

## [ Sports Physical Therapy ]

# Clinical Outcomes and Return-to-Sports Participation of 50 Soccer Players After Anterior Cruciate Ligament Reconstruction Through a Sport-Specific Rehabilitation Protocol

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**Background:** Rehabilitation of soccer players after anterior cruciate ligament reconstruction is usually performed without sport-specific guidelines, and the final phases are often left to the team coaches. The possibility of changing this approach has not yet been investigated.

**Study Design:** Case series.

**Hypothesis:** A specific rehabilitation protocol for soccer players, with direct control of the last on-field rehabilitation phases, may lead to complete functional recovery.

**Methods:** Fifty competitive soccer players who followed a sport-specific rehabilitation protocol for soccer were evaluated during the recovery period until their return to competition. The assessment of the functional outcomes was performed using the Knee Outcome Survey–Sports Activity Scale and isokinetic and aerobic fitness tests.

**Results:** The average start of on-field rehabilitation was  $90 \pm 26$  days after surgery; the average time to return to the competitions was  $185 \pm 52$  days. The improvement in the Knee Outcome Survey–Sports Activity Scale during on-field rehabilitation was significant ( $P < 0.01$ ; from  $79 \pm 15\%$  to  $96 \pm 7\%$ ). The isokinetic and aerobic fitness tests showed a significant improvement of muscle strength (knee extensors,  $+55\%$ ,  $P < 0.01$ ; knee flexors,  $+86\%$ ,  $P < 0.01$ ) and aerobic threshold ( $+23\%$ ,  $P < 0.01$ ) from the beginning to the end of on-field rehabilitation.

**Conclusions:** Adding on-field rehabilitation to the traditional protocols after anterior cruciate ligament reconstruction may safely lead to complete functional recovery in soccer players.

**Keywords:** on-field rehabilitation, Anterior Cruciate Ligament reconstruction, clinical outcomes, return to sport

**A**nterior cruciate ligament (ACL) injury occurs frequently; more than 50% of the cases concern people who practice sports activities, particularly those between the ages of 15 and 25 years.<sup>19</sup> An ACL rupture can lead to a temporary or permanent disability. To return to athletic activities, especially in sports which require torsional, cutting, and jumping movements (eg, soccer, basketball), athletic individuals with ACL rupture often undergo reconstructive surgery.

Even though surgical techniques are very important, rehabilitation plays a recognized role in the recovery of full

function no matter what type of graft or fixation is used for ACL reconstruction.<sup>8</sup> The final goal in the treatment of sports injuries is to restore the function of a reconstructed ligament in a specific neuromuscular environment trained for a specific sport.<sup>11</sup> Thus, it seems suitable to consider surgery and rehabilitation together as a concept of functionally oriented treatment.

Many rehabilitation programs have been presented in the past 20 years, and relevant progresses have been made in terms of modalities and timing of recovery, leading to a faster return to

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sports activities after surgery.<sup>4,16,38</sup> However, most studies have examined several aspects of the acute postoperative period after ACL reconstruction, but such detailed attention rarely extends to the final phases of the rehabilitation program.<sup>2,4,23,31</sup> While medical attention is usually very high during the first months after surgery, it gradually diminishes when the patient returns to his or her first run on the field. The patient is thus often left to follow the advice of a coach or team trainer who is usually better prepared for training healthy athletes than patients recovering from surgery. Handling the final phases of rehabilitation this way can cause some problems, such as complications, relapses, or incomplete neuromuscular recovery.<sup>17</sup> Even if nothing negative occurs, the final phases of the rehabilitation of professional athletes are still risky and delicate<sup>31</sup> and are only remotely controlled by physicians and rehabilitation specialists. The aim of this study is to describe the recovery process and the times for reaching clinical and functional goals in a population of soccer players after ACL reconstructive surgery by following a specific rehabilitation protocol focused on the final phase of functional sport recovery.

## METHODS

### Participants

During a 2-year period, we retrospectively analyzed 50 consecutive soccer players aged  $23 \pm 6$  years (range, 16-37 years; 6 females and 44 males) after ACL reconstruction. Patients were enrolled in the study after providing written informed consent, and the study was approved by the local ethics committee. Inclusion criteria were as follows: (1) Patients had started rehabilitation in our clinics within 45 days of surgery; (2) patients had undergone surgery within 1 year of injury; (3) patients had completed all phases of the rehabilitation treatment (ie, gym, pool, and on-field sessions); and (4) patients had practiced competitive soccer. The patient population included 6 professional and 44 amateur soccer players; all patients had played before injury on structured teams at competitive-level practicing at least 3 days per week. Injuries occurred mostly while playing soccer (40 cases with contact injuries and 8 cases with noncontact injuries) or were caused by accidental falls (2 cases).

Reconstructive surgery was performed by 35 orthopaedic surgeons. In 36 cases, surgeries were semitendinosus-gracilis autografts; 11 additional cases were bone-patellar-bone autografts; and 3 were allografts (Achilles tendon grafts). Twenty patients (40%) had concomitant surgery (meniscus or articular cartilage debridement for grade I-II minor chondral lesions). Three patients had undergone previous surgery for ACL reconstruction on the index knee.

### Rehabilitation

After the first clinical examination following surgery, the patients started the rehabilitation program with gym and

pool sessions. These sessions included specific interventions addressing pain, swelling, range of motion (ROM), proprioception, strength, and aerobic fitness according to well-known protocols.<sup>3,13,25,28,38,41</sup> Early sport-specific patterns designed for soccer players were also performed to recover sport-specific neuromuscular skills.<sup>1,10,18,33</sup>

### On-Field Rehabilitation

The final phases of rehabilitation preceding the return to sport were performed by all patients on a soccer field (grass or synthetic field) under the control of an athletic trainer specifically trained and experienced in rehabilitation and sport recovery; we refer to this phase as *on-field rehabilitation* (OFR).

The criteria for starting OFR were as follows: no ligament instability on clinical tests (Lachman, anterior drawer, pivot-shift), no giving-way episodes during the preceding phases, minimal pain (visual analog scale < 3 out of 10), absence or minimal effusion (grade 0 or 0/1+), complete or nearly complete ROM (full extension, < 10° flexion deficit vs contralateral limb), and an isokinetic maximal peak torque deficit of less than 20% between limbs.<sup>29,31</sup> Patients also had to be able to run on the treadmill at 8 km per hour for more than 10 minutes.<sup>34</sup> The progression regarding the type and intensity of the exercises to reach these goals was based on function and not time.<sup>28</sup> Each OFR session lasted 90 minutes, 2 to 5 days a week. Each session took place outdoors on a grass field or indoors on a synthetic field, depending on the weather. The progression of each type of exercise followed the principles of strength training, conditioning, and increased functional demand<sup>12</sup> with respect to the musculoskeletal and neuromechanical components involved in the recovery process.

OFR for soccer players was divided into 5 phases, each characterized by well-defined, progressive, sport-specific exercises (Table 1). Patients progressed through the on-field phases when exercises of each phase were comfortable, coordinated, tolerable, and without swelling or decreased ROM. When these signs and symptoms occurred, patients were referred to a clinician to check the status of the knee and to decide how to progress with the rehabilitation.

### Clinical Examination

Clinical evaluations were performed at the beginning of the rehabilitation and every 2 to 4 weeks during the entire rehabilitation period. At every evaluation, ROM, pain, swelling, and functional status (eg, partial weightbearing with crutches, normal gait pattern, running) were assessed. ROM was assessed using a universal goniometer (30 cm) in a supine position on the examination table. Pain was assessed with a visual analog scale from 0 to 10, where 0 was defined as no pain and 10 as maximum pain. Effusion was evaluated by a stroke test with a 0-to-4 scale.<sup>9</sup>

Table 1. On-field phases.

Phase	Activity/Intensity	Progressive Sport-Specific Exercises	
1	Activity without ball	Confidence acquisition toward the environment and the ground	
		Running in place without shoes and global coordination exercises	
		Slow running in a straight line	
		Back jogging in a straight line and running patterns with low-speed variations	
		Advanced proprioceptive paths	
		Light jumps and landings	
	Activity with ball	None	
	Cardiovascular intensity	Aerobic	
2	Activity without ball	Proceed with running patterns and coordination exercises	
		Increasing difficulty and speed of proprioceptive paths	
		Increasing speed of straight-line running with “stop and go”	
		Circular running and skip exercises	
		Anaerobic threshold running for 8 minutes	
		Activity with ball	Begin to kick a soft soccerlike ball and run with it
	Cardiovascular intensity	Aerobic	
		Anaerobic (< 10% of the time)	
3	Activity without ball	Running at different speeds with slow changes of direction	
		Slow decelerations	
		Skips (different patterns), jumps, and land-offs associated with rotation	
		Anaerobic threshold running for 12 minutes	
		Activity with ball	Kicking ball exercises associated with lateral movements and jumps
			Technical and specific skill training, dribbling
	Cardiovascular intensity	Aerobic	
		Anaerobic (< 30% of the time)	
4	Activity without ball	Running with fast changes of direction on different proprioceptive paths	
		Anaerobic training with sprinting and fast change of direction	
		Decelerations	
		Anaerobic threshold running for 16 minutes	
		Activity with ball	Proceed with technical exercises with ball of phase 3
			Running with faster changes of direction on different proprioceptive paths
		Anaerobic training with sprinting and fast change of direction with ball	
		Small matches (3 vs 3, 1 vs 1), corner kicks, kick offs, etc	
	Cardiovascular intensity	Aerobic	
		Anaerobic (< 50% of the time)	
		Anaerobic alactacid	

*(continued)*

Table 1. (continued)

Phase	Activity/Intensity	Progressive Sport-Specific Exercises
5	Activity without ball	Proceed in running with sprints and changes of direction
		Acrobatic exercises with little obstacles
		High-intensity exercises
		Anaerobic threshold running for 20 minutes
	Activity with ball	High-intensity exercises in playing-like situations
		Maximal-intensity soccer matches (3 vs 3, 2 vs 2, 1 vs 1), power kicks, and tackling
	Cardiovascular intensity	Aerobic
		Anaerobic (> 50% of the time)
		Anaerobic lactacid

### Functional Assessment

Clinical and functional improvements were assessed through patient self-reported validated questionnaires and by muscular strength and aerobic fitness tests. All tests and questionnaires were administered at the onset of the OFR and at the end of the rehabilitation.

### Self-reported Knee Function

The self-assessment of knee function and performance was evaluated using the Knee Outcome Survey–Sports Activity Scale (KOS-SAS).<sup>24</sup> 12 questions on a 6-point Likert-type scale (from 0 to 5 points). The KOS-SAS scores were computed by dividing the number of points scored by the total possible number of points (60 maximal score for KOS-SAS) and multiplying by 100%. A higher value represents a higher level of function. The Italian version has undergone translation and back translation and has been approved by the author of the questionnaire.

### Isokinetic Muscular Strength Test

The strength of knee extensor and flexor muscles was measured in a sitting position using isokinetic dynamometers (Genu3 Easytech, Florence, Italy). After warm-up exercises, patients performed 4 maximal concentric strokes at an angular speed of 90° per second (knee extension flexion; ROM, 90°–0°). The side-to-side percentage deficit was calculated in the maximal peak torque for the knee extensor and knee flexor muscles. Isokinetic tests were performed when patients had no pain or swelling with ROM more than 120° of flexion with full extension. To ensure maximal effort, 3 to 4 training sessions were allowed before performing the test.

### Aerobic and Anaerobic Threshold Test

Aerobic fitness was assessed by an incremental treadmill running test, which started at 7 km per hour with speed increments of 2 km per hour every 3 minutes until the anaerobic threshold was reached.<sup>7</sup> Threshold was indicated by a capillary blood lactate concentration higher than 4 mmol/L (Lactate Analyzer YSI 1500 Sport, Yellow Spring Corporation, Yellow Spring, Ohio). At each step, we measured the heart rate (Sportester, Polar Electro, Kempele, Finland), and blood lactate concentration was taken (capillary samples from the ear lobe). Aerobic and anaerobic thresholds (2 and 4 mmol/L lactate, respectively) were then calculated in terms of speed and heart rate from the relationship between speed and lactate or between speed and heart rate; these thresholds were used to individualize the intensity of the training sessions.<sup>14</sup> The first aerobic fitness test was performed when patients exhibited resolution of joint pain and swelling, ROM more than 120° of flexion with full extension, and treadmill running at 8 km per hour for a minimum of 10 minutes (Table 2).

### Statistical Analysis

Clinical and functional data are presented as mean ± SD. Statistical analysis was performed using SPSS 10.0 with a paired *t* test to evaluate the difference between pre- and post-OFR values. Differences were considered significant at a probability level of 95% ( $P < 0.05$ ).

## RESULTS

The mean time elapsed between surgery and the beginning of rehabilitation was 17 ± 9 days (range, 4–42 days). The patients completed 60 ± 22 rehabilitation sessions (range, 27–135): 36

Table 2. Time to reach clinical and functional goals (in days).<sup>a</sup>

Clinical and Functional Goals	Days After Surgery	Range (Min-Max)	Coefficient of Variation %
Walking without limping	29 ± 8	13-48	28
Minimal or absent pain (visual analog scale < 3 of 10)	36 ± 29	3-141	81
Swelling resolution (grade 0 or 0/+1)	47 ± 23	8-94	49
Running on treadmill (8 km/hour for 10 minutes)	76 ± 26	41-139	34
Isokinetic test at start of on-field rehabilitation	87 ± 23	54-146	26
Start of on-field rehabilitation	90 ± 26	52-149	29
Full range of motion	91 ± 37	42-175	41
First aerobic fitness test	93 ± 37	50-165	40
Isokinetic test at end of on-field rehabilitation	138 ± 38	74-197	28
End of on-field rehabilitation	138 ± 33	74-204	24
Return to team	148 ± 36	84-218	24
Final aerobic fitness test	149 ± 35	98-214	24
Competition at the same preinjury level	185 ± 52	103-316	28

± 16 (60%) in the gym (range, 15-83), 11 ± 7 (18%) in the pool (range, 1-29), and 13 ± 7 (22%) in the field (range, 6-42). Minimal pain, swelling resolution, and full ROM were the goals showing the highest coefficient of variation (Table 2).

The KOS-SAS score after OFR increased significantly from 79% ± 15% to 96% ± 7% ( $t = 9.17$ ,  $P < 0.01$ ). The KOS-SAS score was divided into 4 categories: excellent (90%-100%), good (80%-89%), poor (70%-79%), and unsatisfactory (< 70%) (Table 3).

Before starting OFR, the isokinetic test showed a mean deficit in maximal peak torque between knee extensor of 12.5% ± 13.2% (range, 0-46) and between knee flexor of 6.9% ± 10.9% (range, 0-45). A maximal peak torque deficit greater than 20% in the operated limb was present in 13 patients for knee extensor and 5 patients for knee flexor. These patients continued the strengthening programs and performed control tests until they reduced the deficit below 20% before starting OFR. At the end of OFR, the mean value of knee extensor and knee flexor deficit decreased to 5.7% ± 9.0% (range 0-20,  $t = 4.79$ ,  $P < 0.01$ ) and 1.0% ± 2.3% (range 0-9,  $t = 3.15$ ,  $P < 0.05$ ), respectively. At the OFR initiation, the running speeds corresponding to the aerobic and anaerobic thresholds were 8.9 ± 1.6 km/h (range, 6.1-13.3 km/h) and 11.4 ± 1.6 km/h (range, 7.7-15.7 km/h), respectively. These speeds at the end of OFR significantly increased to 10.9 ± 1.7 km/h (range, 8.9-14.9 km/h,  $t = -6.96$ ,  $P < 0.01$ ) and 12.8 ± 1.4 km/h (range, 10.6-15.7 km/h,  $t = -5.21$ ,  $P < 0.01$ ), respectively. No significant differences

were noted in OFR beginning, final outcome, or sport recovery times between those with and without associated lesions or surgeries (Table 4).

A faster return to the teams ( $t = -2.3$ ,  $P < 0.05$ ) and to competition ( $t = -2.5$ ,  $P < 0.05$ ) was seen in the professionals. The final KOS-SAS score was similar in the 2 groups at the end of rehabilitation (Table 5).

Professional players completed a higher number of rehabilitation sessions compared with amateurs. The total number of sessions was 75 ± 37 (range, 45-135) and 57 ± 19 (range, 27-123), respectively. Professional players followed a daily rehabilitation program, while amateur players met 3 times per week.

We recorded 5 complications: 2 with associated lesions or surgeries (1 previous ACL reconstruction and 1 concomitant medial meniscus suture) and 3 in the other group. One female patient complained of subjective instability during OFR. After an additional neuromuscular program designed in accordance with Tyler and McHugh,<sup>42</sup> this patient played at 316 days. One patient did not achieve a full ROM (lack of 5° of hyperextension). Despite this, he scored 93 at the KOS-SAS, was able to complete OFR, and returned to competition within 178 days. Two patients had anterior knee pain before OFR; they returned to competition 139 and 200 days after surgery. One patient had a persistent strength deficit and waited 230 days before playing in official matches.

Table 3. Knee Outcome Survey–Sports Activity Scale before and after on-field rehabilitation, No. (%).

On-Field Rehabilitation	Excellent	Good	Poor	Unsatisfactory	Total
Before	11 (22)	15 (30)	14 (28)	10 (20)	50 (100)
After	41 (82)	6 (12)	2 (4)	1 (2)	50 (100)

Table 4. Comparison in on-field rehabilitation beginning, final outcome, and sport recovery times between the groups with and without associated surgeries or lesions.<sup>a</sup>

	Start of OFR, d	Return to Team, d	Competition at the Same Level Preinjury, d	Knee Outcome Survey–Sports Activity Scale, %	
				Start of OFR	Final
No associated lesions or surgeries (n = 30)	89 ± 25	146 ± 36	187 ± 52	78 ± 15	96 ± 8
Associated lesions and surgeries (n = 20)	91 ± 28	150 ± 37	180 ± 55	79 ± 16	95 ± 7

<sup>a</sup>OFR, on-field rehabilitation.

Table 5. Comparison in on-field rehabilitation beginning, final outcome, and sport recovery times between the groups of professional and amateur players.<sup>a</sup>

	Start of OFR, d	Return to Team, d	Competition at the Same Level Preinjury, d	Knee Outcome Survey–Sports Activity Scale, %	
				Start of OFR	Final
Professionals	81 ± 28	114 ± 31	139 ± 30	74 ± 9	96 ± 7
Amateurs	91 ± 26	152 ± 35	193 ± 51	79 ± 16	96 ± 7

<sup>a</sup>OFR, on-field rehabilitation.

## DISCUSSION

We described a rehabilitation protocol aimed to recover the full function in soccer players after ACL reconstruction. Particular attention was paid to the details of the final phases of rehabilitation that involved specific sport “reeducation.” The rehabilitation period can be divided into 2 parts. The first is conducted in the gym and swimming pool<sup>4,5,13,38,39</sup>; the second cannot be easily structured. This study introduced the OFR concept and proposed criteria for beginning OFR.

The functional criteria considered for starting OFR were a strength deficit lower than 20% in isokinetic maximal peak torque of the operated limb for both knee extensor and knee flexor and the capacity to run on a treadmill for more than 10 minutes at 8 km per hour without the appearance of pain, swelling, or decreased ROM. The latter goal was attained 2 weeks before starting OFR (Table 2) because aerobic conditioning may be started early with low-impact activities (eg, swimming, arm cranking, cycling, elliptical, uphill walking). In contrast, isokinetic strengthening safely

starts approximately  $8.7 \pm 1.7$  weeks after surgery.<sup>32</sup> A crucial characteristic of OFR is the cardiovascular intensity of each training session controlled by heart rate monitors established in advance of the incremental treadmill test. This allows the players to get an early start on a personalized aerobic conditioning program, allowing them to progress to the fitness level required for matches. This plays a relevant role in the rapid and successful return to competitive soccer.<sup>34</sup>

The KOS-SAS questionnaire is considered a good indicator of the overall patient outcome<sup>6,26,27</sup> to evaluate clinical and functional goals. The average KOS-SAS score after OFR improved significantly by 20%, with 82% of the results classified as excellent. Another study using the same scale in 206 consecutive ACL patients<sup>21</sup> showed a lower percentage of excellent results (49%), with 26% good, 10% poor, and 15% insufficient after 2 years of follow-up.

There are limitations to this study. Objective measurements of knee laxity were not performed. Patients were clinically examined before and after OFR sessions, and no laxity (negative Lachman and anterior drawer test) or other alterations of the knee function were reported. Another limitation was the wide range and frequency of sessions between patients. Professional players performed a higher total number of rehabilitation sessions and more frequent rehabilitation sessions and showed a faster recovery to sport activity. However, the rehabilitation protocol was based on specific functional goals instead of temporal criteria. Patients progressed through the rehabilitation phases on the basis of individual responses, leading to different times in the achievement of final goals and with a different number of sessions.

Medical and rehabilitation specialist supervision<sup>22</sup> during OFR can facilitate return to competition. OFR and its protocols help address the patient's fear of relapse, which is a common cause of poor performance in sports after ACL reconstruction.<sup>27</sup>

Clarifying what "return to sport" means is fundamental; the term allows for various interpretations. Not all studies agree on a single meaning, and the definition of functional recovery is still debated. Using the criterion of full knee function, Sauter et al<sup>37</sup> reported that patients returned to sports about 6 months after ACL reconstruction. Wilk et al<sup>43</sup> suggested that a return to athletic competition or cutting sports such as soccer occurs at 4 to 6 months. In Harner et al,<sup>20</sup> the average time for return to strenuous sports was 8.1 months with great variability. Similar results have been reported in a mail survey among orthopaedic surgeons<sup>30</sup> and in a review study.<sup>28</sup> A strict 3-step criteria set was adopted to address this issue. First, clinical evaluation and functional tests were used before starting OFR. Second, a standardized progression of on-field exercises was implemented, up to a level of physical fitness that allowed the athletes to return to their team (Table 1). Third, return to play occurred when the athlete competed with other athletes at the same level in official games. The injured players in this study returned to their teams within  $148 \pm 36$  days after surgery (range, 84-218 days) and to official competitions within  $185 \pm 52$  days (range, 103-316 days) (Table 2). In a retrospective

study performed on 38 soccer players competing in the Italian First 312 Division after ACL reconstruction,<sup>35</sup> players returned to official matches within  $231 \pm 134$  days (range, 77-791 days) after surgery. This wide range of time was independent of the arthroscopic technique utilized but dependent on the severity of the injuries and complications. In this standardized rehabilitation approach, no differences in the mean time of sport recovery were noted in the 2 groups (associated lesions or surgeries).

The multiple surgeons who performed the ACL reconstruction in our soccer player population should not be considered a limitation of the study but rather a strength. This rehabilitative protocol does not depend on the surgeon or the graft type, especially in the last phase of rehabilitation. This program represents a valuable addition to the rehabilitation specialist's treatment options after ACL reconstruction.

The FIFA (Federation Internationale de Football Association) has proposed the F-MARC test battery for physical performance in football (soccer) players. These tests provide normative data regarding warm-up, flexibility, soccer skills, power, speed, and endurance for healthy players and mean values for similar age groups and skill levels.<sup>36</sup> The player's profile may also be used by the physician and the physical therapist in monitoring the recovery after an injury. These tests will likely reconcile the main goal of surgeons (to obtain the safest return to sports for their patients) with the main goal of coaches (to obtain the fastest return to competition for their players).

## CONCLUSIONS

A standardized, medically supervised OFR program for soccer players based on measurable criteria instead of time frames can provide the basis for a complete functional recovery and return to team competition.<sup>15,40</sup>

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