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ORIGINAL

VIBRATION TRAINING AND QUADRICEPS MUSCLE STRENGTH IN SOCCER PLAYERS' KNEE JOINTS

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ABSTRACT

Objective: This paper discusses the effect of vibration training on the strength of knee flexion and extension muscle group of football players. **Methods:** This test was carried out in a local sports college from January 2021 to January 2022. Taking 22 football players in the college as an example, the athletes were divided into experimental group and observation group by digital grouping method, with 11 people in each group. The observation group was trained with the conventional lower limb physical training method, but also on the equipment. In the process of the experiment, the researchers will focus on the analysis of vibration training on the knee flexion and extension muscle group of football players, and compare the data and effects of the two groups of athletes. The experiment lasted for eight weeks. **Results:** The data of the experimental group were better than those of the observation group. Vibration training had a significant effect on improving the muscle strength of knee flexion and extension muscle group of football players, $P > 0.05$. **Conclusion:** In this eight-week experiment, the vibration training program with 30Hz frequency and 2mm amplitude can significantly improve the muscle strength of knee flexion and extension muscles of college athletes. Compared with the traditional training method, the vibration training program has more advantages, mainly reflected in the tolerance of athletes. However, there is little difference between the method and the traditional training method in the athlete's explosive power, and no great advantage is seen.

KEYWORDS: Vibration training; A football player; Knee joint; The flexor and extensor muscles

1. INTRODUCTION

In recent years, the research on the improvement of football players' physical fitness and lower limb training in our country has become more and more in-depth. Many advanced football training methods have been vigorously used in regular football training, among which vibration training method is one of them (Yu & Liu, 2019). Vibration training is a scientific method designed and developed to improve the strength of muscle groups. This method has been well popularized and promoted in football training abroad (He, 2022). Vibration training is a new training method developed on the basis of traditional football training techniques (W. Wang, 2020). Compared with traditional football training methods, the most unique feature of this training method is that it improves muscle strength with smaller load training, helps athletes to strengthen muscle strength of lower limb muscles (Xu, Yi, & Wang, 2021), and reduces the amount of weight-bearing exercises. In addition, this method can also significantly enhance the athletes' physical reaction ability and tolerance (L. Li, Li, & Liu, 2023). Among them, Bosco's study showed that a significant increase in muscle contraction power could be detected immediately after vibration training (Yin, 2021). Football is a popular sport all over the world. The reason why this sport is fascinating is that football has strong visual enjoyment, which makes people crazy and eager to stop in a very short time. For players, if they want to improve their ball skills, ball control, shooting and other abilities, they must constantly improve their lower limb muscle group strength (Z. Wang, Zhou, & Lu, 2021). It is not difficult to see that football has high requirements for its own comprehensive quality. At present, the traditional training methods are obviously unable to adapt to the current needs of football training, and can not better improve the strength of the knee flexion and extension muscle group of football players (Chen, 2022), let alone help athletes improve their own movement strain and movement energy. The influence of lower limb muscle strength on football players is very large (Deng, Wang, & Xue, 2021a). At present, our domestic research on the strength of knee flexion and extension muscle group has made some progress, but there is still a certain gap in the vibration training of football, which is one of the current problems that many football players, exchanges and researchers are very concerned about (Y. Zhang, QIN, & He, 2021). Now, the experimental research report is organized as the following.

2 Study materials and methods

2.1 Research Information

This trial will be carried out in a local physical education college from January 2021 to January 2022, and the experimental process will focus on the analysis of the effect of vibration training on the knee flexion and extension muscles of football athletes. The test data and data of 22 athletes in a local

physical education college will be collected, and they will be divided into the experimental group and the observation group by the digital grouping method, with 11 people in each group.

The athletes of the two groups were 18 to 23 years old, with an average age of 22.55±1.93 years, height of 171.76±3.23 years, weight of 63.68 to 6.75Kg, and training duration of 3.01±1.09 years. All the athletes received physical examination before the experiment, and they were required to have a face-to-face conversation with the researchers alone. There was no significant difference between the two groups of athletes in all aspects, so they met the basic requirements of this test, $P > 0.05$. The inclusion and exclusion criteria were as follows.

1) Inclusion criteria: All the athletes included in this trial had no history of major injuries or major upper body diseases or diseases affecting flexion and extension during the previous year of exercise. In the process of this experiment, the coach will be responsible for the regular training of the athletes and guide the athletes to complete the special training tasks strictly.

All subjects volunteered to participate in the experiment, and underwent physical examination and medical diagnosis before training whether there were any diseases that would affect the experiment, such as mental illness, malignant disease, cardiovascular and cerebrovascular disease, etc. In addition, none of them had any major knee or fracture diseases. All the athletes in this test had a level 2 or above sports level.

2) Exclusion criteria: The athletes must meet the requirements and standards of this test. If there are physical health problems, athletes cannot participate in this test, or athletes with injuries and serious diseases cannot participate in this test.

If the athletes are not the same coach, they do not meet the requirements of this test. If the athletes do not voluntarily participate in this test, they do not meet the requirements of this test.

2.2 Research Methods

2.2.1 Methods of training

In this trial, considering the needs of training differentiation, the athletes were divided into experimental group and observation group. The two groups of athletes will use two different experimental methods. The experimental group uses vibration training method for training, and the observation group uses conventional training method for training. In order to better reflect the improvement effect of the two training methods on the muscle strength of knee flexion and extension muscle group of football players.

1) Experimental Group: In this experiment, the vibration training of college football players will be carried out by PowerPlate made in the United States, mainly to explore the muscle strength analysis of knee flexion and extension muscle group of college football players, and summarize the training experience so as to provide more research basis for scientific exercise training. The experimental group received vibration training with 30Hz frequency and 2mm amplitude for 30s. During the training process, the subject stood at attention on the vibration training instrument, held the 8RM barbell in hand and placed it on the shoulders, the waist remained upright, and the lower limbs slowly squatted to the position of 150° of the knee joint. At this time, the body weight was maintained on the training instrument platform, and then gradually stood up, repeated eight times. Five sessions a day, spaced about 1 minute apart, were performed three times a week for about eight weeks. During the training period, the coach will be responsible for the whole process of guidance and assist the athletes to complete a series of experimental training matters.

2) Observation group: The observation group was trained with the conventional lower limb physical training method, but the muscle training was also carried out on the vibration training instrument. The difference was that the athletes in this group did not receive vibration training.

2.2.2 Index test method

The CYBEX-6000 isokinetic test system manufactured by an American company will be selected in this test. The instrument is mainly used for muscle strength testing of knee flexion and extension muscle group. The subjects were tested in the isokinetic system chair, and the researchers fixed their limbs, while all the subjects' knees and hips were flexed 90°, but the knee flexion and extension ability of the athletes was retained, and then the resistance pad was fixed on the athletes' calves and ankles, and then the test began. The rotation axis of the knee joint and the rotation axis of the isokinetic system were aligned, and the test was mainly the isokinetic concentric flexion and extension movement of the dominant knee joint of the athlete. Before the test, the athletes will warm up, and the researchers will arrange the athletes to perform three sub-maximum flexion and extension exercises for 10 minutes in order to allow the athletes to adapt to the testing equipment in advance, and then the athletes will be tested at 60 (°) /s (slow) and 180 (°) /s (fast) conditions. Each speed was cycled three times during the test, and then the highest value obtained during the test was obtained, with an interval of 20s between each test. The main indexes of the test include peak torque, time to peak torque and total work.

2.3 Indicators of observation

① This study mainly observed the peak torque of knee flexion and extension muscle group. ② This test will compare the total function of knee

flexion and extension group between the experimental group and the observation group. ③ Comparison of the peak torque time of the joint flexion and extension muscles between the experimental group and the observation group in this test.

2.4 Statistical Analysis

In this experiment, SPSSfor Windows was used for statistical analysis. The results of the test will be expressed by, and the comparison between the experimental group and the observation group will be tested by independent sample t, and the comparison between the two groups will be tested by t. The significant statistical difference is $P < 0.05$.

3. Results

The peak torque of knee flexion and extension muscles under 60 (°) /s angular velocity was compared between the experimental group and the observation group

Table 1: Comparison of peak torque of knee flexion and extension muscles before and after 60 (°) /s angular velocity in the experimental group and the observation group （$\overline{x} \pm s$，n=10，N·m）

MUSCLE GROUPS	GROUPS	BEFORE TRAINING	AFTER TRAINING
THE KNEE EXTENSOR MUSCLE GROUP	Experimental Group	230.89±16.11	305.19±17.25^{ab}
	Observation group	223.64±15.73	279.48±18.04^{a}
THE KNEE FLEXION MUSCLE GROUP	Experimental Group	172.76±9.54	201.40±8.56^{ab}
	Observation group	171.18±8.78	198.70±7.38^{a}

Notes: *Compared with before training, aP < 0.05; Compared with the observation group after training, bP < 0.05*

From Table 1, the data of the experimental group and the observation group before and after training were significantly different. Among them, the extensor and flexion muscles of the experimental group were 305.19±17.25ab and 201.40±8.56ab after training, respectively (Liu, Zhou, & Rubio-Aris, 2021).

The knee extensor muscle group and knee flexion muscle group in the observation group were 279.48±18.04a and 198.70±7.38a after training, respectively. Significant statistical significance, $P < 0.05$. The peak torque of knee flexion and extension muscles under 180 (°) /s angular velocity before and after treatment were compared between the experimental group and the observation group.

Table 2: Comparison of peak torque of knee flexion and extension muscles at 180 (°) /s angular velocity before and after training between the experimental group and the observation group （$\overline{x} \pm s$，n=10，N·m）

MUSCLE GROUPS	GROUPS	BEFORE TRAINING	AFTER TRAINING
THE KNEE EXTENSOR MUSCLE GROUP	Experimental Group	224.31±13.34	299.20±18.35[ab]
	Observation group	223.64±15.73	279.48±18.04[a]
THE KNEE FLEXION MUSCLE GROUP	Experimental Group	171.77±9.56	202.41±8.67[ab]

Note: *Compared with pre-training, aP < 0.05.*

As can be seen from Table 2, the data obtained before and after training in the experimental group and the observation group were significantly different, P < 0.05. The knee extensor muscle group and knee flexion muscle group in the experimental group were 299.20±18.35ab and 202.41±8.67ab after training (Xingyu Zhang, 2021), and the knee extensor muscle group and knee flexion muscle group in the observation group were 279.48±18.04a and 189.68±7.68a after training. The time to peak torque of knee flexion and extension muscles of the experimental group and the observation group before and after training was compared.

Table 3: Comparison of the time to peak torque of the knee flexion and extension muscles before and after training between the experimental group and the observation group

MUSCLE GROUPS	GROUPS	BEFORE TRAINING	AFTER TRAINING
THE KNEE EXTENSOR MUSCLE GROUP	Experimental Group	30.02±7.64	21.84±6.46[ab]
	Observation group	31.64±7.50	25.49±6.77[a]
THE KNEE FLEXION MUSCLE GROUP	Experimental Group	39.74±9.56	24.43±7.69[ab]
	Observation group	41.52±6.79	26.38±6.86[a]

As can be seen from Table 3, the data obtained before and after training in the experimental group and the observation group were significantly different, P < 0.05. The knee extensor and flexion muscles of the experimental group were 21.84±6.46ab and 24.43±7.69ab after training (Ma, 2021), and the knee extensor and flexion muscles of the observation group were 25.49±6.77a and 26.38±6.86a after training, respectively. The total muscle work of knee flexion and extension muscle group was compared between the experimental group and the observation group before and after training.

Table 4: Total comparison of knee flexion and extension muscle groups before and after 60 (°) /s angular velocity in the experimental group and the observation group

MUSCLE GROUPS	GROUPS	BEFORE TRAINING	AFTER TRAINING
THE KNEE EXTENSOR MUSCLE GROUP	Experimental Group	499.45±123.02	539.52±147.9[ab]
	Observation group	497.32±157.29	523.34±131.46[a]
THE KNEE FLEXION MUSCLE GROUP	Experimental Group	287.45±79.83	306.63±81.23[ab]
	Observation group	291.91±85.12	303.53±91.05[a]

As can be seen from Table 4, the data obtained before and after training in the experimental group and the observation group were significantly different, $P < 0.05$. The knee extensor and knee flexion muscles of the experimental group were 539.52±147.9ab and 306.63±81.23ab after training (Xin Zhang, 2023), and the knee extensor and knee flexion muscles of the observation group were 523.34±131.46a and 303.53±91.05a after training, respectively.

Table 5: Total comparison of knee flexion and extension muscle groups before and after 180 (°) /s angular velocity in the experimental group and the observation group

MUSCLE GROUPS	GROUPS	BEFORE TRAINING	AFTER TRAINING
THE KNEE EXTENSOR MUSCLE GROUP	Experimental Group	389.15±124.08	458±124.12[ab]
	Observation group	378.13±157.29	408.24±167.36[a]
THE KNEE FLEXION MUSCLE GROUP	Experimental Group	222.15±82.63	248.03±84.13[ab]
	Observation group	234.92±80.12	240.51±80.73[a]

As can be seen from Table 5, the data obtained before and after training in the experimental group and the observation group were significantly different, $P < 0.05$. The knee extensor and knee flexion muscles of the experimental group were 458±124.12ab and 248.03±84.13ab after training (Deng, Wang, & Xue, 2021b; Liang, 2022), and the knee extensor and knee flexion muscles of the observation group were 408.24±167.36a and 240.51±80.73a after training, respectively.

4. Conclusions

Football is one of the most popular sports in the world. Due to the intense competition in the process of competition, the high degree of cooperation and the high technical requirements, this sport has become a difficult sports project.

However, football is a kind of competitive sports, and makes these sports very strong to watch, compared with basketball is even better. At present, the school sports function mainly includes: exercise, education, intelligence, emotion, group education, entertainment and other functions. We can see from this that school sports and health are unified with each other. Under the background of the rapid development of football in our country, strengthening the physical exercise of athletes can not only bring great benefits to the physical and mental quality of athletes, but also help to improve the comprehensive quality of football players in our country, so as to lay a good foundation and prepare for better participation in competitions and playing football in the future. One of the main tasks of the experiment is to further improve the physical quality of the athletes, enhance their physical fitness, master the basic sports health knowledge and related football basic skills, and cultivate the athletes to develop correct and scientific exercise habits; For our country football sports enterprise transportation more reserve backbone talent. In recent years, more and more attention has been paid to the development of lower limb muscle strength training of football players in the world football world, and this training concept has been recognized by football researchers. As long as football training and talent planning and cultivation are strengthened, the level of football in our country can be improved (Mary, 2022).

At present, vibration training has been widely used in the training of international football teams. This training method can significantly increase the muscle strength and sports performance of athletes. Although the amplitude and vibration frequency required by vibration training are still being explored, and the mechanism of enhancing neuromuscular performance is still being explored, this training method has a great effect on improving the comprehensive sports quality and explosive power of athletes. Through the use of CNKI to retrieve relevant research literature, it is not difficult to find that although the research on the strength of knee flexion and extension muscle group of football players is very deep, but the research on vibration training is still relatively few. Based on this, it is easy to see that introducing vibration training into regular football training has great research value, although this aspect is still in the exploratory stage (KARAN et al., 2019). Therefore, this is the purpose of this trial, trying to demonstrate the strength improvement effect and influencing factors of vibration training method on knee flexion and extension muscle group of football athletes.

Constantly improve the athletes' physical quality and lower limb muscle strength, enhance the sports park training enthusiasm, stimulate the athletes' interest and desire in sports, and set up a good football training consciousness, so that the athletes can get more exercise, promote the development of the comprehensive quality of athletes (C. Li & Zhai, 2021). Among them, some literature reports that the use of vibration training method for 3 weeks of high-load elbow joint chat training for ordinary men found that the strength of the

vibration group and the control group increased, and the data of the vibration group was significantly higher than that of the control group. According to the above tests, the data of the experimental group were better than those of the observation group, and the data of the experimental group were better than those of the observation group. Vibration training had a significant effect on improving the muscle strength of knee flexion and extension muscle group of football players, P > 0.05. The 8-week, 30Hz, 2mm amplitude vibration training protocol used in this trial can significantly improve the muscle strength of the knee muscle group in college football players (Thompson, Everett, Rowell, Rychtář, & Rueppell, 2015).

The test showed that the experimental group and the observation group before and after the training data were significantly different. Among them, the experimental group knee extensor muscle group and knee flexion muscle group after training were 305.19±17.25ab, 201.40±8.56ab, respectively. The knee extensor muscle group and knee flexion muscle group in the observation group were 279.48±18.04a and 198.70±7.38a after training, respectively. Significant statistical significance, P < 0.05. There was a significant difference in the data obtained before and after training between the experimental group and the observation group (P < 0.05). The knee extensor muscle group and knee flexion muscle group in the experimental group were 299.20±18.35ab and 202.41±8.67ab after training, and the knee extensor muscle group and knee flexion muscle group in the observation group were 279.48±18.04a and 189.68±7.68a after training. There was a significant difference in the data obtained before and after training between the experimental group and the observation group (P < 0.05).

The knee extensor and flexion muscles of the experimental group were 21.84±6.46ab and 24.43±7.69ab after training, and the knee extensor and flexion muscles of the observation group were 25.49±6.77a and 26.38±6.86a after training, respectively. There was a significant difference in the data obtained before and after training between the experimental group and the observation group (P < 0.05). The knee extensor and knee flexion muscles of the experimental group were 539.52±147.9ab and 306.63±81.23ab after training, and the knee extensor and knee flexion muscles of the observation group were 523.34±131.46a and 303.53±91.05a after training, respectively. There was a significant difference in the data obtained before and after training between the experimental group and the observation group (P < 0.05). The knee extensor and knee flexion muscles of the experimental group were 458±124.12ab and 248.03±84.13ab after training, and the knee extensor and knee flexion muscles of the observation group were 408.24±167.36a and 240.51±80.73a after training, respectively. To sum up, football is a confrontational sport that focuses on the combination of technology and strength, which has high requirements for the physical quality of athletes. The development of the strength quality of athletes needs to be achieved through

scientific and compliance strength training, which plays a certain role in remodeling the body muscle structure, physiological and biochemical environment and sports function of athletes. In addition, the improvement and development of the strength quality is through the excitation and inhibition of the human nerve center and the full coordination of the corresponding neural processes as a prerequisite.

This is the result obtained after reflection. This is of great help to improve the explosive power of athletes. Vibration stimulation during vibration training can significantly activate the excitability of muscle spindles, especially the Iα afferent fibers, and reflexively cause the contraction of spindle muscle fibers, which can promote a wide range of different motor units to participate in the activity. This experiment was carried out for eight weeks. In the experiment, the vibration training program with 30Hz frequency and 2mm amplitude was used to significantly improve the muscle strength of knee flexion and extension muscles of college athletes. Compared with the traditional training method, it has more advantages, mainly reflected in the tolerance of athletes. However, there is little difference between the method and the traditional training method in the athlete's explosive power, and no great advantage is seen.

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