INTRODUCTION

Exercise rehabilitation after anterior cruciate ligament (ACL) reconstruction has changed dramatically in recent years. Previous exercise rehabilitation programs required a period of 9-12 months to return to the sports field, because of the perceived need for a period of 8-10 weeks to perform limited range of motion (ROM) and full weight bearing. However, after Shelbourne et al. [1,2] introduced the accelerated rehabilitation program, the ability to return to the sports field within 4-6 months after ACL reconstruction became practical due to the implementation of immediate exercise rehabilitation that facilitated recovery of ROM and weight bearing (Table 1). In this review, we discuss recent changes in exercise programs related to ACL rehabilitation.

Accelerated rehabilitation program

The accelerated rehabilitation program, which allows patients to achieve full extension of the knee early in the postoperative period, is now a widely practiced rehabilitation program. A prospective study of rehabilitation programs after ACL reconstruction showed that early joint exercises do not interfere with the healing of grafts. Instead, they alleviate pain, thereby reducing the negative impact. Moreover, according to several biomechanical studies, open kinetic chain exercises are potentially disadvantageous to knee stability. There is no evidence that early weight bearing results in weakening of graft distraction or internal fixation compared with delayed weight bearing.

CONCLUSIONS:

In conclusion, prevention of ACL injuries and rehabilitative exercise training can help to achieve optimal exercise performance while avoiding the risk of sports-related injury.
chain exercises, restoration of dynamic stability of the joint through premature hamstring strengthening, proprioceptive functional training and neuromuscular rehabilitation, muscle strength training, and agility training [1]. Preferably, this accelerated rehabilitation exercise program is implemented in an individualized manner, according to the condition of the patient.

A prospective study of rehabilitation programs after ACL reconstruction showed that early joint exercises do not interfere with the healing of grafts or prevent the limitation of ROM. Instead, they alleviate pain, thereby reducing the negative impact [3-7]. Moreover, Jørgensen & Thomsen [8] reported that there is no evidence that early weight bearing results in weakening of graft distraction or internal fixation compared with delayed weight bearing.

Open kinetic chain and closed kinetic chain exercises
In one prospective study, Bynum et al. [9] reported anterior instability one year postoperatively and decreased patient satisfaction with open kinetic chain exercises compared with closed kinetic chain exercises [9]. However, other studies observed no difference between open and closed kinetic chain exercises [10-12]. According to these biomechanical studies, open kinetic chain exercises are potentially disadvantageous to knee stability, but the effects of their application remains controversial. Some prospective randomized controlled studies have compared home-based exercise rehabilitation with hospital-based rehabilitation centers and other rehabilitation centers. Although researchers were more involved, there was no significant difference in outcomes between the two groups [13-16].

**Returning to the sports field**
The recommended time for returning to the sports field has varied significantly based on largely different findings of various researchers. However, the researchers suggest the same preconditions for returning to the sports scene after surgery, such as restored ROM, disappearance of joint edema, isokinetic muscularkeletal test (unaffected side), muscle strength of quadriceps recovered to 80-90% full strength, muscle strength of hamstring recovered to 85-90% full strength, unininvolved in one-leg hop test, and the elapses after surgery during the 9-month postoperative period [17]. So far, we have discussed how rehabilitation is most effective after ACL injury; however, the innovative paradigm of future rehabilitation programs will require the development of preventive programs to prevent ACL injuries in advance.

**ACL injury prevention programs**
ACL injury prevention programs consist of programs for improving muscular training and exercise performance such as plyometrics, strength training, balance training, and resistance training [18]. The trained athletes are in-

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Table 1. Accelerated rehabilitation program

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<tr>
<th>Time after reconstruction</th>
<th>Rehabilitation program</th>
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<tr>
<td>Day 1</td>
<td>Continuous passive motion (CPM), rigid knee immobilizer in full extention for walking, weight bearing as tolerated without crutches</td>
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<tr>
<td>2-3 days</td>
<td>CPM, passive range of motion (ROM) 0° to 90°(emphasis on full extension), weight bearing as tolerated without crutches</td>
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<td>2-4 day</td>
<td>Discharge from hospital; CPM at home. Note: Prerequisite to discharge is 1) satisfactory pain management, 2) full extention symmetrical to non-operated knee, 3) able to do SLR for leg control, 4) full weight bearing with or without crutches</td>
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<td>7-10 day</td>
<td>ROM terminal extension, prone hangs (2 pounds) if patient has not achieved full extension, towel extension, wall slide, heel slides, active-assisted flexion, strengthening-knee, bends, step-ups, calf raise; weight bearing-partial to full weight bearing; gradual elimination of required use of knee immobilizer</td>
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<tr>
<td>2-3 weeks</td>
<td>ROM(0°-110°), unilateral knee bends, step-ups, calf raises, Stair Master 4000, weight room activities; leg press, quarter squats and calf raises in the squat rack, stationary bicycling, swimming, custom-made functional knee brace with no preset limits (to be used at all times out of the home for the next 4weeks)</td>
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<td>5-6 weeks</td>
<td>ROM(0°-130°), isokinetic evaluation with 20° block at 180 and 240 deg/sec. When strength is 70% or greater than the opposite un-operated knee, the patient can being lateral shuttles, cariocas, light jogging, jumping rope, agility drills, weight room activities, stationary bicycling, and swimming. Note: Functional brace discontinued (except for sports activities) when muscle tone and strength are sufficient.</td>
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<tr>
<td>10 weeks</td>
<td>Full ROM; isokinetic evaluation at 60, 180, and 240 deg/sec, KT 1000, increased agility workouts, sport-specific activities</td>
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<tr>
<td>16 weeks</td>
<td>Isokinetic evaluation, KT 1000, increased agility workouts</td>
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<tr>
<td>4-6 months</td>
<td>Return to full sports participation (if patient has met, criteria of full ROM, no effusion, good knee stability, and completed the running program)</td>
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structed by the trainer to perform biomechanically correct motions and receive feedback during and after the training [18]. The training protocol focuses on the practice of correct training techniques. Especially at the beginning of training, exercises should be performed with correct form. The trainer must be familiar with the correct training exercises and constantly encourage the athletes to perform the exercises with precise form. If the players are tired and unable to perform the exercises with correct form, the exercise training should be stopped.

CONCLUSIONS
In conclusion, prevention of ACL injuries and rehabilitative exercise training can help to achieve optimal exercise performance while avoiding the risk of sports-related injury.

Conflicts of interest
The authors declare no conflicts of interest.

REFERENCES