MUSCULAR STRENGTH TRAINING IMPACTS IN YOUNG ATHLETES

IMPACTOS DO TREINAMENTO DE FORÇA MUSCULAR EM JOVENS ATLETAS

IMPACTOS DEL ENTRENAMIENTO DE LA FUERZA MUSCULAR EN JÓVENES ATLETAS

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ABSTRACT

Introduction: Muscle strength is directly related to its cross-sectional area and the volume of its fibers, but there is no absolute linear relationship between hypertrophy and improvement in athletic performance. Under this complex perspective, muscle training strategies have been implemented to promote relevant muscle strength and improve overall athletic ability. Objective: Explore the impacts of muscle strength training on young athletes based on sport kinetic principles. Methods: we adopted the method of intragroup statistical comparison with body indexes of 10 volunteers undergoing muscle training focused on the core and lower limb set. Results: Muscle strength gain was effectively verified via electromyogram, and the test of athletic skills showed an evolution in jumping, balance, and reduction of wrong passes. Conclusion: Evidence-based muscle training can increase muscle strength and promote sports skill gain in young athletes. ***Level of evidence II; Therapeutic studies - investigation of treatment results.***

Keywords: Physical Education and Training; Athletic Performance; Kinetics.

RESUMO

Introdução: A força muscular está ligada diretamente à área de sua seção transversal e ao volume de suas fibras, porém não há relação linear absoluta entre hipertrofia e melhora no desempenho atlético. Sob essa complexa perspectiva, estratégias de treinamento muscular vêm sendo implementadas para promover a força muscular relevante, no intuito de promover a melhora da capacidade atlética geral. Objetivo: Explorar os impactos do treinamento de força muscular nos jovens atletas baseado nos princípios cinéticos do esporte. Métodos: adotou-se o método de comparação estatística intragrupo com índices corporais de 10 voluntários submetidos ao treinamento muscular focado no conjunto do core e membros inferiores. Resultados: O ganho de força muscular foi efetivamente constatado via eletromiograma e o teste das habilidades atléticas demonstrou uma evolução no salto, equilíbrio e redução de passes errados. Conclusão: O treinamento muscular baseado em evidências consegue aumentar a força muscular e promover o ganho de habilidade esportiva nos jovens atletas. ***Nível de evidência II; Estudos terapêuticos - investigação dos resultados do tratamento.***

Descritores: *Educação Física e Treinamento; Desempenho Atlético; Cinética.*

RESUMEN

Introducción: La fuerza muscular está directamente relacionada con su área transversal y con el volumen de sus fibras, pero no existe una relación lineal absoluta entre la hipertrofia y la mejora del rendimiento deportivo. Bajo esta compleja perspectiva, se han implementado estrategias de entrenamiento muscular para promover la fuerza muscular pertinente, con el fin de promover la mejora de la capacidad atlética general. Objetivo: Explorar los impactos del entrenamiento de la fuerza muscular en jóvenes atletas basándose en los principios de la cinética deportiva. Métodos: se adoptó el método de comparación estadística intragrupo con los índices corporales de 10 voluntarios sometidos a un entrenamiento muscular centrado en todo el núcleo y las extremidades inferiores. Resultados: La ganancia de fuerza muscular se verificó eficazmente a través del electromiograma y la prueba de habilidades atléticas mostró una evolución en los saltos, el equilibrio y la reducción de los pases erróneos. Conclusión: El entrenamiento muscular basado en la evidencia puede aumentar la fuerza muscular y promover la ganancia de habilidades deportivas en los atletas jóvenes. ***Nivel de evidencia II; Estudios terapéuticos - investigación de los resultados del tratamiento.***

Descriptores: *Educación y Entrenamiento Físico; Rendimiento Atlético; Cinética.*

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INTRODUCTION

As an important part of the sports science system, biological sports mechanics analyzes the human body structure, simulates the human body into a sophisticated instrument, discusses its movement law, and puts forward training strategies scientifically according to the parts involved in the movement. Literature research shows that in the process of muscle training, because it is impossible to record the muscle movement and increase intuitively, the surface EMG signal is selected as the research index, and the muscle movement and its abnormalities are measured and analyzed qualitatively and quantitatively by recording the muscle bioelectrical activity.[1] This non injury detection method can minimize the impact of the experiment on athletes. Relevant literature suggests that in this exquisite model of human body, the movement of muscle is controlled by motor neurons, which together form a group of motor units to complete relevant instructions through the electrical signals transmitted by the nervous system. In the muscle model, the muscle movement of the same function is roughly the same, and the amount of tension is directly proportional to the cross-sectional area and volume of muscle fibers. From a macro point of view, the larger the cross-sectional area and volume of muscle, the stronger the force it produces. However, for athletes, there is no absolute linear relationship between the increase of strength and the improvement of competitive ability. Therefore, it is necessary to scientifically design muscle training strategies and improve relevant muscle strength, so as to promote the improvement of overall sports ability.[2]

METHOD

Experimental equipment and data acquisition method

The surface electromyography signal was measured by the surface electromyography tester produced in Finland. Before measurement, clean the muscle surface of athletes with 75% alcohol, then paste the electrode paste as closely as possible, import the measured data into the computer to obtain the original EMG, and use RMS for full wave rectification to obtain the relevant surface EMG signal data.[3]

The balance ability test indicators include overall stability index (SI), front and rear stability index (APSI) and left and right stability index (mlsi). The experiment adopts dynamic and static balancer equipment. With the help of professionals, athletes stand in the center of the detection platform, fully maintain their own balance, and measure the balance ability of both feet under static and dynamic conditions. In order to minimize the contingency of the experiment, when measuring and recording the three groups of data of Si, APSI and mlsi, the method of taking the average value of three measurements is selected, if there is a large deviation in the three data, re measure it.

Experimental design

In this paper, by means of intra group comparison and voluntary registration, after fully understanding and informing the experimental contents and requirements, 12 subjects were selected from the registered young athletes. The study and all the participants were reviewed and approved by Ethics Committee of Suzhou University (NO. 2019SU302). Before the experiment, the time of buffer period and pedal extension period, iEMG value and EMG root mean square of buffer period and pedal extension period were measured; Dynamic and static Si, APSI and mlsi indexes; Measure the values of various sports indexes such as standing long jump (m), second frog jump (m), sitting and turning 30-meter run (s), 30-meter run (s), prone back extension (Times), t sensitivity (s), and complete the data recording. During the whole experiment, one athlete terminated the experiment due to accidental injury and another athlete terminated the experiment due to accident. After removing the exfoliated samples, this paper takes 10 subjects as the exercise object to complete the whole experiment.

Mechanical analysis of athletes' lower limb muscles

The muscle is in a state of relaxation, contraction and stretching. In the process of exercise, the muscle length when the muscle group is in a relaxed state is XF. When the muscle length is less than XF, the muscle will not produce tension. When the length is greater than XF, the muscle will stretch to produce a certain muscle strength. At this time, the muscle strength is as shown in formula (1):

$$F_1 = \begin{cases} 0 & ,x \le x_f \\ m_m x + c_m x + k_m x & ,x > x_f \end{cases} \quad (1)$$

In formula (1), m_m is the equivalent mass of muscle group, c_m is its equivalent damping and k_m is its equivalent stiffness.

The movement of athletes' lower limbs can be simplified as a kind of swing, and according to the principle of swing dynamics, set θ Is the angle of motion, and the mechanical equation of muscle motion at rest is:

$$rk_m b = MgLsin\theta_v \quad (2)$$

The mechanical equation of muscle motion during exercise is:

$$\begin{cases} (J + ram_m)\theta + rac_m\theta + (rak_m + MgL)\theta = 0 ,\theta > \theta_f \\ J\theta + MgLsin(\theta - \theta_v) = 0 \quad ,\theta \le \theta_f \end{cases} \quad (3)$$

Among them, the included angle between the lower leg and the balance position under the condition of muscle relaxation is θ_f. The included angle with the vertical direction is θ_v.

RESULTS

Analysis of muscle changes during training based on sports mechanics

The jumping ability of athletes plays a very important role in improving the competitive level of athletes. In some sports involving jumping, under the premise of the same reaction ability, timely and rapid jumping can seize the dominant position first, so as to lay a certain advantage for subsequent operations. Jumping time consists of buffer period and kicking and stretching period. Buffer period refers to the landing stage after jumping. In terms of sports mechanics, kinetic energy is quickly transformed into potential energy, so as to achieve the purpose of energy storage and prepare for kicking and stretching period. The pedaling and stretching period is from the end of the buffer period to the stage when the muscles completely leave the ground. The potential energy stored in the buffer period is transformed into mechanical energy and displayed in the explosive force of the lower limbs. The shorter the buffer period, the less energy is consumed and the more energy is stored; The longer the pedal extension period, the higher the jumping ability of lower limbs. For athletes, on the premise of reaching the same jumping range, shortening the buffer period and increasing the pedal extension period as much as possible are of great help to improve their sports level.

As shown in Table 1, the time of buffer period and pedal extension period before and after training is shown. From table 1, it can be seen that the buffer period is shortened by 0.01 seconds on average from (0.135 ± 0.002) s before training to (0.112 ± 0.018) s after training, and $P < 0.01$, indicating that there is a very significant difference. The pedaling and stretching period increased by an average of 0.01 seconds from (0.139 ± 0.006) s before training to (0.141 ± 0.012) s after training, and $P < 0.01$, indicating that there was a very significant difference. This shows that lower limb muscle training and core strength training can effectively shorten the buffer period in the jumping process and increase the pedaling and stretching period, so as to enable athletes to obtain better jumping results.

Table 1. Time of buffer period and pedal extension period before and after training (s).

Training method	Buffer period	Pedal extension period
Before training	0.135±0.002	0.139±0.006
After training	0.112±0.018	0.141±0.012
Variation	-0.01	0.01
P value	0.019	0.009

As shown in Table 2, the characteristic changes of iEMG values in the buffer stage before and after training are shown. It can be seen from table 2 that iEMG values have increased before and after sports training, and the medial femoral muscle with the largest increase is (50.269 ± 4.424) μV·s before training increased to (53.571 ± 8.275) μV·s after training, $P < 0.05$, indicating that there is a significant difference. In addition, the iEMG values of gluteus maximus, lateral femoral muscle and anterior tibial muscle were improved to a certain extent, and there was significant difference ($P < 0.05$). The iEMG values of rectus femoris, biceps femoris, medial head of gastrocnemius and lateral head of gastrocnemius also improved to a certain extent, and there was a very significant difference ($P < 0.01$), which proved that lower limb muscle strength and core strength training can significantly improve the iEMG value in the buffer stage, so as to enhance the jumping ability of athletes

As shown in Table 3, the characteristics of EMG root mean square amplitude (RMS) in the buffer stage before and after training are shown. From table 3, it can be seen that the RMS values of major muscles have decreased in different ranges, among which the rectus femoris muscle has the largest reduction, from (432.141 ± 11.642) μV before training decreased to (402.574 ± 6.375) μV after training. And $P < 0.05$, indicating that there is a significant difference. In addition, the RMS values of other muscles were reduced to a certain extent, and there was significant difference ($P < 0.05$). This proves that the lower limb muscle strength and core strength training can significantly reduce the RMS value in the buffer stage, so as to make the movement more balanced, improve the athletes' stable ability and reduce the errors in the process of competition.

Influence of muscle training on young athletes

The stability of athletes' lower limbs is also an essential basic skill in sports training. If the stability of lower limbs is low, it is easy to lead to insufficient fluency and coordination, and then lead to sports injury or sports mistakes. Therefore, taking the overall stability index (SI), anterior posterior stability index (APSI) and left-right stability index (mlsi) as indexes, this paper studies the changes of athletes' static and dynamic foot balance indexes before and after muscle training. The experimental results are as follows.

Table 2. Characteristic change analysis of iEMG value in buffer stage before and after training (μV·s).

Muscle type	Before	After	Increase quantity	P valve
Hip muscle	25.982±6.145	27.994±5.121	2.028	0.0198
Strand	42.374±2.846	44.754±11.298	2.275	0.0061
Continental side muscle	50.269±4.424	53.571±8.275	2.932	0.0227
Outer side muscle	52.137±5.276	53.571±4.525	1.286	0.0122
Biceps	21.371±7.574	25.341±7.842	3.752	0.0091
Natamus muscle side	31.751±6.732	33.571±11.547	1.314	0.0061
Natamus	32.314±2.537	33.571±9.537	0.989	0.0081
Tibia	16.241±2.121	18.577±1.836	2.332	0.0148

Table 3. Characteristic analysis of EMG root mean square amplitude (RMS) before and after training (UV).

Muscle type	Before	After	Reduction	P valve
Hip muscle	264.421±9.512	245.341±10.251	19.187	0.0237
Strand	432.141±11.642	402.574±6.375	29.913	0.0307
Continental side muscle	590.714±13.821	567.573±8.781	22.055	0.0260
Outer side muscle	631.274±4.742	623.271±7.563	7.813	0.0168
Biceps	275.421±10.672	253.758±8.524	22.815	0.0416
Natamus muscle side	406.541±8.557	389.427±9.371	16.912	0.0158
Natamus	280.358±9.412	266.414±7.864	14.044	0.0129
Tibia	190.437±6.875	182.242±6.357	8.209	0.0277

Table 4 shows the changes of various indexes of static feet before and after training. It can be seen from table 4 that the Si index decreased from (0.288 ± 0.091) before training to (0.112 ± 0.060) after training. $P < 0.05$ shows that there is a significant difference. The APSI index decreased from (0.241 ± 0.092) before training to (0.148 ± 0.054) after training ($P < 0.05$). Mlsi index decreased from (0.132 ± 0.062) before training to (0.097 ± 10.057) after training ($P < 0.01$). The results showed that muscle training had a good promoting effect on the stability of static feet ($P < 0.05$).

Table 5 shows the changes of various indexes of dynamic feet before and after training. It can be seen from table 5 that the Si index decreased from (1.189 ± 0.261) before training to (1.044 ± 0.290) after training. $P < 0.01$ shows that there is a very significant difference. The APSI index decreased from (0.746 ± 0.121) before training to (0.568 ± 0.123) after training ($P < 0.05$). Mlsi index decreased from (0.832 ± 0.152) before training to (0.812 ± 0.121) after training ($P < 0.01$). The results show that muscle training can promote the stability of dynamic feet ($P < 0.05$).

Table 4. Changes of various indexes of static feet before and after training.

Index	Before	After	P
SI	0.288±0.091	0.112±0.060	0.0142
APSI	0.241±0.092	0.148±0.054	0.0135
MLSI	0.132±0.062	0.097±10.057	0.0091

Table 5. Changes of various indexes of dynamic feet before and after training.

Index	Before	After	P
SI	1.189±0.261	1.044±0.290	0.0071
APSI	0.746±0.121	0.568±0.123	0.0145
MLSI	0.832±0.152	0.812±0.121	0.0098

DISCUSSION

Muscle is one of the foundations for athletes to complete all sports. It produces a certain force to drive the bone through contraction and stretching, so that the precise instrument of human body can operate. Each muscle is composed of many muscle fibers. The muscle fibers of the same muscle are roughly the same, which can be regarded as a whole. Under the control of the nervous system, all muscle fibers gather to complete the same action, which will make the muscle complete the relevant contraction or stretching, so as to make the macro muscle move. All the muscle fibers on this muscle and the neurons that control it form a motor unit. The complete action of the human body is composed of multiple motor units. The supply of metabolic energy is carried out through ATP. Macroscopically, it is the supply of energy by the human body to complete the movement of the muscle.[4]

From the perspective of sports mechanics, muscle fiber can be regarded as a spring. When the stretched length is less than the critical value, it will not produce the corresponding tension. When the stretched length exceeds this value, it will produce the corresponding passive tension.[5] From the macro point of view, the muscle starts to exert force. Similarly, the stretching range of muscle fibers is limited. Exercise should be carried out under the condition that they can support. If the generated force is too large, resulting in a significant increase in passive tension, and the stress of connective tissue is also overloaded, it is easy to lead to muscle strain and sports injury.[6] Therefore, it is necessary to configure the exercise plan step by step, scientifically and reasonably in the process of exercise.[7]

CONCLUSION

Based on the principle of sports mechanics, this paper scientifically and systematically analyzes the muscle movement of young athletes, and combined with the data results of sEMG signal, athletes' lower limb stability and related sports scores, it is concluded that scientific muscle training plays a good role in promoting the increase of teenagers' muscle strength and sports ability, Therefore, athletes should carefully do relevant training in the process of sports training. Coaches should scientifically formulate muscle training strategies in combination with athletes' own situation and development needs, so as to improve athletes' muscle level and sports ability, improve their competitive level, and obtain good results in the field.

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