EXERCISE FATIGUE INJURY UNDER SPORT RESISTANCE

LESÃO DE FADIGA CAUSADA POR EXERCÍCIO SOB RESISTÊNCIA ESPORTIVA

LESIÓN POR FATIGA CAUSADA POR EJERCICIO BAJO RESISTENCIA DEPORTIVA

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ABSTRACT

Introduction: Athletes are prone to local muscle fatigue due to high-intensity training and to long-term accumulation of musculoskeletal injuries. Musculoskeletal complications represent a large proportion of occupational health problems and, for this reason, have received increased attention from the sports industry. In this sense, studies on muscle fatigue should be intensified. Objective: Verify muscle fatigue and injury involving the strain characteristics of lower limb joints in the eccentric and centripetal contraction of the jump. Methods: A total of 691 individuals aged 20 to 40 years were selected. Fatigue was caused by active muscle contraction. The characteristic curves of active muscle contraction in different isometric, isotonic, and isokinetic training were analyzed. The degree of fatigue caused by three different sports states was tested by experimentation. The corresponding active muscle contraction characteristics were also analyzed. The potential for homeostasis at different ages was compared. Results: The delay in recovery to fatigue is directly proportional to the athlete's age. The return to post-exercise relief proportion from fatigue gradually decreases. Conclusion: The experimental results showed that active muscle contraction could reduce exercise fatigue to some extent. This beneficial biochemical property of active muscle contraction is not found in people with advanced age. The findings have a guiding potential for the relief of sports fatigue. **Evidence Level II; Therapeutic Studies - Investigating the result.**

Keywords: Muscle contraction; Muscle fatigue; Endurance training; Sports.

RESUMO

Introdução: Os esportistas estão propensos à fadiga muscular local devido ao treinamento de alta intensidade, e ao acúmulo de lesões musculoesqueléticas a longo prazo. As complicações musculoesqueléticas representam uma grande fatia dos problemas de saúde ocupacional e por isso têm recebido maior atenção da indústria esportiva. Nesse sentido, os estudos sobre a fadiga muscular devem ser aprofundados. Objetivo: Verificar a fadiga e lesão muscular envolvendo as características de esforço das articulações dos membros inferiores na contração excêntrica e contração centrípeta do salto. Métodos: Foram selecionados 691 indivíduos com idade entre 20 a 40 anos. A fadiga foi ocasionada por contração muscular ativa. Foram analisadas as curvas características da contração muscular ativa em diferentes estados nos treinos isométrico, isotônico e isocinético. O grau de fadiga causado por três estados esportivos diferentes foi testado através de experimentos. Também foram analisadas as características de contração muscular ativa correspondentes. O potencial de homeostase em diferentes idades foi comparado. Resultados: O retardo na recuperação à fadiga é diretamente proporcional a idade do esportista. A proporção de retorno ao alívio pós-exercício sobre a fadiga diminui gradualmente. Conclusão: Os resultados experimentais mostram que a contração muscular ativa pode reduzir até certo ponto a fadiga ao exercício. Os efeitos dessas propriedades bioquímicas benéficas da contração muscular ativa não são encontrados em pessoas com idade avançada. Os achados tem um potencial orientador para o alívio da fadiga esportiva. ***Nível de evidência II; Estudos Terapêuticos - Investigação de Resultados.***

Descritores: *Contração Muscular; Fadiga Muscular; Treino Aeróbico; Esportes.*

RESUMEN

Introducción: Los deportistas son propensos a la fatiga muscular local debido al entrenamiento de alta intensidad, y a la acumulación de lesiones musculoesqueléticas a largo plazo. Las complicaciones musculoesqueléticas representan una gran parte de los problemas de salud laboral y por ello han recibido una mayor atención por parte de la industria del deporte. En este sentido, hay que profundizar en los estudios sobre la fatiga muscular. Objetivo: Verificar la fatiga muscular y las lesiones que implican las características de esfuerzo de las articulaciones de los miembros inferiores en la contracción excéntrica y centrípeta del salto. Métodos: Se seleccionaron 691 individuos de entre 20 y 40 años. La fatiga fue causada por la contracción muscular activa. Fueron analizadas las curvas características de la contracción muscular activa en diferentes estados en el entrenamiento isométrico, isotónico e isocinético. El grado de fatiga provocado por tres estados deportivos diferentes se comprobó mediante experimentos. También se analizaron las correspondientes características de la contracción muscular activa. Se comparó el potencial de homeostasis a diferentes edades. Resultados: El retraso en la recuperación a la fatiga es directamente proporcional a la edad del deportista. La proporción de retorno al alivio de la fatiga después del ejercicio disminuye gradualmente. Conclusión: Los resultados experimentales

muestran que la contracción muscular activa puede reducir la fatiga del ejercicio en cierta medida. Los efectos de estas propiedades bioquímicas beneficiosas de la contracción muscular activa no se encuentran en las personas mayores. Los hallazgos tienen un potencial orientador para el alivio de la fatiga deportiva. ***Nivel de evidencia II; Estudios terapéuticos - Investigación de resultados.***

Descriptores: *Contracción Muscular; Fatiga Muscular; Entrenamiento Aeróbico; Deportes.*

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INTRODUCTION

Muscles are the basic structure of the human body, and muscles support various movements and behaviors. The theory of active muscle contraction is an early study of muscles. Some early researchers have proposed that the contraction characteristics and processes of muscles are due to the contraction of human muscles caused by the elongation and shortening of proteins and molecules in the human body.[1] In the structure of the human body, protein molecules have the behavior of shortening or elongating. It is essentially the result of increased protein folding by folding molecules. Or because the helical protein molecules change the helical pitch or the diameter of the protein molecules during the contraction process. Myofilament sliding theory advocates those muscles will actively produce a relative sliding effect during the deformation process when the length of the muscle remains unchanged. This is the result of the interaction between the myosin of the muscle and the other muscle units due to the myosin cross-bridge activity.

There are many theories about the mechanism of muscle fatigue. Due to the continuous excitement of the muscles, there will be feedback in the relevant areas of the cerebral cortex. Inhibitory protection measures will spread in the brain and feel muscle fatigue.[2] As carbohydrates in the body are broken down into lactic acid, the accumulation of lactic acid in the blood indirectly or directly leads to a decrease in the physiological level of muscles. Especially after rapid and strenuous exercise, the secretion of lactic acid in the human cell fluid increases. After the H-ions in the body enter the cells, the hydrogen ion concentration index of muscle cells and fibers decreases. This slows down the transmission of neurotransmitters to synaptic nerves, causing nerve impulses to be unable to be transmitted to muscle cells. This will cause the body to show a decline in the physiological level of muscles. Studies have pointed out that if the reserve of adenosine triphosphate cannot keep up with the consumption of muscles, exercise will not last and cause fatigue. Some scholars believe that the secretion of more free radicals (ROS) by muscle cells is also an important reason for muscle fatigue. ROS is an unsaturated electronic substance that captures electrons everywhere in the human body.[3] This also means that a chemical reaction with compounds essential to life leads to the destruction of the body's cellular machinery and loss of function. The physique of the mechanism of the normal state has a perfect physique of elimination. However, the ROS content increases due to the muscle fiber cell membrane rupturing under the condition of high-intensity continuous intense exercise. This causes the accumulation of calcium ions in the cell fluid and reduces the excitability of muscle fibers. This affects the activity of biological enzymes, resulting in damage to cell structure and reduced cell function because the mechanism of self-protection leads to sensory muscle fatigue.

This paper analyzes the characteristic curves of active muscle contraction in different states. The fatigue level under three different sports states, isometric training, isotonic training, training characteristics under isokinetic training. And the corresponding active muscle contraction characteristics are tested through experiments.[4] The survey analyzed the ability of people of different ages to relieve exercise fatigue underactive muscle contraction. Our curve test and relief analysis of dynamic muscle contraction characteristics. The experiment tested the relationship between the two in detail. Analyzed the recovery ability of people of different ages to relieve exercise fatigue.

METHOD

The mechanism of active muscle contraction

Monolithic muscle contraction refers to the action potential in which the action unit takes the entire muscle unit as a unit or a single muscle fiber in the muscle generates a response with stimulation during muscle contraction. Then the muscle unit performs a mechanical muscle contraction accordingly.[5] We call it a single contraction. Single contraction is the basic form of muscle response. So, it reflects the basic characteristics of active muscle contraction. The muscle structure is shown in Figure 1.

From the three-time periods of the muscles, the different factions of the muscles can be distinguished. Therefore, a single contraction in different periods is the start and end of the asymmetric control period.

Muscle rigidity and contraction

Tonic contraction is based on the principle of longer muscle reaction time. The relationship between muscle and nervous system stimulus and response is shown in Figure 2. The force of the tonic contraction of the muscle is greater than the single contraction of the muscle. This is because part of the muscle's energy is consumed in the repetitive inter-muscle state changes during the single contraction of the muscle, while the interaction between the different muscles during the severe contraction of the muscle results in most of the energy not being consumed.[6] This allows more energy from contraction to be used for muscle work. When muscle rigidity contracts, the muscles interact with the connecting units of the corresponding bones.

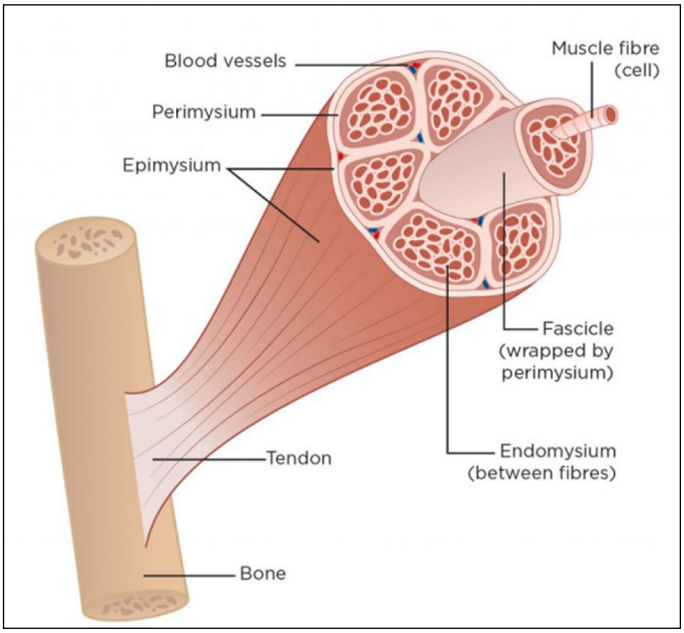

Figure 1. Muscle structure relationship.

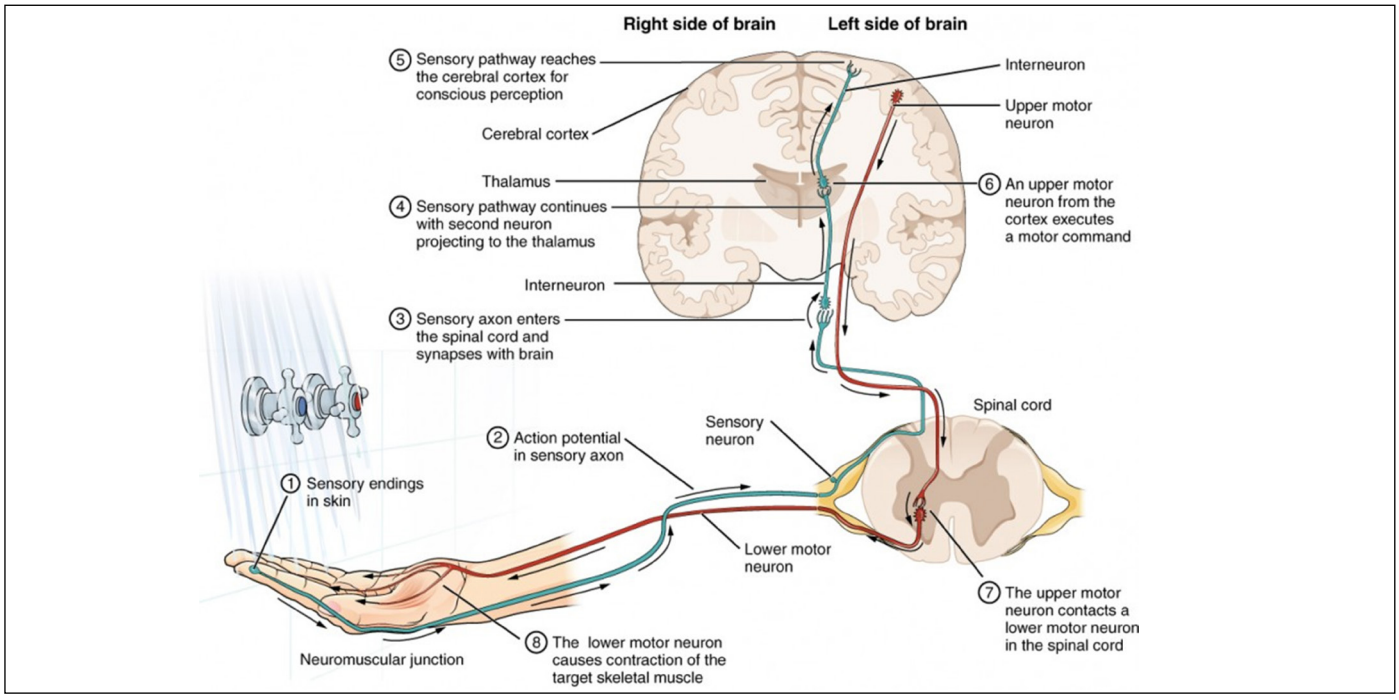

Figure 2. The relationship between stimulus and response of muscles and nervous system.

A certain stimulation frequency is required for the tonic contraction of muscles. The minimum stimulation frequency is called the minimum stimulation frequency.[7] The minimum stimulation frequency depends on the length of the single muscle contraction. Therefore, different body structures lead to different critical frequencies.

The effect of active muscle contraction on alleviating sports fatigue

Relief mechanism of sports fatigue

There are many reasons for chronic fatigue caused by exercise, such as excessive exercise, excessive stimulation during exercise, distress, high mental stress, etc. Long-term fatigue is very serious. It may cause intestinal infections and reduce the absorption of nutrients and cause nutrient insufficiency.[8] Therefore, to fight against sports fatigue, it is necessary to balance diet and nutrition. Athletes need to eat more grains, meat, fish, eggs, etc. Add melons, fruits, vegetables, etc., and coordinate with each other in a certain proportion to ensure that the human body obtains various relevant and rich nutrients needed for metabolism.

Adjustment based on active muscle contraction mechanism

Based on achieving balanced nutritional intake above, special attention should be paid to the supply of protein. Protein is very important for the body's alleviation and regulation.[9] In regulating the contractile muscles of the human body, the stimulating exercise of the muscles has a huge change in protein. In the process of muscle contraction, various proteins will produce corresponding changes, which is very important for regulating the human body. In the process of active muscle contraction, the human body realizes the adjustment of the ability to relieve sports fatigue through the regulation of protein.

Muscle fatigue recognition algorithm

Assume that the fatigue identification EEG indicator sample set $\{x_i, y_i\}, x_i = (x_{i1}, x_{i2}, \mathrm{L}, x_{ip})^T \in \mathrm{i}^d\, y_i \in \{+1, -1\}$ is the class label. $i = 1, 2, \cdots, n$, n is the number of fatigue identification index samples. Its classification surface function is set to

$$g(x_i) = \sum_{i=1}^{n} \alpha_i y_i k(x_i, x_j) + b, i = 1, 2, \cdots, n \quad (1)$$

α_i is a scalar constant. b is the classification threshold. $k(x_i, x_j)$ is the kernel function. On this basis, this paper selects the RBF kernel function. Calculate the optimal solution set of α_i in the above classification surface function according to formula (1):

$$\begin{cases} \max Q(\alpha) = \sum_{i=1}^{n} \alpha_i - \frac{1}{2} \sum_{i,j=1}^{n} \alpha_i \alpha_j y_i y_j k(x_i, x_j) \\ s.t. \quad \sum_{i=1}^{n} y_i \alpha_i = 0 \\ 0 \le \alpha_i \le C \\ i = 1, 2, \cdots, n \end{cases} \quad (2)$$

C is the upper limit set by the Lagrange multiplier, $C > 0$. In the optimal solution set obtained by formula (2), the corresponding samples of $\alpha_i > 0 (i = 1, 2, \cdots, s, s < n)$ are selected as input to construct the decision function of the recognizer as

$$y_i \left[\sum_{i=1}^{s} \alpha_i y_j k(x_i, x_j) + b \right] - 1 = 0 \quad (3)$$

Assume that the characteristic index vector of muscle fatigue in the unknown state is $X_r = \{x_{r1}, x_{r2}, \cdots, x_{rp}\}$. We substitute it into equation (3). If $f(X_r) = -1$, the muscle is judged to be mildly fatigued. If $f(X_r) = +1$, the muscle is judged to be in a state of severe fatigue.

RESULTS

We analyzed the results of the adjustment relationship between people of different ages for the relief of sports fatigue underactive muscle contraction.[10] The response curve of a single active muscle contraction is shown in Figure 3.

It can be seen from Figure 3 that the single contraction curve of the muscle is divided into three different periods: the incubation period, the shortening period, and the diastolic period. Show different characteristics in different muscle response periods. Investigations have shown that with the increase of age, the adjustment of fatigue relief gradually weakens

with the adjustment of active muscle contraction.[11] Use people of different ages as research objects for analysis and testing.[12] The number and prevalence of diseases in each age group are shown in Table 1. The relationship curve between exercise fatigue relief adjustment and age is shown in Figure 4.

It can be seen from Figure 4 that the mechanical characteristics of active muscle contraction decrease with age, and the proportion of exercise fatigue alleviation adjustment to achieve the expected effect is gradually decreasing. Therefore, the active muscle contraction mechanism analysis has a very good guiding role in alleviating sports fatigue.

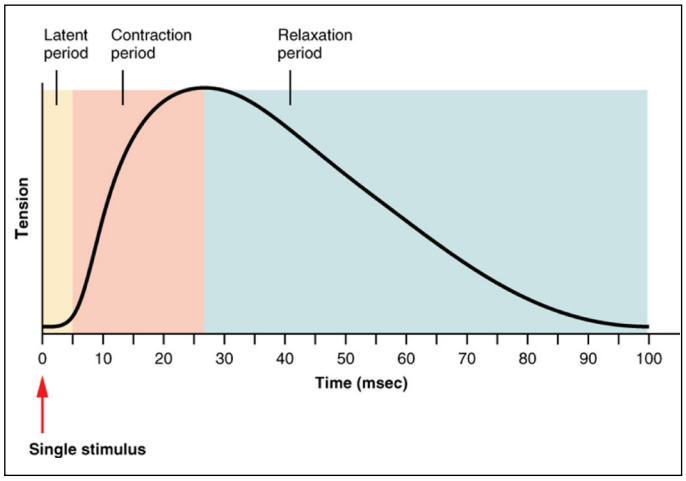

Figure 3. Single muscle contraction curve.

Table 1. The relationship between exercise fatigue relief adjustment and age.

Age	N	Relieve adjustment to achieve the desired effect	Prevalence rate/%
20-25	200	181	90.5
26-30	165	132	80
31-35	120	93	77.5
36-40	206	81	39.3
Total	691	487	70.4

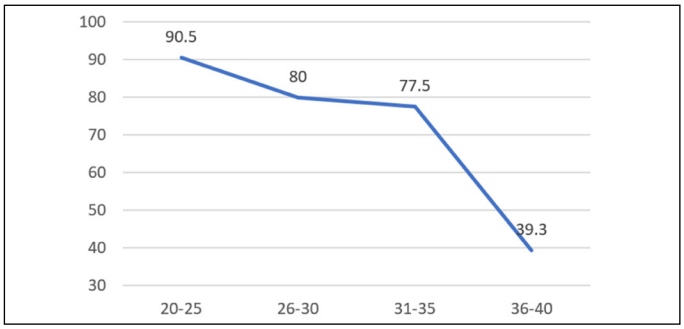

Figure 4. The relationship between exercise fatigue relief adjustment and age.

DISCUSSION

Through detailed analysis and measurement of proteins in the human body, the mechanism analysis of the body's active muscle contraction on alleviating fatigue is inferred. But the result is only a qualitative analysis that does not describe the detailed process of the body's muscle contraction.[13] This article proposes a method based on the characteristics of active muscle contraction. Based on the detailed description of the active muscle contraction mechanism, the characteristic curves of active muscle contraction in different states are analyzed. The fatigue degree caused by three different sports states was tested through experiments. We analyze isometric training, isotonic training, isokinetic training, and the corresponding active muscle contraction characteristics. At the same time, it investigated and analyzed the ability of people of different ages to relieve exercise fatigue underactive muscle contraction.

CONCLUSION

Experimental results show that active muscle contraction can reduce exercise fatigue to a certain extent. With the increase of age, the proportion of fatigue relief adjustment to achieve the expected effect gradually decreases. The mechanical properties of active muscle contraction are also decreasing. This has a good guiding significance for alleviating sports fatigue.

All authors declare no potential conflict of interest related to this article

AUTHORS' CONTRIBUTIONS: Each author made significant individual contributions to this manuscript. NP: writing manuscript. JG: data analysis, article review and intellectual concept of the article.

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