Proceedings of ICBioMed 2025 Symposium: AI for Healthcare: Advanced Medical Data Analytics and Smart Rehabilitation
DOI: 10.54254/2753-8818/2025.AU24092

# *The Relationship Between ACL Injury and Sports Performance of Basketball Players*

**Jingquan Zhang**

*School of Physical Education, Huazhong University of Science and Technology, Wuhan, China*
*m202475614@hust.edu.cn*

***Abstract:*** Anterior cruciate ligament (ACL) injuries are common and serious musculoskeletal injuries in basketball players, with significant impact on both performance and career. Basketball players are particularly susceptible to ACL ruptures, primarily through non-contact mechanisms, due to the frequent high-impact movements involved in the sport, such as rapid changes of direction, deceleration, and unstable landings. Recent evidence suggests that anatomical factors such as narrow intercondylar femoral notch width, increased posterior tibial tilt, and shortened ACL length are important factors in the risk of ACL injury. Clinical diagnosis of ACL injury is usually performed with a combination of manual examination and magnetic resonance imaging (MRI), and surgical reconstruction remains the standard of care to restore knee function to athletes. Postoperative outcomes depend largely on a systematic, long-term rehabilitation strategy aimed at improving muscle strength, neuromuscular control, and limb symmetry. In addition, psychological factors—particularly fear of re-injury and decreased self-efficacy—can significantly impact an athlete's ability to successfully return to competitive play. This article systematically reviews the epidemiological characteristics, anatomical risk factors of lower limbs, injury mechanisms, and diagnosis and rehabilitation strategies of ACL injuries. It focuses on the innovative perspective of quantitative analysis of the anatomical risk factors of ACL injuries in basketball players based on high-quality English literature in the past five years, and deeply discusses the impact of ACL injuries on the short-term and long-term sports performance of basketball players.

***Keywords:*** ACL injury, basketball athletes, anatomical risk factors, rehabilitation strategies, return to sport.

## 1. Introduction

Anterior cruciate ligament (ACL) injury is a common and serious injury among basketball players. Due to the high-intensity running, jumping, and rapid changes in direction frequently required in competitive basketball, athletes face a significantly higher risk of ACL injury compared to the general population—the annual incidence rate of ACL injuries among professional basketball players ranges from 0.21% to 3.67%, while it is only around 0.03% in the general population [1]. Another study also indicated that higher competition levels correlate with increased ACL injury rates: amateur athletes experience approximately 0.06 injuries per 1000 athlete exposures (AEs), semi-professional athletes 0.16 per 1000 AEs, and elite professional athletes up to 0.25 per 1000 AEs [2]. Additionally, gender differences significantly impact ACL injury rates. Female basketball athletes are reported to have an ACL injury risk 2 to 7 times higher than males [3]. NCAA data show that in competitive sports (such

DOI: 10.54254/2753-8818/2025.AU24092

as basketball and soccer), female athletes generally have a higher ACL tear incidence than their male counterparts, with female basketball athletes experiencing ACL injury rates around 0.29 per 1000 AEs compared to 0.08 per 1000 AEs for males, highlighting that women's basketball has a notably higher ACL injury rate [4]. These gender disparities are widely attributed to differences in anatomical structure, biomechanics, and hormonal factors. For example, the wider pelvis in females creates a greater quadriceps (Q-angle), increased ligament laxity, and differences in muscle strength distribution, all contributing to a higher risk of ACL injury [1].

## 1.1. Leg structure and ACL injury risk

The anterior cruciate ligament is composed of bundles of fibers originating from the posteromedial aspect of the lateral femoral condyle and inserting onto the anteromedial aspect of the tibial intercondylar eminence. It consists of an anteromedial bundle, which resists anterior tibial translation during knee flexion, and a posterolateral bundle, which provides rotational stability during knee extension [5]. These two fiber bundles dynamically regulate joint stability through coordinated tension during three-dimensional knee movements. From an anatomical perspective, the ACL is primarily composed of type I collagen (approximately 90%) and type III collagen, with its main blood supply coming from the middle genicular artery. It can withstand forces of up to 2200 N, providing substantial stability by preventing anterior tibial displacement relative to the femur [5].

The following table (Table 1) integrates key studies before 2020 and in the past five years that examined the relationship between lower limb structural parameters and ACL injury risk, with a focus on basketball players (if available). It also lists the author/year, sample and design, structural variables measured, and the main findings on the relationship between these variables and ACL injury risk for each study.

Table 1: Key studies before 2020 and representative studies in the past five years

| Study (Year) | Sample & Design | Structural Parameter(s) | Relationship to ACL Injury Risk |
|---|---|---|---|
| Shambaugh et al. (1991) [6] | 45 adult basketball players; prospective season-long cohort | Q-angle (static knee valgus angle) | Injured players had larger Q-angles on average (≥1 standard deviation higher) than non-injured, suggesting greater valgus alignment predisposes to injury |
| Stijak et al. (2008) [7] | 33 ACL-injured vs 33 matched controls; case-control (radiograph & MRI) | Posterior tibial slope (medial & lateral) | Steeper lateral tibial slope was found in the ACL-injured group (significant, P<0.001); medial slope was slightly lower in injured (n.s.) [7].Concluded high lateral PTS is a risk factor for ACL tear. |
| Souryal & Freeman (1993) [8] | 902 high-school athletes; 2-year prospective study | Femoral notch width index (radiographic) | Athletes who sustained non-contact ACL injuries had significantly smaller NWI (mean 0.189) vs uninjured (mean ~0.231) [8]. 71.4% of ACL injuries occurred in players with NWI ≥1 SD below mean, indicating narrow notch stenosis = higher risk[8]. |
| Myer et al. (2008) [9] | 19 female athletes with ACL tear vs 76 controls (from 1558 screened); case-control within prospective cohort | Knee joint laxity (anterior tibial translation; knee hyperextension) | Greater laxity strongly predicted ACL injury: Each +1.3 mm in anterior translation increased odds ~4-fold, and having knee hyperextension >5° increased odds ~5-fold [9]. Identified ligamentous laxity as a significant risk factor. |
| Nakase et al. (2020) [10] | 290 female high-school players (basketball & handball) (27 excluded); 3-year prospective cohort | General joint laxity; anterior knee laxity; femoral anteversion; etc. | Joint laxity not predictive: Baseline general laxity and anterior knee laxity were similar in injured vs uninjured (e.g. ~3.7 mm vs 4.0 mm, n.s.) [10]. Instead, other factors emerged (higher BMI, greater hip abductor strength, and smaller femoral anteversion were significant risk factors) [10]. |

DOI: 10.54254/2753-8818/2025.AU24092

Table 1: (continued)

| | | | |
|---|---|---|---|
| Li et al. (2020) [11] | Meta-analysis of 28 studies (n≈2700 total); MRI and radiograph measures | Femoral notch width (NW) and NWI | Confirmed notch stenosis risk: Pooled results showed significantly narrower NW in ACL-injured cases than controls (WMD ≈ 1.88 mm) [11]. Pooled NWI was also lower in ACL-injured (notably in male subgroups) [11]. Authors recommend extra preventive attention for athletes with a stenotic notch. |
| Hohmann et al. (2021) [12] | 325 adults (142 ACL-injured vs 183 controls; 82 men/60 women in injured group); retrospective MRI cohort | Medial & lateral posterior tibial slope (MRI-based) | Increased PTS = risk factor for ACL injury in both men and women (though absolute differences were small) [12]. |
| Gupta et al. (2022) [13] | 110 professional athletes (multi-sport, 44 M/11 F in each group); case-control MRI study | Notch width & index; tibial slope; ACL volume | ACL-injured athletes had narrower notch width (20.24±2.68 mm vs 22.04±2.56 mm) and lower NWI (0.29±0.03 vs 0.31±0.03) than controls [13]. ACL volume was also smaller in injured cases (1181.63±326 mm³ vs 1352.61±279.84 mm³) [13]. No significant difference in tibial slope between groups [13]. Concluded that a narrow notch and low ACL volume increase ACL injury risk, while slope was not associated in this sample. |
| Gültekin et al. (2023) [14] | 100 ACL-rupture patients vs 100 controls; case-control MRI study (adult athletes) | ACL length (ACLL) & width; ACL inclination angle; tibial slopes; notch dimensions; etc. | ACL-injured knees showed smaller ACL length and width, lower ACL inclination angle, and smaller notch width/index than controls (all $p<0.01$) [14]. Multivariate analysis found low ACL inclination angle (reflecting a shorter, more vertically oriented ACL) as an independent predictor of injury[14]. Although steeper lateral tibial plateau slope was significantly associated with ACL injury in univariate analysis, this association was no longer independently significant after controlling for other variables. |

Based on recent high-quality literature and previous research results, the academic community has reached a preliminary consensus on multiple structural risk factors: such as intercondylar notch stenosis [8,13], increased posterior tibial slope [12], smaller ACL volume or length [13,14], and increased knee laxity [9], which are all considered to be closely related to ACL injury. These anatomical features increase the likelihood of injury by affecting the movement path, force distribution, and stability of the ACL in the joint. Especially, in high-intensity, frequently changing-direction sports such as basketball, the role of related risk factors is particularly prominent. Studies have also pointed out that these structural differences are more common in women, which may explain the phenomenon that their ACL injury incidence is generally higher than that of men [10].

However, existing studies are still divided on some anatomical parameters. For example, while some studies have identified a larger Q angle as an important risk factor for ACL injury [6], other studies have failed to establish a consistent association. Therefore, the role of the Q angle in ACL injury risk remains a controversial topic. In addition, the structural risk effects between professional athletes and adolescent amateur groups are also different, indicating that functional factors such as neuromuscular control and sports exposure level may play a moderating role in anatomical risk [10].

Overall, the anatomical risk of ACL injury is a comprehensive result of multi-factor interaction and obvious individual differences, and needs to be evaluated in combination with multi-dimensional indicators.

DOI: 10.54254/2753-8818/2025.AU24092

## 1.2. Mechanisms of injury

In addition to anatomical factors, high-intensity movements or abnormal body postures in athletes commonly lead to ACL injuries. In basketball, most ACL injuries do not result directly from knee collisions but from athletes performing aggressive maneuvers such as rapid deceleration and twisting.

Non-contact ACL tears in basketball commonly occur during rapid changes of direction or during unstable landings [15]. Through video analysis, found that approximately 83% of ACL injuries occur in three primary scenarios: offensive cutting maneuvers (especially the initial step of driving to the basket, accounting for 47%), landing from a jump (such as landing after rebounding or shooting, accounting for 22%), and defensive lateral quick stops (such as abrupt direction changes during defense, accounting for 14%) [15]. These actions commonly feature sudden directional changes or high-impact landings that subject the knee joint to multidirectional stresses. At the moment of injury, the knee typically is slightly flexed, with insufficient forward trunk and hip flexion and inadequate plantar flexion at the ankle (flat-footed landing) [15]. Such landing or abrupt stopping without adequate muscular buffering support increases the likelihood of knee valgus (dynamic knee abduction) and abnormal anterior tibial displacement [15]. Significant knee valgus stress is observed in up to 75% of ACL injury cases [15]. Multiplanar mechanical stresses quickly exceed the ligament's load-bearing capacity, resulting in ACL rupture [15]. Generally speaking, ACL injuries result from combined sagittal-plane excessive anterior shear forces and rotational stresses from the frontal or horizontal planes.

Internal muscular contraction patterns also play critical roles. Studies have shown that when the knee is flexed at a small angle (e.g. <20°), forceful quadriceps contraction creates significant anterior tibial displacement, imposing tremendous strain on the ACL [16]. Especially during rapid stops or landings, a vigorous, active quadriceps contraction aimed at stabilizing the body while the knee is overly extended can instantly rupture the ACL [17]. Gene DeMorat et al. demonstrated in their study that simulating a quadriceps contraction of 4500 N at approximately 20° knee flexion resulted in nearly 20 mm anterior tibial translation, causing ACL fiber rupture in about half of their test specimens [17]. Strong contraction of the quadriceps at minimum knee flexion can cause anterior displacement of the tibia and may result in a tear or rupture of the ACL. This finding highlights that the quadriceps muscle is an important intrinsic factor in non-contact ACL injuries [17]. If, during such scenarios, the hamstrings fail to co-contract promptly and sufficiently counteract anterior tibial displacement, the ACL becomes highly susceptible to injury due to overload.

## 1.3. Major causes of ACL injuries

Causes of ACL injury can broadly be categorized into non-contact and contact injuries. In team sports like basketball, most ACL tears are non-contact injuries. Research indicates that approximately 70–75% of ACL ruptures in basketball are non-contact injuries (around 70.1% in males and 75.7% in females) [4], often occurring during rapid directional changes, abrupt deceleration, or landing after a jump [3]. A study analyzing video footage of ACL injuries among NBA players from 2006 to 2022 identified three primary scenarios most likely leading to ACL injuries: sudden initiation of offensive dribble maneuvers (especially during directional changes), single-leg landings following aerial collisions, and abrupt deceleration during jump-stops [18]. These movements place the knee joint under rotational and shear forces within a very short time. If body posture control is compromised—for example, excessive trunk forward or lateral tilt, or improper knee alignment—ACL injuries can readily occur due to mechanical overload [18]. Poor landing techniques also significantly increase ACL injury risk. Another prospective study showed that injured athletes exhibited increased knee abduction moments, higher ground reaction forces, shorter stance durations, and abnormal knee positions compared to uninjured counterparts [19]. By contrast, direct contact injuries leading to ACL

DOI: 10.54254/2753-8818/2025.AU24092

tears are less common. ACL injuries resulting directly from knee collisions, such as hyperextension or damage to medial knee structures due to a direct blow, are relatively rare. In studies of professional men's basketball, only about 3% of ACL injuries were attributed directly to collisions; most were due to non-contact or indirect-contact mechanisms [15]. Gill et al. reported that no ACL injuries resulted from direct knee impacts; instead, indirect-contact mechanisms—such as losing balance during aerial duels, awkward landing positions, or being pushed by an opponent leading to abnormal single-leg loading—were more common [18]. However, direct external forces causing excessive knee hyperextension or valgus stress can still cause ACL tears [3]. Typically, ACL injuries result from the interplay of multiple factors. Instantaneous incorrect movements leading to abnormal loading patterns (e.g., excessive knee valgus, inadequate knee flexion cushioning), improper body posture causing abnormal anatomical stress (e.g., ligament laxity, narrow femoral intercondylar notch), and inadequate muscle strength control (e.g., slower muscular response under fatigue conditions) can all contribute to injuries. Fatigue is notably an important external factor. One study examining NBA players' injury timing distribution found nearly two-thirds of ACL tears occurred in the second half of games, with approximately 40% occurring in the fourth quarter [20]. While statistical differences between the first and second half were not significant, this trend suggests that fatigue-induced loss of motor control and reduced knee stability could increase injury risk.

## 2. Diagnosis

### 2.1. Diagnostic process

When an ACL injury is suspected, a systematic diagnostic assessment should be promptly conducted. At the initial stage following acute injury or upon the first medical examination, clinicians generally evaluate ACL integrity using specific knee stability tests. Manual tests commonly used for rapid initial diagnosis include the Lachman test, anterior drawer test, and pivot shift test.

The Lachman test is widely recognized as one of the most reliable clinical methods for detecting ACL rupture due to its high sensitivity [21]. The Lachman test involves flexing the knee joint to approximately 30°, stabilizing the femur with one hand while pulling the tibia anteriorly with the other, and assessing the degree of anterior tibial displacement and endpoint firmness. An intact ACL limits tibial displacement and provides a clear, firm endpoint; a significantly displaced tibia with a soft endpoint indicates ACL rupture [3]. For acute complete ACL ruptures, the Lachman test has sensitivity ranging from 81%–86% and specificity above 90% [22], meaning most patients with ACL ruptures test positive with very few false positives. Because it requires minimal knee flexion and causes minimal pain, the Lachman test is easily performed in acute conditions, making it the preferred clinical test for ACL evaluation [22].

The Anterior Drawer Test is performed with the patient lying supine and the knee flexed at 90°. The examiner sits on the patient's foot to stabilize it, grasping the proximal tibia and pulling it anteriorly. An abnormal anterior tibial displacement greater than 6 mm without a firm endpoint suggests possible ACL rupture . However, this test has limited sensitivity in the acute phase due to pain-induced muscle spasm and guarding, which can lead to false negatives. Reported sensitivity for this test ranges from 38%–92% [22]. Thus, the Anterior Drawer Test is less valuable in acute diagnostics compared to the Lachman test but is more diagnostically significant in chronic ACL injuries when pain is less of an issue.

The Pivot Shift Test involves the patient lying relaxed and supine. The examiner internally rotates the lower leg, applies axial load, and gently pushes the proximal tibia from an anterolateral to posteromedial direction while slowly flexing the knee. If the ACL is ruptured, a sudden shift ("pivot shift") of the tibia from anterior to posterior occurs at around 30° knee flexion, signifying transient knee joint instability. The Pivot Shift test has high specificity for ACL instability, especially under anesthesia (sensitivity approximately 75%) [22]. However, its sensitivity in an awake state ranges from only 18%–48% [22], so its clinical application is mainly limited to preoperative evaluation or research purposes.

Recently, novel physical examination methods have been proposed, such as the Lever Sign Test (also known as the Lelli Test). This test is performed with the patient lying supine and the knee extended; the examiner places a fist beneath the calf at the proximal tibia (near the popliteal fossa) and presses downward on the distal femur with the other hand [23]. A normal knee will act as a lever, elevating the heel off the bed. If the ACL is completely ruptured, anterior tibial displacement prevents heel elevation, indicating a positive Lever sign [23]. Preliminary reports suggest that the sensitivity of the lever sign ranges from 94% to 100% [23], higher than traditional anterior drawer testing. Subsequent studies have shown that it has slightly lower sensitivity compared with Lachman (85% without anesthesia and 92% with anesthesia, compared with 94%–99% for Lachman). Therefore, Lever Sign testing is considered a useful adjunct to, but not a replacement for, the Lachman test.

Imaging modalities are also critical for diagnosing ACL injuries. Magnetic Resonance Imaging (MRI) is widely considered the gold standard for confirming anterior cruciate ligament (ACL) rupture, with a sensitivity of approximately 95.45%, a specificity of 91.67%, and an overall diagnostic accuracy of 94.87% [24]. MRI is widely used in clinical practice for suspected ACL injuries because it can fully evaluate the integrity of the ligament as well as associated soft tissue damage [3]. In addition, standard radiographs (X-rays) are also commonly used to exclude concurrent fractures or other bone injuries. Although X-rays cannot directly demonstrate ligament tears, they can reveal some suggestive indicators, such as tibial spine avulsion fractures or subtle cortical irregularities, which can raise suspicion of potential ACL injury. In emergency situations, radiographs are a rapid and cost-effective tool for emergency skeletal trauma diagnosis, while MRI can provide precise assessment of intra-articular structures. Arthroscopy is an invasive technique that allows direct visualization of the anterior cruciate ligament (ACL) and is usually used for treatment rather than diagnosis.

## 2.2. Advantages and limitations of diagnostic methods

Manual testing and imaging techniques each have their advantages and disadvantages, and combining these methods can optimize the accuracy and efficiency of ACL diagnosis. Manual testing has the advantage of being simple, rapid, and requiring no specialized equipment, allowing for a rapid initial assessment immediately following an injury. In the hands of experienced physicians, the Lachman test, anterior drawer test, and pivot shift test have high diagnostic accuracy. The Lachman test, in particular, has a high sensitivity for ACL ruptures [21]. Compared to expensive imaging procedures, manual testing is inexpensive and quickly executable. Studies comparing various diagnostic tools found no significant difference in positive rates between skilled clinical examinations (e.g., Lachman test and KT-1000 arthrometer testing) and MRI assessments, suggesting inexpensive manual testing alone can rapidly diagnose ACL injury without routine dependence on MRI [21]. Nevertheless, manual testing has limitations: acute knee swelling, pain-induced muscle guarding, or patient discomfort can cause false negatives. Additionally, the subjective nature of these tests requires extensive clinical experience to avoid misdiagnosis or exacerbating injuries.

MRI imaging offers the advantage of visual reliability, accurately identifying complete and partial ACL tears with high sensitivity (up to 97%) and specificity. It is considered one of the gold standards for definitive ACL injury diagnosis, clearly visualizing ligament integrity and identifying associated injuries such as meniscal and cartilage damage [3,21]. However, MRI has disadvantages, including high cost and equipment limitations that prevent immediate on-site examination. Furthermore, MRI may be less accurate in evaluating chronic ligament injuries or partial tears compared with direct arthroscopic visualization, and imaging quality may be compromised by metallic implants or other artifacts. Rarely, MRI may misinterpret complete ACL tears, reducing accuracy to about 82% [21].

DOI: 10.54254/2753-8818/2025.AU24092

Although X-rays cannot directly diagnose ligament injuries, they can quickly and economically detect associated bone injuries, thus ruling out the need for emergency intervention. However, X-rays cannot directly assess soft tissues.

In conclusion, optimal ACL injury diagnosis combines a high-quality clinical examination with appropriate imaging. Experienced sports medicine clinicians can reliably diagnose ACL injuries through clinical history and physical examination alone [21], subsequently utilizing MRI to confirm diagnoses and comprehensively evaluate knee structures to inform treatment planning. This strategy enhances diagnostic accuracy while balancing efficiency and cost-effectiveness.

## 3. Treatment

For basketball players and other high-demand athletes, surgical ACL reconstruction is commonly performed following complete ACL rupture, aiming to restore knee joint stability and prevent repetitive episodes of instability ("giving way") that negatively affect sports performance [25]. Recent data show a steady increase in the rate of ACL reconstructions, particularly among younger and female athletes, with the primary objective of restoring rotational and anterior stability of the knee to maintain long-term athletic performance [25]. Non-surgical (conservative) treatment is typically considered only for older patients with lower functional demands, or in cases of partial ACL tears where knee stability remains intact. However, even after rigorous muscle-strengthening rehabilitation, ACL-deficient knees remain at considerable risk during high-intensity directional changes. Therefore, ACL reconstruction is nearly always necessary for professional and elite basketball players. Surgery significantly reduces the risks of chronic instability and secondary meniscal injury, thereby offering athletes an opportunity to return successfully to competitive play.

Currently, ACL reconstruction commonly involves using autologous tendon grafts to replace the ruptured ligament. The bone-patellar tendon-bone (BPTB) autograft provides excellent initial stability due to robust bone-to-bone healing, secure fixation, and a low rate of recurrent rupture. However, postoperative complications may include anterior knee pain, discomfort during squatting, or kneeling pain. Alternatively, hamstring tendon autografts cause less trauma and less postoperative discomfort in the anterior knee and patellar region [26]. A meta-analysis comparing BPTB and hamstring tendon reconstructions found no significant differences between the two methods regarding knee stability and return-to-sport rates; both techniques effectively restore ACL function [26]. However, the hamstring tendon group experienced significantly lower rates of kneeling pain, anterior knee pain, and limited knee extension postoperatively [26]. Some studies suggest that young female athletes using hamstring tendon grafts may have increased risks of re-rupture due to smaller tendon size; in such cases, surgeons might prefer thicker grafts (e.g., patellar tendon) or additional lateral extra-articular stabilization techniques [1]. Although novel ACL repair methods have been explored for certain types of ligament injuries, such as those located near the bony insertion site, these techniques are still under development and currently see limited application in elite athletic populations. Therefore, anatomical ACL reconstruction remains the gold standard treatment for basketball players. Thus, anatomical ACL reconstruction remains the gold standard treatment for basketball players.

Surgical outcomes largely depend on postoperative rehabilitation and patient compliance. Generally, ACL reconstruction surgery achieves high success rates: if performed properly and followed by appropriate rehabilitation, over 90% of patients recover good knee stability and high subjective satisfaction [3]. Long-term follow-up studies indicate that most athletes return to competitive sports post-surgery. Re-rupture rates of reconstructed ligaments vary among populations—typically under 5% in the general population [3], though slightly higher among young, high-intensity athletes, emphasizing the need for secondary injury prevention. Overall, ACL

DOI: 10.54254/2753-8818/2025.AU24092

reconstruction surgery has become the gold standard in sports medicine for restoring knee joint stability, allowing many severely injured athletes to continue their professional careers.

## 4. Relationship with athletic performance

ACL tears significantly affect basketball players' athletic performance. Many studies have compared performance metrics and fitness tests of athletes before and after ACL injury, observing their recovery trajectories over time.

### 4.1. Performance differences before and after injury

Substantial evidence indicates that basketball athletes typically experience decreased performance levels immediately after returning to play following ACL reconstruction. For example, a study examining 26 NBA players who underwent ACL reconstruction between 2010 and 2019 reported that 84% successfully returned to NBA competition, with an average return time of approximately 372.5 days (about 12.4 months). However, in the first season after his comeback, the player's playing time and game data dropped significantly, and his participation in the game also dropped significantly, appearing in only 48.4% of games compared to 78.5% before injury, indicating that coaches are cautious about their use. Player Efficiency Rating (PER), a comprehensive measure of performance, declined by approximately 19.3% ($P = 0.0056$) during the first postoperative season compared to pre-injury levels [27]. Specific performance metrics also suffered: explosive power and agility were particularly affected, leading to reductions in points, rebounds, assists, and even shooting accuracy in some players [28]. For example, an early study by Busfield et al. analyzed 27 NBA players and found that post-injury shooting percentages were significantly lower than pre-injury performance [20]. Importantly, performance decline is most evident soon after injury, but many indicators gradually improve over time with continued rehabilitation and experience. Some NBA players perform close to their pre-injury levels in their second season post-injury. The previously mentioned NBA study indicated that by the second postoperative season, player game participation increased to 62.1%, nearing pre-injury levels, with PER and other key metrics no longer significantly different compared to their pre-injury status [27]. Thus, after roughly one year of adaptation, many athletes can recover close to their prior competitive condition. Similarly, studies of WNBA female basketball players reported that 78% returned to competition with only minor decreases in shooting percentages, steals, and other statistical categories [28].

In summary, ACL injuries typically result in a short-term decrease in athletic performance, but many athletes are able to recover over the long term gradually. Numerous factors influence the extent of recovery, including athlete age, pre-injury performance levels, surgical and rehabilitation quality, and team support. Nonetheless, there are individual differences; some players never regain their previous competitive level, especially if complications or repeated injuries occur.

### 4.2. Impact of recovery time on athletic performance

Return to play (RTP) timing post-ACL reconstruction is critical for athletes and teams due to its strong association with athletic performance and re-injury risk. Early return carries considerable risks and potential costs. Studies of young athletes (15–30 years old) indicate that the 9-month postoperative period is a crucial threshold: athletes returning within 9 months experienced approximately a 6.7-fold higher incidence of secondary ACL injury (either ipsilateral or contralateral) compared to those who delayed return beyond 9 months. Early return to high-intensity sports activities significantly increases re-rupture risk, negatively impacting long-term athletic careers [29]. Thus, despite some elite athletes attempting return around 6 months postoperatively after passing physical tests, an increasing number of medical teams recommend extending recovery to 9–12 months

DOI: 10.54254/2753-8818/2025.AU24092

[29] to ensure adequate biological ligament healing, muscular strength, and neuromuscular control, ultimately reducing recurrence risk.

Modern sports medicine guidelines employ objective functional benchmarks and testing standards to determine ACL rehabilitation progress. Ensuring athletes achieve pre-injury functional and technical levels before returning generally yields improved sports performance and reduced re-injury probability. Recent evidence-based reviews suggest basketball players meet specific key criteria before returning to competition[25],like shown in table 2.

Table 2: Key conditions for basketball players to return to play

| Criteria | Detailed Standards |
|---|---|
| Pain-Free | The patient should not experience pain during running, jumping, abrupt stopping, or directional changes relevant to basketball. Pain presence indicates incomplete tissue healing or functional impairment, thus premature return is not advisable. |
| No Instability or Fear | During basketball-related activities, the knee must not exhibit buckling or clear instability. Subjectively, the athlete should have no fear or insecurity regarding potential re-injury and should demonstrate confidence in fully performing all movements. |
| Normal Dynamic Function | The patient should have recovered normal gait and running patterns. Running and jumping actions should appear natural, without limping or abnormal movements, showing bilateral symmetry and coordination. |
| Muscle Strength Symmetry | Quadriceps and hamstring muscle strength in the injured limb should reach at least 90% of the healthy limb (LSI ≥ 90%). This can be confirmed via isokinetic testing or equivalent strength measurement methods to ensure adequate lower limb muscle strength support. |
| Functional Hop Test | The injured limb must achieve ≥ 90% of the strength of the healthy limb in a series of hop tests. These include single-leg vertical hops, distance hops, single-leg continuous hops (hop-stop), and side hops. Performance of the injured limb should not differ by more than 10% compared to the healthy limb. These tests assess explosive power and stability balance of the lower limb. |
| Drop Jump Assessment | During bilateral drop jump tests, there should be no visible knee valgus. The patient must maintain symmetry, stability, and a neutral knee position throughout the landing. Smooth and normal landing mechanics indicate appropriate neuromuscular control. |

The above criteria can serve as an important reference for athletes returning to play. Athletes who fail to meet these criteria should continue rehabilitation training to reduce the risk of re-injury. This review also found that only about 65% of ACL-reconstructed athletes who returned to sport followed some form of objective standard, while most lacked uniform standards [25], highlighting the practical significance of establishing clear criteria for return-to-play. Clinical experience has also demonstrated that strictly screened athletes who meet these standards before returning to play have significantly lower rates of secondary injury. For example, one study showed that athletes who passed most of the above tests before returning had significantly lower re-injury rates compared to those who prematurely returned without meeting functional benchmarks [29].

In summary, the saying “more haste, less speed” is particularly true in ACL rehabilitation, appropriately extending the recovery period and gradually improving competitive status are wise strategies for achieving stable performance and long-term sports longevity.

DOI: 10.54254/2753-8818/2025.AU24092

### 4.3. Long-term performance of athletes following ACL reconstruction

In the long term, basketball players who undergo ACL reconstruction still have opportunities to maintain a high-level competitive career, though their average career longevity and peak performance may be somewhat impacted. Several studies have tracked career length and performance post-ACL reconstruction. For instance, in the previously mentioned NBA study, the 26 injured players continued playing for an average of 3.36 additional seasons (approximately 3-4 years) after surgery [27]. Compared to the typical NBA career length (varies individually, typically 5-10 years), careers after ACL injury may be somewhat shorter. This may be because some players' competitive performance declines after injuries, gradually losing their competitive advantages and thus leaving the league prematurely. Nevertheless, many elite athletes still reach or even surpass their previous levels after ACL reconstruction and maintain top-level performance for many years, closely related to individual talent, quality of rehabilitation, and team support.

Statistical data indicate that around 80%–86% of NBA players successfully return to NBA competition post-ACL reconstruction, and if including other professional stages such as FIBA or NBA Development League, the overall return rate to professional basketball approaches approximately 98% [28]. This demonstrates that the vast majority of elite players who undergo ACL reconstruction can continue professional competition. For those who return to play, their post-injury performance typically follows a trend of initial decline followed by gradual recovery: performance metrics decline in the first year, rebound in the second, and, provided they avoid re-injury, stabilize in subsequent years [27]. Notably, some research comparing post-ACL players to uninjured control groups found a similar decline in performance over several years post-injury [28]. This suggests that performance decreases might partly relate to aging or normal performance fluctuations rather than solely resulting from the ACL injury itself. Thus, cases with less ideal post-injury performance should be assessed comprehensively and not entirely attributed to ACL injury alone.

Long-term follow-up should also monitor re-injuries and complications. Besides potential re-tear of the reconstructed ligament, athletes also face a risk of contralateral ACL injury. Literature reports indicate that the total risk of ACL re-injury on either knee within a few years post-surgery among young competitive athletes could reach approximately 20% (high-risk groups) [30]. Therefore, these athletes need to wear appropriate support devices or enhance their awareness of protection to protect their knee joints after resuming high-intensity activities. Additionally, long-term follow-up shows higher rates of knee osteoarthritis (OA) post-ACL reconstruction than in the general population, due to initial cartilage and meniscal injuries and long-term mechanical alterations post-surgery. Persistent issues like quadriceps weakness may further exacerbate joint degeneration [31].

### 4.4. Psychological issues and their relationship with athletic performance after ACL injury

ACL injuries and the rehabilitation process significantly impact athletes psychologically [32]. Immediately following an acute injury, athletes commonly experience shock, anxiety, and uncertainty about the future. During subsequent rehabilitation, prolonged absences from competition and monotonous training routines can further heighten psychological stress. Research indicates that ACL rupture can trigger pronounced psychological responses, including fear of reinjury (kinesiophobia), reduced self-confidence, frustration, and depression [33]. Many athletes worry, "Will my knee ever be the same as before?" Such fears can lead to hesitation during rehabilitation exercises or altered movement patterns when athletes return to play. These psychological factors have aptly been described as the "invisible injuries" after ACL damage.

One survey showed that only about 54% of ACL reconstruction patients eventually returned to their pre-injury competitive level, with psychological barriers being the main reason for those who do not return [34]. Most notably, fears surrounding reinjury and concerns about pain significantly impact their recovery [34]. This subconscious fear often drives athletes to avoid high-intensity exercise, and even when they are physically able, they may be reluctant to attempt activities that previously resulted in injury [34]. Therefore, strong self-efficacy and lower fear of reinjury are crucial factors for optimal recovery after ACL reconstruction (ACL-R) [35]. Another study showed that, even when functional recovery was good, psychological state often determined whether athletes chose to return to high-level competition. Statistics from that study revealed that, despite 90% of ACL postoperative athletes having nearly normal objective functional evaluations, only 44% genuinely returned to their original competitive levels [36]. This implies that a significant number of athletes may give up competing at the elite level for psychological reasons—some choosing to compete in lower intensity competitions, while others retire from competitive sport altogether.

## 5. Muscle impacts after ACL injuries

ACL injuries affect not only affects the ligament itself, but can also severely impact the surrounding muscles, particularly the quadriceps, hamstrings, and calf muscle groups. Psychological factors during the post-injury and recovery phase often lead to muscle atrophy and loss of strength. Changes in muscle function are both consequences of injury and obstacles to overcome during rehabilitation.

The quadriceps muscle (anterior thigh muscles) is usually the most affected muscle group. Shortly after ACL rupture, patients often experience quadriceps inhibition, characterized by difficulty voluntarily contracting the thigh muscle and knee weakness. This phenomenon partially arises from joint sensory inhibition caused by pain and effusion (joint proprioceptive input inhibiting quadriceps reflexive contraction) [37]. Even with surgical reconstruction and conventional rehabilitation, complete recovery of quadriceps strength typically requires considerable time. Studies indicate that around six months post-surgery, the quadriceps strength of the injured limb is still about 23% lower than that of the healthy limb on average. Even after one year, the difference is still around 14%, which is not enough to achieve ideal symmetry [31]. Numerous studies and clinical experience have shown that persistent quadriceps atrophy and weakness post-ACL surgery is a common problem [38]. This strength deficit not only limits athletic performance (such as decreased jumping ability) but is also considered a factor increasing future risks of knee degeneration and osteoarthritis due to abnormal knee load distribution [31]. Therefore, rehabilitation programs emphasize quadriceps activation and strengthening, aiming to reduce bilateral differences to within 10%, which is regarded as an essential criterion for returning to sport [31].

The hamstrings play a critical role in knee joint activity, contracting to help limit anterior tibial translation, serving as dynamic stabilizers assisting the ACL. Therefore, prevention and rehabilitation frequently emphasize strengthening hamstrings to balance quadriceps forces [1]. After ACL injury, the hamstrings may weaken due to disuse, but generally recover faster than quadriceps. Many rehabilitation exercises inherently involve the hamstrings to stabilize the knee joint. Furthermore, if hamstring tendons are harvested as grafts, strength temporarily decreases, but most patients regain pre-injury strength after months of compensation. Studies show that after ACL surgery, both knee extensors and flexors (quadriceps and hamstrings) weaken in the injured limb, impairing knee stability [39]. Muscle imbalance (such as strong quadriceps versus relatively weak hamstrings, resulting in a low H/Q ratio) is considered a risk factor for ACL re-injury. Hence, balanced quadriceps and hamstring strength training is essential.

The calf muscles are often overlooked but can also be affected by ACL injuries. The posterior calf primarily includes the gastrocnemius and soleus muscles. Both attach via the Achilles tendon to the heel but differ in knee stabilization roles. The gastrocnemius crosses the knee, potentially pushing the tibia forward upon contraction, thus acting antagonistically to the ACL [40,16]; the soleus, which attaches only to the tibia, pulls the tibia backward when the foot is grounded, acting as a synergistic stabilizer assisting the ACL [16]. Research concludes: "the gastrocnemius antagonizes ACL load,

DOI: 10.54254/2753-8818/2025.AU24092

whereas the soleus synergistically stabilizes it" [40,16]. Thus, calf strengthening, especially of the soleus muscle, is essential in ACL rehabilitation.

Hip muscles (e.g., gluteus maximus, iliopsoas) may also indirectly be affected, changing lower limb mechanics after ACL injury. Studies report decreased strength in hip flexors and hip adductors post-surgery [39], suggesting the need for comprehensive lower limb muscle rehabilitation.

In summary, ACL injury and reconstruction have a significant impact on lower limb muscle strength and control ability, especially quadriceps weakness, emphasizing targeted rehabilitation exercises to achieve comprehensive muscle recovery and knee stability recovery. Thus, ACL injury and reconstruction significantly affect lower limb muscular strength and control. Quadriceps weakness is the most prominent problem, hamstring function is critical for knee stability, and the calf and hip muscles also need attention. Rehabilitation programs should specifically target these muscular changes, for example, emphasizing early quadriceps activation training and electrical stimulation to prevent disuse atrophy. In the mid-to-late stages, coordinated strengthening of the quadriceps and hamstrings and improvement of proprioception are necessary to compensate for ligamentous proprioceptive deficits. Only when muscle strength and coordination return to near-normal can the knee maintain stability under high-intensity activities, enabling athletes to return to competition and achieve optimal performance.

## 6. Conclusion

The impact of ACL injuries and rehabilitation on basketball players' performance is complex and significant. Through the analysis presented above—including epidemiology, diagnosis, treatment, rehabilitation, and muscular effects—the following conclusions can be drawn:

ACL tears are relatively common in competitive sports like basketball, with higher risk among female athletes. Injuries typically occur during high-speed directional changes and landing from jumps. Surgical reconstruction combined with evidence-based rehabilitation enables most athletes to return to competition. However, temporary performance declines post-injury are common, often requiring more than a year to gradually recover athletic abilities [27]. Initially after injury, athletes may experience limited playing time and reduced athletic performance metrics. Nonetheless, with successful rehabilitation, many can approach pre-injury performance by their second postoperative season, and many athletes eventually regain or even exceed previous levels in the long term [27]. Modern studies also show that ACL reconstruction success rates are high, with professional treatment resulting in return-to-competition rates among elite athletes exceeding 80–90% [28], indicating that ACL rupture no longer necessarily ends a career.

Comprehensive rehabilitation following ACL injury is crucial for restoring athletic performance. Surgical repair alone is insufficient to guarantee functional recovery; systematic rehabilitation training to rebuild muscle strength, stability, and technical movements is essential. Recovery of muscle groups such as the quadriceps is slow, with many athletes still exhibiting strength deficits 6–12 months post-surgery, requiring ongoing strength training [31]. Rushing the return-to-play process must be avoided. Research explicitly advises athletes to wait at least around 9 months before resuming competitive games to minimize re-rupture risks [29]. Athletes who return prematurely not only underperform but also significantly increase their risk of severe re-injury, making early returns detrimental in the long run.

Athletes should continue preventive training and monitoring after rehabilitation and return-to-play to regain pre-injury levels as closely as possible and prolong their athletic careers. Preventive training to avoid ACL re-injury—including strengthening lower limbs, improving jump-landing mechanics, and enhancing core and hip control—is highly effective. Such exercises not only prevent injuries but also benefit athletic performance. For example, strengthening hamstring and hip muscles improves explosive power and agility, while correcting poor movement patterns increases efficiency. Athletes

DOI: 10.54254/2753-8818/2025.AU24092

should regularly perform strength and balance tests to ensure symmetrical strength and dynamic stability of both legs. If performance declines are observed, adjustments in training should be promptly implemented to prevent risks.

In terms of psychological and competitive recovery, ACL injury poses more than physical challenges. Rebuilding self-confidence and overcoming fears of re-injury are crucial aspects of restoring athletic performance. Many athletes who successfully return emphasize positive psychological support and team encouragement as key factors enabling their return to high-level competition.

In summary, athletic performance after ACL injury can often gradually recover through scientific treatment and rehabilitation. Although fully regaining pre-injury peak performance may be challenging for some athletes, ample evidence shows it is possible for athletes to reclaim their prior competitive levels given sufficient time and effort [27]. Advanced surgical techniques, rehabilitation concepts, and injury-prevention training methods continue improving recovery quality for athletes post-ACL injury. For basketball players, the goal after ACL injury extends beyond merely returning to competition—it involves striving to reach or surpass pre-injury performance levels. Through interdisciplinary collaboration among sports physicians, physical therapists, strength and conditioning coaches, and sports psychologists, personalized rehabilitation and training strategies can minimize performance losses due to injury, allowing athletes to experience a "rebirth" and return to elite-level competitive performance.

## References


[1] *Mancino F, Kayani B, Gabr A, Fontalis A, Plastow R, Haddad FS. Anterior cruciate ligament injuries in fe male athletes: risk factors and strategies for prevention. Bone Jt Open. 2024;5(2):94-100. doi:10.1302/2633-1462.52.BJO-2023-0166*

[2] *Stojanović E, Faude O, Nikić M, Scanlan AT, Radovanović D, Jakovljević V. The incidence rate of ACL injuries and ankle sprains in basketball players: A systematic review and meta-analysis. Scand J Med Sci Sports. 2023 Jun;33(6):790-813. doi: 10.1111/sms.14328. Epub 2023 Feb 19. PMID: 36752659.*

[3] *Corewell Health. ACL Tears. Sports Injuries | Anterior Cruciate Ligament (ACL) Tears | Corewell Health*

[4] *Wheeless' Textbook of Orthopaedics. ACL Epidemiology. ACL Epidemiology : Wheeless' Textbook of Orthopaedics*

[5] *Thayaparan A, Kantharuban S (August 27, 2024) Anterior Cruciate Ligament Rupture: Evidence-Based Concepts on Reconstruction, Repair and Future Developments. Cureus 16(8): e67956. doi:10.7759/cureus.67956*

[6] *Shambaugh, J. P., Klein, A., & Herbert, J. H. (1991). Structural measures as predictors of injury basketball players. Medicine and science in sports and exercise, 23(5), 522–527.*

[7] *Stijak, L., Herzog, R. F., & Schai, P. (2008). Is there an influence of the tibial slope of the lateral condyle on the ACL lesion? A case-control study. Knee surgery, sports traumatology, arthroscopy : official journal of the ESSKA, 16(2), 112–117. https://doi.org/10.1007/s00167-007-0438-1*

[8] *Souryal, T. O., & Freeman, T. R. (1993). Intercondylar notch size and anterior cruciate ligament injuries in athletes. A prospective study. The American journal of sports medicine, 21(4), 535–539. https://doi.org/10.1177/036354659302100410*

[9] *Myer, G. D., Ford, K. R., Paterno, M. V., Nick, T. G., & Hewett, T. E. (2008). The effects of generalized joint laxity on risk of anterior cruciate ligament injury in young female athletes. The American journal of sports medicine, 36(6), 1073–1080. https://doi.org/10.1177/0363546507313572*

[10] *Nakase, J., Kitaoka, K., Shima, Y., Oshima, T., Sakurai, G., & Tsuchiya, H. (2020). Risk factors for noncontact anterior cruciate ligament injury in female high school basketball and handball players: A prospective 3-year cohort study. Asia-Pacific journal of sports medicine, arthroscopy, rehabilitation and technology, 22, 34–38. https://doi.org/10.1016/j.asmart.2020.06.002*

[11] *Li, Z., Li, C., Li, L., & Wang, P. (2020). Correlation between notch width index assessed via magnetic resonance imaging and risk of anterior cruciate ligament injury: an updated meta-analysis. Surgical and radiologic anatomy: SRA, 42(10), 1209–1217. https://doi.org/10.1007/s00276-020-02496-6*

[12] *Hohmann, E., Tetsworth, K., Glatt, V., Ngcelwane, M., & Keough, N. (2021). Medial and Lateral Posterior Tibial Slope Are Independent Risk Factors for Noncontact ACL Injury in Both Men and Women. Orthopaedic journal of sports medicine, 9(8), 23259671211015940. https://doi.org/10.1177/23259671211015940*

DOI: 10.54254/2753-8818/2025.AU24092

[13] *Gupta, R., Jhatiwal, S., Kapoor, A., Kaur, R., Soni, A., & Singhal, A. (2022). Narrow Notch Width and Low Anterior Cruciate Ligament Volume Are Risk Factors for Anterior Cruciate Ligament Injury: A Magnetic Resonance Imaging-Based Study. HSS journal : the musculoskeletal journal of Hospital for Special Surgery, 18(3), 376–384. https://doi.org/10.1177/15563316211041090*

[14] *Gültekin, M. Z., Dinçel, Y. M., Keskin, Z., Arslan, S., & Yıldırım, A. (2023). Morphometric risk factors effec ts on anterior cruciate ligament injury. Joint diseases and related surgery, 34(1), 130–137. https://doi.org/10. 52312/jdrs.2023.910*

[15] *Tosarelli F, Buckthorpe M, Di Paolo S, Grassi A, Rodas G, Zaffagnini S, Nanni G, Della Villa F. Video Analysis of Anterior Cruciate Ligament Injuries in Male Professional Basketball Players: Injury Mechanisms, Situational Patterns, and Biomechanics. Orthop J Sports Med. 2024 Mar 22;12(3):23259671241234880. doi: 10.1177/23259671241234880. PMID: 38524890; PMCID: PMC10960353.*

[16] *Maniar N, Cole MH, Bryant AL, Opar DA. Muscle Force Contributions to Anterior Cruciate Ligament Loading. Sports Med. 2022 Aug;52(8):1737-1750. doi: 10.1007/s40279-022-01674-3. Epub 2022 Apr 18. PMID: 35437711; PMCID: PMC9325827.*

[17] *DeMorat G, Weinhold P, Blackburn T, Chudik S, Garrett W. Aggressive quadriceps loading can induce noncontact anterior cruciate ligament injury. Am J Sports Med. 2004 Mar;32(2):477-83. doi: 10.1177/0363546503258928. PMID: 14977677.*

[18] *Gill VS, Tummala SV, Boddu SP, Brinkman JC, McQuivey KS, Chhabra A. Biomechanics and situational patterns associated with anterior cruciate ligament injuries in the National Basketball Association (NBA). Br J Sports Med. 2023 Nov;57(21):1395-1399. doi: 10.1136/bjsports-2023-107075. Epub 2023 Aug 30. PMID: 37648410.*

[19] *Hewett TE, Myer GD, Ford KR, et al. Biomechanical measures of neuromuscular control and valgus loading of the knee predict anterior cruciate ligament injury risk in female athletes: a prospective study. Am J Sports Med. 2005;33:492-501*

[20] *Busfield BT, Kharrazi FD, Starkey C, Lombardo SJ, Seegmiller J. Performance outcomes of anterior cruciate ligament reconstruction in the National Basketball Association. Arthroscopy. 2009; 25: 825-830*

[21] *Liu SH, Osti L, Henry M, Bocchi L. The diagnosis of acute complete tears of the anterior cruciate ligament. Comparison of MRI, arthrometry and clinical examination. J Bone Joint Surg Br. 1995 Jul;77(4):586-8. PMID: 7615603.*

[22] *Valsalam P, Sha I I, Edwin A. Lever Test: Role of Its Assistance in Diagnosis of Anterior Cruciate Ligament Injury. JROS 2020; 7 (3) :115-120*

[23] *Wikem. Segond fracture. Segond fracture – WikEM*

[24] *Zhao M, Zhou Y, Chang J, Hu J, Liu H, Wang S, Si D, Yuan Y, Li H. The accuracy of MRI in the diagnosis of anterior cruciate ligament injury. Ann Transl Med. 2020 Dec;8(24):1657. doi: 10.21037/atm-20-7391. PMID: 33490169; PMCID: PMC7812197.*

[25] *Okoroha, K.R., Haunschild, E.D., Gilat, R., Cole, B. (2020). Management of ACL Injuries in Basketball. In: Laver, L., Kocaoglu, B., Cole, B., Arundale, A.J.H., Bytomski, J., Amendola, A. (eds) Basketball Sports Medicine and Science. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-662-61070-1_30*

[26] *Zhao L, Lu M, Deng M, Xing J, He L, Wang C. Outcome of bone-patellar tendon-bone vs hamstring tendon autograft for anterior cruciate ligament reconstruction: A meta-analysis of randomized controlled trials with a 5-year minimum follow-up. Medicine (Baltimore). 2020 Nov 25;99(48):e23476. doi: 10.1097/MD.0000000000023476. Erratum in: Medicine (Baltimore). 2022 Aug 26;101(34):e29873. doi: 10.1097/MD.0000000000029873. PMID: 33235137; PMCID: PMC7710199.*

[27] *DeFroda SF, Patel DD, Milner J, Yang DS, Owens BD. Performance After Anterior Cruciate Ligament Rec onstruction in National Basketball Association Players. Orthop J Sports Med. 2021 Feb 26;9(2):2325967120 981649. doi: 10.1177/2325967120981649. PMID: 33738307; PMCID: PMC7934048.*

[28] *Harris JD, Erickson BJ, Bach BR Jr, Abrams GD, Cvetanovich GL, Forsythe B, McCormick FM, Gupta AK, Cole BJ. Return-to-Sport and Performance After Anterior Cruciate Ligament Reconstruction in National Basketball Association Players. Sports Health. 2013 Nov;5(6):562-8. doi: 10.1177/1941738113495788. PMID: 24427434; PMCID: PMC3806178.*

[29] *Beischer S, Gustavsson L, Senorski EH, Karlsson J, Thomeé C, Samuelsson K, Thomeé R. Young Athletes W ho Return to Sport Before 9 Months After Anterior Cruciate Ligament Reconstruction Have a Rate of New I njury 7 Times That of Those Who Delay Return. J Orthop Sports Phys Ther. 2020 Feb;50(2):83-90. doi: 10. 2519/jospt.2020.9071. Erratum in: J Orthop Sports Phys Ther. 2020 Jul;50(7):411. doi: 10.2519/jospt.2020.5 0.7.411. PMID: 32005095.*

[30] *Welling W, Benjaminse A, Seil R, Lemmink K, Zaffagnini S, Gokeler A. Low rates of patients meeting return to sport criteria 9 months after anterior cruciate ligament reconstruction: a prospective longitudinal study. Knee Surg Sports Traumatol Arthrosc. 2018 Dec;26(12):3636-3644. doi: 10.1007/s00167-018-4916-4. Epub 2018 Mar 24. PMID: 29574548; PMCID: PMC6267144.*

DOI: 10.54254/2753-8818/2025.AU24092


*[31] Lepley LK. Deficits in Quadriceps Strength and Patient-Oriented Outcomes at Return to Activity After ACL Reconstruction: A Review of the Current Literature. Sports Health. 2015 May;7(3):231-8. doi: 10.1177/1941 738115578112. PMID: 26131300; PMCID: PMC4482305.*

*[32] Liew, B. X. W., Feller, J. A., & Webster, K. E. (2022). Understanding the psychological mechanisms of retu rn to sports readiness after anterior cruciate ligament reconstruction. PloS one, 17(3), e0266029. https://doi. org/10.1371/journal.pone.0266029*

*[33] Ardern, C.L.; Taylor, N.F.; Feller, J.A.; Webster, K.E. Fear of re-injury in people who have returned to sport following anterior cruciate ligament reconstruction surgery. J. Sci. Med. Sport 2012, 15, 488–495.*

*[34] Longo, U. G., De Salvatore, S., D'Orrico, F., Bella, M., Corradini, A., Rizzello, G., De Marinis, M. G., & Denaro, V. (2023). The Impact of Psychological Factors on Return to Sports after Anterior Cruciate Ligament Reconstruction: A Systematic Review. Osteology, 3(3), 78-93. https://doi.org/10.3390/osteology3030009*

*[35] Piussi, R.; Beischer, S.; Thomeé, R.; Senorski, E.H. Superior knee self-efficacy and quality of life throughout the first year in patients who recover symmetrical muscle function after ACL reconstruction. Knee Surg. Sports Traumatol. Arthrosc. 2020, 28, 555–567.*

*[36] Gobbi A, Francisco R. Factors affecting return to sports after anterior cruciate ligament reconstruc tion with patellar tendon and hamstring graft: a prospective clinical investigation. Knee Surg Sports Traumatol Arthrosc. 2006;14(10):1021–8.*

*[37] Shakespeare DT, Stokes M, Sherman KP, Young A. Reflex inhibition of the quadriceps after meniscectomy: lack of association with pain. Clin Physiol. 1985;5(2):137–144. doi: 10.1111/j.1475-097x.1985.tb00589.x.*

*[38] Tourville TW, Jarrell KM, Naud S, Slauterbeck JR, Johnson RJ, Beynnon BD. Relationship between isokinetic strength and tibiofemoral joint space width changes after anterior cruciate ligament reconstruction. Am J Sports Med. 2014;42:302-311.*

*[39] Thomas, A. C., Villwock, M., Wojtys, E. M., & Palmieri-Smith, R. M. (2013). Lower extremity muscle streng th after anterior cruciate ligament injury and reconstruction. Journal of athletic training, 48(5), 610–620. htt ps://doi.org/10.4085/1062-6050-48.3.23*

*[40] Elias JJ, Faust AF, Chu YH, Chao EY, Cosgarea AJ. The soleus muscle acts as an agonist for the anterior cruciate ligament. An in vitro experimental study. Am J Sports Med. 2003 Mar-Apr;31(2):241-6. doi: 10.117 7/03635465030310021401. PMID: 12642259.*