

Functional rehabilitation of the knee joint after cruciate ligament reconstruction in the football players – recovery in therapy room

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The objective of this study is to present the range of therapeutic exercises used in the recovery program of functional parameters of the knee joint in a group of 37 football players who suffered anterior cruciate ligament (ACL) reconstruction after the ACL rupture, without any associate lesions. *Material and method.* This paper is a prospective study over a period of 6 years, interval according March 2010 - May 2015, and refers to a group of 37 athletes, football players, from League I (12) League II (14) and League III (11), who suffered a knee injury resulting in acute complete rupture of the anterior cruciate ligament (ACL). Patients age limits were in the range of 18-35 years old. The right knee was affected in 23 (62%) patients and left knee in 14 (38%) patients. The recovery program included the recovery of preoperative 11 (28%) athletes and postoperative recovery to the whole group of athletes/patients. In this article we will refer to the stage of recovery, held in physical therapy room, physiotherapy exercises conducted targets for recovery and functional parameters of the knee joint. *Results and interpretation.* Assessing the evolution and progression at this stage of the recovery process was performed by self assessment, functional tests International Knee Documentation Committee (IKDC) subjective score, and objective tests, compared to healthy knee, thigh circumference measurement suprapatellar level, and isokinetic test. *Conclusion.* Prescribing progressively graded exercise therapy, postoperative in relation to the time elapsed since surgery, it is essential to protect the graft, and finally return to the level of performance athlete closer to the previous injury.

Key words: knee, ACL reconstruction, postoperative recovery, therapeutic exercises.

Introduction

Anterior cruciate ligament (ACL) injury is one of the most treaded injuries among football players. ACL tear in soccer, is quite frequent and they seriously affect players' career with short-term and long-term consequences (1-3). It has also been seen that ACL injuries are very invalidating events that require surgical treatments and keeps majority of soccer players out of competition at least four months every season (2, 4). The reconstruction after an anterior cruciate ligament (ACL) tear is one of the most common procedures among orthopedic surgeons around the globe. The rehabilitation protocol of the patients with an anterior cruciate ligament reconstruction (ACLR) is very important for a successful return to play, and the way we assess their improvement during this process is critical (5, 6).

Material and method

This paper is a prospective study over a period of 6 years, interval according March 2010 - September 2015. In total 57 athletes from different sports branches patients who have received treatment by the recovering knee arthroscopic consecutive reconstruction of the anterior cruciate ligament. We selected a total of 37 athletes, football players from League I (12), League II (14) and League III (11) who suffered acute trauma of the knee that lead to complete rupture of anterior cruciate ligament (ACL). Patient age limits were in the range 18-35 years, mean 25.5 years. Right knee was affected in 23 (62%) patients and left knee in 14 (38%) patients.

All patients were informed about the need for surgery for reconstruction of a neoligament and were explained in detail what the surgical procedure and protocol for the recovery of function knee operated stages of recovery and duration for the achievement of objectives. Arthroscopic surgery reconstruction of the

torn anterior cruciate ligament was performed by an orthopedic surgeon, physician with expertise in arthroscopy and sports traumatology with more than 10 years' experience.

Reconstruction of neoligament was made to all athletes by autologous grafts of muscle tendons gracilis and semitendinosus, using a graft mono fascicular "single bundle" 12 patients (32%) and graft bifascicular "single-bundle" 25 patients (68%) (7).

Post surgery rehabilitation program. Postoperative functional rehabilitation program was conducted over 24 weeks (6 months) and comprised two stages: - the first stage took place in the physical therapy room and included the time from the first postoperative day until 12-14 weeks; - the second stage took place on the football field and covered the range from 12 to 14 weeks - to resume sporting activity average 20 to 26 weeks. Each stage has aims physiotherapy exercises for recovery of several operating functional parameters of the knee joint. In this article we present protocol for functional recovery after ACL reconstruction of the knee joint in the first stage performed in the physical therapy room. The objectives of the first phase consisted in eliminate pain and inflammation restoring joint mobility, muscle strength, recovery proprioception and exercise capacity.

Stage functional recovery in physical therapy room (fig 1). For a sportsman to become competitive after anterior cruciate ligament reconstruction (ACLR), it is imperative to regain muscle strength and neuromuscular control lower limb affected, maintaining static stability of the joint. Thus, to achieve functional recovery in physical therapy room the emphasis is on regaining joint range of motion (ROM), normalize gait and quadriceps muscle activation, and restore static knee stability.

Functional recovery program applied by our team in the recovery room was focused on the following objectives: eliminate pain and inflammation, restore full knee extension motion, gradually progress knee flexion motion, maintain patellar mobility, restore volitional quad control, restore independent ambulation.

These objectives were achieved progressively in 3 phases: immediate postoperative phase (days 1-7), maximum protection phase (weeks 2-8) and moderate protection phase (weeks 8 -12). Each stage has aims physiotherapy exercises for recovery each operating parameter of the knee joint.

- *Phase 1. Immediate postoperative phase (days 1-7)*

Objectives were to eliminate pain and swelling, achieve full active knee extension equal to the uninvolved side, restore the ability to control the leg while weight bearing, achieve at least 125° of knee flexion, ability to lift the leg in all directions without assistance, normalize walking pattern with the assistance of crutches and/or brace.

Prior to leaving the operating room a knee immobilizer was applied to patient knee. The postoperative knee brace helps to maintain extension and is to be worn at all times while walking otherwise it can be removed. The patient will walk for two weeks with two crutches, and two weeks with one in the opposite arm. To achieve objectives of these phase we control of pain and inflammation and performing therapeutic exercises progressively applied in relation to the regression of pain and inflammation (8, 6).

Eliminate pain and swelling. To reduce swelling and pain, on patients knee injured applied an ice pack or gel for 20 minutes every hour, elevate leg with knee in full extension (knee must be above heart level) and a compression sleeve filled with ice cold water. Also we used ankle pumps exercises for decrease knee and leg swelling avoid blood pooling in the leg veins.

Restore full knee extension and progressive knee flexion motion exercises. 1) Patients began exercises with continuous passive motion (CPM) 0° - 120°, depending on the tolerance to pain, in two rounds of 1.30 hours per day. 2) Heel prop to straighten the knee. The patient lie on his back with a rolled up towel under the heel. 3) Prone Hang .4) Patellar mobilization.5) Passive range-of-motion (PROM). Flexion (bending) was obtained by doing the following exercises: passive knee bend of the knee to 90 degrees. The patient sit on the edge of a table and let the knee bend under the influence of gravity.

Develop muscle strength. Quadriceps Exercises. 1) Neuromuscular electrical stimulation COMPLEX device (fig. 1A). 2) Isometric contraction of the quadriceps muscle in three stations at different angles. 3) Straight leg raises (SLR).Started by doing these exercises while patient lying down. This exercise can be performed out of the brace when the leg can be held straight without sagging (quad lag).Once the patient have gained strength, straight leg exercises can be performed while seated. 4) Straight leg raises with a sand bag above the knee. 5) Resisted ankle plantar flexion with elastic band (fig. 1B).



Figure 1. The therapeutic exercises performed in the recovery room.

1A- Quadriceps Neuromuscular Electrical Stimulation. B- Ankle pumps. Sit on floor with both knees extended. Loop the middle of the band around the foot and grasp the ends of the band. Push the foot down against the resistance of the band. *C- Roller knee flexion.* Sit on a bench or chair and put your foot on a ball or a roller. Flex the knee to the maximum point and maintain the position for five seconds. *D- Heel slides.* The athlete lies on their back on a hard surface. The heel is slowly moved up towards the buttocks, as far as is comfortable (socks can be worn to ensure that the foot slides). A towel or strap wrapped around the ankle can be used to help in the very early stages. *E- Miniband isometric stations.* Sit on bench with a miniband around the ankles. Extend the knee and maintain the position 30 seconds. *F- Neuromuscular Electrical Stimulation Leg Extension. G and H- Medicine ball split squat on Togu Jumper (TOGU, Germany).* Place two Jumpers on the floor approximately 0.5 – 1 meter apart with the dome side up. Place one foot on each Jumper dome with the upper thigh of front leg parallel to the floor. With a medicine ball (3-5 kg.) in your hands make the split squat while the trunk execute an external rotation. Try to maintain your balance. *I- Medicine ball abs.* Lie on your back holding a medicine ball in front of your chest. Bend your knees slightly and curl your torso up so your upper body is at a 45° angle. This is your starting position. Maintain isometric position for trunk and make the bicycle maneuver. *J-Bulgarian squat.* Place one foot on the floor 1 meter in front of you and rest the instep of the other on the surface of a chair, bench, or bed. Balancing on your front foot, execute a split squat. *K- Isokinetic Test. L- TRX.* Simply kneel on a mat so that your knees are comfortable. Hold on to the TRX handles with your palms facing your thighs. While keeping your abs and core engaged and your arms straight, slowly extend your arms out in front of you. Move as far forwards as you can before you feel your lower back moving out of good alignment and hold at that position for a brief second before returning to the starting position.

- *Phase 2. Maximum protection phase (weeks 2 - 8)*

Objective: Maintain full extension. Achieve 100 – 120 degrees of flexion. Control swelling in the knee. Restore proper body alignment and control with basic movements, such as walking without assistance. Build lower extremity and body core strength.

Range of motion exercises. Achieve active range of motion equal to the uninvolved knee. 1) Patellar mobilization. 2) Knee flexion with the foot on a ball or a roller and maintain 5 seconds in maximum flexion (fig. 1C). 3) Heel prop with a sand bag above the kneecap. 4) Heel slides (fig. 1D). 5) Stationary bike in the 5-th week. 6) Hydrotherapy is also another therapy that the patient done during this phase to develop muscle strength and maintain range of motion. This program should continue until the patient have achieved a full range of motion and good muscular control of the leg (he should be able to walk without a limp)

Develop muscle strength. 1) Dynamic neuromuscular electrical stimulation (SLR sets with sand bag on the ankle). 2) SLR isometric stations with sand bag on the ankle. 3) Isometric sets with miniband (fig.1E). 4) Isometric sets on the wall squishing a sponge ball. 5) Calf raises.

Hamstrings. The hamstring muscles need about 6 weeks to heal, and excessive hamstring stretching during this period can result in a "pulled" hamstring muscle and increased pain. The hamstring muscles are exercised by pulling heel back producing a hamstring contraction. For our patients who have had ACL reconstruction using the hamstring tendons, we avoided excessive stretching of the hamstring muscles during the first 6 weeks after surgery.

Gait Drills. These drills should be done with slow controlled movement: forward high knee walk, backward high knee walk, forward high knee hurdler walk with hip circles, backward high knee hurdler walk with hip circles, side exercise that can be done during this phase to develop muscle strength and maintain range of motion.

Balance. In Phase 2 we can start simple exercises of balance and proprioception. Exercises that challenge different planes of balance will be emphasized, including: single leg balance, single leg balance involving arms, single leg balance with various head, arms, trunk and leg positions to challenge balance.

Independent Ambulation. Full knee extension is needed for normal gait. Exercises: diagonal weight shifting. The patient place his involved foot in front of the uninvolved foot, maintaining shoulder width distance between them. Start with all of his weight on the uninvolved foot. The involved leg should start in front of the other with only the heel contacting the ground. As shift weight towards the front foot, gradually let the entire foot come into contact with the ground and slightly flex the knee. Hold for 5 seconds and then return to the starting position. Do 2-3 sets of 15-20 repetitions.

Core stability. Abdominal muscles, low back muscles and pelvic stabilizing muscles are considered the patient core. Strong abdominals are important in every motion. The trunk and torso transfer and stabilize all forces generated by the upper and the lower body musculature. The core is the foundation in activities of daily living and in athletic movements.

- *Phase 3. Moderate protection phase (weeks 9 - 12)*

By week 6 the range of motion should be full extension to at least 135 degrees of flexion. Exercises conducted: 1) Quad sets, squats, calf raises, elliptical machine, leg presses and leg curls. 2) Hamstring reconstruction patients can start leg curls in a sitting position. If the patient develop hamstring pain, then decrease the amount of weight that he is lifting, otherwise he can increase the weight as tolerated. 3) Continue hydrotherapy program. 4) Start treadmill.

Range of Motion. If full range of motion has not been achieved by this phase, physical therapist may want to consider additional measures such as modalities or manual therapy to assist in regaining range of motion. Continue with stretching 6-8 times of 30 seconds for hamstrings and quadriceps.

Functional Strengthening. Start isotonic machines: Leg extension NMES (fig. 1F), isometric, eccentric, concentric). Leg Press (isometric, eccentric, concentric), leg curl, adductors, abductors, gluteus and body weight exercises: squats, split squat, Bulgarian squat (fig. 1J), step up, lateral lunge walk, forward lunge walk, calf raises (concentric and eccentric single leg), intrarotators.

Balance. In Phase 3, the focus will be on the development of balance and proprioception. Exercises that challenge different planes of balance will be emphasized, including: single leg toe raises, involving arms and legs, single leg balance, eyes closed, and single leg balance with various head, arm, trunk and leg positions to challenge balance. Then progress to dynamic both legs balance on an unstable surface (fig. 1G and 1H).

Core stability. Continue program for a better core stability with more challenging exercises: 1) Medicine ball (fig. 1I); 2) TRX (fig. 1L); 3) TRX Rip Training.

Results

According to International Knee Documentation Committee (IKDC), the following subjective and objective parameters were evaluated: subjective survey was used to evaluate pain, the range of motion activity, muscle deficiency, and isokinetic quadriceps muscle strength (9, 10). For pain assessment patients were asked to complete the questionnaire independently at the 4th and 12th weeks after surgery. The IKDC subjective survey evaluates both severity and frequency of pain on a scale of 0 to 10, with 0 being "no pain" and frequency as "never" and 10 being "worst pain imaginable" and "constant" frequency. The final total IKDC subjective scores for the study group compared with normative data is shown in table 1, which include the mean IKDC standardized score, showing the standard deviation above or below the population average.

Knee joint circumference measurements (cm) ± SD	Postop 1week			Postop 6 week			Postop 12 Week		
	patella midpoint	at 5cm over patella	at 15cm over patella	patella midpoint	at 5cm over patella	at 15cm over patella	patella midpoint	at 5cm over patella	at 15cm over patella
Involved knee	41.26± 2.57	46.12± 4.30	50.05± 4.35	38.77± 2.31	4.131± 3.65	50.08± 4.52	38.56± 2.12	42.45± 3.80	51.75± 4.51
Uninvolved knee	37.60± 2.33	41.76± 3.85	51.27± 4.64	37.64± 2.20	42.20± 3.68	52.23± 4.43	37.94± 2.06	43.29± 3.74	53.26± 4.28

Table 1. Range of motion (extension and flexion degrees) of the affected and unaffected knees between the 1-12 week postoperatively

The measurements of the range of movement (ROM) active and passive flexion, extension degree of the affected and unaffected knees were taken using a goniometer and were performed twice – at the end of the first week and the end of the twelfth week of surgery. The mean score of pain frequency significantly improved from 8.9 ± 3.3 points to 3.2 ± 2.8 points ($p < 0.008$). Similarly, the mean score for pain severity significantly improved from 6.1 ± 2.0 points to 2.4 ± 2.3 points ($p < 0.008$).

Muscle deficiency mass was measured with a metric tape. The measurements of circumference were made bilaterally at the level of the lower leg and thigh, at patella midpoint and 5-15 cm over patella. Results revealed significantly decreased and were close to the values obtained for the unaffected limbs (tab. 2).

Quadriceps muscle strength was evaluated by the athletic trainer with isokinetic strength testing performed at 90° and $180^\circ/\text{sec}$ after 12 weeks. Isokinetic test (fig. 1K) measures the strength in the extensor and flexor muscles. The value of MT (muscle torque) measured in Newton meters (Nm) of the involved and uninvolved knee was carried out at the end of the 12th week of rehabilitation on the isokinetic device Easy Tech Prima Doc. Prior to the measurement, a 10 minutes warm-up was performed on a treadmill, and another 10 minutes on elliptical. The strength test was performed 4 repetition at 90 degrees per seconds, and for endurance 20 repetition at 180 degrees per seconds.

The presented stages of physiotherapy are very useful in complex physiotherapeutic procedures following ACL reconstruction and provide the players an opportunity of return to the pre-injury sport activity (11-13).

Knee joint circumference measurements (cm) ± SD	Postop 1week			Postop 6 week			Postop 12 Week		
	patella midpoint	at 5cm over patella	at 15cm over patella	patella midpoint	at 5cm over patella	at 15cm over patella	patella midpoint	at 5cm over patella	at 15cm over patella
Involved knee	41.26± 2.57	46.12± 4.30	50.05± 4.35	38.77± 2.31	4.131± 3.65	50.08± 4.52	38.56± 2.12	42.45± 3.80	51.75± 4.51
Uninvolved knee	37.60± 2.33	41.76± 3.85	51.27± 4.64	37.64± 2.20	42.20± 3.68	52.23± 4.43	37.94± 2.06	43.29± 3.74	53.26± 4.28

Table 2. Knee joint circumference measurements

During this stages of rehabilitation (about 12 weeks) after ACL reconstruction, the players regained their full range of movements (ROM), baseline values of knee circumferences in the operated extremities and most of the kinematic parameters of gait which were then close to the values obtained for the unaffected knees. The results of this study show the effectiveness of a rehabilitation program that focused on increasing range of motion equal to the opposite normal knee, to improve subjective symptoms in patients with ACLR.

Conclusion

In our study post-operative rehabilitation begins the day after surgery. During the first stage of functional recovery in the physical therapy room done in three phases after ACL reconstruction. The patients from our study eliminate pain and inflammation, normalized circumference in the knee surgery, and exercises applied progressively, restore full knee extension, gradually progress knee flexion motion, maintained patellar mobility, restored volitional quad control and restored independent ambulation.

The results of this study showed the effectiveness of our rehabilitation program that focused on increasing range of motion equal to the opposite normal knee, to improve subjective symptoms in patients with ACLR. All patients accomplished the criteria for transition to the recovery phase on the playground for performing specific exercises of football game.

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