Return to Sports and Proprioception

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13.1 Introduction

The return to sport is one of the most important phase in the rehabilitation of sports injuries. Many protocols and guides have been published on when it should take place after the various sports injuries. When examining the return criteria to sports contained in these guides, it is seen that the return to sport is associated with many factors. The type of injury, injury severity, the level of sport, and the intrinsic and extrinsic risk factors that will cause reinjury are some of them [1]. Besides, psychological, ethical, social, and legal factors other than injury that may affect the return to sport may need to be considered. When all these factors are taken into account, the difficulty of establishing a standard model based on scientific evidence, covering all injuries and sports is obvious. Nevertheless, various models and algorithms have been defined that can guide the decision to return to sport based on evidence [1, 2].

"How much is the effect of the sense of proprioception on the decision to return to sport?" In order to be able to answer this question correctly, the components of the decision to return to sport must be well analyzed. In this section, the factors effecting to return to sport following sports injury and the place of proprioception in return to sport and its effect on reinjury were examined in detail.

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13.2 Evidence-Based Decision of Return to Sport

The return to sport, which is one of the main parts of the rehabilitation program after sports injuries, is one of the most important phases in terms of restoration of sportive performance. This phase of rehabilitation consists mainly of a variety of exercises based on strength, endurance, flexibility, agility, and restoration of reaction time. However, the sport-specific requirements that need to be improved are different for every athlete and injury. Therefore, the rehabilitation program needs to be designed and implemented individually. Perhaps the most critical decision on the return to sport is the timing of the return after injury. Timing is crucial to the risk of reinjury; therefore, efforts have been made to establish standards based on evidence to help ensuring that the decision to return to sport is given correctly [2]. It is defined that there are three basic evidence-based steps of the decision of the return to sport. These are: *Evaluation of health status, participation risk, and decision modification* [2].

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The first step, *evaluation of health status*, is to assess whether the patient's general health status has reached the normal state before injury. Undoubtedly, the key factor that affects the decision in this step is tissue damage and the correct assessment of how well the injured tissue healed. However, it is of utmost importance that what extent the improvement in the measured tissue damage in this period or the decrease of symptoms affect the athlete's functional ability. Therefore, evaluation of improvement performed at this stage contains the subjective outcome measures and functional tests to be performed in clinics or field. The second step is the *evaluation of participation risk*. What should be assessed at this stage is to analyze how much the specific requirements of the sport are met by the athlete. For example, the sport-specific requirements and sport-related expectations of a football player and swimmer with an anterior cruciate ligament injury are different. This difference can even be observed in players playing in different positions in the same sport. For example, the risk of participating in a sport following upper extremity injury may be different for a goalkeeper and midfielder. Similar differences are also affected by factors such as competition level and effectiveness of the use of protective equipment [2]. Therefore, it is a very important advantage that the clinician has a good understanding of the athlete's special position for that sport and knowledge of the sport features. The third stage that affects the decision to return to sports is *decision modifiers*. These are external factors that are usually independent of the medical condition of the athlete resulting from injury. The situations such as the condition of the contract of the athlete, expectation from his career, the occurrence timing of the injury (inside or outside the season), and pressure of a coach or manager are the basic examples for the factors that modifies decision for the return to sport. Sometimes these factors can be much more effective than it is predicted. For example, an athlete who has come to the end of his/her career and is perhaps on the brink of losing his/her biggest contract can take considerably bigger risk.

13.3 The Role of Proprioception in the Return to Sport

The requirements for high level sportive activity are defined as strength, power, endurance, flexibility, balance, proprioception, speed, and agility [3]. As it is seen, proprioception is defined as a requirement for top-class sporting performance. However, although proprioception is the primary criteria for the decision to return to sport, it is not usually tested as isolated in practical applications. There are two reasons for this: First, there is no gold standard in the tests used to measure proprioceptive performance. It is not possible to suggest that the joint position sense and kinesthesia tests frequently used in scientific studies are isolated and precise measurement of the proprioceptive sensation [4]. Furthermore, even conflicting results have been reported in joint position sensation and kinesthesia tests performed after injuries leading to loss of proprioceptors, such as tearing anterior cruciate ligament [5]. The second possible reason is that these tests require specific clinical or laboratory conditions and equipment that the environmental conditions are well controlled. This makes proprioceptive tests difficult to use widely in clinical decision to the return of sport.

Instead, the tests conducted at the first step of the decision to return to the sport usually consist of performance tests that measure basic functions [4]. For example, one of the most frequent functional tests following knee injury is the functional hop test. It was shown that the painless score of this test was one of the lower extremity performance indicators and especially correlated with the quadriceps muscle strength [6]. Similarly, functional performance tests based on muscular, endurance, flexibility, and agility are frequently applied when a decision to return to sport is given but proprioception is not measured isolated during this period. However, what should not be overlooked at this point is that not performing proprioception tests in the decision of return to sport does not mean proprioceptive sense is completely ignored.

Stability and balance-related tests that can be applied when a decision to return to sport is given has proprioceptive components as well [7]. Because, proprioception is one of the important factors required for successful ensuring of postural stabilization, neuromuscular control, and functional movement [8]. Long-term analyses of active athletes show that the application of exercise programs with integrated proprioceptive approaches to the training program has improved sportive performance parameters and reduced the incidence of injuries by up to 400% [9].

13.4 Proprioceptive Tests and Exercises in Return to Sport

The disturbances in kinematic components of the functional movements can be seen after lower extremity ligament injuries. These disorders also increase the risk of reinjury during sports and limit the achievement of optimal performance [10–14]. Testing all of the factors while deciding to return to sport following the lower extremity ligament injuries is the most important step that can be taken to reduce the risk of reinjury. It has been reported that testing of the joint position sense or kinesthesia would be beneficial in reducing the risk of injury [4, 15]. Although there is no consensus on a reliable method to objectively determine the proprioception [4], direct proprioceptive tests can be used to measure proprioceptive deficits resulting from injury during the return to sport. *Active reproduction* and *threshold to detection of passive movement* are the tests directly used for the proprioception and is most commonly used to determine joint position sense after injury. Electrogoniometers or isokinetic measuring devices are used for these tests to be valid and reliable [16, 17]. The impairments of the kinesthesia and active reproduction test scores are expected after various ligament injuries. Studies have revealed that knee joint position sense is not restored after ACL injuries [18, 19] and reconstruction [20–23].

Similarly, study conducted with meniscus abnormality has shown that knee angle reproduction capability significantly reduces in subjects with medial meniscus injury compared to healthy controls [24]. Therefore, although joint position tests are not included in the standard criteria of the return to sport, they may be useful for the decision to return to sport safely after ligament injuries and surgery [25].

Another evaluation method that can be used in relation to proprioceptive sense in the return to sport is postural stability tests. Since the proprioception is closely related to postural control, functional stability and balance tests may be used as a predictor of return to sport safely. Modified Star Excursion Balance Test (SEBT), one of the most frequently used tests, measures not only the dynamic stability and neuromuscular control [26–28] but also lower limb strength, coordination, balance, and flexibility [29–32]. Modified SEBT has high test-retest reliability [33–35] as well as it has been shown that it is able to distinguish dynamic balance and proprioceptive control strategies between the extremities following unilateral lower extremity injury [36]. It was reported that the athlete after ACL surgery showed poorer and worse performance in both injured and uninjured extremities compared to uninjured athletes [37]. Therefore, this test can also be preferred in the decision to return to the sport phase to determine the functional stability status after lower extremity injuries.

Another method that can be used to measure postural stability in connection with proprioception in the return to sport is to detect postural sway. Postural sway can be recorded during the test on the computerized balance board called stabilometer [4, 38]. It has been widely used in athletes with lower extremity ligament injuries and defects in the performance of the injured side have been showed [38–40]. However, the disadvantage of these tests compared to the isolated proprioceptive tests is that it is not possible to attribute the result completely to the proprioception due to the balance can be affected by various

parameters such as strength and flexibility as well as proprioceptive sense.

Although a valid and reliable proprioceptive test method is not described in the literature as a gold standard for the return to sport, it has been shown in studies that athlete should be tested proprioceptively before the return to sport. According to these test results, neuromuscular rehabilitation should be applied with proprioceptive education. These programs include training that allows the best postural response to sudden changes given in the sport, thus reducing the risk of reinjury [41]. The difficulty of exercise should be adjusted to the level of the athlete's neuromuscular control. It advances from low-density movements, usually concentrated on a single plane, to multi-planar high-density movements. Drills regarding to reflex activities that require rapid stabilization of the joints are used instead of planned and voluntary muscle activities [4, 42, 43].

It is the balance exercises that ignite the proprioceptive receptors. The most commonly used in clinics after lower extremity injuries is perturbation training on one foot in softer grounds with varying degrees of difficulty (Figs. 13.1 and 13.2).

In addition, leg press, squat, single leg hop, side and figure eight running, and crossover walking on unstable grounds will help improve joint neuromuscular control in more dynamic conditions. The most important point to be noticed during the vertical hop is to teach the right landing strategies. Exercises are often given as closed kinetic chain activity. This is due to the fact that limbs are used as a part of closed kinetic chains during sports and activities of daily living. Another reason is that mechanoreceptors can be stimulated more effectively during closed kinetic chains exercises [43]. In addition to these general stability exercises, sport-specific drills should be included. Such exercises help to reinforce the proprioceptive pathways that are specific to activities that the athletes may encounter in the return to sport [36]. At the same time, it provides application of sport-specific drills bearing the risk of reinjury in controlled conditions and will facilitate proprioceptive adaptation of the athlete to these conditions [4].

As a result, the decision to return to the sport is based on not only performance tests, but also social and psychological factors. Although proprioception is among performance-based multi-

Fig. 13.1 Basic balance exercises for lower extremity

Fig. 13.2 Postural stability exercises for upper extremity and trunk

factorial factors, studies show conflicting results on a reliable method to objectively determine the proprioception. Athletes can show significant proprioceptive deficit following sports injuries but there is no consensus how to use proprioceptive test during return to sports. Establishing evidence-based standards for the use of proprioceptive tests in the decision to return to the sport may contribute to reduce reinjury risk.

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