

Current Physiotherapy Approaches in Elite Athlete Injury Factors

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Introduction

Throughout history, sport has existed in various shapes and governed by diverse rules, adapting to each era of human development. In the early ages, sports included physical movements for various purposes such as hunting, preparation for war, protection of physical fitness, entertainment or play. As societies progressed culturally, transitioning from traditional frameworks to modern social systems, these activities experienced ongoing transformation, aligning with social and cultural evolution. As a consequence of this evolution, these physical activities, which were initially carried out with different goals, were organised within the framework of certain rules and became structured movements, which are now called sports. In this context, sport is as old and meaningful as the history of humanity (Çumralıgil and Görücü, 2007).

Engaging in physical activity and sports has numerous benefits for physical health, cognitive abilities, and overall life quality. Developing and sustaining appropriate sports habits is especially critical for young individuals. However, inadequate precautions can lead to injuries, as the physical demands of sports often result in injuries caused by both intrinsic and extrinsic factors. It is estimated that sports-related injuries make up approximately 14% of all cases that require medical attention. Nearly 6 million individuals seek medical treatment for such injuries annually, with 10% requiring at least a day's hospitalisation. Moreover, approximately 7,000 fatalities due to sports injuries occur each year (Kisser and Bauer, 2012).

These injuries can hinder athletes from pursuing their professional careers or make it challenging to regain their previous performance levels. Sports-related injuries are responsible for 30% of cases where athletes decide to leave sports entirely. In addition to threatening an athlete's career, such injuries can also have negative impacts on their physical and mental health.. Additionally, this issue imposes a considerable financial strain on the athlete, their club, and the nation (Cumps, Verhagen, Annemans & Meeusen, 2003).

Factors such as improper equipment use, unfavorable weather, uneven surfaces, excessive

physical load, and a history of previous injuries are known to increase the likelihood of future sports injuries. While tools like insoles, external joint supports, and balance boards have been shown to significantly reduce injury risks, the effectiveness of other practices, including warm-up exercises and stretching, still requires further scientific exploration (Leppanen et al., 2014; Tranaeus et al., 2015).

External factors like the condition of the playing surface, footwear, equipment, and the maintenance of sports facilities play a crucial role in the occurrence of sports injuries. For instance, studies have shown that harder field and grass surfaces elevate the risk of injury (Orchard, 2002). Additionally, risks may arise from issues like surface slipperiness, uneven terrain, and variations in grass length and type. Research also indicates that selecting footwear appropriate for the playing surface can significantly reduce injury risks. These external factors, while substantial, are modifiable and thus offer opportunities for injury prevention (Donaldson et al., 2003; Dobbins et al., 2006).

Athletes' individual traits, such as balance, flexibility, muscle strength, endurance, core stability, and proprioception, play a significant role in determining the risk of injury. To sustain performance and reduce injury likelihood, it is crucial for athletes to develop sufficient muscle strength, flexibility, and endurance tailored to their specific sport. Experts highlight the importance of designing scientifically based training programmes tailored to the athlete's physical attributes and needs, a responsibility that falls to health professionals and coaches (Sekendiz et al., 2007; Radwan et al., 2014).

In recent years, the growing young population has led to an increase in individuals participating in long-term physical activity and sports. However, without adequate precautions, the demands of high physical performance combined with internal and external factors heighten the risk of sports injuries. These injuries can disrupt healthy activity habits and strain individuals' financial conditions. Socially and economically, preventing sports injuries is more beneficial than addressing them after they occur. As a result, recognizing potential risk factors, creating preventive programs, and ensuring their execution are essential steps. (Verhagen & van Mechelen, 2010; Karabörklü & Çelik, 2018).

Risk Factors:

In general, risk factors that cause sports injuries are divided into two as internal (intrinsic) factors and external (extrinsic) factors.

Internal (Intrinsic) Factors

Athlete-related risk factors. These factors are

1. Age (training age),
 2. Gender,
 3. General health (previous injury, joint instability),
 4. Body composition (body mass index, fat mass, anthropometry),
 5. Physical structure (height, body weight, joint characteristics),
 6. Ability level (sport-specific technique, postural stability),
 7. Fitness status (muscle strength, max VO₂, range of motion),
 8. Neuromuscular and biomechanical factors (such as tibial rotation, dynamic foot pronation, trunk proprioception),
 9. Psychological factors (sense of competition, motivation, ability to cope with stress)
- (Bahr, 2005; Ergen, 2003).

External.(Extrinsic).Factors:

It relates to the interaction between the athlete and their environment.. Extrinsic factors; influencing the athlete's state from the moment they commence the activity:

1. Sport-related factors (sport branch, risk-taking time, opponent's condition),
2. Sport-specific equipment, protective equipment,
3. Sports fields,
4. Weather conditions (temperature, humidity),
5. Referee (game rules),
- 6.Trainer.(guidance,,behaviour) (Ergen,2003).

This book will explain the tests commonly used by physiotherapists in the clinic to examine biomechanical causes, focusing on both intrinsic and extrinsic factors.

Functional Movement Screening: The Functional Movement Screening (FMS) includes seven subtests designed to evaluate an individual's postural stability and functional movement asymmetries: deep squat, hurdle step, line lunge, shoulder mobility assessment, active straight-leg raise, trunk stability push-up, and rotational stability test. Each movement is performed three times, and the highest score is recorded.

The scoring system of the FMS consists of four levels:

- 3 points: Perfect execution of the movement with correct form.
- 2 points: Completion of the movement with compensatory movements.
- 1 point: Failure to perform the movement.
- 0 points: Pain during the movement.

The overall FMS score is determined by adding the results from each subtest, with a maximum possible total of 21 points. In tests involving bilateral movements (e.g. with the right and left leg), the lower score is added to the total score. During this assessment, movement errors, compensatory movements, mobility deficits and muscle imbalances are analysed (Minick et. al, 2010).

FMS has a certain threshold value, especially in predicting the risk of disability: A score below 14 points has been linked to an increased risk of injury. For instance, in a study of American football players, individuals scoring 14 or below have been reported to be at a higher risk of experiencing serious injuries. (Kiesel et. al, 2011). Nevertheless, the method's validity has been questioned because all movements are given equal weight, and the total score is accepted as an indicator of overall movement quality. (Kazman et. al, 2014).

Isokinetic Dynanometer: Isokinetic dynamometers are devices that measure muscle strength and imbalances and are widely used to evaluate muscle performance and rehabilitation processes (Dvir, 2004). These devices measure the force produced by the muscles while moving against a constant resistance at a certain speed, thus revealing maximum performance over the course of the full range of motion of the muscle (Cadore et. al, 2014). Isokinetic measurement systems play an important role, especially for the evaluation of athlete performance, analysis of muscle strength ratios and monitoring

of recovery in rehabilitation processes (Coudeyre et. al, 2016). A primary function of the device is that it can reliably analyse bilateral muscle differences, agonist/antagonist muscle ratios and performance changes during the rehabilitation process (Papadopoulos et. al, 2014). In addition, since it operates at constant speed, it minimises the risks that may arise from uncontrolled movement and the reliability of the results is increased as it provides standard test conditions (Dvir, 2004).

However, isokinetic dynamometers (AID), which traditionally focus on single joint movements, have functional limitations (Cadore et. al, 2014). For instance, it has been criticised for its inability to simulate multiple joint movements that occur in daily life or during sports (Coudeyre et. al, 2016). Multi-joint isokinetic dynamometers (MID), designed to address these limitations, enable the measurement of more complex movement patterns and can assess movements involving multiple joints working together, such as the hip-knee-ankle complex (Pijnappels et. al, 2008). These devices are especially preferred to minimize the risk of falls in elderly individuals (Bily et. al, 2016), to be used in the treatment of osteoarthritis (Coudeyre et. al, 2016) and to measure leg strength in athletes (Baur et. al, 2006).

Y-Balance Test (YBT): It was developed to evaluate the dynamic postural control of the individual (Plisky et. al, 2009). During the test, the participant stands on a platform with one leg while moving the other leg in three main directions (anterior, posterolateral and posteromedial) to reach the maximum distance. The participant's leg length is measured by determining the distance from the top of the hip (anterior superior iliac spine) to the inner ankle bone (medial malleolus), and this measurement is used to normalize the scores (Plisky et. al, 2006).

During the test, the participant must stand on one leg without losing balance, move the other leg correctly to reach the box in the specified direction and go back to the initial position. If the participant loses his/her balance, leans his/her foot on the moving box or pushes the box by kicking it, these attempts are invalidated. Before the test, each participant is given six practice trials to familiarise themselves with the movements, followed by three valid trials in three different directions and the best score in each direction is recorded (Hertel et. al, 2000). The distances reached are normalised to the participant's leg length and these scores are expressed as percentages. Finally, a 'composite score' is calculated by dividing the sum of the best scores in the three directions by the leg length; this score represents the overall balance and postural control capacity of the individual (Plisky et. al, 2006).

HRCT is an effective tool for assessing an individual's risk of lower limb injury. For instance, an asymmetry of 4 cm or more in the anterior direction is associated with an increased risk of injury in high school basketball players. Furthermore, a normalised composite score below 94% indicates a higher risk of injury (Plisky et. al, 2006). The results of the test have often been correlated with modifiable factors such as hip abduction and extension muscle strength, and thus can be used for both injury risk reduction and setting rehabilitation goals (Leetun et. al, 2004; Hubbard et. al, 2007; Khayambashi et. al 2016).

Biodex Balance System (BBS): BBS, offers different test protocols to assess the dynamic postural stability of individuals. During use, the individual stands on a moving platform and the stability level of the platform can be changed during the test. These levels can range from a stable surface to a highly unstable surface, with a total of eight different stability levels. The individual's ability to maintain balance is assessed by their

reaction to the movement of this platform (Parraca et. al, 2011; Pickerill and Harter, 2011; Cug and Wikstrom, 2014).

During the assessment, the individual is tested in various stance positions: open-eye on double legs, closed-eye on double legs, open-eye on single legs and closed-eye on single legs. The performance of maintaining balance in each situation is measured by the degree of deviations caused by the movements of the platform. The system evaluates metrics such as the Overall Stability Index (OSI), the Anterior-Posterior Stability Index (APSI), and the Medial-Lateral Stability Index (MLSI). OSI measures the total movement deviations on the platform, APSI determines the movement deviations in the sagittal (anterior-posterior) plane and MLSI determines the movement deviations in the frontal (lateral) plane. Higher values of these parameters indicate more movement and lower balance, while lower values indicate better stability (Winter et. al, 1990; Lee et. al, 2001, Cug and Wikstrom, 2014).

In the test procedures, three trials are performed for each position and each trial lasts 20 seconds. As a result, the three trials are averaged. Individuals are asked to keep their centre of gravity in a certain area on the platform to maintain their balance. During the test, the dominant leg of the individual is used for the assessment and a break period of 60 seconds is allowed between each trial. Whether the eyes are open or shut during the evaluation reveals the individual's dependence on visual cues. Especially when the eyes are closed, individuals need to use their proprioceptive (body position perception) senses more effectively, which provides important information about balance control (Parraca et. al, 2011; Cug and Wikstrom, 2014).

Weightbearing Lunge Test (WBLT): It is a practical and reliable test used to assess ankle dorsiflexion range of motion. The ability to dorsiflex the ankle is crucial for everyday tasks like walking, running, stair climbing, and transitioning between sitting and standing. (Powden et. al, 2015). This test differs from other measurement methods by better reflecting real-life functionality, especially due to its application in the weight-bearing position (Hoch and McKeon, 2011; O'Reilly et. al, 2017).

In the WBLT, the individual takes a lunge stance with bare feet and tries to bring the front knee closer to the wall, ensuring the heel remains flat on the ground (Langarika-Rocafort et. al, 2017). If the participant's knee does not reach the wall, the foot is gradually moved backward and the attempt is made again (Williams et al., 2013). When the maximum position is reached, the distance between the big toe and the wall is recorded (Chan et al., 2019). The test is performed on both the right and left foot, and the difference between the two sides is assessed (Padua et al., 2019).

This test plays a crucial role in rehabilitation and sports performance assessments by evaluating ankle range of motion in a weight-bearing position. The results provide insights into the individual's ankle function, help identify movement restrictions, and assist in guiding the treatment process. (Zhang et. al, 2020).

Single leg hop (SLH) Test: SLH is a simple test used to determine the likelihood of lower limb injury in athletes and to evaluate functional performance. The athlete jumps as far as possible while standing on one leg and must remain balanced for 2 seconds on landing. If the athlete fails to maintain balance, makes other jumps or places the other foot on the ground, the attempt is invalidated. The test is normalized to the athlete's height, or the symmetry index is determined by calculating the distinction in span between the two legs.(Brumitt et. al, 2013).

SLH has been investigated as a prognostic indicator for lower extremity injuries, such as anterior cruciate ligament (ACL) tears and ankle sprains, conditions that are notably prevalent among female collegiate athletes. (Hootman et. al, 2007; Kerr et. al, 2015). Five different prospective cohort studies have examined whether SLH predicts the injury risk of pre-sport season test results. Among these studies, only one indicated that SLH alone was significantly associated with injury risk. For example, a study by Brumitt et al. found a predisposition to ankle and foot injuries in athletes with a greater than 10 per cent difference in distance between the two legs, but no association with knee or thigh injuries.

Two other studies combined SLH with performance tests such as standing long jump and lower-extremity functional test (LEFT). These combinations offered better results in determining injury risk in some areas, such as knee and thigh injuries (Brumitt et. al, 2018; Brumitt et. al, 2019). For instance, athletes with an SLH distance of less than 64% of their height were found to have a greater likelihood of knee and thigh injuries. (Brumitt et. al, 2019).

However, the use of SLH testing alone in pre-sport season screening is based on limited evidence (Walbright et. al, 2017; Warren et. al, 2019). The applicability of the results is restricted because of the differences in protocols and methods employed across the studies. For example, in some studies, athletes kept their arms stationary during the jump, while in others they were released. In addition, some studies performed a pre-test warm-up while others skipped this process (Brumitt et. al, 2013; Walbright et. al, 2017; Warren et. al, 2019)). Such differences make the standardisation of SLH difficult.

Despite these limitations, the SLH test remains a low-cost, simple method that can be easily conducted in field settings.. In particular, it is widely used in return to sport decisions after injury (Noyes et. al 1991; Hegedus et. al, 2015). To better understand the role of SLH in predicting injury risk, future large-scale studies with more consistent protocols are required. (Knowles et. al, 2006; Bahr, 2009).

Drop-Jump Test: It is a technique created to evaluate the likelihood of ACL injury. It is based on athletes jumping from a certain height (usually 30 cm), landing on the ground and then performing a maximum vertical jump. In this process, the neuromuscular control levels and landing mechanics of the athletes are observed. In particular, risk factors such as dynamic knee valgus (inward collapse of the knees) are evaluated. Research has shown that a high dynamic knee valgus angle is directly related to ACL injury (Hewett et. al, 2005). This test is an important tool for the inclusion of athletes in injury prevention programmes by screening them with a low-cost and easily applicable method (Redler et. al, 2016). In variations with fatigue, fatigue has been found to increase dynamic knee valgus, further increasing the risk of injury Liederbach et. al 2014;. Behrens et. al, 2015).

Closed Kinetic Chain Upper Extremity Stability Test (CKCUEST): This is a performance test designed to assess the stability and strength of the upper extremity within a closed kinetic chain. The athlete begins in a push-up position, placing their hands on the ground at a specific distance. The test involves performing as many touches as possible with diagonal movements between the hands within a set time limit. (Borms et al., 2018; Declève et al., 2020).

In addition to measuring shoulder strength and stability, this test also assesses dynamic control and neuromuscular coordination of the upper limb. The results of the CKCUEST allow comparing the performance of athletes according to reference populations (e.g.,

sport branch, age, gender) (Borms et al., 2018). In addition, the test shows a moderate correlation with shoulder strength and stands out with its applicability in the field environment (Declève et al., 2020).

Results

More comprehensively risk factors in injury prevention strategies in athletes should include their internal and external factors. Internal factors include age, sex, body type, strength and flexibility, psychological factors, prior injuries and so on. The latter also encompasses things like looking at social or environmental factors such as the surface turned on or off, the type of equipment used, outdoor climate, and even the influence of a coach. These risk factors, and more importantly, how to mitigate their potential effects, constitute an invaluable aspect of the management of training and competition activities and protection of an athlete from trauma.

Such methods of assessment as Functional Movement Screening (FMS), isokinetic dynamometry, Y-Balance Test, and other tests for balance and stability allow researchers and in this instance coaches in particular to assess the age related physical shortcomings and movement deficiencies of the athletes. It is expected that once a loss of static or dynamic balance, associated with muscle imbalance and joint stiffness is diagnosed, training to rectify this specific problem will be possible. These devices are also useful in the evaluation of rehabilitation and reintegration of athletes into full weight bearing activities. In the area of sport injuries prevention, training devised by researchers is also multi-faceted and is supported by evidence and can be individualised according to the athlete. Warm-up and cool-down period including stretching and balance training have been found to suffice in injury prevention. Further also, internal attributes like proper quality of playing surfaces and correct types of footwear also assists in diminishing external hazards.

This helps the athlete in question to give optimum performance without compromising their health and their career duration and achievement in the long run. Finally, injury management in sports is a process which is complex and continues in nature where an emphasis is placed on the appropriate training of the athlete and reducing external factors and interdisciplinary strategies. Such practices ensure not only the physical and mental well-being of the athletes, but also enhancing the involvement in sports activities of any kind in a positive way.

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