the duration of exercise and different types of exercise will have a certain difference in the impact of fat.

Exercise also has an effect on the inflammatory factors of obese people. Obesity is a chronic inflammatory disease, which is related to the expression level of inflammatory factor IL-6 and circulating volume concentration. After weight loss, the expression level and content of IL-6 will decrease.The possible mechanisms of exercise-induced anti-inflammatory include the release of endogenous substances, changes in the composition of immune cells, selective reduction of visceral adipose tissue volume and mutual solubility. In addition to energy storage, adipose tissue is also an important endocrine organ that secretes a variety of adipokines. There are a lot of fat cells, especially adipose tissue, in obese people. Among them, white fat blood vessels are few, blood circulation is not good, adipose tissue far away from blood vessels will produce ischemia and hypoxia, thus causing chronic inflammation. Exercise can improve body composition and reduce body weight by reducing body fat. It also plays an important role in regulating glucose metabolism of obese people. Acute exercise may promote the production of inflammatory factors, but regular exercise can reduce the chronic inflammation of skeletal muscle. The anti-inflammatory effect of exercise is affected by physical health status, exercise intensity, exercise time, glucose utilization possibility and sampling time.

Proper exercise can reduce weight because it increases energy consumption and improves metabolic status of obese patients. Exercise also has anti-inflammatory effect. Reducing body fat, improving body composition and regulating glucose metabolism can achieve anti-inflammatory effect.

3. Experimental Design

3.1. Experimental Materials and Instruments

Experimental instruments: forceps, scissors, hemostatic forceps, silica gel tube, vascular forceps, suture, gauze, disposable syringe, paraffin section machine, electron microscope; atropine sulfate, rat interleukin-10 enzyme-linked immunosorbent assay kit, chloral hydrate, 2% Pentobarbital Sodium, 0.9% normal saline, SABC immunohistochemical staining kit;

Forty eight healthy SD rats, half male and half female, weighing 100-150 g, were purchased from the animal experimental center of the municipal hospital. Rats were fed with normal diet for one week. Methods: 48 healthy SD rats were randomly divided into two groups: blank control group (n = 9) and obesity group (n = 36). The blank control group (group A) continued to be fed with ordinary diet, while the experimental group (group B) was fed with high-fat diet, which contained 62% fat and 18% carbohydrate, with higher calories than ordinary diet.

The weight and weight of each rat were measured at 10:00 a.m. every Tuesday. In addition, the diet of each rat was recorded in time for 8 weeks. At the 8th week, the standard deviation of the number of rats in group B was 1.3 times larger than that in group A. Twenty seven obese rats were randomly divided into three groups: Group B1, group B2 and group B3. There were 9 rats in B1 group and 9 rats in B2 group. Exercise for 1 hour every day; group B3 had 9 rats. The rats in group A were given exercise for 2 hours a day.

3.2. Experimental Steps

(1) Exercise intervention

During the intervention period, the experimental group continued to feed high-fat diet, and the AB and ab groups in the experimental group were given adaptive training for one week. The animal treadmill exercise mode was used to exercise for half an hour at the speed of 10 meters per minute, once every other day. After the adaptive training, formal intervention training was carried out for 5 weeks. The speed of 15 meters per minute was carried out 5 days a week. The total exercise time of group A was 1 hour and that of group B was 2 hours. Rest on Monday, easy to measure data.

(2) Sample collection and detection methods

Before and after the experiment, the heart rate of rats at rest was measured. At 24 hours after exercise intervention, rats in group A and group B1, group B2 and group B3 were intraperitoneally injected with atropine sulfate in a quiet state. After 10 minutes, the heart rate of rats was measured with a non-invasive sphygmomanometer. The measured heart rate represents the intrinsic heart rate of rats.

(3) At the end of heart rate detection rats were fasted for 24 hours, and were intraperitoneally injected with chloral hydrate. After the body fat content of rats was detected by DEXA, the abdominal cavity of rats was opened, and the heart blood was collected for centrifugation, and the serum was retained. The perirenal adipose tissue was isolated and the wet weight of adipose tissue was measured. Blood, heart and adipose tissue were cryopreserved in time.

(4) Blood enzyme linked immunosorbent assay

The serum samples were thawed and recovered to liquid, and then put into the set enzyme label instrument, incubated at 35 ℃ for 30 minutes, and then added washing solution for cleaning. The

enzyme labeled reagent was added for incubation and cleaning again. After adding the developer, the color was developed in dark for 10 minutes. Add the termination solution and measure it with enzyme label instrument. Set the OD value to 400nm. After zero adjustment, read, record and sort out the data.

4. Analysis of Experimental Results

4.1. After 8 Weeks, the Body Weight and Resting Heart Rate and Blood Pressure of Rats in Each Group Were Measured

After 8 weeks, the body weight and resting heart rate and blood pressure data of rats in groups A and B1, B2 and B3 are shown in Table 1:

Table 1. After 8 weeks, the body weight and resting heart rate and blood pressure of rats in each group were measured

Heart Rate / Group	Average weight(g)	Quiet Heart Rate(bpmin)	Quiet SBP(mmHg)	Quiet MBP(mmHg)
A Group	306.58	451.36	140.45	123.25
B1 Group	335.78	385.62	138.35	124.68
B2 Group	341.68	389.79	136.78	125.89
B3 Group	329.54	383.12	137.65	123.69

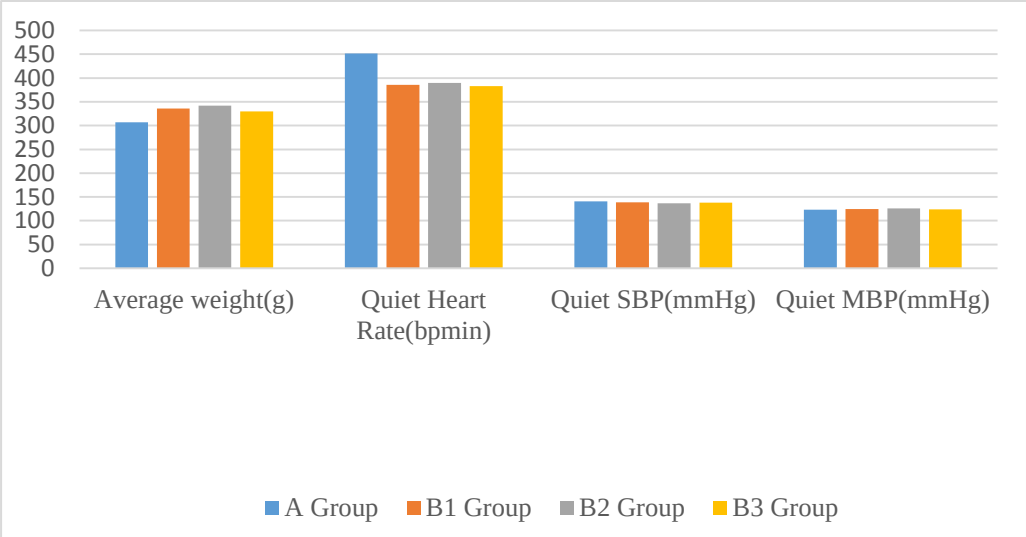

Figure 1. After 8 weeks, the body weight and resting heart rate and blood pressure of rats in each group were measured

It can be seen from Figure 1 that group A was fed with ordinary diet for 8 weeks, and group B1, B2 and B3 were fed with high-fat diet for 8 weeks. There was no significant difference in body weight among groups B1, B2 and B3, which could be ignored. The weight of rats in group B1, B2 and B3 was significantly greater than that of group A by 1.3 SD. The average resting heart rate of group A was 451.36bpmin, while that of group B1, B2 and B3 was 385.62bpmin, 389.79bpmin and 383.12bpmin. The average resting heart rate of group A was 65.74bpmin, 61.57bpmin, 68.24bpmin,

17.04%, 15.81% and 17.81% higher than that of group B1, B2 and B3, respectively. As obesity increases, the pressure on the heart increases, leading to a decrease in heart rate.

4.2. Heart Rate Comparison of Rats in Each Group after 10 Weeks of Exercise

After 10 weeks, the heart rates of rats in group A and B1, B2 and B3 after exercise and after atropine sulfate injection are shown in Table 2:

Table 2. Heart rate of rats in each group before and after exercise at 10 weeks

Heart Rate / Group	Quiet Heart Rate	Δ Heart Rate-Quiet	Inherent Heart Rate	Δ Heart Rate-Inherent
A Group	385.36	158.68	382.57	142.78
B1 Group	403.59	121.68	412.39	132.25
B2 Group	415.68	125.79	399.65	168.35
B3 Group	409.94	135.49	425.65	129.65

In Table 2, Δ Heart Rate-Quiet represents the difference between heart rate after atropine sulfate injection and heart rate at rest; Δ Heart Rate-Inherent represents the difference between heart rate after atropine sulfate injection and heart rate at rest.

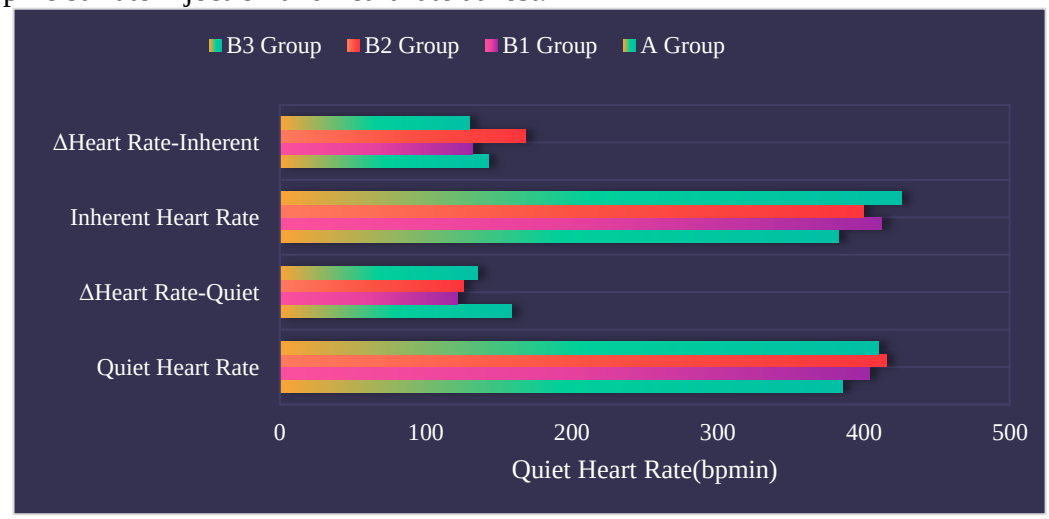

Figure 2. Heart rate of rats in each group before and after exercise at 10 weeks

It can be seen from Figure 2 that after 10 weeks of feeding with common diet, the average resting heart rate of rats in group A was 385.36bpmin, while that of rats in groups B1, B2 and B3 were 403.59bpmin, 415.68bpmin and 409.94bpmin respectively after 10 weeks of high-fat diet. After different time of exercise, the heart rate of B2 and B3 groups was 7.8% and 6.3% higher than that of B1 rats. The results showed that the heart rate regulation function of autonomic nerve was enhanced in group B2 after 1 hour of exercise, and decreased in group B3 after 2 hours of exercise.

4.3. Comparison of Serum CRP, M2 Receptor and Rgs6 in Right Ventricular Atrium of Rats in Each Group after 10 Weeks

After 10 weeks, the data of serum CRP, M2 receptor and rgs6 in right ventricular atrium of rats in group A and B1, B2 and B3 were as shown in the figure:

Figure 3. Data of serum CRP, M2 receptor and rgs6 in rats of each group

It can be seen from Figure 3 that after 10 weeks of feeding with common diet in group A and 10 weeks of high-fat diet in group B1, B2 and B3, the serum CRP concentration detected in each group has no obvious change, which indicates that high-fat and high-sugar diet and high-fat and high-sugar diet combined with two different exercise time have no obvious effect on serum CRP of rats, and will not lead to heart disease and cardiovascular disease in rats Illness. After feeding with high-fat diet for 10 weeks, the content of M2 receptor in right atrium of group B1, B2 and B3 was significantly higher than that of group A, indicating that high-fat diet changed the content of M2 receptor in right atrium of rats, and increased with time. The expression of M2 receptor and rgs6 in right atrium of group B1, B2 and B3 showed no significant difference in the expression of M2 receptor and rgs6 in group B1, B2 and B3. The results showed that M2 receptor and rgs6 did not change significantly in different exercise intensity.

4.4. Comparison of Rgs6, Kcnj5 and Kir3.4 in Each Group after 16 Weeks

After 16 weeks, the data of rgs6, kcnj5 and Kir3.4 in groups A and B1, B2 and B3 were shown in the figure:

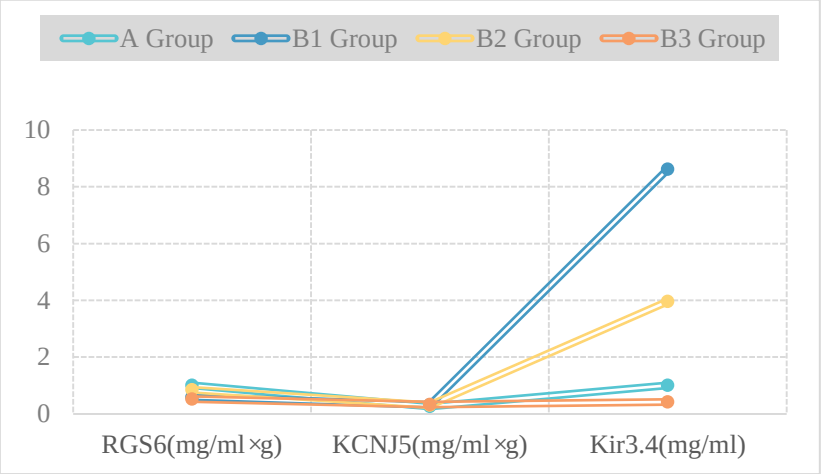

Figure 4. Comparison of rgs6, kcnj5 and Kir3.4 in each group after 16 weeks

As can be seen from Figure 4, kcnj5 of rats in group A and B1, B2 and B3 groups did not change significantly. After feeding with high-fat diet for 16 weeks, the content of rgs6 in groups B1, B2, B3 and a decreased. The content of rgs6 in B2 and B3 groups increased with the increase of exercise load as compared with group B1. However, with the increase of exercise intensity, the content of rgs6 in group B3 decreased with the increase of exercise intensity. It shows that the content of rgs6 in rats is very sensitive to exercise, and different exercise modes lead to different change trend of rgs6 content. Kir3.4 mRNA in group B1, B2 and B3 decreased with the prolongation of exercise time, indicating that exercise training can reduce the content of Kir3.4 mRNA in right ventricular atrium of rats, and the effect of high-intensity exercise training is obvious.

The results showed that: after 10 weeks of feeding with common diet, the average resting heart rate of rats in group A was 385.36bpmin, while that of rats in groups B1, B2 and B3 were 403.59bpmin, 415.68bpmin and 409.94bpmin respectively. After different time of exercise, the heart rate of B2 and B3 groups was 7.8% and 6.3% higher than that of B1 rats. The results showed that the heart rate regulation function of autonomic nerve was enhanced in group B2 after 1 hour of exercise, and decreased in group B3 after 2 hours of exercise. It is proved that exercise has an effect on the heart rate regulation function of autonomic nerve in rats. Moderate exercise can better improve the imbalance between parasympathetic nerve and sympathetic nerve in the heart of obese rats, promote nerve excitation, increase heart rate and improve heart rate variability.

5. Conclusion

The autonomic nervous system is mainly composed of sympathetic nerve and parasympathetic nerve. It can regulate the activities of visceral and vascular smooth muscle, myocardium and glands, and also participate in endocrine regulation and metabolism of glucose, fat, water and electrolyte. Under normal or stress conditions, the autonomic nervous system can maintain the homeostasis of cardiovascular system, gastrointestinal tract and body temperature.

This paper mainly studies the effect of exercise on the heart rate regulation function of autonomic nerve in normal and obese rats. This paper mainly introduces the nerve heart rate, its regulating function, obesity and exercise. Forty eight healthy SD rats, half male and half female, weighing 100-150 g, were purchased from the animal experimental center of the municipal hospital. Rats were fed with normal diet for one week. Methods: 48 healthy SD rats were randomly divided into two groups: blank control group (n = 9) and obesity group (n = 36). The blank control group (group A) continued to feed with normal diet, while the experimental group (group B) was fed with

high-fat diet. The results showed that: after 10 weeks of feeding with common diet, the average resting heart rate of rats in group A was 385.36bpmin, while that of rats in groups B1, B2 and B3 were 403.59bpmin, 415.68bpmin and 409.94bpmin respectively. After different time of exercise, the heart rate of B2 and B3 groups was 7.8% and 6.3% higher than that of B1 rats. The results showed that the heart rate regulation function of autonomic nerve was enhanced in group B2 after 1 hour of exercise, and decreased in group B3 after 2 hours of exercise. It is proved that exercise has an effect on the heart rate regulation function of autonomic nerve in rats. Moderate exercise can better improve the imbalance between parasympathetic nerve and sympathetic nerve in the heart of obese rats, promote nerve excitation, increase heart rate and improve heart rate variability.

Due to my limited experience and small sample size, the results of this paper have some limitations. There are not many ways to record the heart rate of rats. In the future research work will further improve the deficiencies in this study.

Funding

This article is not supported by any foundation.

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.

References

[1] *Walsh G S , Kawaja M D .(2015).“Sympathetic Axons Surround Nerve Growth Factor-Immunoreactive Trigeminal Neurons: Observations in Mice Overexpressing Nerve Growth Factor.”. Developmental Neurobiology, 34(4),pp.347-360. https://doi.org/10.1002/(SICI)1097-4695(199803)34:4<347::AID-NEU5>3.0.CO;2-6*

[2] *Seravalle G , Lonati L , Buzzi S , et al. (2015).“Sympathetic Nerve Traffic and Baroreflex Function in Optimal, Normal, and High-Normal Blood Pressure States”. Journal of Hypertension, 33(7),pp.1411-7. https://doi.org/10.1097/HJH.0000000000000567*

[3] *Stocker S D , Lang S M , Simmonds S S , et al.(2015).“ Cerebrospinal Fluid Hypernatremia Elevates Sympathetic Nerve Activity and Blood Pressure via the Rostral Ventrolateral Medulla”.Hypertension,66(6),pp.1184-90.1.https://doi.org/10.1161/HYPERTENSIONAHA.115.05936*

[4] *Smith P G , Fan Q , Zhang R , et al.(2015).“ Cellular Terrain Surrounding Sympathetic Nerve Pathways in the Rat Orbit: Comparisons of Orbital Connective Tissue and Smooth Muscle Cell Phenotypes”. Journal of Comparative Neurology, 400(4),pp.529-543.1 https://doi.org/10.1002/(SICI)1096-9861(19981102)400:4<529::AID-CNE7>3.0.CO;2-C*

[5] *Wanigasekara Y , Keast J R .(2015).“ Neurturin Has Multiple Neurotrophic Effects on Adult Rat Sacral Parasympathetic Ganglion Neurons”. European Journal of Neuroence, 22(3),pp.595-604. https://doi.org/10.1111/j.1460-9568.2005.04260.x*

[6] *Buijs R M , Chun S J , Niijima A , et al. (2015).“Parasympathetic and Sympathetic Control of the Pancreas: a Role for the Suprachiasmatic Nucleus and Other Hypothalamic Centers That are Involved in The Regulation of Food Intake”. Journal of Comparative Neurology,*

431(4),pp.405-423.https://doi.org/10.1002/1096-9861(20010319)431:4<405::AID-CNE1079>3.0.CO;2-D

[7] Berthoud H R , Powley T L . (2015).“Interaction Between Parasympathetic and Sympathetic Nerves in Prevertebral Ganglia: Morphological Evidence for Vagal Efferent Innervation of Ganglion Cells in the Rat”. Microscopy Research & Technique, 35(1),pp.80-86. https://doi.org/10.1002/(SICI)1097-0029(19960901)35:1<80::AID-JEMT7>3.0.CO;2-W

[8] Muhr-Becker D , Ziegler A G , Druschky A , et al.(2015).“ Evidence for Specific Autoimmunity Against Sympathetic and Parasympathetic Nervous Tissues in type 1 Diabetes Mellitus and the Relation to Cardiac Autonomic Dysfunction”. Diabetic Medicine A Journal of the British DiabeticAssociation,15(6),pp.467-472.https://doi.org/10.1002/(SICI)1096-9136(199806)15:6<467::AID-DIA621>3.0.CO;2-Q

[9] Calupca M A , Vizzard M A , Parsons R L . (2015).“Origin of Neuronal Nitric Oxide Synthase (Nos)-Immunoreactive Fibers in Guinea Pig Parasympathetic Cardiac Ganglia.”. Journal of ComparativeNeurology,426(3),pp.493-504.https://doi.org/10.1002/1096-9861(20001023)426:3<493::AID-CNE10>3.0.CO;2-P

[10] Myers A C .(2015).“ Anatomical Characteristics of Tonic and Phasic Postganglionic Neurons in Guinea Pig Bronchial Parasympathetic Ganglia”. Journal of Comparative Neurology, 419(4),pp.439-450.https://doi.org/10.1002/(SICI)1096-9861(20000417)419:4<439::AID-CNE3>3.0.CO;2-3

[11] Kaya D , Karaca S , Barutcu I , et al. (2015).“Heart Rate Variability in Patients with Essential Hyperhidrosis: Dynamic Influence of Sympathetic and Parasympathetic Maneuvers”. Annals of Noninvasive Electrocardiology,10(1),pp.1-6. https://doi.org/10.1111/j.1542-474X.2005.00578.x

[12] Hinnant J B , Erath S A , El-Sheikh M . (2015).“Harsh Parenting, Parasympathetic Activity, and Development of Delinquency and Substance Use”. J Abnorm Psychol, 124(1),pp.137-151. https://doi.org/10.1037/abn0000026

[13] Shuren Zhou, Bo Tan.Electrocardiogram soft computing using hybrid deep learning CNN-ELM. Applied Soft Computing Journal,Volume 86,2020,105778. https://doi.org/10.1016/j.asoc.2019.105778

[14] Choi, G. H. , Ko, H. , Pedrycz, W. , Singh, A. K. , & Pan, S. B. . (2020). Recognition system using fusion normalization based on morphological features of post-exercise ecg for intelligent biometrics. Sensors, 20(24), 7130. https://doi.org/10.3390/s20247130

[15] Abedallah Zaid Abualkishik , Sundus Naji AL-Aziz, The Regulation and Influence of Physical Exercise on Human Body's Neutrosophic Set, Respiratory System and Nervous System, International Journal of Neutrosophic Science, 2022, Vol. 18, No. 3, pp: 111-124. https://doi.org/10.54216/IJNS.1803010

[16] A. A. Hamad, A. S. Al-Obeidi, E. H. Al-Taiy, O. I. Khalaf and D. Le, "Synchronization phenomena investigation of a new nonlinear dynamical system 4d by gardano’s and lyapunov’s methods," Computers, Materials & Continua, vol. 66, no.3, pp. 3311–3327, 2021. https://doi.org/10.32604/cmc.2021.013395