The Effect of Vibration Strength Training on the Enhancement of Lower Limb Strength in Mice

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Abstract: With the development of competitive sports, the physical quality requirements of athletes are getting higher and higher. The biggest feature of vibration strength training is that it can effectively increase the maximum strength, rapid strength and strength endurance of the muscle under relatively small load conditions. However, there are not many researches on the application of vibration strength training to athletes. This is also the problem that the current competitive sports field needs to solve. The purpose of this paper is to study the effects of vibration strength training on the enhancement of lower limb strength in mice. In this paper, experimental experiments and mathematical statistics are used to train different frequencies of experimental mice. In this paper, by studying the maximum strength and explosive power of the lower limbs of the mice, the increase of the block jump and run-up jump of the experimental group was 33.3% and 25%, respectively, and the increase of the block take-off and run-up jump of the control group were 10% and 6.25%, respectively. It can be seen that the vibration strength training has a positive effect on the strength enhancement of the lower limbs of the mice.

Key words: Vibration Strength Training, Lower Limb Strength, Strength Enhancement, Lower Limbs of Mice

1. Introduction

Strengthening the development of sports is an important step to further improve the national 12th Five-Year Sports Development Strategy. As the core leadership force for the development of social sports, college sports undertake the task of social sports construction development integrating education, training and scientific research [1]. Sports is an examination of the comprehensive sports quality of athletes, the growth of elite athletes is inseparable from the comprehensive physical quality training, the current sports have developed to a certain extent in China, especially in the high-level sports teams sports performance [2]. Any sports program is a comprehensive survey of athletes' physical fitness, tactical literacy, technical and tactical mentality, technical and tactical level, only when these competitive sports capabilities are fully coordinated and developed can them be more objective, angle to illustrate the excellence of athletes [3].

Physical fitness is an important factor in any sporting event to improve the level of competition. It is also true for sports competitions. Good physical fitness is a prerequisite for athletes to better play their technical and tactical arrangements and abilities [4]. The research on mice will help to further explore the new features and forms of sports development in the new era, and implement them to the public level to enhance the overall quality of citizens [5]. Theories and methods related to strength training have always been the difficulty and hotspot of sports training, and have always been the focus of attention of all countries. As a new training method, vibration strength training has been favored by many scholars at home and abroad [6]. Domestic research on vibration strength training has undergone a period of development. It has been applied in many projects such as badminton, handball, long jump and volleyball, and has achieved certain results, but there is no vibration strength training for the study of lower limb strength. Quantitative evaluation lacks an understanding of the sources of strength growth, and lacks an in-depth study of individual differences in vibration training [7]. It can be seen that the training research on lower limb strength is imperative.

The goal of Paohung and his team was to compare the effects of an 8-week whole-body vibration training program on the strength and strength of the knee extensor at the same acceleration and at different frequency and amplitude settings. Sixty-four young participants were randomly assigned to one of four groups, each with the same acceleration (4g): high frequency and low amplitude (n = 16, 32 Hz, 1 mm) group, intermediate and medium amplitude (n = 16, 18 Hz, 3 mm), low frequency and high amplitude (n = 16, 3 Hz, 114 mm) and control (n = 16, no vibration) groups. All participants performed 3 physical mass training sessions per week for 8 weeks. They found that the isometric contraction strength of the high-frequency low-amplitude group and the constant-speed concentric contraction strength of 120°/s were significantly increased. The IF and mid-amplitude groups increased significantly in both 60°/s and 120°/s isocenter strengths of concentric and eccentric contractions; the low-frequency and high-amplitude groups increased at 60°/s and 120°/s, respectively [8]. Clynes and his team found that hip fractures were the most common complication of osteoporosis, with low mortality, long-term disability, and quality of life. In recent years, different techniques have been developed to assess lower limb strength and ultimate fracture risk. Here, they examined the relationship between the bone geometry and strength of the lower extremities; the proximal femur geometry and the quantitative computed tomography scan around the humerus. They studied samples of 431 women and 488 men between the ages of 59-71. The Hip Arthroscopic Analysis (HSA) procedure was used to measure the structural geometry of the left hip joint, each DXA scan was obtained using a Hologic QDR 4500 instrument, and the pectoral PQCT measurement was obtained using the Stratec 2000 instrument in the same population. They observed strong gender differences in the geometry of the proximal femur in the narrow neck, intertrochanteric, and femoral shaft regions [9]. Weng and his team reported the use of stealth dicing (SD) for defect characterization and reduction and tube strength enhancement on 2D NAND memory wafers with high back reflectance (82%). This was done by a three-layer surface infrared (1.342 μm) nanosecond pulsed laser die cut (with partial SD) prior to the grinding integration method. The combination of simulation, characterization and optimization of the multi-layer SD process eliminates defects associated with mechanical and absorptive laser cutting, such as ablation of the front and back surfaces as well as front, back and edge cracking [10]. At the same time, the kerf width and the straightness of the slit are stable to the effect of the test element structure placed along the scribe line. High-quality SD slitting production is consistent, with nearly zero cut loss across the entire 300 mm wafer. Solved the unique defects of multi-layer SD, such as interference effects and interlaminar splitting surface damage. It also addresses SD-related integration defects, including repaired silicon powder residues and defects associated with chip-attached films after chip separation. They demonstrate the performance of this method by demonstrating a stack of eight 25 μm thick memory dies without defects [11].

In this paper, 20 mice were used as research objects, and the “Pro5HP” vibration table was used as the experimental instrument. The relationship between vibration training and the explosive force and vibration frequency of the lower limbs of mice was studied by experimental method and mathematical statistics. The relationship between vibration force and vibration frequency of the lower limbs is separately analyzed by vibration training. Proposing a suitable vibration strength training strategy provides support for the promotion of vibration strength training to the public level.

2. Proposed Method

2.1. Vibration Training

(1) Definition of vibration strength training

Vibration Training is a training method that uses mechanical vibration to cause muscle oscillation. Vibration stimulation is first used in the field of medical rehabilitation. Medical personnel use a vibrator to stimulate the patient to induce muscle contraction, thereby improving the patient's pain and paralysis. Adding vibration training to the athlete's strength training, intervening in the traditional strength training to intervene in the vibration training, compared with the traditional strength training effect: the vibration stimulation can make the traditional strength training effect more obvious, and can effectively improve the muscles strength and stretchability. Therefore, the strength training combined with vibration stimulation is called vibration strength training. Vibration strength training involves the intervention of vibration stimulation in conventional strength training. This stimulation is transmitted to the nerve center through the body and causes nerve excitation to improve the ability of nerve recruitment, which can enhance the effect of conventional strength training. As an emerging and effective training method, vibration strength training is more and more widely used in competitive sports, mass sports and rehabilitation.

(2) Method of vibration strength training

Vibration training is a training method that uses mechanical oscillations to cause muscle oscillations, reflected by vibration frequency and vibration amplitude. Vibration training is the application of vibration as a stimulus to training activities, generally refers to vibration strength training. The vibration frequency refers to the number of vibrations per unit time, that is, the number of fluctuations per second, usually measured in Hertz (Hz); the vibration amplitude refers to the actual distance of the vibration fluctuation, and the maximum value of the equilibrium position in the periodic vibration the half difference of the minimum value represents the strength of the vibration in mm.

Methods of vibration training include vibration characteristics and training programs. Vibration characteristics include vibration application methods, vibration frequencies, and vibration amplitudes. The intensity of the vibration load experienced by the neuromuscular system is determined by the vibration frequency and the amplitude of the vibration. The exercise training program includes the type of vibration, training intensity, amount of training, number of exercises, and duration of continuous pauses and training frequency. According to different application methods, vibration training can be divided into two types, the direct stimulation method and the indirect stimulation method. The direct stimulation method means that during the implementation process, the vibration stimulation generated by the vibrator is directly attached to the muscle abdomen or tendon, and the vibrator is fixed by hand or other external support. Another type of indirect stimulation is to transmit vibrational stimulation through a part of the body to the target muscle group that you want to train through a vibration trainer placed at the distal end of the target training muscle group. Since both the direct stimulation method and the indirect stimulation method can exert effects on the muscles, when the effect of the vibration training is detected, the two methods can be combined. The magnitude of the original vibration and the magnitude of the vibration frequency acting on the target training muscle group are the key to distinguishing the two methods. The duration of the vibration is also an important factor affecting the vibration training effect. Its effects should be analyzed in conjunction with time points when assessing neuromuscular function.

(3) Theoretical basis of vibration training

1) Fundamental of neurophysiology

The muscles of the human body belong to a kind of viscoelastic body. When subjected to vibration stimulation of certain amplitude, the joint angle changes slightly, and at the same time, the joint receptor and the joint torque are changed, thereby affecting the changes of muscle tension and muscle length, and generating muscles. Passive contraction and relaxation. Through the susceptor, this information is transmitted to the central nervous system, and the central nervous system responds and issues instructions to adapt and change the muscle spindle and the Golgi apparatus. Muscle spindle (muscles pindle) is an important proprietor of human muscle tissue. It can feel the muscles being stimulated by stretching or muscle length. It is widely distributed in human muscle fibers and is about a few millimeters long. It is a special kind of fusiform receptor. Muscle spindles include two types of afferent fibers: Class I (12-20 microns) and Class II (4-12 microns). The central efferent motor has a 12-20 micron diameter alpha-efferent fiber that innervates the extrafusal muscle fiber; a gamma-emission fiber with a diameter of 2-6 micrometers, which occupies the intrafusal muscle fiber. The intrafusal muscle fibers contract when the gamma-extracting fiber activity is strengthened, which can increase the sensitivity of the sensory device in the muscle spindle. Therefore, the activity of the γ-efferent fiber plays an important role in regulating the stretch reflex. Studies have shown that vibrational stimulation can activate the excitability of primary Ia afferent fibers, and reflexively cause contraction of extrafusal muscle fibers. Maximize the recruitment of participating sports units under the premise of active muscle contraction.

Golgi Tendon Organs (GTO), also known as the scorpion, is another proprietor of human muscle tissue. It is located at the junction of tendon and muscle fibers, which is widely distributed between collagen fibers and tendons, and is in series with the extrafusal muscle fibers. As a high-threshold receptor, the Golgi device acts as an inhibitor of the active muscle and facilitates the production of antagonistic muscle. When the vibration training device is turned on and the vibration is transmitted, the nerve impulses of the active muscles are greatly increased, and the antagonistic muscles and the auxiliary muscles are suppressed, the frequency at which they contract and relax alternately in the range of 30-50 Hz. While the muscle spindle stimulates the contraction of the active muscle, the sputum senses muscle tension and inhibits the contraction of the antagonist muscle. The multiple synaptic pathways transmit information between tissues and organs. This is the principle and foundation for the simultaneous improvement of the ability of the body to achieve various qualities through the vibration platform.

Experts and scholars at home and abroad have generally believed that the concept of vibration strength training originally originated from electrophysiological tonic vibration reflex (TVR). TVR refers to the continuous contraction of muscles under the stimulation of exogenous vibration. Causes Ia afferent nerve fiber excitation, leading to reflex muscle contraction. At the same time, the vibration stimulation by the vibrator increases muscle tone, activates the proprietors of the muscles, and then undergoes multi-synaptic and single-synaptic neurofeedback regulation, which causes muscle contraction that causes involuntary contraction, thereby increasing muscle mass activity, leading to changes in muscle strength. For example, a half-twisting action on the shaking table increases the load to increase the traction of the quadriceps muscle. After sensing the change, the muscle spindle transmits the signal to the spinal cord through the Ia afferent fiber, and the spinal cord mono-synaptic pathway Excitability is enhanced and the muscle strength of the agonist is enhanced by efferent nerves.

2) Biomechanical basis

The adaptation of the human body to vibration training is based on Newton's second law: $F = m *a$. Acceleration is the rate of change of speed and is proportional to the amount of external force. When the multiple of the acceleration increases, the multiple of the external force also increases accordingly. Conversely, the relationship between acceleration and mass is inversely proportional. When the multiple of mass increases, the acceleration is divided by the same multiple. The vibration training device generates a force by changing the acceleration. Vibration in the vertical direction can produce acceleration on the platform. The change in acceleration will effectively stimulate the excitability of the muscle spindle and cause reflex muscle contraction. In the vibration training, the phenomenon of "overweight" and "weight loss" caused by acceleration makes the human body bear the load in the "overweight" stage far exceeding the actual load weight. Therefore, in order to adapt and correspond to this kind of gravity, the human body needs to increase the resistance to it by recruiting more exercise units, which makes the muscle strength grow faster under a smaller load.

3) Fundamentals of physics

When people participate in sports activities, body tissues will vibrate due to physical contact with external objects or forces. Usually, the cause of vibration of human tissue is caused by a collision between a part of the human body and a sports machine. For example, in sports such as horse riding, sailing, and alpine skiing, the soft tissue is vibrated when the body is subjected to external forces. Therefore, vibration is an important feature of the human body structure.

The three factors that affect the vibration of the human body are the vibration frequency, amplitude and acceleration. From a physical point of view, the amplitude and vibration frequency are determined by the natural frequency and resistance characteristics of the body tissue, and the natural frequency of vibration depends on its hardness and quality. Inside the skeletal muscle, the transverse bridge between myosin and actin produces stiffness, and an increase in muscle activity also increases the stiffness of the tissue. Related studies have shown that external vibrations can be weakened by muscles, and the activated muscles absorb more vibrational energy than the unactivated muscles, thus confirming that positive cross-bridge periodic work is to weaken vibrations. An important part of the process. The muscles that are maximally activated by the block, after several cycles, the tissue vibration is eliminated. From this, it can be considered that the activation of the muscle is to keep the vibration occurring in the tissue to be minimized, that is, the weakening of the vibration activates the muscle.

When the intensity of the vibration stimulus is appropriate, the muscle fibers of the whole muscle will be activated and contracted, and the muscle will produce maximum contraction force. However, even if vibration affects muscle activation, the effect of external vibration is still unclear. Because part of the vibration stimulation may be buffered by the soft tissue and synovial fluid of the human body.

2.2. Lower Limb Strength

(1) Classification of muscle strength

1) According to the relationship between strength and professionalism, strength can be divided into general strength and special strength.

General strength refers to the ability to complete non-professional technical tactics and anti-fatigue physical exercise. The purpose of general strength training is to improve the basic strength of athletes, that is, the ability of athletes to overcome resistance when performing non-special sports, including general ability to walk, run, jump, and cast. On the other hand, general forces also lay the foundation and provide guarantee for the improvement of the special strength level. Special strength refers to the ability of muscles to contract and resist fatigue when completing special skills and tactics.

Special forces are based on general strength. The purpose of this strength training is to further develop the strength of athletes based on the physiology and methodological characteristics of the special sport. A high level of special strength guarantees the high quality of the special technology and also helps to carry more load in training and competition.

2) According to the relationship between strength and weight, it can be divided into relative strength and absolute strength. Relative strength is the maximum strength of athletes per unit weight. Relative power directly affects the ability of the player to accelerate and slow down while moving on the court. The stronger the relative strength of the athlete, the easier it is to exercise on the playing field. Absolute strength refers to the muscle strength that is produced without regard to body shape or muscle size.

(2) Factors affecting muscle strength

1) The power output of the muscle varies according to the level of power output required. This ability to modify or rank strength is critical to a balanced and coordinated ability to perform athletically. Muscle strength can be changed in two ways: first, by changing the frequency of the active motion unit. If a motion unit is activated, the resultant force will be large. However, if the frequency of stimulation increases and the vibrational forces begin to accumulate or accumulate, the unit of motion produces more force. By increasing the frequency of activation of a single motion unit, the output of overall muscle strength can be enhanced; another way to change skeletal muscle strength is to increase the number of athletic units that recruit different activation modes. Just like the large muscle groups on the thigh, the motor unit is activated at a frequency close to tetanus, and the force output is obtained by recruiting more exercise units.

2) Another mechanism that affects muscle strength is the degree of synchronization of the motor unit. At low intensities, the activation of the motion unit is not synchronized. However, when the maximum force level is applied, some units are activated simultaneously with other units. At low muscle tension, you can hardly see

synchronization. The motion unit is activated in particular in a short time of dynamic expansion. Asynchronously activated records show that when one unit is disabled, another unit is activated. This form can lead to muscle tone, which occurs in relatively soft motion. Enhancing muscle activation can increase muscle strength by recruiting or coding rates. A higher level of synchronization occurs when the force output increases. The maximum activation frequency in the range of 30-50 Hz is the low threshold of the motor unit and increases to a high threshold at 100 Hz, depending on the type and intensity of muscle activity. In addition, strength training can increase the number of synchronization units and cause synchronization at lower power outputs. However, the degree of synchronization affects maximum strength, especially in equidistant practice, seems small. Synchronization plays an important role in flexible activities.

(3) Definition and assessment of the concept of maximum strength and explosive power

1) Definition and assessment of the concept of maximum strength

Maximum force is the maximum force that muscles can overcome by maximizing voluntary contraction. There are many ways to evaluate the maximum intensity, which can be measured during the action or near the completion of the action of the game action. It can be measured statically or dynamically. Dynamic and static assessment of muscles has drawbacks. As the key curvature of the muscle changes during work, the strength of the muscle changes. Therefore, the results of the assessment are not very accurate. The static assessment of the athlete's maximum strength is of little significance for periodic projects. Even in the static state, even if the maximum strength of the muscle is high, the muscle strength under dynamic motion is also very important. At a high level, the strength assessment in static exercises only is at rest and does not accurately represent the power of the entire movement. The ideal way to assess the athlete's maximum strength is to measure the maximum strength of the muscle during exercise. The advantage of this test method is that the machine can display the maximum intensity when moving at various speeds. In the process of assessing the maximum intensity, it should be noted that the test must establish different evaluation criteria according to the special characteristics; when measuring the maximum strength of the working muscle group, we should also pay attention to measuring the maximum strength of the measured muscle to the working muscle group. We should pay attention to the assessment of the maximum strength and overall maximum strength of the main part of the movement.

2) Definition and assessment of the concept of explosive power

Rapid strength refers to the ability of muscles to exert force quickly, and is an organic combination of strength and speed. Explosive power is a fast force. Muscles have begun to increase the tension to overcome the resistance as quickly as possible. The magnitude of the explosive force is usually assessed by a dynamic graph. In regular sports, explosive forces can also be assessed through various forms of comprehensive measurements. Such as the periodic movement of the project begins and slows down.

3. Experiments

3.1. Data Collection

In this paper, 20 adult male mice weighing about 35 grams were selected. The 20 mice were randomly divided into experimental group (10 rats) and control group (10 rats).

3.2. Experimental Design and Implementation

(1) Experimental action

Vibration group: Lower limb vibration training: through the "Pro5HP" vibration table, the vibration frequency is 30Hz-45Hz, and the amplitude is 2mm.

Control group: lower limb training action: training was carried out by traditional conventional training methods such as picking up, kicking, and leapfrog.

(2) Experimental parameters

The experimental design includes various aspects such as vibration frequency, amplitude, training time and test indicators, which is the key link for the successful completion of the experiment.

1) Setting of vibration frequency and amplitude in the experiment

The mouse has three resonance peaks with mechanical vibration. These resonance peaks are: the first resonance peak that occurs between 1 Hz and 2 Hz. This resonance peak will cause resonance in the human thoracic cavity, and the internal organs of the experimental individual will Causes certain damage; the second resonance peak occurs between 2Hz and 4Hz. This resonance peak will cause the rabbit to resonate in the abdominal cavity, which will cause greater damage to the abdominal system of the experimental individual; the vibration frequency is between 4Hz. The third form-ant that appears between -5Hz, this resonance peak will cause the muscles of the mouse to resonate, causing greater damage to the muscles of the experimental individual. When the vibration frequency is between 5Hz and 6Hz, it will cause certain damage to the "head-neck-shoulder" system of the mouse; when the vibration frequency is between 6Hz and 9Hz, it will cause certain damage to the eye of the mouse. When the vibration frequency is between 10Hz and 15Hz, it will cause certain damage to the "squatting-cap bone" of the mouse. Therefore, for experimental safety reasons, the vibration frequency should be chosen between 3Hz and 6Hz in the experiment. The purpose of this experiment is to study the quantitative relationship between vibration frequency and upper and lower lipid strength. Therefore, several vibration frequencies should be selected as much as possible during the experimental design process to ensure the accuracy of the research results. The vibration frequency is between 3 Hz and 6 Hz, and the amplitude of 2 mm plays a positive role in the health of the mice. In summary, the vibration frequency of this experimental design is between 3Hz and 6Hz (the vibration frequency interval is 1Hz), and the amplitude is 2mm.

2) Setting of experimental vibration training time

The tested mice should take adequate rest after vibration training to eliminate muscle fatigue caused by vibration; the time for the initial vibration training of the mouse to receive vibration stimulation is not too long and the number of times is not too much, the number should be lower than Twice a week. Therefore, the vibration time at different frequencies is set to 1 min, the vibration test interval is 1 min, and the number of vibrations is set to twice a week. Continuous staggered jumps will quickly consume the vertical energy energy material ATP. Therefore, the bounce test interval should be controlled, preferably 30s. In summary: the vibration training time of this experiment is set to 1min, the vibration test interval is 1min, the vibration frequency is set to twice a week, and the vibration stimulation interval of different frequencies is 1 week.

4. Discussion

4.1. Comparison and Analysis of Maximum Limb Strength

(1) Analysis of the trend of peak force variation in the mouse

In the take-off of the block, there was no significant difference between the two groups of mice before the experiment. After nine weeks of strength training, the mice in the experimental group showed significant changes compared with those before the experiment. Before and after the experiment, there was a significant difference between the experimental group and the experimental group ($P<0.01$), and the control group also increased from 19 before the experiment to 21, and the difference between the two groups was statistically significant ($p<0.05$). The trend analysis of the peak force of the mouse block is shown in Figure 1:

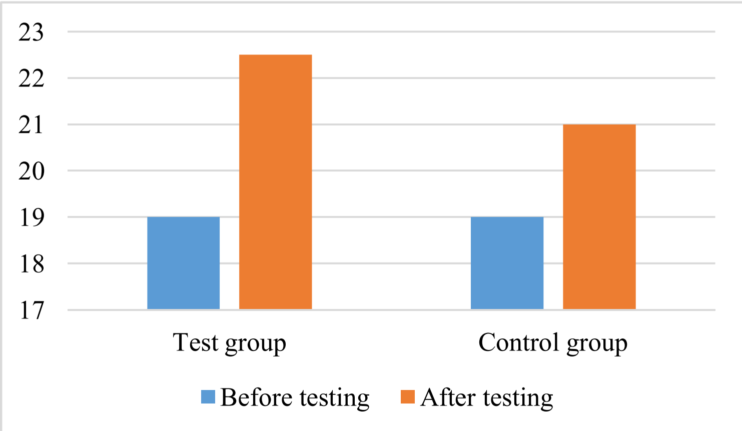

Figure 1. Block peak force change trend chart

(2) Analysis of the trend of peak force in the run-up and take-off

In the run-up, there was no significant difference between the two groups of mice before the experiment. After nine weeks of strength training, the mice in the experimental group showed significant changes compared with those before the experiment. There was a significant difference between the experimental group before and after the experiment ($P<0.01$), while the difference in the control group was small. The trend analysis of the peak force of the running and jumping of the mouse is shown in Figure 2:

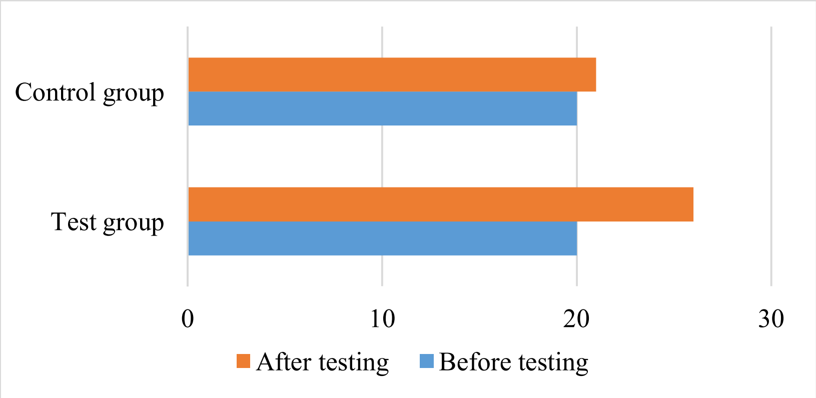

Figure 2. Peak trend of the peak force of the run-up

4.2. Comparison and Analysis of Explosive Force of Lower Limbs

(1) The level of speed strength depends on the rate of rise of the force value, the maximum force value achieved by it, and the time of action of the force. Therefore, in order to remove the influence of individual body weight on the test indicators, the relative impulse (total impulse/body weight) was selected as the index to reflect the explosive force of the lower limbs of the mice. The trend of the relative impulse of the block takeoff is shown in Table 1 and Figure 3:

Table 1. Test results of the relative impulse of the block take-off

		Test Group	Control Group
Block Jump	Before Test	10	10
	After Test	13	11
	Difference	3	1
	Increase	33.3%	10%

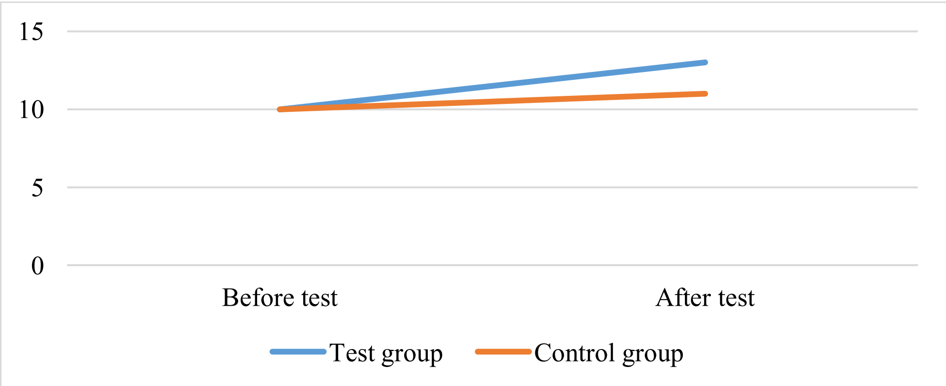

Figure 3. Trend diagram of the relative impulse of the take-off of the block

(2) When the run-up jumped, the relative impulses of the two groups of mice were significantly different from those before the experiment. After the experiment, the results of the test were compared between the groups, and the difference between the experimental group and the control group was statistically significant ($P<0.05$). The relative impulse test results of the run-up and take-off are shown in Table 2 and Figure 4:

(3)

Table 2. Relative impulse test results of running and jumping

		Test Group	Control Group
Run Jump	Before Test	8	8
	After Test	10	8.5
	Difference	2	0.5
	Increase	25%	6.25%

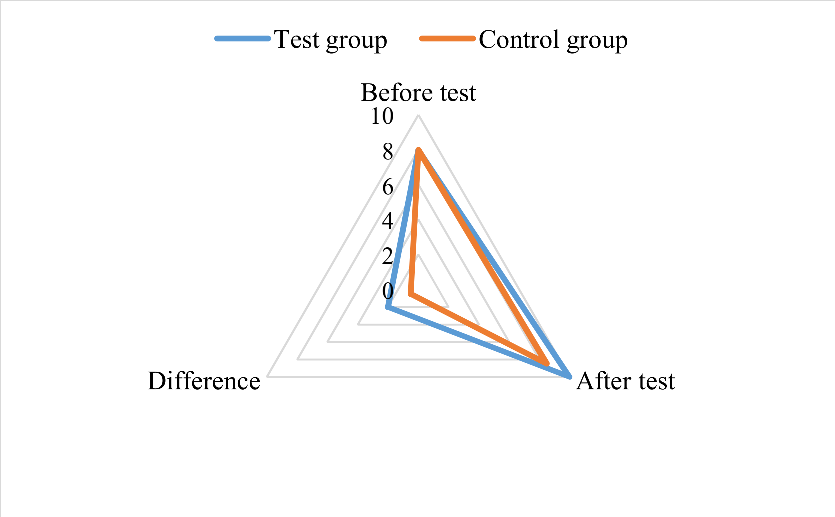

Figure 4. Relative impulse test results of the run-up and take-off

5. Conclusions

(1) Vibration training can effectively improve the lower limb strength of mice. The eight-week strength training improved the maximum strength and explosive power of the lower limbs of the mice. Compared with the control group, the vibration stimulation was better for improving the maximum strength and explosive power of the lower limbs. The vibration frequency of 6 Hz was used to improve the white rats. Lower limb strength is significantly better than 3Hz.

(2) For the vibration strength training, this paper experiments on the relative impulses of the nets in the nets and the run-ups. The experimental results show that the vibration training can effectively improve the lower limb strength of the mice.

(3) This thesis aims to use the experimental method of experimental mice, from the perspective of physical training, combined with the characteristics of hoof movement, using the vibration frequency as the entry point, and selecting two representative methods for calculating the lower limb strength. Study and explore new ideas for the enhancement of the power of mice, in order to reveal the influence of vibration stimulation on the strength training effect of mice, grasp the appropriate stimulation frequency of mice, explore the improvement of vibration training methods and the enhancement of lower limb strength in mice.

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