

## Anterior Cruciate Ligament Injuries in Sports

**Daniel Ferreira Moreira Lobato\***

*Applied Physical Therapy Department, Federal University of Triangulo Mineiro, Brazil*

**\*Corresponding Author:** Daniel Ferreira Moreira Lobato, Applied Physical Therapy Department, Federal University of Triangulo Mineiro (UFTM), Uberaba, MG, Brazil.

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Sports are a common cause of injuries reaching about 30% of overall injuries in many countries [1,2]. It is believed that about 60% of these lesions involves the lower extremity joints [3]. These data lead many authors to consider sports injuries as a public health problem. In this sense, sports injuries should be extensively studied, from an epidemiological point of view, in order to recognize the risk factors involved. This is extremely relevant for help the clinician to elaborate prevention strategies against these lesions [4].

One of the most common lesions of the lower extremity is the anterior cruciate ligament (ACL) injury. Although the incidence of ACL injury is unknown [5], it is estimated that 350,000 ACL reconstructions (ACLRs) are performed annually in the USA. Despite surgical repair, approximately 79% of those individuals develop knee osteoarthritis (OA) and 20% suffer reinjury within 2 years [6]. Besides, athletes who suffer a knee injury prior to participation in a professional career have an eightfold increased risk of suffering another knee injury during their professional career [7] and one in four youths who suffer an ACL injury will suffer a second ACL injury again in their athletic career [8]. Thus, ACL lesions need to be better elucidated in order to reduce the immediate and delayed impacts on the athlete's health and on the health systems around the world.

The "ACL injury enigma" [9] stated that we can't prevent what we don't understand. In fact, we known that women have a four to six-fold increased risk of ACL injuries [10,11] and that there are anatomical [12,13], biomechanical/neuromuscular [13,14] and hormonal [15,16] factors which account for this greater female predisposition to ACL injuries. Considering that the last two categories are the only ones liable to conservative intervention [17], the focus of the studies has been on biomechanical/neuromuscular and hormonal factors [16,18].

An increased knee valgus angle during landing is one of the main causative factors for ACL injuries [16]. Dynamic knee valgus, described as a combination of hip adduction, hip internal rotation, and knee abduction is recognized as a common lower extremity alignment seen in non-contact ACL injury situations [11,13,18]. These studies suggested the importance of knee injury prevention for athletes who land with a greater dynamic knee valgus [13,19,20].

### Key topics in reducing risk factors to anterior cruciate ligament injuries

Previous studies [21,22] have suggested that a diminished capacity to attenuate the impact imposed on the body during the deceleration phase of landings is one of the factors that cause knee injuries, including injuries to the ACL. To prevent knee injury, the impact imposed on the body must be attenuated in the lower extremity joints in order to create soft landings.

Since knee and hip joints are the primary shock absorber during landings, dynamic knee valgus during landings may be one of the biomechanical factors that reduce an individual's capacity to attenuate the impact imposed on the knee joint during landings. In this context, Hewett, *et al.* (2010) [23] address four key points for reducing the risk of ACL injury: 1) Dynamic knee valgus ("ligament dominance"); 2) Landing with lower knee flexion ("quadriceps dominance"); 3) Bilateral asymmetries ("leg dominance") and 4) Trunk asymmetries ("trunk dominance").

Ligament dominance is characterized by use of anatomic (bony configuration and articular cartilage) and static stabilizers (ligaments) to absorb the ground reaction forces encountered during activity, rather than the use of the muscular prime movers of the lower extremity. In this condition, muscles do not sufficiently absorb the ground reaction forces, so the joint and the ligaments must absorb high amounts of force over a brief time period. High amounts of force sustained over a short period of time lead to higher impulse forces, which is what likely results in ligament rupture [23]. Thus, clinicians should emphasize training of the correct body alignment technique during landing (from a high position to a lower position alignment), in order to increase muscular demand, and decrease ligaments demand.

Quadriceps dominance refers to the tendency to stabilize the knee joint by primarily using the quadriceps muscles. Women appear to preferentially use the quadriceps more than males in order to stiffen and stabilize the knee joint. In addition, females tend to land from a jump with less knee flexion than males. The extended knee joint component of the injury mechanism relates to a neuromuscular imbalance that occurs in females that the authors term quadriceps dominance [23]. In this sense, clinicians should be able to modify the quadriceps dominance pattern, encouraging athletes to assume a posture with more hip and knee flexions during sports activities. In addition, they should emphasize the eccentric and concentric function of gluteal and hamstrings muscles, associating with trunk control exercises. At the end, they should encourage exercises that require the quadriceps-hamstrings muscle co-activation, as well as reduce the predominant activation of quadriceps muscles.

Leg dominance refers to the tendency to preferentially utilize one limb, in a pronounced manner, relative to the contralateral limb. In tasks that normally require side-to-side symmetry of the lower extremities, women tend to be more one-leg dominant than their male counterparts [23]. As result, those that have greater asymmetry in these aspects have greater risk of injury. In this sense, clinicians should be able to modify the athlete's leg dominance pattern, reducing functional asymmetries during exercises and sports tasks. Furthermore, they should to evaluate the athlete's movement in one limb and determine the bilateral symmetry index in functional and isokinetic tests (target > 90%). When an asymmetry is detected, discrepancy between members should be corrected by specific training.

Trunk dominance is defined as the inability to precisely control the trunk in three dimensional space. Those athletes, typically women, who do not adequately sense the position of their trunk in three-dimensional space, or allow greater movement following a perturbation or disturbance of their trunk, have greater risk of future knee, ligament, and ACL injury [23]. Thus, clinicians should modify trunk dominance and stimulate athlete's trunk control (CORE function) and sensoriomotor exercises [24]. In other words, clinicians should "to see very beyond the knee" and always consider the relationship between the CORE muscles and the movement of lower extremities.

Given the above, clinicians needs to identify muscular imbalances in order to optimize neuromuscular responses and to correct athlete's movements patterns. Altering the landing strategy in motor learning could change the load on the hip and knee joints and could be useful when considering movement strategies for landings by athletes with knee injuries such as ACL tears. As result, it was expected that clinicians could reduce the risk of ACL injury or reinjury in sports arena [13,25,26].

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