SASTA OLIPHANT SCIENCE AWARDS

Prize Winner

Science Writing

Year 9-10

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Avoiding Sports Injuries

Prevention of Anterior Cruciate Ligament Injuries in Sports

How significant is the anterior cruciate ligament?

The anterior cruciate ligament (ACL) is a band of connective tissues inside the knee joint that courses from the back of the femur to the front of the tibia (Figure 1) (Physiopedia 2019). Primarily composed of collagen fibres of 70% dry weight, the ACL exhibits a complex structural interplay, consisting of 90% Type I collagen and 10% Type III collagen, with its length approximately ranging from 27 to 38mm and its width from 10 to 12mm (Physiopedia 2019; Yoo and Marappa-Ganeshan 2023). The ACL plays a fundamental role in its functions to stabilise the knee joint through resisting excessive anterior tibial translations, managing internal tibial rotation loads, and controlling valgus angulation (Physiopedia 2019). The ACL can withstand forces of up to 500 pounds (Physiopedia 2017). Composed of two distinct bundles, the anteromedial and posterolateral, which are named after their respective points of tibial insertion, these bundles of the ACL cooperate to ensure stability and prevent injury throughout the knee range of motion (Figure 2) (Physiopedia 2017b). While the anteromedial bundle is predominantly responsible for resisting hyperflexion and regulating rotational laxity, the posterolateral bundle restricts hyperextension and contributes to controlling rotational movements (Amis 2012). The dynamic and complex functionality of the ACL is necessary for both daily movements and high-performance activities involving the knee, underscoring its significance in orthopaedics and sports medicine.

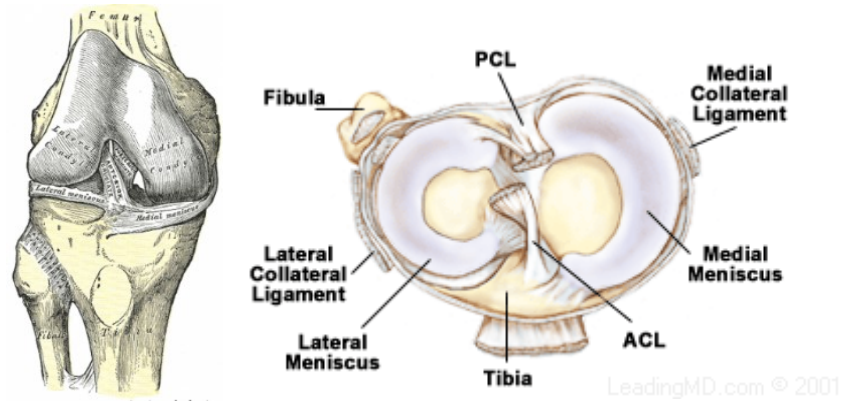

Figure 1. Anatomy of the anterior cruciate ligament. (Physiopedia 2019)

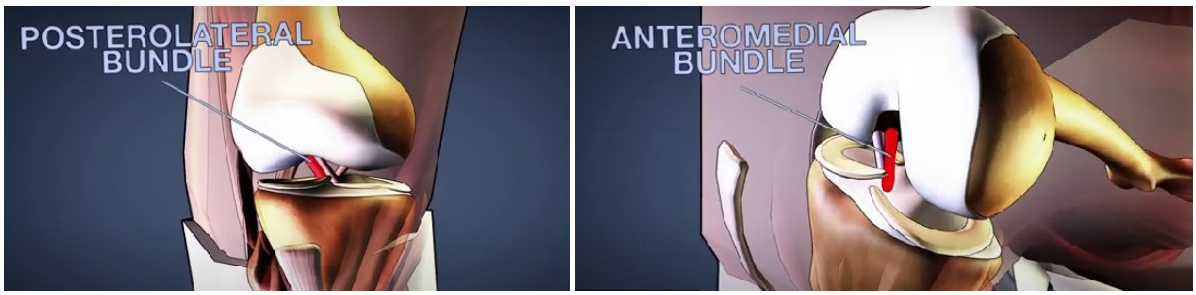

Figure 2. The anteromedial and posterolateral bundles of the ACL provide stability throughout the knee range of motion. (ReadySetMed 2014)

Nerve fibres from the posterior articular branches of the tibial nerve are essential for its proprioceptive function and supply the afferent arc for signalling variations in knee alignment. These nerve fibres penetrate the posterior joint capsule and travel along with the synovial peri-ligamentous vessels surrounding the ligament. Through feedback loops from stimulation of groups II or III fibres, deformations within the ligament, such as stretching or twisting, can influence the output of muscle spindles (sensory receptors) via the fusimotor system, which regulates the sensitivity of muscle spindles. This phenomenon is referred to as the ACL reflex, where motor activity in the muscles around the knee is affected by the activation of afferent nerve fibres in the ACL's proximal region. In the event of ACL injuries, the loss of the ACL reflex may result in knee muscle weakness. The complex interplay of homeostasis via a reflexive response to return deviations to normal range using nerve fibres in the ACL plays a crucial role in proprioception, which is the body's ability to sense its orientation and movement (Physiopedia 2019).

The ACL is primarily vascularized by the branches of the middle genicular artery, inferior genicular arteries, and diffusion through the synovial sheath of the ACL. The vascular supply contributes to the health and function of the ACL, ensuring adequate nourishment and thereby enhancing its capacity to provide stability to the knee joint (Physiopedia 2019).

Mechanism of ACL injury in sports

Injuries to the ACL are relatively prevalent in sports, particularly those associated with abrupt changes in direction or speed, pivoting, decelerating, and jumping, such as football, basketball, and netball (Physiopedia 2017a). In 2015–2020, the Australian High Performance Sports System records that a total of 132 ACL injuries constitute 6.4% of knee injuries, most commonly reported in netball, winter sports, basketball, field hockey, and gymnastics, of which 32 (25.8%) sustained a prior ACL injury, with 26 occurring to the ipsilateral knee and 6 to the contralateral knee (Rigg et al. 2023).

The mechanisms of an ACL injury are classified as direct contact, non-contact, and indirect contact, out of which non-contact tears and ruptures account for 70% while direct contact injuries account for 30% of the cases (Figure 3) (Physiopedia 2017a). Non-contact injuries are largely initiated by the forces generated within the body due to repeated sudden deceleration, landing, and pivoting manoeuvres, whereas direct contact ACL injuries are caused by direct external forces applied to the knee (Physiopedia 2017a). Contrastingly, indirect contact ACL results from an external force that is transferred indirectly to the knee joint, which involves an impact elsewhere, such as the tibia or femur. ACL injuries can vary in severity from minor sprains and tears to a completely torn ligament (Physiopedia 2017a). Modifiable risk factors predisposing to ACL injuries can be categorised as anatomical, biomechanical, and neuromuscular factors and should be understood to prevent ACL injuries (Wetters et al. 2016).

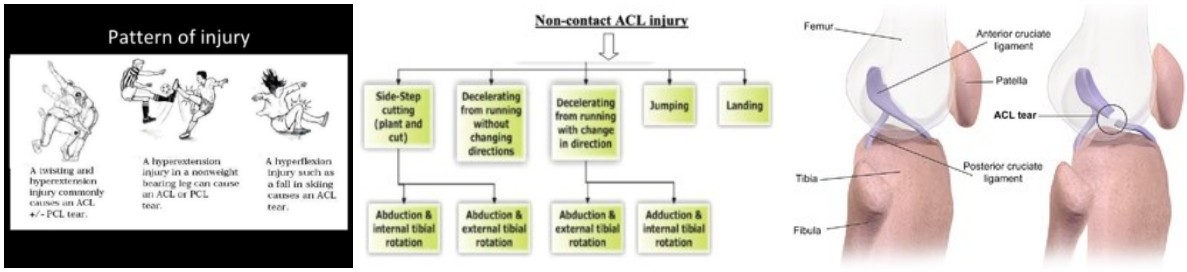

Figure 3. Mechanism of ACL injury in sports and ACL tear (Physiopedia 2017a)

Management of acute and chronic ACL injuries

Following acute soft tissue injury, treatment incorporating the RICE method, which includes rest, ice, compression, and elevation, is widely used for 48 to 72 hours This approach aims to reduce swelling, ease pain, and accelerate healing. As the knee should be rested in an elevated position with ice packs administered for 15 to 20 minutes every 2 to 3 hours during the first 24 to 48 hours after injury, weight-bearing activities are typically discouraged during the first two days of recovery. The injured individual should be referred to a healthcare professional for evaluation. Reconstruction surgery is common among athletes with a completely torn ACL. Consideration for surgeries is influenced by various factors, including the degree of knee instability, associated knee injuries, and socioeconomical aspects such as treatment cost. Additionally, the athlete's type of sports, age, and anticipated demands on the knee are considered in the decision making.

After ACL reconstruction surgery conducted by an orthopaedic surgeon, a rehabilitation programme supervised by a physiotherapist generally initiates with an early stage of protected mobilisation followed by strengthening exercises, and subsequently progresses to functional exercises, ensuring an optimum recovery. The journey of ACL rehabilitation normally takes six to nine months (Sports Medicine Australia 2024).

The timeframe between surgery and returning to play between eight to twelve months or more is recommended. Median time for return to sport following ACL injury in the Australian High Performance Sports System is one year (Rigg et al. 2023). There is no standardised protocol for return-to-play. However, clinical requirements must be fulfilled to ensure the safety of an athlete when resuming play. The performance criteria to return to sports include a negative Lachman or pivot shift test result, no pain or effusion, and adequate knee range of motion comparable to the contralateral knee. In addition, the athlete should be able to complete hop tests at over 85% to 90% of the performance of the contralateral knee with no signs of dynamic valgus, along with ability of jumping and landing such as the drop vertical jump (Sherman, Raines and Naclerio 2017).

Injury Prevention

ACL injury can pose a significant threat to an athlete's career to the extent of termination of career in severe cases. Following ACL reconstruction surgery, 82% manage to participate in sports but merely 44% return to competitive sports (Padua et al. 2018). ACL re-tear was reported in 14% of adults and

28% of males under the age of 18 (Sherman, Raines and Naclerio 2017). Notably, the risk of developing knee osteoarthritis after ACL injury is increased by 4 folds, with a prevalence of 10 to 90% within 10 to 20 years (Padua et al. 2018). Not only do ACL injuries lead to significantly chronic disability, but also impose a considerable strain on the health care system, including substantial financial costs incurred on the ACL reconstruction process (Padua et al. 2018, Arundale et al. 2023). As such, the prevalence, disability, and costs associated with ACL injuries warrant an urgent need for effective prevention strategies (Padua et al. 2018, Arundale et al. 2023).

Neuromuscular control serves a significant role in preventing injuries to the ACL and is considered the most modifiable risk factor. Neuromuscular-based injury prevention programmes allow athletes to continue sports participation while reducing the risk of ACL injury (Sherman, Raines and Naclerio 2017). Research shows that neuromuscular training improves dynamic knee stability and decreases noncontact ACL injuries in female athletes (Sherman, Raines and Naclerio 2017).

Multicomponent injury-prevention training programmes that involve strength, plyometrics, agility, balance, and flexibility, are implemented to reduce noncontact and indirect-contact ACL injuries (Padua et al. 2018, Arundale et al. 2023). These programmes are associated with enhancements in lower limb biomechanics, neuromuscular control encompassing coordination and muscle activation, functional performance such as strength, power, agility and speed, as well as a reduction in landing impact forces (Padua et al. 2018). Emphasis on these benefits can promote the long-term adoption of multicomponent injury-prevention training programmes by athletes and coaches. The effectiveness of these multicomponent injury-prevention training programmes has been analysed, revealing a significant reduction in ACL injuries by 51% to 62% (Padua et al. 2018).

There is no evidence to indicate the existence of one universally optimal preventive training programme (Padua et al. 2018, Arundale et al. 2023). Numerous prevention programmes are developed, each with variations in the type and order of exercises, intensity, repetitions, sets and duration. However, a study of meta-analyses reveals that two or more training sessions per week was found to reduce the risk of ACL injuries by 27% compared to a single session per week (Sugimoto et al. 2013). Collective studies indicate that multicomponent preventive training programmes should be performed 2–3 times per week for 20 minutes each session to achieve the minimum dosage required to decrease ACL injury occurrences (Padua et al. 2018, Arundale et al. 2023). Adhering to the recommended training frequency can lead to a reduction of up to 75% in ACL injury rates among females participating in high-risk sports such as basketball and soccer (Padua et al. 2018) The Royal United Hospitals Bath NHS Foundation Trust's (2022) multicomponent preventive training programme serves as an excellent example in this context (Table 1).

Table 1. Multicomponent injury-prevention training program (Royal United Hospitals Bath NHS Foundation Trust 2022)

Warmup (50 metres each)
- Jog in a straight line - Shuttle run - Backward running

Stretching (30 x 2 reps each) - Calf stretch - Quadriceps stretch - Hamstring stretch - Inner thigh stretch - Hip flexor stretch
Strengthening - Walking lunges (20 metres x 2 sets) - Bridging (3x10) - Russian hamstring (3 sets x 10 reps) - Single toe raises (30 reps on each side)
Plyometric (20 reps each) - Lateral hops over 2 to 6 inch cone - Forward / backward hops over 2 to 6 inch cone - Single leg hops over 2 to 6 inch cone - Vertical jumps with headers - Scissors jumps
Agilities - Shuttle run with forward / backward running (40 metres) - Diagonal run (40 metres) - Bounding run (40 – 50 metres)

Particularly among populations at higher risk, preventive training programmes should be integrated into athletes' pre- and in-season training regimens to effectively minimise the risk of severe ACL injuries (Padua et al. 2018, Arundale et al. 2023). Incorporating these programmes early on and maintaining these efforts through an individual's competitive years is recommended (Arundale et al. 2023). This approach allows for the optimisation of motor-learning principles and guarantees the sustained improvement of neuromuscular control, thereby reducing injury risk (Padua et al. 2018). Ongoing research and initiatives are necessary for the development of an optimal multicomponent injury-prevention training programme, which should be considered a mandatory component for all athletes.

Conclusion

The functionality of a healthy ACL is essential to cater for daily movements and high-performance sports involving the knee. There is high prevalence of ACL injuries in sports. ACL injuries may lead to long-term consequences and chronic disability along with high healthcare costs, therefore, effective injury prevention interventions involving multicomponent training programmes are necessary across all levels of sports to reduce the risk of ACL injuries.

Word Count

- 1570 words
- Headings, titles, figure captions, tables, and references are not included in the word count.

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