FUNCTIONAL TRAINING ON ANKLE SPRAIN REHABILITATION IN SOCCER PLAYERS

TREINAMENTO FUNCIONAL SOBRE A REABILITAÇÃO DA ENTORSE DE TORNOZELO NOS JOGADORES DE FUTEBOL

ENTRENAMIENTO FUNCIONAL EN LA REHABILITACIÓN DEL ESGUINCE DE TOBILLO EN LOS JUGADORES DE FÚTBOL

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ABSTRACT

Introduction: An ankle sprain is a common soccer injury. Functional training is used to rehabilitate muscle strength with undiscovered benefits on soccer players' recovery. Objective: Explore the functional training effects on ankle injury recovery in soccer players. Methods: 29 amateur soccer players were randomly assigned to control (n=15) and experimental (n=14) groups with no statistical difference in age or sex (P>0.05). The experimental group used functional rehabilitation training, while the control group was treated with traditional rehabilitation methods. Both groups practiced 30 to 40 minutes of rehabilitation, three times a week, for two months. Mathematical statistics were used to analyze the effects of different injury rehabilitation on the two groups, estimating the ankle joint continuous motion angle by the tibialis anterior muscle electromyogram responses. Results: The ankle instability assessment questionnaires were statistically different between the two groups of patients after rehabilitation training (P<0.05). There was a statistical difference in the agility test after the intervention. The ankle capacity score and agility test score were better in the experimental group (P<0.05). Conclusion: Functional rehabilitation training can improve ankle performance after a sprain. This training can also help athletes avoid future sprains and is recommended as preventive training. ***Evidence Level II; Therapeutic Studies - Investigating the result.***

Keywords: Ankle Joint; Resistance Training; Exercise Therapy; Soccer.

RESUMO

Introdução: Entorse no tornozelo é uma lesão comum no futebol. O treinamento funcional é utilizado na reabilitação da força muscular com benefícios ainda explorados sobre a recuperação dos jogadores de futebol. Objetivo: Explorar os efeitos do treinamento funcional na recuperação das lesões no tornozelo em jogadores de futebol. Métodos: 29 jogadores de futebol amador foram aleatoriamente distribuídos em grupo controle (n=15) e experimental (n=14) sem diferença estatística de idade ou sexo (P>0,05). O grupo experimental utilizou treinamento de reabilitação funcional enquanto o grupo controle foi tratado com os métodos tradicionais de reabilitação. Ambos os grupos praticaram 30 a 40 minutos de reabilitação, três vezes por semana, durante dois meses. Estatísticas matemáticas foram utilizadas para analisar os efeitos da reabilitação de lesões diferentes nos dois grupos por estimativa do ângulo de movimento contínuo na articulação do tornozelo com as respostas do eletromiograma do músculo tibial anterior. Resultados: Os questionários de avaliação da instabilidade do tornozelo entre os dois grupos de pacientes após o treinamento de reabilitação foram estatisticamente diferentes (P<0,05). Houve diferença estatística no teste de agilidade após a intervenção. A pontuação na capacidade do tornozelo e o escore no teste de agilidade foram melhores no grupo experimental (P<0,05). Conclusão: O treinamento de reabilitação funcional pode melhorar o desempenho do tornozelo após a entorse. Este treinamento também pode ajudar os atletas a evitarem futuros entorses, sendo recomendado como treino preventivo. **Nível de evidência II; Estudos Terapêuticos - Investigação de Resultados.**

Descritores: *Articulação do Tornozelo; Treinamento de Força; Terapia por Exercício; Futebol.*

RESUMEN

Introducción: El esguince de tobillo es una lesión común en el fútbol. El entrenamiento funcional se utiliza en la rehabilitación de la fuerza muscular con beneficios aún explorados en la recuperación de los jugadores de fútbol. Objetivo: Explorar los efectos del entrenamiento funcional en la recuperación de lesiones de tobillo en jugadores de fútbol. Métodos: 29 jugadores de fútbol amateur fueron distribuidos aleatoriamente en los grupos de control (n=15) y experimental (n=14) sin diferencias estadísticas en cuanto a edad o sexo (P>0,05). El grupo experimental utilizó un entrenamiento de rehabilitación funcional mientras que el grupo de control fue tratado con métodos de rehabilitación tradicionales. Ambos grupos practicaron entre 30 y 40 minutos de rehabilitación, tres veces por semana, durante dos meses. Se utilizó la estadística matemática para analizar los efectos de las diferentes rehabilitaciones de lesiones en los dos grupos mediante la estimación del ángulo de movimiento continuo en la articulación del tobillo con las respuestas del electromiograma del músculo tibial anterior. Resultados: Los cuestionarios de evaluación de la inestabilidad del tobillo entre los dos grupos de pacientes después del entrenamiento de rehabilitación fueron estadísticamente *diferentes (P<0,05). Hubo una diferencia estadística en la prueba de agilidad después de la intervención. La puntuación de la capacidad del tobillo y la puntuación de la prueba de agilidad fueron mejores en el grupo experimental (P<0,05). Conclusión: El entrenamiento de rehabilitación funcional puede mejorar el rendimiento del tobillo tras un esguince. Este entrenamiento también puede ayudar a los atletas a evitar futuros esguinces y se recomienda como entrenamiento preventivo.* ***Nivel de evidencia II; Estudios terapéuticos - Investigación de resultados.***

Descriptores: *Articulación del Tobillo; Entrenamiento de Fuerza; Terapia por Ejercicio; Fútbol.*

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INTRODUCTION

An ankle sprain is a common football injury. A survey has shown that one case of ankle joint injury occurs every day in every 10,000 general population in the United States. Because of the richer sports life of college students, the proportion of ankle joint injuries will be higher. If the injury is not treated promptly and correctly, the instability of the ankle joint will increase. This leads to an increase in the chance of recurring injury or other joint injuries.[1] At this time, adverse chain reactions and a vicious circle occur, and chronic ankle instability (CAI) is formed.

Functional strength training (FST) is rehabilitation training that includes existing rehabilitation methods for single-link muscle strength. FST has formed a systematic training concept in competitive sports.[2] It closely combines strength training with special events and maximizes the simulation of special movements. This plays a very important role in improving athletes' special ability, preventing sports injuries, and speeding up the process of athletes' injury recovery. This research attempts to apply the FST training concept of competitive sports to the CAI rehabilitation treatment of ordinary college students. We study the effectiveness of FST rehabilitation therapy relative to conservative rehabilitation training methods. The research has received good results.

METHOD

General information

This research conducted a preliminary survey of 9,583 students in the sophomore physical education optional course from September to October 2019. We found that more than 100 students have had ankle sports injuries within a year. Fourteen cases were selected and listed as the experimental group.[3] We use functional strength training therapy. In addition, we selected 15 experimental subjects during the same period and listed them as the control group. They are only treated with traditional methods. In the experimental group, there were 3 males and 11 females. Age 18-21 (20.5±1.83) years old. In the control group, there were 5 males and 10 females. Age from 17 to 23 (20.9±3.05) years old. There was no statistical difference in gender and age between the two groups of experimental subjects (P>0.05). The main manifestations of the condition are subjective feelings of weakness, repeated slight swelling, pain, repeated sprains, or instability in the bare joints of the affected foot. No objective signs of ankle slack were found.[4] There was no statistical difference in the angle of joint movement between the two groups (P>0.05).

Inclusion and exclusion criteria

Inclusion criteria: (1) At least one obvious unilateral lateral ankle ligament injury in the past year. No serious injuries and no fractures occurred in the lower limbs. (2) Feeling ankle joint instability or transient weakness at least once. (3) The drawer test is negative, and there is no obvious structural instability. (4) Did not receive formal or informal rehabilitation treatment. Exclusion criteria: (1) Combined ankle ligament injury of degree II or more. (2) Volunteers have fractures and joint dislocations. (3) Severe osteoarthritis and traumatic arthritis. (4) Combined rheumatic diseases and metabolic diseases.

Experimental method

(1) The control group adopts traditional rehabilitation methods. The content includes heel lift, weight-bearing heel lift, single-leg jump, straight knee jump, weight-bearing half-squat, weight-bearing half-squat jump, internal resistance rotation, external rotation, flexion and extension, step jumping, tiptoe walking, etc. (2) The experimental group's rehabilitation methods are mainly functional strength and focus on multi-step rehabilitation. Considering that the ankle sprain is caused by the body in a state of unconsciousness or sudden imbalance, we mainly use strength plus various instability exercises. The content includes single and double leg squat, squat exercises, single and double leg standing balance plate, and squat up exercises.[5] The two groups of volunteers practiced 3 times a week, each lasting 30-40 minutes. Five rehabilitation methods are used each time. We observe the rehabilitation effect after 2 months. Rehabilitation training is carried out without touching or slightly touching the pain points. If you feel unbearable pain, stop practicing. The intensity of rehabilitation ranges from small to large, from simple to complex.

Adaptive human-computer interaction control method based on EMG signal

We estimate the patient's continuous motion angle of the ankle joint expected based on the three characteristic values of EMG. If class=1, the classification result is classified as a dorsiflexion state.[6] At this time, we use the normalized eigenvalues of the anterior tibial muscle to estimate the angle. An online estimation method of joint angle is defined for dorsiflexion motion.

$$angle_i^{dor}(k) = f(\overline{a}_i(k)), i = 1,2,3 \qquad (1)$$

$f(a)$ represents the mapping relationship between the normalized feature value of the anterior tibial muscle and the joint dorsiflexion motion angle. $angle_i^{dor}(k)$ represents the dorsiflexion angle value estimated using the MAV, RMS, and WA characteristic values of the anterior tibial muscle. The mapping function $f(a)$ is described by offline induction.[7] In the actual control, it is found that the closer to the extreme motion position of the joint, the greater the force that needs to be actively applied by people for the same angle of motion. At this time, the slope of the curve between the joint motion angle and the normalized characteristic value is greater. The relationship curve between the angle of ankle dorsiflexion motion and a normalized characteristic value of the anterior tibial muscle can be expressed as the following relationship:

$$\overline{a}_i(k) = f^{-1}(angle_i^{dor}(k)) = l_i^1 \cdot e^{m_i angle_i^{dor}(k)} + l_i^2 \qquad (2)$$

This function passes through two points $(0,a_i)$ and $(\Theta_{dor}, 1)$. In the function. a_i represents the threshold of the corresponding characteristic value under the channel. Θ_{dor} indicates the set limit position of dorsiflexion. $m_i(i = 1, 2, 3)$ represents the curvature coefficient between the set characteristic values of the anterior tibial muscle and the joint dorsiflexion angle. l_i^1 and l_i^2 are the parameters to be identified for the curve.[8] The parameters conform to the following relationship:

$$l_i^1 = \frac{(1-a_i)}{e^{m_i \cdot \theta_{dor}} - 1}, l_i^2 = a_i^1 \quad (3)$$

At this time, we get the mapping relationship between the normalized eigenvalues of the anterior tibial muscle and the joint dorsiflexion angle:

$$angle_i^{dor}(k) = \frac{1}{m_i}\ln\left(\frac{\overline{a}_i(k) + \frac{1-a_i}{e^{m_i \cdot \theta_{dor}} - 1} - a_i}{\frac{1-a_i}{e^{m_i \cdot \theta_{dor}} - 1}}\right) \quad (4)$$

The mapping relationship between the normalized eigenvalues of the gastrocnemius muscle and the joint plantarflexion motion angle can be obtained for the plantar flexion motion state:

$$angle_i^{pla}(k) = g(\overline{b}_i(k)) = -\frac{1}{n_i}\ln\left(\frac{\overline{b}_i(k) + \frac{1-\beta_i}{e^{n_i \cdot \theta_{pla}} - 1} - \beta_i}{\frac{1-\beta_i}{e^{n_i \cdot \theta_{pla}} - 1}}\right) \quad (5)$$

Θ_{pla} represents the set limit angle value of plantar flexion movement. $n_i\ (i = 1, 2, 3)$ represents the curvature coefficient between each characteristic value of the gastrocnemius muscle and the joint plantarflexion angle. $angle_{pla}\ (i)(i = 1, 2, 3)$ represents the value of the plantarflexion movement angle estimated by using each characteristic value of the gastrocnemius muscle.[9] The final desired joint motion angle $\Theta_d\ (k)$ of the subject is expressed as follows.

$$angle_i(k) = \begin{cases} angle_i^{dor}(k), & class(k) = 1 \\ 0, & class(k) = 0 \\ angle_i^{pla}(k) & class(k) = -1 \end{cases} \quad (6)$$

$$\theta_d(k) = \sum_{i=1}^{3} \frac{angle_i(k)}{3}, i = 1,2,3 \quad (7)$$

Statistical methods

We use SPSS17.0 software to process data. The measurement data is represented by $\bar{x} \pm s$. We use a t-test. P<0.05 indicates that the difference is statistically significant.

RESULTS

Compared with the pre-rehabilitation training, it was found that the CAIT score and T-type agility test of the two groups of patients were significantly improved after the rehabilitation training [10]. The difference was statistically significant (P<0.05). The experimental group's CAIT score and T-type agility test were better than those of the control group (all P<0.05). There was no statistical difference between the two groups in the Sargent vertical jump test (P>0.05). (Table 1)

Table 1. Comparison of the three evaluation results before and after rehabilitation training between the two groups.

Group	N	CAI	T-shaped agility test(s)	Sargent vertical jump test effective coefficient
Test group	14			
Before training		13.65±3.12	12.87±0.89	28.82±1.43
After training		0.41±2.81	10.03±0.31	30.43±1.47
Control group	15			
Before training		12.76±2.14	12.93±0.92	28.74±1.52
After training		18.57±2.45	11.02±0.63	30.81±1.63

DISCUSSION

Joint stability depends on the dual control of muscles, ligaments' structure, and neuromuscular. Neuromuscular control of joints is realized by transmitting information from proprioceptors. Which can sense muscles and ligaments stretched in muscles, joints, and skin. Repeated ankle joint injuries can cause damage to the elastic tissues of the ankle joint muscles. At this time, the patient will have reciprocal inhibition, muscle atrophy, reduced motor unit recruitment, and decreased muscle strength. In turn, the patient's proprioception is decreased, and the sensory integration mechanism of the central nervous system is changed. Under normal circumstances, due to neuromuscular compensation, people will respond to sudden uneven ground or emergencies to avoid sprains.[11] This will further lead to repeated sprains of the ankle joint and form a vicious circle. Therefore, rehabilitation training for CAI patients must solve muscle atrophy problems, decrease muscle strength, reduce motor unit recruitment.

Functional strength training is the rehabilitation of neuromuscular control. Through the sensory coordination between muscle spindles, ligaments, joint capsules, and skin, proprioception automatically controls local joints and muscle tension. The goal of rehabilitation is in the form of exercise. It involves the acceleration, deceleration, and stability of the ankle joint. The ankle joint performs compound movements in multiple joints and multiple planes. Recovered persons regulate various instability factors. The focus is on the interaction of the target area system centered on the ankle joint. Functional strength rehabilitation involves training the ankle muscles and ligaments in a multi-joint, multi-link, and unbalanced state. It can increase the tension and toughness of the ankle joint muscles and further strengthen the stability of the ankle joint. This forms a "flexible force." This training can improve the coordination ability among active, auxiliary, and antagonist's muscles. This can achieve the purpose of restoring the control of the nerves to the muscles and restoring the proprioception of the muscles. This exercise can effectively improve joint function decline or obstacles caused by CAI and avoid repetitive sprains.

CONCLUSION

Colleges and universities should improve the emergency response mechanism after a student is injured. Teachers and the school hospital jointly develop a system suitable for acute and chronic ankle rehabilitation students. At the same time, appropriately increase some sports facilities that can exercise the functional strength of students. This study shows that the ankle joint condition of the experimental group of functional strength training patients is significantly improved after 2 months of rehabilitation compared with the traditional group of patients. At the same time, the students in the experimental group increased their muscle strength and joint stability.

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AUTHORS' CONTRIBUTIONS: The author made significant contributions to this manuscript. XD: writing and performing surgeries; data analysis and performing surgeries; article review and intellectual concept of the article

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