REHABILITATION OF NEUROMUSCULAR FUNCTION BY PHYSICAL EXERCISE

REABILITAÇÃO DA FUNÇÃO NEUROMUSCULAR POR MEIO DE EXERCÍCIOS FÍSICOS

REHABILITACIÓN DE LA FUNCIÓN NEUROMUSCULAR MEDIANTE EJERCICIO FÍSICO

ORIGINAL ARTICLE
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ABSTRACT

Introduction: In long-term sports, especially in explosive sports such as accelerated starting, athletes are prone to rupture the anterior cruciate ligament (ACL). It is the ultimate goal of ACL reconstruction for athletes to restore the stability (static and dynamic) and mechanical structure of the knee joint through reconstruction surgery. Object: This article uses ACL reconstruction to repair patients' ACL and explores the effect of athletes' nerve recovery after sports. Methods: We collected 35 ACL reconstruction athletes and randomly divided them into two groups (experimental group, 18; control group, 17). After reconstruction, the athletes in the experimental group were treated with sports rehabilitation. Results: The experimental and control groups had great differences in knee joint exercise indexes and nerve function recovery. Conclusion: Sports rehabilitation training can effectively improve the nerve function of the knee joint after ACL reconstruction. ***Level of evidence II; Therapeutic studies - investigation of treatment results.***

Keywords: Physical exercise; Anterior cruciate ligament; Rehabilitation.

RESUMO

Introdução: Em esportes de longa duração, especialmente em esportes explosivos, como partidas aceleradas, os atletas têm tendência a romper o ligamento cruzado anterior (LCA). O objetivo final da reconstrução do LCA para atletas é restaurar a estabilidade (estática e dinâmica) e a estrutura mecânica da articulação do joelho por meio da cirurgia de reconstrução. Objetivo: Este artigo considera a reconstrução do reparo do LCA em pacientes e explora o efeito da recuperação nervosa em atletas após a prática de esportes. Métodos: Foram coletados 35 atletas de reconstrução do LCA e os dividimos aleatoriamente em dois grupos (grupo experimental, 18; grupo controle, 17). Após a reconstrução, os atletas do grupo experimental foram tratados com reabilitação esportiva. Resultados: Os grupos experimental e controle tiveram grandes diferenças nos índices de exercício da articulação do joelho e recuperação da função nervosa. Conclusão: O treinamento de reabilitação esportiva pode efetivamente melhorar a função nervosa da articulação do joelho após a reconstrução do LCA. ***Nível de evidência II; Estudos terapêuticos: investigação dos resultados do tratamento.***

Descritores: *Exercício físico; Ligamento cruzado anterior; Reabilitação.*

RESUMEN

Introducción: En deportes de larga duración, especialmente en deportes explosivos como la partida acelerada, los deportistas son propensos a romperse el ligamento cruzado anterior (LCA). El objetivo final de la reconstrucción del LCA para los atletas es restaurar la estabilidad (estática y dinámica) y la estructura mecánica de la articulación de la rodilla mediante la cirugía de reconstrucción. Objeto: Este artículo considera la reconstrucción para reparar el LCA de los pacientes y explora el efecto de la recuperación nerviosa de los atletas después de los deportes. Métodos: Recogimos 35 deportistas de reconstrucción del LCA y los dividimos aleatoriamente en dos grupos (grupo experimental, 18; grupo de control, 17). Después de la reconstrucción, los atletas del grupo experimental fueron tratados con rehabilitación deportiva. Resultados: Los grupos experimental y de control tuvieron grandes diferencias en los índices de ejercicio de la articulación de la rodilla y la recuperación de la función nerviosa. Conclusión: el entrenamiento de rehabilitación deportiva puede mejorar eficazmente la función nerviosa de la articulación de la rodilla después de la reconstrucción del LCA. **Nivel de evidencia II; Estudios terapéuticos: investigación de los resultados del tratamiento.**

Descriptores: *Ejercicio físico; Ligamento cruzado anterior; Rehabilitación.*

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INTRODUCTION

Sports athletes are also part of the professional population, with their unique professional characteristics. In the competitive arena, athletes are striving for "higher, faster, stronger." When they perform long-term repeated starting acceleration, emergency stop deceleration, rotation change or kick-off and other sports, the anterior cruciate ligament (ACL) rupture is a common knee injury.[1] ACL fracture causes the tibia to move forward and internally rotate, causing joint instability and damage to the meniscus and articular surface. Restoring the stability (static and dynamic) and the knee joint's mechanical structure is the ultimate goal of ACL reconstruction. In the thesis, autologous bone-patellar tendon-bone (BPTB) reconstruction can restore the knee joint's static stability.[2] Still, the postoperative loss of muscle strength will lead to the dynamic instability of the knee joint. Some scholars pointed out that female athletes still lack knee extensor strength after two years of ACL reconstruction, leading to the premature end of their sports career.[3] This study intends to conduct regular isokinetic muscle strength training for ACL reconstructed athletes to explore the influence of isokinetic training on the knee joint muscle strength (absolute strength, explosive power and muscle endurance) and position perception of ACL reconstructed athletes, and to provide a scientific basis for ACL reconstruction athletes. Rehabilitation training, recovery of competitive ability as soon as possible, and an early return to the field to provide a basis.

METHOD

Object

From January 2017 to April 2020, we recruited ACL reconstruction athletes at the Sports Technical College Rehabilitation Center. Inclusion criteria: 1) Unilateral autologous BPTB reconstruction; 2) National level athletes (sports performance ranked among the top eight in national championships in individual or group events); 3) Early postoperative full-angle knee extension, early weight-bearing, and progressive Closed chain training. Exclusion criteria: 1) meniscus resection; 2) combined fracture; 3) the previous history of knee surgery; 4) other forms of muscle or bone injury of the lower limbs.[4]

During the period, we recruited 35 subjects. All research subjects signed an informed consent form and have been approved by the school ethics committee. In the paper, six weeks after ACL reconstruction, the experimental group received isokinetic centripetal and eccentric training for eight weeks, while the control group did not have this training activity.

Isokinetic training and testing

The thesis uses the German IsoMed 2000 isokinetic muscle strength test training instrument to perform 60°/s and 240°/s on the ACL reconstruction side knee joint of the experimental group (joint range of motion is 80°, knee flexion 10°~90°) s (12 exercises per group, five groups in total, 1 min rest between groups, 30 min between different angles of training interval) isokinetic centripetal and eccentric training, the training period is eight weeks (3 times/week). We performed 60°/s5 times and 240°/s25 times on all subjects before and after eight weeks of ACL reconstruction on the knee joints. The measurement indicators include peak torque (PT) and muscle endurance. The athlete test site and the 60°/s and 240°/s force and joint motion angle curves are shown in Figure 1.[5]

Statistical analysis

The data is represented by. The thesis uses SPSS17.0 for independent sample t-test analysis between groups and paired sample t-test analysis within groups. The inspection level α=0.05.

Based on the learning rate requirement in deep learning, the stable value of the hybrid cloud data's redundant value function is obtained. To meet these two requirements, we need to introduce new parameters and perform repeated training. The formula for the redundant value function of the hybrid cloud data is

$$\varphi = \frac{\Delta W_d \square \Delta W_{rg}}{\Delta W_d \square \Delta W_{rg} - \Delta W_{rg} \square \Delta W_{rg}} \qquad (1)$$

φ is the value function of the redundant value of the hybrid cloud data; ΔW_d and ΔW_{rg} are the two weight vectors of the redundant value of the hybrid cloud data.

In the iteration of the hybrid cloud data's redundant value, when $0 \le \varphi < 1$, the convergence of the iterative algorithm can be guaranteed.[6] After completion, verify whether the value of Dφ satisfies the condition of $0 \le \varphi < 1$, and calculate the value function parameters:

$$\Delta W_r = k(1-\varphi)\Delta W_d + \varphi W_{rg} \qquad (2)$$

In the formula ΔW_r is the value function parameter. We then use the value function parameters to update the weight vectors ΔW_d and ΔW_{rg}, and introduce a new parameter μ in the update. This parameter is a minimal positive number called the forgetting factor. After μ is introduced, the weight vector ΔW_d and The update result of ΔW_{rg} is

$$W_d = (1-\mu)\Delta W_d - \mu k^2 \qquad (3)$$

$$W_{rg} = (1-\mu)\Delta W_{rg} - \mu k^2 \qquad (4)$$

The update of the weight vectors ΔW_d and ΔW_{rg} accelerates the convergence rate of the iterative algorithm and obtains the stable value of the value function, namely

$$\varphi = \frac{\sum_k W_d \square W_{rg}}{\sum_k (W_d - W_{rg}) \square W_{rg}} + \mu \qquad (5)$$

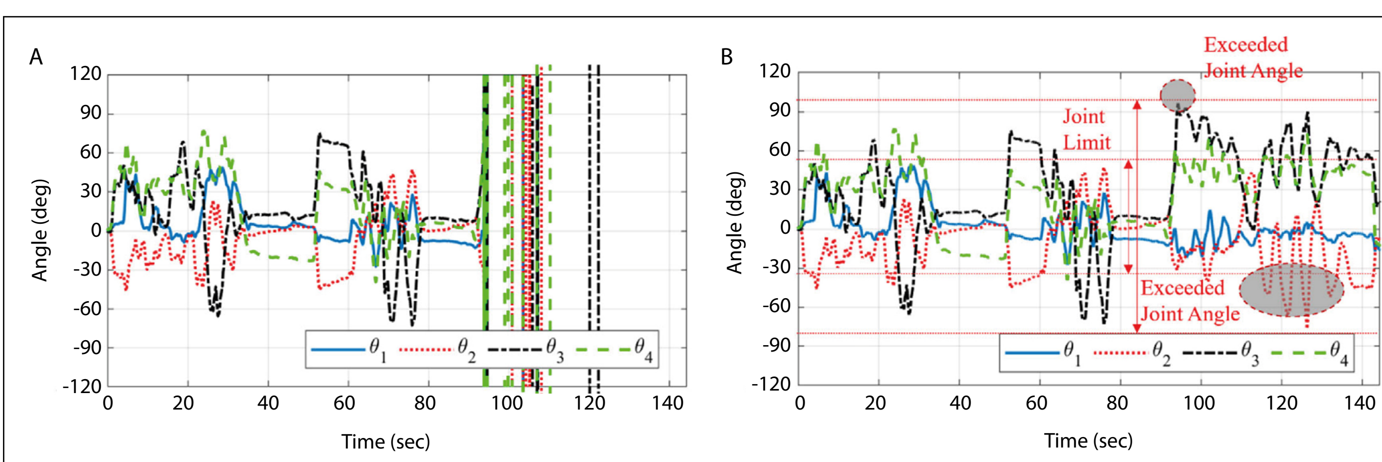

Figure 1. Schematic diagram of 60°/s and 240°/s force and joint motion angle curves. Among them, (A) represents the 60°/s force vs. joint motion angle curve. (B) Represents the curve of 240°/s force and joint motion angle.

RESULTS

The basic situation of research objects

The indexes of age, height, weight, training years, pre-experiment (baseline) isokinetic muscle strength, and position perception between the experimental and control groups are shown in Table 1. There was no statistically significant difference between the two groups (P>0.05).

Isokinetic muscle strength test results

Table 2 shows the test results of the isokinetic muscle strength of the two groups of subjects' injured knee joints before and after the experiment. Comparison between the 8th week and the 0th week: the absolute power of knee flexion and extension, explosive power and muscular endurance of the experimental group increased (P<0.01); the absolute power of knee extension and flexion muscular endurance of the control group increased (P<0.05). Comparison between groups in the 8th week: Compared with the control group, the experimental group's knee joint absolute flexion, explosive and extension explosive power increased by 19.3%, 19.7% and 19.1%, respectively (P<0.01), the absolute extension power and muscle endurance Increased by 17.7% and 18.2% respectively (P<0.05), but there was no significant change in flexor endurance (P>0.05).

Location test results

Table 2 shows the test results of the positional perception of the two groups of subjects' injured knee joints before and after the experiment. The comparison between the 8th and 0th-week groups: the experimental group's knee joint 30° and 60° positional angles decreased (P<0.01). 8th-week comparison between groups: Compared with the control group, the experimental group's knee joint 30° position perception angle decreased by 41.4% (P<0.01), and the 60° position perception angle also decreased by 19.0% (P<0.05).

DISCUSSION

The lack of absolute strength of ACL reconstruction athletes' knee flexors and extensors will increase the risk of re-sport injuries, such as torn ligaments or joint pain. In this study, the absolute strength and explosive strength training of ACL reconstruction athletes were performed, and the improvement range was statistically significant. Some scholars have conducted 24 weeks of isokinetic strength training for 15 ACL reconstruction athletes and believe that the extensor's absolute strength is increased more than the flexor.[7] This study further validated and expanded previous studies and found that the absolute strength and explosive strength of the knee joint extensor increased more than the flexor muscle in both the experimental and control groups.

There is no research report on the changes in the muscle endurance of ACL reconstruction athletes. In this study, the isokinetic muscle strength test system was used to analyze the subjects' knee joint flexion and extensor endurance. It was found that increasing isokinetic muscle strength training based on rehabilitation did not increase knee flexors' endurance.[8] The reason may be that the intervention time is not long enough, and the change of flexor endurance lags behind that of the extensor. As we all know, athletes have higher requirements for muscle endurance. Therefore, the training of muscle endurance cannot be ignored in the ACL reconstruction and rehabilitation process. This study hopes to provide a quantitative test method for future research.[9]

Knee joint proprioceptors are divided into Passini and Rafini corpuscles distributed in the joint capsule, cruciate ligament, collateral ligament, meniscus and tendon. They can feel the deformation and pressure of the tissue and sense the acceleration and deceleration of joint movement.

Table 1. Basic information of subjects and baseline data before the experiment.

Basic Information	The experimental group (n=18)	Control group (n=17)	*t*	*P*
Age (year old)	20.3±6.6	21.1±7.9	-0.072	0.738
Height (cm)	176.2±11.0	175.9±10.6	0.086	0.683
Weight (kg)	70.3±9.6	71.0±8.2	-0.093	0.537
Training years (years)	11.2±3.6	10.6±4.2	0.102	0.505
Absolute force (Nm)				
Bend	80.6±15.5	81.5±16.9	-0.113	0.46
Stretch	102.6±20.7	101.8±19.7	0.082	0.693
Explosive power (Nm)				
Bend	79.3±16.4	79.6±15.8	-0.07	0.741
Stretch	92.5±19.0	97.6±19.6	-1.316	0.067
Muscular endurance flexion	0.53±0.11	0.54±0.14	-0.066	0.828
Stretch	0.64±0.13	0.63±0.15	0.069	0.772
Position sense				
30°	4.45±1.46	4.53±1.58	-0.11	0.452
60°	5.43±1.76	5.32±1.16	1.007	0.103

Table 2. Changes in peak torque, muscle endurance and position perception of the injured knee after isokinetic training.

Index	Mode	The experimental group (n=18)	
		Week 0	Week 8
Absolute force (Nm)	Bend	80.6±15.5	106.1±24.2
	stretch	102.6±20.7	141.5±26.4
Explosive power (Nm)	Bend	79.3±16.4	96.2±19.3
	stretch	92.5±19.0	127.3±24.1
Muscle endurance	Bend	0.53±0.11	0.65±0.13
	stretch	0.64±0.13	0.78±0.12
Position sense	30°	4.45±1.46	2.48±1.02
	60°	5.43±1.76	4.13±1.66
Index	**mode**	**Control group (n=17)**	
		Week 0	**Week 8**
Absolute force (Nm)	Bend	81.5±16.9	88.9±18.7
	stretch	101.8±19.7	120.2±17.8
Explosive power (Nm)	Bend	79.6±15.8	80.4±16.4
	stretch	97.6±19.6	106.9±26.2
Muscle endurance	Bend	0.54±0.14	0.61±0.19
	stretch	0.63±0.15	0.66±0.18
Position sense	30°	4.53±1.58	4.23±1.70
	60°	5.32±1.16	5.10±1.30
Index	**mode**	**Comparison between groups in week 8**	
		t	**P**
Absolute force (Nm)	Bend	11.62	<0.001
	stretch	2.334	0.012
Explosive power (Nm)	Bend	11.556	<0.001
	stretch	10.077	0.003
Muscle endurance	Bend	1.621	0.056
	stretch	-2.339	0.01
Position sense	30°	23.11	<0.001
	60°	-2.339	0.01
Index	**mode**	**Percentage change after eight weeks (%)**	
		Test group	**Control group**
Absolute force (Nm)	Bend	31.6	9.1
	stretch	37.6	18.1
Explosive power (Nm)	Bend	37.9	1
	stretch	22.6	9.5
Muscle endurance	Bend	21	12.9
	stretch	21.9	4.8
Position sense	30°	-44.3	-6.6
	60°	-23.9	-4.1

Studies have confirmed that the mechanical stimulus receptors in ACL are important proprioceptive carriers. This research shows that isokinetic training can improve the proprioception of ACL reconstruction athletes. Studies have believed that the closer the knee joint is to the extended position, the more sensitive the sense of movement will be, which is in line with the "self-protection" needs of the knee joint for weight-bearing exercise. This conclusion explains this study's conclusion to a certain extent (the 30° position perception changes more obviously).

Regarding the mechanism by which isokinetic training improves the subject's proprioception, research suggests that muscle strength is the basis of proprioception, and proprioception is strengthened through neuromuscular training. Besides, isokinetic muscle training is a periodic stability exercise that can release the elastic energy stored in the subject's tendon structure, strengthen the tactile muscle reflex, and promote the recovery of proprioception by improving the central nervous system. However, this study has certain limitations. It has not been able to collect more samples to explore gender differences, and it lacks neuromuscular response tests.

CONCLUSION

The addition of 8 weeks of isokinetic muscle training based on traditional rehabilitation effectively improved the absolute strength, explosive power and endurance of the knee flexors and extensors of the ACL reconstruction athletes, and at the same time improving the position of the knee joints at 30° and 60°. Still, The effect on the knee joint flexor endurance is not apparent.

The author declare no potential conflict of interest related to this article

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