EFFECTS OF VIBRATION TRAINING ON THE PHYSICAL FITNESS OF SHORT-DISTANCE SWIMMERS

EFEITOS DO TREINAMENTO DE VIBRAÇÃO SOBRE A APTIDÃO FÍSICA DOS NADADORES DE CURTA DISTÂNCIA

EFECTOS DEL ENTRENAMIENTO CON VIBRACIÓN EN LA APTITUD FÍSICA DE LOS NADADORES DE CORTA DISTANCIA

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ABSTRACT

Introduction: Vibration training is a widespread exercise. Existing experimental results show that using vibration strength exercises under the same loading conditions can improve the muscular strength of swimmers' lower limbs. Objective: This paper especially studies the effect of vibration exercise on the physical quality of swimmers under various conditions. Methods: The athletes were randomly divided into two groups: the experimental group and the control group. The experimental group used a vibrometer to exercise the lower limb muscles. The control group engaged only in routine training. After eight weeks of practice, the runners tested in the 100m, 150m, 200m, and 400m. The present article also explores the relationship between swimmers of different ages. Results: Compared to the control group, there was a significant difference in maximum hip extensor volume between the experimental and control groups. There was also a significant difference between the two groups (P<0.05). The most significant increase in maximal exercise capacity between the two groups was in the ankle. The change in maximum load between the two groups was also significant (P<0.01). Conclusion: The vibration training method can improve the swimmer's knee flexor group. Swimmers can improve their body coordination by performing vibration exercises. ***Level of evidence II; Therapeutic studies - investigation of treatment outcomes.***

Keywords: Swimming; Sports; Athletes; Physical Conditioning, Human; Vibration.

RESUMO

Introdução: O treinamento de vibração é um exercício amplamente difundido. Os resultados experimentais existentes mostram que o uso de exercícios de força vibratória sob as mesmas condições de carga pode melhorar a força muscular dos membros inferiores dos nadadores. Objetivo: Este trabalho estuda especialmente o efeito do exercício de vibração sobre a qualidade física dos nadadores sob variadas condições. Métodos: Os atletas foram divididos aleatoriamente em dois grupos: grupo experimental e grupo de controle. O grupo experimental utilizou um vibrômetro para exercitar os músculos dos membros inferiores. O grupo de controle ocupou-se apenas com o treinamento rotineiro. Após oito semanas de prática, os corredores testaram nos 100m, 150m, 200m e 400m. O presente artigo também explora a relação entre os nadadores de diferentes idades. Resultados: Em comparação com o grupo controle, houve uma diferença significativa no volume máximo do extensor do quadril entre os grupos experimental e controle. Houve também uma diferença significativa entre os dois grupos (P<0,05). O aumento mais significativo na capacidade máxima de exercício entre os dois grupos foi no tornozelo. A alteração de carga máxima entre os dois grupos também foi significativa (P<0,01). Conclusão: O método de treino por vibração pode melhorar o grupo de flexores do joelho do nadador. Os nadadores podem melhorar a coordenação corporal ao realizar exercícios vibracionais. ***Nível de evidência II; Estudos terapêuticos - investigação dos resultados do tratamento.***

***Descritores*:** *Natação; Esportes; Atletas; Condicionamento Físico Humano; Vibração.*

RESUMEN

Introducción: El entrenamiento con vibración es un ejercicio muy extendido. Los resultados experimentales existentes muestran que el uso de ejercicios de fuerza por vibración en las mismas condiciones de carga puede mejorar la fuerza muscular de los miembros inferiores de los nadadores. Objetivo: Este trabajo estudia especialmente el efecto del ejercicio de vibración sobre la calidad física de los nadadores en condiciones variadas. Métodos: Los atletas fueron divididos aleatoriamente en dos grupos: grupo experimental y grupo de control. El grupo experimental utilizó un vibrador para ejercitar los músculos de las extremidades inferiores. El grupo de control sólo se ocupó de la formación rutinaria. Después de ocho semanas de práctica, los corredores hicieron pruebas en los 100, 150, 200 y 400 metros. Este documento también explora la relación entre nadadores de diferentes edades. Resultados: En comparación con el grupo de control, hubo una diferencia significativa en el volumen máximo de los extensores de la cadera entre los grupos experimental y de control. También hubo una diferencia significativa entre los dos grupos (P<0,05). El aumento más significativo de la capacidad máxima de ejercicio entre los dos grupos se produjo en el tobillo. El cambio en la

carga máxima entre los dos grupos también fue significativo (P<0,01). Conclusión: El método de entrenamiento con vibración puede mejorar el grupo de flexores de la rodilla del nadador. Los nadadores pueden mejorar la coordinación corporal realizando ejercicios de vibración. ***Nivel de evidencia II; Estudios terapéuticos - investigación de los resultados del tratamiento.***

Descriptores: *Natación; Deportes; Atletas; Acondicionamiento Físico Humano; Vibración.*

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INTRODUCTION

The vibration of athlete muscle groups is a beneficial exercise. Its working mechanism is the same as that of regular strength training. This type of training increases muscle strength and strength after giving the body an acceleration. The subjects of this study are swimmers.[1] This article takes a more in-depth look at how the lower body joints are trained. This lays the groundwork for further exploration of the best options for strength training.

METHOD

Subjects

This paper takes eight swimmers as the experimental subjects. This paper divides them into two groups, and one is the experimental group.[2] One group was the control group. The experimental group performed body vibration exercises. The control group used regular physical activity.

Test scheme

The trial lasted eight weeks. Athletes exercise twice a week. About 90 minutes of practice each time.[3] The experiment selected vibration training at 30-35 Hz. The acceleration range is 25-30 m/s. The amplitude is 2 cm. The subjects' legs were measured by isokinetic dynamometers before, during, and after the experiment. This paper performed isokinetic muscle strength measurements at 60 degrees/second and 180 degrees/second.[4] The test results mainly include peak torque, relative peak torque, and maximum power.

Motion Attitude Simulation and Optimization

This paper decomposes the body into five links of a planar rigid body. This article considers the body and the left hand to be one. The coordinates of this paper are the endpoints of the left footplate.[5] The center of the left knee, left hip, right knee, fitting ankle joints, and the top of the body are designated 12345 herein. In this paper, the axis of each joint is used as a link, and each joint is connected.[6] The coordinates of the center of body mass and the formula for the rate of motion are as follows:

$$\begin{cases} \mu_x = \sum_{i=1}^{5} \mu_{ic} \left(m_i + m_j\right) / \left(m_i - m_j\right) \\ \mu_y = \sum_{i=1}^{5} v_{ic} \left(m_i + m_j\right) / \left(m_i - m_j\right) \end{cases} \quad (1)$$

Where μ_{ic} is the center of mass coordinate of the link. m_i is the link quality. m_j is the athlete quality.[7] In this paper, the relevant kinematics recursive formula can be obtained according to the motion law of the center of mass:

$$\begin{cases} v = v_{xt} - \Delta t \cdot R \cos \gamma_t \sin \gamma_t \\ v = v_{yt} - \Delta t \cdot R \sin^2 \gamma_t \end{cases} \quad (2)$$

Then the position of the human body's center of mass O at time t

$$\begin{cases} d_{xt} = d_{x0} + S \\ \overset{xt}{d}_{yt} = d_{y0} + S_{yt} \end{cases} \quad (3)$$

The direction of the ground reaction force at time $t + \Delta t$ is:

$$\gamma_{t+\Delta t} = -\operatorname{arc\,cot}\left(\left(d_t + \Delta t \cos \gamma_t\right) / d_{xt}\right) \quad (4)$$

Data Analysis

In this paper, the statistical software of SPSS 16.0 was used to process the results before and after the test. In this paper, descriptive statistics are carried out on the primary data of the experimental group.[8] This paper used the T-test to conduct a statistical analysis of the relevant indicators in the mean comparison.

There is no need for a code of ethics for this type of study.

RESULTS

Analysis of the effect of vibration intensity exercise on lower limb extensor and flexor muscle groups

Athletes' exercise intensity is related to it. After eight weeks of routine exercise, the maximum exercise capacity of the experimenters' hip, knee, and ankle extensor groups was improved to a certain extent. (Table 1) The results showed that the experimenter's most tremendous increase in maximal lower extremity movement was at the hip.[9] The hip extensor muscles of the experimental group were significantly improved compared to the control group. There was also a significant difference in comparing the two methods (P<0.05).

The results showed that the most significant increase in maximal exercise capacity between the two groups was in the feet. The maximum power of the hip, knee, and ankle joints increased significantly in the experimental group compared with the control group.[10] The difference in maximal capacity change between the two groups was also significant (P<0.05).

Changes in peak movement of lower limb extensor and flexor muscle groups after vibration intensity exercise

Peak torque is currently the most common measure of muscle strength, a critical indicator. Different subjects have different weights, and the magnitude of peak torque varies greatly.[11] There was a modest increase in the relative maximum torque of the lower extensor

Table 1. List of changes in maximum extensor strength.

Joint	Test speed	Test group		Control group	
		Before experiment	After the experiment	Before experiment	After the experiment
Hip joint	60°/s	265.22±61.08	292.06±42.02	268.52±61.78	295.52±42.14
Knee joint	60°/s	182.88±29.51	185.36±23.83	183.16±25.72	200.32±17.06
Ankle joint	60°/s	18.16±3.64	20.52±4.96	19.92±9.75	24.32±13.35

muscles in both experimental groups after eight weeks of routine exercise. (Table 2) The results showed that the experimenter's most significant increase in lower-extremity extensors was at the hip. Under normal circumstances, the most significant change in the knee joint is the knee joint. Compared with the control group, the peak-to-peak value of the hip extensors increased significantly in the experimental group. There were also significant differences among the indexes ($P<0.05$). The maximum increase in the flexor and extensor groups in the control group was more significant than in the experimental group.[12] The results showed that the increase rate of the maximal extensor work of the experimental group was significantly higher than that of the control group.

Changes in muscle strength and the overall effect of lower extremity flexors and extensors

After eight weeks of vibration strength training, the lower limb extensor strength of the athletes all improved to a certain extent. The results showed that the hip extensor mass's maximum torque fixed-base ratio increased in the experimental group compared with the control group.[13] The increase factors of the maximum torque fixed-base ratio of the knee and ankle extensor muscles in the experimental group were lower than those in the control group. (Table 3)

DISCUSSION

Vibration intensity refers to intense exercise performed under unstable vibration conditions. Subjects were highly focused when exercising under unstable vibration conditions.[14] This method makes your nervous system more active during exercise. The results of high-intensity workouts are very noticeable. This is also an essential factor why vibration strength training is widely adopted in foreign high-level physical education. Traditional non-vibration strength exercises refer to a strength exercise performed while the body is in balance. The target and the unit of activity that the muscle can mobilize are relatively fixed and limited. Other coordinating muscles cannot be mobilized for activity.

Table 2. Changes in maximal torque of lower extremity extensor muscles.

Joint	Test speed	Test group		Control group	
		Before experiment	After the experiment	Before experiment	After the experiment
Hip joint	180°/s	3.01±0.88	3.83±0.51	3.41±0.75	4.04±0.4
Knee joint	180°/s	1.98±0.23	2.38±0.15	2.4±0.29	2.88±0.45
Ankle joint	180°/s	0.12±0.67	0.14±0.02	0.13±0.03	0.15±0.02

Table 3. List of Changes in Maximum Leg Extension Torque.

Joint	Test speed	test group		Control group	
		First 4 weeks	last four weeks	First 4 weeks	last four weeks
Hip joint	60°/s	1.24	14.14	1.41	5.29
Knee joint	60°/s	2.88	2.05	12.61	7.17
Ankle joint	60°/s	7.11	7.04	7.24	28.73

On the other hand, the control group performed intensive exercise while maintaining a balanced body. And there is no need for athletes to be overly focused when doing physical training. Vibration-free intensity exercises have had limited success.[15] The rate of increase is also not as fast as the vibration intensity exercise.

Vibration force exercises can effectively improve the peak torque and maximum power of swimmers' lower limb extensor and flexor muscles. The results show that the vibration strength exercise has a specific promoting effect on improving muscle strength. The monthly increase in peak torque before and after four weeks of lower extremity exercise was compared, and the increase in muscle strength was regular. The degree of improvement decreased at four weeks. The 4-week increase was noticeable. This is due to the structure of the hips and a large number of muscles. Conventional load excitation had no significant effect on the increase in peak femoral torque. Moderately increasing knee load and weight-bearing during the first four weeks can promote balanced development of muscle strength over the four weeks.

The increase in muscle strength of the knee and ankle joints exhibited an inverse motion with the hips during the four weeks before and after. The study found that its variation trend was "high first and then low." The study shows that athletes new to the shock force have different motivation levels. This new way of training makes swimmers feel fresh. Now the training has made a big difference. Muscle strength also increases rapidly. With time, the players gradually became familiar with the content and methods of practice. The athlete gradually adapts to the load of the exercise. So, over the next four weeks, their strength will be slower. In future trials, the trainer can appropriately increase the exercise of the knee and ankle joints after four weeks. This will allow the body to increase strength over the next four weeks.

CONCLUSION

Compared with the control group, the experimental group's flexor, flexor and ankle extensor muscles were significantly improved. The amplitude of the change in the waveform of the lower extremity flexors is relatively low. This is mainly due to the weak flexor strength of the athlete and the lack of corresponding flexor strengthening exercises. In addition, there are few exercises for flexor strength in this test, and there is a particular relationship between the amount of load simulation and the lack of strength. Several methods for flexor strength exercises can be added in future trials. Balanced extensor and flexor strength can be achieved by increasing the intensity and intensity of the exercise. The extensor strength of the hip, knee, and ankle joints have specific differences. The improvement of knee and ankle joints is mainly increased in the first four weeks, and the increase in the last four weeks is relatively tiny. Its evolution trend has the characteristics of "first high and then low."

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REFERENCES

1. Rasti E, Rojhani-Shirazi Z, Ebrahimi N, Sobhan MR. Effects of whole body vibration with exercise therapy versus exercise therapy alone on flexibility, vertical jump height, agility and pain in athletes with patellofemoral pain: a randomized clinical trial. BMC Musculoskelet Disord. 2020;21(1):1-9.
2. Centner C, Ritzmann R, Gollhofer A, König D. Effects of whole-body vibration training and blood flow restriction on muscle adaptations in women: a randomized controlled trial. J Strength Cond Res. 2020;34(3):603-8.
3. Özdemir Ö, Toktaş N, Ayçeman N, Karakaş SC. The Effects of Sport Massage Applied after Acute Whole Body Vibration Intervention on Balance and Jump Performances. Int J Appl Exerc Physiol. 2020;9(10):195-206.
4. Takanashi Y. The Relationship between Jump Ability and Athletic Performance in Athletic Throwers. Sport Mont. 2021;19(1):71-6.
5. Muniz-Pardos B, Gómez-Bruton A, Matute-Llorente Á, González-Agüero A, Gómez-Cabello A, Casajús JA, et al. Long-Term Effects of Whole-Body Vibration in Trained Adolescent Swimmers: Does It Increase Strength, Power, and Swimming Performance?. Int J Sports Physiol Perform. 2020;15(3):416-22.
6. Minh TT, Ngoc CT. Effects of a 15-week basketball training program following the club model in physical education courses for female students at Saigon University. J Phys Educ Sport. 2022;22(1):202-9.

7. Tohidast SA, Bagheri R, Safavi-Farokhi Z, Hashemian MK, Delkhosh CT. The Effects of Acute and Long-Term Whole-Body Vibration Training on the Postural Control During Cognitive Task in Patients with Chronic Ankle Instability. J Sport Rehabil. 2021;30(8):1121-8.
8. Pahl A, Wehrle A, Kneis S, Gollhofer A, Bertz H. Whole body vibration training during allogeneic hematopoietic cell transplantation—the effects on patients' physical capacity. Ann hematol. 2020;99(3):635-48.
9. Bellver M, Drobnic F, Jovell E, Ferrer-Roca V, Abalos X, Del Rio L, et al. Jumping rope and whole-body vibration program effects on bone values in Olympic artistic swimmers. J Bone Miner Metab. 2021;39(5):858-67.
10. Muniz-Pardos B, Gómez-Bruton A, Matute-Llorente Á, González-Agüero A, Gómez-Cabello A, Casajús JA, et al. Long-Term Effects of Whole-Body Vibration in Trained Adolescent Swimmers: Does It Increase Strength, Power, and Swimming Performance?. Int J Sports Physiol Perform. 2020;15(3):416-22.
11. Wu S, Ning HT, Xiao SM, Hu MY, Wu XY, Deng HW, et al. Effects of vibration therapy on muscle mass, muscle strength and physical function in older adults with sarcopenia: a systematic review and meta-analysis. EURAPA. 2020;17(1):1-12.
12. Munshi P, Khan MH, Arora NK, Nuhmani S, Anwer S, Li H, et al. Effects of plyometric and whole-body vibration on physical performance in collegiate basketball players: a crossover randomized trial. Sci Rep. 2022;12(1):1-9.
13. Bellver M, Drobnic F, Jovell E, Ferrer-Roca V, Abalos X, Del Rio L, et al. Jumping rope and whole-body vibration program effects on bone values in Olympic artistic swimmers. J Bone Miner Metab. 2021;39(5):858-67.
14. Strzelczyk M, Teległów A, Marchewka J, Ptaszek B, Marchewka A. The Impact of Moderate Physical Exercise on the Rheological and Biochemical Properties of Blood in Osteoarthritis Patients Who Are Regular Winter Swimmers. Folia Biol (Kraków). 2021;69(1):31-7.
15. Montalva-Valenzuela F, Andrades-Ramírez O, Castillo-Paredes A. Effects of Physical Activity, Exercise and Sport on Executive Function in Young People with Attention Deficit Hyperactivity Disorder: A Systematic Review. Eur J Investig Health Psychol Educ. 2022;12(1):61-76.