INFLUENCE OF PROGRESSIVE UPPER LIMB STRENGTH TRAINING ON TABLE TENNIS ATHLETES

INFLUÊNCIA DO TREINAMENTO PROGRESSIVO DE FORÇA NOS MEMBROS SUPERIORES EM ATLETAS DE TÊNIS DE MESA

INFLUENCIA DEL ENTRENAMIENTO PROGRESIVO DE FUERZA DE LOS MIEMBROS SUPERIORES EN ATLETAS DE TENIS DE MESA

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ABSTRACT

Introduction: Progressive strength training can help athletes improve their strength levels quickly and safely. By controlling the frequency and amplitude of vibrations, muscles can produce unconscious and voluntary contractions that help prevent diseases such as osteoporosis. Objective: To explore the change in sports performance caused by progressive upper limb muscle strength training in table tennis players. Methods: 12 table tennis players with a minimum experience of 5 years were randomly divided into experimental and control groups. The control performed traditional strength training methods while the experimental group used the progressive directed strength training method developed by the research team for nine weeks. Tests were performed on ISOMED 2000 equipment at the conditions of 60°/s and 450°/s. Results: Circumference, muscle strength, and relative upper limb strength increased. In addition, a difference in the rate of the maximum elbow flexion moment of the athletes in the experimental group in the 60°/s test conditions was observed. At 450°/s, the maximum flexion and extension elbow moment showed a significant difference ($P<0.05$). Conclusion: The progressive strength training method significantly affects the athletes' maximum elbow flexion moment and maximum elbow extension moment than traditional strength training methods. Muscle strength progress was noted mainly in the elbow and wrist joints, with less intensity in the shoulders. ***Evidence Level II; Therapeutic Studies – Investigating the results.***

Keywords: Muscle Strength Dynamometer; Resistance Training; Limbs, Upper; Athletes.

RESUMO

Introdução: O treinamento progressivo da força pode ajudar os atletas a melhorar seus níveis de força de maneira rápida e segura. Controlando a frequência e a amplitude das vibrações, os músculos podem produzir contrações inconscientes e voluntárias que ajudam a prevenir doenças como a osteoporose. Objetivo: Explorar a alteração no desempenho esportivo ocasionado pelo treinamento progressivo da força muscular nos membros superiores dos jogadores de tênis de mesa. Métodos: 12 jogadores de tênis de mesa com experiência mínima de 5 anos foram aleatoriamente divididos em grupos experimental e controle. O controle efetuou métodos tradicionais de treinamento de força enquanto o grupo experimental utilizou o método progressivo de treinamento de força dirigida, desenvolvido pela equipe de pesquisa, por nove semanas. Os testes foram realizados no equipamento ISOMED 2000 nas condições de 60°/s e 450°/s. Resultados: A circunferência, força muscular e a relativa força dos membros superiores aumentaram. Houve diferença na taxa do momento de flexão máxima do cotovelo dos atletas do grupo experimental nas condições de teste de 60°/s. A 450°/s, o momento máximo de flexão do cotovelo e o momento máximo de extensão do cotovelo também mostraram uma diferença significativa ($P<0,05$). Conclusão: O método de treinamento progressivo de força afeta significativamente o momento máximo de flexão do cotovelo e o momento máximo de extensão do cotovelo dos atletas do que os métodos tradicionais de treinamento de força. O progresso da força muscular foi notado principalmente nas articulações do cotovelo e pulso, com menor intensidade nos ombros. ***Nível de evidência II; Estudos Terapêuticos - Investigação de Resultados.***

Descritores: *Dinamômetro de Força Muscular; Treinamento de Força; Membros Superiores; Atletas.*

RESUMEN

Introducción: El entrenamiento de fuerza progresivo puede ayudar a los atletas a mejorar sus niveles de fuerza de forma rápida y segura. Al controlar la frecuencia y la amplitud de las vibraciones, los músculos pueden producir contracciones inconscientes y voluntarias que ayudan a prevenir enfermedades como la osteoporosis. Objetivo: Explorar el cambio en el rendimiento deportivo provocado por el entrenamiento progresivo de la fuerza muscular en las extremidades superiores de los jugadores de tenis de mesa. Métodos: 12 jugadores de tenis de mesa con una experiencia mínima de 5 años fueron divididos aleatoriamente en grupos experimental y de control. El grupo de control realizó métodos de entrenamiento de fuerza tradicionales, mientras que el grupo experimental utilizó el método de entrenamiento de fuerza dirigido progresivo desarrollado por el equipo de investigación durante nueve semanas. Las pruebas se realizaron en el equipo ISOMED 2000 en las condiciones de 60°/s y 450°/s. Resultados: La circunferencia, la

fuerza muscular y la fuerza relativa de los miembros superiores aumentaron. Hubo una diferencia en la velocidad del momento de flexión máxima del codo de los atletas del grupo experimental en las condiciones de prueba de 60°/s. A 450°/s, el momento máximo de flexión del codo y el momento máximo de extensión del codo también mostraron una diferencia significativa (P<0,05). Conclusión: El método de entrenamiento de fuerza progresivo afecta significativamente al momento de flexión máxima del codo de los atletas y al momento de extensión máxima del codo que los métodos tradicionales de entrenamiento de fuerza. El progreso de la fuerza muscular se observó principalmente en las articulaciones del codo y la muñeca, con menor intensidad en los hombros. ***Nivel de evidencia II; Estudios terapéuticos - Investigación de resultados.***

Descriptores: *Dinamómetro de Fuerza Muscular; Entrenamiento de Fuerza; Miembros Superiores; Atletas.*

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INTRODUCTION

Progressive strength training can help athletes improve their strength levels quickly and safely. The muscles can produce unconscious, voluntary contraction.[1] This can help prevent diseases such as osteoporosis. Progressive strength training has attracted wide attention from experts and scholars at home and abroad for its characteristics of the low resistance value, high load intensity, short effective period, an obvious effect. This research is based on the principle of progressive strength training to impose a smaller resistance value on the experimental subjects.[2] We combined the characteristics of table tennis-specific movements to design a functional vibration strength training program for the experimental subjects. In this way, progressive strength training on the muscle strength of the shoulder, elbow, and wrist joints of table tennis players and specific sports performance are explored.

METHOD

Research object

Twelve male table tennis players from the Institute of Physical Education. The age is between 21.46±2.3 years old. The height is 175.18±3.14cm. The duration of the special training is 5-8 years.

Experimental method

We randomly divided 12 table tennis players into two groups. The control group used traditional strength training methods (resistance training).[3] The experimental group used the targeted progressive strength training method developed by the scientific research team.

This experiment conducted a 9-week follow-up study on 12 table tennis players. The experimental group developed a special vibration strength training plan according to the athletes' training level and competition period. We use the Power Plate progressive strength training platform. The frequency is 35Hz, the amplitude is 3mm, and the vibration acceleration is 20m/s2. The training is divided into three levels of difficulty for training, and the difficulty will increase by one level every three weeks.[4] The first difficult training methods include prone hand support, side-lying one-hand support (both sides), and handstand. The second level of difficulty training includes shoulder joint weight-bearing horizontal flexion and extension, push-ups, horizontal bench press, and balance pad push-ups. The third-level difficulty training methods include high-five push-ups, fast horizontal bench presses, reverse extensions, and arm pulls. Train 2 times a week for a total of 9 weeks. Intermittently for about 2 minutes between exercises. Intervals between groups are 3 minutes. The control group used the same training method as the experimental group but withdrew the progressive strength training platform.

In this experiment, the ISOMED 2000 isokinetic muscle strength tester made in Germany was used for testing under the conditions of 60°/s and 450°/s. The test content is the peak torque of the three shoulder, elbow, and wrist joints.

Quantitative control of movement speed to develop muscle speed and strength

If the fitted curve cannot meet the requirements of the equation, the equation needs to be corrected.[5] If it is still not satisfied after the correction, it will be invalidated. Correction principle the normal curve is logarithmic.

$$mi = \frac{Vi}{Fo - Fi}(i = 1, 2, 3 \cdots 7) \quad (1)$$

When $i > j$, there must be $mi < mj$. If a certain set of data does not conform to the above mathematical relationship, delete the data set and recalculate the a, b value. The weight load at which the athlete reaches the maximum output power is specified as the optimal weight and maximum load.[6] Only this weight load has the greatest significance for developing speed power, and the corresponding speed is the optimal speed load.

$$P = F \cdot V = \frac{b \cdot F(Fo - F)}{F + a} \quad (2)$$

We take the derivative of (2) $F\,Fo$

$$P / F = \frac{b \cdot a(Fo + a)}{(F + a)} - b \quad (3)$$

Let $P / F = 0$ then $Best\text{-}F = \pm a\,(Fo + a)\text{-}a$. $\because Best\text{-}F$ must fall between $F_1 \sim Fo$.

$$F_1 < Best - F < Fo \quad (4)$$

The condition for forming the largest rectangular area of a right triangle under the curve is

$$K = \frac{Best - V}{Best - F} = I \quad (5)$$

Assuming that the coefficient of curve K is 1, and the angle of Q is 45^o, there are the following judgment criteria. Off-speed criterion $1 < K < \infty$, $45^o < Q$, 90^O. Partial force criterion $1 < K < O$, $45^o < Q < O$.

Mathematical Statistics

We use SPSS18.0 statistical software to perform independent sample T-test and multivariate analysis of variance on the experimental data.

RESULTS

Analysis of shoulder joint test indicators

It can be seen from Table 1 that there is no significant difference in the peak torque of the shoulder muscles between the two groups of athletes before the experiment. Under the high resistance condition, the peak torque of shoulder flexion before and after the experiment in the experimental and control groups showed statistical significance (P<0.05). The comparison between groups showed no significant difference in the parameter indexes of the two groups of athletes.[7] This shows that this experimental program has a greater effect in improving the maximum strength of the shoulder flexor group. Under the test condition of 450°/s, it reflects the strength of the subject's explosive power.

The difference in the peak torque index of the athletes in the experimental group was highly significant (P<0.01). It shows that progressive strength training has a good effect on improving the explosive power of the athletes' shoulder flexor muscle group, but helping its maximum strength is not obvious.

Analysis of elbow joint test indicators

As shown in Table 2, there was no significant difference in the indicators of the two groups of athletes before the experiment. There was no significant difference in the peak torque index of the elbow joint muscles of the athletes in the control group before and after the experiment.[8] However, there is a significant difference in the index of peak elbow flexion moment of athletes in the experimental group under the test conditions of 60°/s (P<0.05). At 450°/s, the elbow flexion's peak torque and elbow extension's peak torque also had a significant difference (P<0.05). The comparison between groups showed a significant difference in the index of peak elbow flexion moment of athletes in the experimental group when the elbow joint was flexed and extended at 60°/s (P<0.05). At 450°/s, the progressive strength training method significantly affects athletes' elbow flexion peak torque and elbow extension peak torque than traditional strength training methods. Both parameters showed significant differences (P<0.05).

Analysis of Wrist Joint Test Index

As shown in Table 3, the intra-group comparison before and after the experiment showed no significant difference in the peak torque index of the wrist muscles of the athletes in the control group.[9] The experimental group athletes' peak wrist extension torque showed significant differences under the test conditions of 60°/s and 450°/s (P<0.05). It shows that the strength of the wrist extensor group of athletes increases significantly with the help of the progressive strength training method, while traditional strength training does not help much increase the strength of the wrist joint.

Table 1. Analysis of shoulder joint test indicators.

Combination		Control group (n=6)		Experimental group (n=6)	
Test Conditions		60°/s	450°/s	60°/s	450°/s
Before the experiment	Bend	73.11±4.36	69.64±7.15	74.49±5.74	8.73±6.65
	stretch	106.68±9.49	91.09±9.82	108.28±8.37	89.67±10.25
After the experiment	Bend	80.74±5.29	74.48±5.64	82.31±2.17	80.92±1.78
	stretch	110.92±5.53	96.21±5.32	114.76±9.76	104.31±1.17
Increment	Bend	7.63±0.93	4.48±1.47	7.82±3.57	12.19±4.87
	stretch	4.24±3.96	5.17±4.50	6.48±1.39	14.64±8.47

Table 2. elbow joint test index analysis.

Combination		Control group (n=6)		Experimental group (n=6)	
Test Conditions		60°/s	450°/s	60°/s	450°/s
Before the experiment	Bend	45.62±8.79	34.93±6.56	44.89±7.92	36.71±3.63
	stretch	53.42±9.19	43.11±11.02	54.01±7.32	44.81±6.43
After the experiment	Bend	51.47±4.71	41.38±6.62	57.31±2.78	49.12±3.73
	stretch	57.09±10.12	50.78±3.43	60.82±8.41	56.22±4.14
Increment	Bend	5.85±4.08	6.45±0.06	12.42±5.14	12.41±0.10
	stretch	3.67±0.93	7.67±6.59	6.81±1.09	11.41±2.29

Table 3. Analysis of Wrist Joint Test Index.

Combination		Control group (n=6)		The experimental group (n=6)	
Test Conditions		60°/s	450°/s	60°/s	450°/s
Before the experiment	Bend	15.92±3.14	13.02±4.51	16.31±1.10	13.17±2.18
	stretch	17.82±2.29	13.83±3.87	16.97±1.78	14.12±2.76
After the experiment	Bend	16.88±2.31	13.52±3.48	19.76±4.82	17.69±5.32
	stretch	18.33±3.42	14.17±2.11	24.01±3.51	19.48±2.94
Increment	Bend	0.96±0.83	0.50±1.03	3.45±3.72	4.52±3.14
	stretch	0.51±1.13	0.34±1.76	7.04±1.73	5.36±0.18

DISCUSSION

The peak torque index of the elbow joint flexors and extensors of the control group athletes did not change significantly after the experiment. The elbow joint data of athletes in the experimental group is statistically significant.[10] This shows that the progressive strength training method is better than the traditional strength training method for training the elbow joint muscles of table tennis players. Newton's second law F=ma. Among them, m is the mass of the load, and a is the acceleration of the elbow joint movement. F is resistance. When m is in a certain range, the larger a is, the greater the resistance of the elbow joint muscles and the better the exercise effect. In traditional strength training, a pass = g (gravitational acceleration). The quality of m adjusts the strengthening of the load. In progressive strength training, a vibration = a1 + g. Among them, a1 is the acceleration provided by the progressive strength training device. A vibration> a pass. In the case of a certain m, the effect of progressive strength training is better than that of traditional training.[11] In this experiment, because the athletes in the groups have the same weight, F vibration>F pass. Therefore, the training effect of the elbow joint muscles of the experimental group is better than that of the control group.

Compared with the control group, the most noticeable difference in the experimental group is reflected in the significant differences in the peak moments of the shoulder, elbow, and wrist joint muscles under the test conditions of 450°/s. Progressive strength training significantly improved the rapid contraction ability of each joint muscle group of the upper limbs of the athletes in the experimental group. On the one hand, it may be related to specific characteristics such as the rapid bursting of muscles required by table tennis and intermittent aerobic energy recovery. In this way, the athlete's muscle contraction mode, nerve stress mode, and energy supply mode become automated feedback actions.[12] Thereby enhancing the rapid contraction ability of each muscle group of the upper limbs.

On the other hand, it also shows that progressive strength training is of great help in improving the explosive power of athletes. The increased explosive power of progressive strength training is achieved by enhancing the activation degree of high-threshold motor units. The effective superposition of the acceleration is generated by the vibration stimulation and the acceleration of gravity. In this way, the body's resistance exercises will repeatedly appear "overweight" and "weightlessness" without increasing the load. This stimulates the motor nerve center to increase the intensity and frequency of impulse. This will activate more type IIb muscle fibers controlled by high-threshold motor nerves to participate

in the exercise. This improves the work efficiency of the muscles and the gradient of the contraction force. Enhance the flexibility and coordination of nerve control. The muscle strength has been strengthened under the premise of reducing the risk of body damage caused by overloading.

CONCLUSION

Progressive strength training can quickly improve athletes' explosive power in a short period. In this experiment, progressive strength training improved the strength of the elbow and wrist joint muscles more significantly than the joint shoulder muscles. The strength level of each joint muscle group of the upper limbs of athletes is improved with the help of the two training methods, but the effect of the progressive strength training method is more significant. As an effective physical training method, progressive strength training should be combined with traditional strength training. This will jointly promote the overall development of athletes.

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