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RESTORATION OF AMPLITUDE-POWER CHARACTERISTICS OF THE LOWER LIMB OF BOXERS AFTER RUPTURE OF THE ANTERIOR CRUCIATE LIGAMENT AT THE STAGE OF SPORTS REHABILITATION

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Annotation. The article presents the content of a comprehensive program of physical rehabilitation for boxers after reconstruction of the anterior cruciate ligament at the stage of sports rehabilitation, aimed at restoring the amplitude-strength characteristics of the knee joint.
Keywords: boxers, anterior cruciate ligament rupture, sports rehabilitation stage.

Introduction. Among all injuries of the musculoskeletal system, knee joint injuries of athletes occupy about 50% [1], among which cruciate ligament injuries are on second place in incidence. Damage to the anterior cruciate ligament and meniscus occurs in 70% of cases [2]. This injury is one of the most serious ones, as the supporting ability of the limb and the walking process are disrupted, which leads to a restriction of the patient's motor activity and a decrease of social adaptation [3].

Rupture of the anterior cruciate ligament (ACL) is a serious injury requiring immediate medical care, rapidly reducing the mobility and performance of athletes, requiring a systematic approach to recovery and the use of comprehensive rehabilitation for the functional restoration of the injured limb [4]. Rehabilitation measures usually take from 5 months to 1 year, however, even after the restoration of limb function, there is a high percentage of complications associated with the consequences of injuries and diseases caused by knee joint injury [3-4], mainly related to a decrease in the amplitude-power characteristics of the injured joint. At the same time, the risk zone of injury recurrence is represented by the stage of sports rehabilitation – the period of transition to full-fledged training sessions, in which the intensification of physical loads initiated by a coach or athlete can occur without taking into account the functional fitness of the injured joint to the proposed loads.

It should be taken into account that as a result of the injury, the athlete's performance and fitness noticeably decrease, while the athlete at the stage of sports rehabilitation after the removal of immobilization overestimates his capabilities, which can lead to overstrain, deterioration of the general condition and slowing down the recovery process [3].

In connection with the above, the urgency of restoring the amplitude-strength characteristics of the knee joint of boxers after reconstruction of the anterior cruciate ligament at the stage of sports rehabilitation is identified.

Methods and organization. The functional state of the lower limb after reconstruction of the anterior cruciate ligament (ACL) during rehabilitation measures was studied by the dynamics of following indicators: the amplitude of flexion and extension of the knee joint, the strength of the muscles of the lower leg, the presence of pain syndrome at rest and during exercise, presented in a scaled score. We have identified the strength endurance of the lower leg muscles using manual muscle testing, in which 0 points corresponded to the absence of muscle contraction, 5 points corresponded to normal muscle strength. The amplitude of movement in the knee joint was registered with a goniometer. The evaluation scale is presented in table 1.

Table 1

Evaluation of the amplitude of movements in the knee joint

Condition	Norm	Limited movement		
		Minor	Moderate	Significant
Points	3	2	1	0
Flexion	30-45	46-50	51-60	>60
Extension	180-170	169-150	149-130	<130

The presence and severity of pain syndrome in the injured limb was assessed at rest and during physical loads on a visual analog scale (VAS), 10 points in total. The dynamics of the results of the study during the recovery measures were processed using mathematical statistics methods with the calculation of the average value, standard deviation, the level of confidence was calculated using the Wilcoxon T-test ($p<0.05$).

The study was conducted in the V.P. Ageev National Boxing Center (Moscow), the study involved athletes (n=8) professionally engaged in boxing, the level of sports qualification – Candidates for Masters of Sports (CMS) and Masters of Sports (MS). All participants were active athletes who have a high rating both in the Russian Boxing Tour and in the international arena. Criteria for inclusion in the study: sport – boxing; sports qualification – CMS, MS; diagnosis – rupture of the ACL; the period is no more than 3 months after the ACL reconstruction surgery; the stage of rehabilitation treatment is the stage of sports rehabilitation. The exclusion criteria are the presence of combined knee joint injuries, exceeding the period of post-surgical intervention for the ACL reconstruction for more than 3 months.

A preliminary study of the studied indicators demonstrates low amplitude values and indicators of the strength of the muscles flexing and extending the lower leg, a significant pain syndrome, especially pronounced during exercise (table 2).

The principles of constructing a program for restoring the amplitude-power characteristics of the knee joint in particular and the functional state of the musculoskeletal system as a whole, at the stage of sports rehabilitation, athletes had a differentiated type of physical activity depending on the morphofunctional state of the damaged link, the functional state of the body and the level of physical fitness.

Table 2

Initial results of the studied pain indicators and amplitude-power characteristics of the knee joint in boxers after the ACL reconstruction

Studied indicators	Pain assessment by VAS (points)		Strength of the flexor muscles of the lower leg (points)	Strength of the extensor muscles of the lower leg (points)	Estimation of the amplitude of movement (points)	
	At rest	Under loads			Flexion	Extension
Values of indicators	4.87±0.04	6.47±0.01	1.33±0.03	1.47±0.02	1,67±0,04	1,73±0,02

The program of functional recovery is designed for 4 weeks, included a comprehensive application of means and forms of physical rehabilitation.

The predominant importance in the recovery process of the amplitude-strength characteristics of the injured link of the musculoskeletal system was the use of physical exercises. Following general developmental exercises for all muscle groups, breathing exercises of a dynamic and static nature, special exercises for the injured link of the musculoskeletal system were used: passive, passive-active and active exercises performed with a free maximally possible

amplitude in the joints of the injured link, stretching exercises of a free and forced nature, exercises with a free and increasing amplitude in the joints of the injured link, exercises with gradually increasing resistance and weights, with subsequent relaxation of the loaded muscles.

At the beginning of the course, the exercises were performed with equipment that facilitates the performance of exercises (elastic expanders of varying degrees of rigidity, TRX loops, mechanotherapy devices), then the emphasis was placed on the correctness of the technique of performing exercises. After the restoration of the technical parameters of the structure of the exercises performed, further emphasis was placed on their complication by adding new elements, changing the initial position, conditions (unstable support, weights, reduction of the area and points of support, etc.) of the exercises, the use of equipment, etc. Successfully mastered elements were included in the technical elements of the main actions performed in boxing.

Exercises with a therapeutic and restorative purpose were used not only in the gyms, but also in the aquatic environment, in the form of hydro-kinesiotherapy, freestyle swimming with equipment, then with equipment and weights with a gradual increase in the distance covered.

After performing a training session or a set of exercises for therapeutic purposes, massage was applied to the muscles endured greater load in the training session, as well as the muscles of the injured segment. Along with this, athletes performed self-massage of muscles and joints after exercise and in the sets between them.

For fixing, limiting and anti-inflammatory purposes, kinesio taping of the injured link of the musculoskeletal system was used, the volume and technique of applying tapes were selected taking into account the individual characteristics of the functional state of the injured link of the musculoskeletal system of athletes.

Mechanotherapy, the use of block and pendulum type simulators aimed at restoring the amplitude of movement in the joints of the injured link (first free, then forced, with weights and resistance), the use of simulators (elliptical machine, stepper, exercise bike, rowing simulator, treadmill) were widely used. Elements and game exercises with a soccer ball were included, performed individually, in pairs and in small groups.

After the performed load, athletes were recommended a short rest in conditions of unloading the spine and an elevated injured link of the musculoskeletal system.

Meanwhile, we were solving tasks to restore impaired motor skills, professional skills with simultaneous recovery and development of physical qualities against the background of an increase in the functional state of the rehabilitated athlete.

The use of means and forms of physical rehabilitation was carried out under control not only in order to improve performance, but also to prevent physical overloads of the body of the injured link of the musculoskeletal system of athletes.

Results and discussion. After the physical rehabilitation program, boxers were retested the studied indicators (table 3).

There was a decrease in pain syndrome when performing loads, the results of pain assessment by VAS at rest significantly decreased (by 52%) from the initial values and, on average, amounted to 1.67±0.02 points, indicating only minor soreness. After the load, athletes identified an increase in pain, however, it reaches values of 4.87±0.03 points, which is (74%) below the initial values.

The reduction of pain in the knee joint of the injured limb is probably associated with the use of stretching, relaxation exercises, with the use of hydro kinesotherapy, therapeutic massage and self-massage, kinesio taping, which had an anti-edematous, anti-inflammatory, resorbing, regenerating effect.

Table 3

Comparison of the pain assessment results before and after the experiment

Indicators	X±σ		Difference in %	p<
	Before PR	After PR		
Assessment of pain at rest (points)	4.87±0.04	1.67±0.02	52	0.05
Assessment of pain during exercise (points)	6.47±0.01	4.87±0.03	74	0.05
Strength of the flexor muscles of the lower leg (points)	1.33±0.04	4.9±0.01	73	0.05
Strength of the extensor muscles of the lower leg (points)	1.47±0.02	4.8±0.01	69	0.05
Knee flexion amplitude (points)	1.67±0.04	3.0±0.02	58	0.05
Knee extension amplitude (points)	1.73±0.02	3.0±0.01	55	0.05

Note: PR – physical rehabilitation

There was an increase in the strength of the flexor (4.9±0.01 points) and extensor muscles of the lower leg (4.8±0.01 points), which reflects an increase in muscle strength endurance by 73% and 69% accordingly, approaching the values typical for normal muscle strength, estimated at 5 points in healthy athletes.

It should be noted that a significant increase in the strength of the flexor and extensor muscles of the lower limb is additionally due to a decrease in pain syndrome and symptoms of inflammation, which allowed athletes to cope with the load on the injured limb, close to the maximum (habitual training).

The amplitude of movement in the injured knee joint during flexion, on average, was 3.0±0.02 points, when extended – 3.0±0.01 points, increased by 58% and 55% respectively, and reached the normal values of movement in the knee joint.

The increase in the amplitude of movements is explained by the use of stretching exercises for muscles and ligaments, which increased the elasticity and, accordingly, the mobility (amplitude of movements) of the joint.

Conclusion. As a result of the application of a comprehensive physical rehabilitation program for boxers after the reconstruction of the anterior cruciate ligament of the knee joint at the stage of sports training, there is an improvement in the functional state of the injured link of the musculoskeletal system, reflected in a significant reduction of pain syndrome both at rest and under stress, in an increase in the amplitude of movements of the damaged joint and the strength of the flexor and extensor muscles of the lower leg. The restoration of the amplitude-strength characteristics of the knee joint after the anterior cruciate ligament reconstruction of against the background of a significant reduction in pain syndrome at rest and during physical loads makes it possible for athletes to transition to full-fledged training loads, which is the ultimate goal for the application of a comprehensive rehabilitation treatment program at the stage of sports training.

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