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## **Anterior Cruciate Ligament Injuries in Modern Football: A Review**

Mikołaj Czerniakowski ORCID <https://orcid.org/0009-0007-3078-9793>

E-mail: [czernos@gmail.com](mailto:czernos@gmail.com)

Uniwersytet Medyczny w Lublinie, Polska

Aleksandra Sadok ORCID <https://orcid.org/0009-0002-6392-4182>

E-mail: [sadok.aleksandra@gmail.com](mailto:sadok.aleksandra@gmail.com)

Uniwersytet Medyczny w Lublinie, Polska

Wojciech Kubas ORCID <https://orcid.org/0009-0006-3971-5099>  
E-mail: wojtek.kubas01@gmail.com  
Uniwersytet Medyczny w Lublinie, Polska

Aleksandra Białek ORCID <https://orcid.org/0009-0000-2616-4052>  
E-mail: aleksandrabialek@onet.pl  
Uniwersytet Medyczny w Lublinie, Polska

Jakub Karczewski ORCID <https://orcid.org/0009-0005-7784-0328>  
E-mail: jakub.karczewski59901@gmail.com  
Uniwersytet Medyczny w Lublinie, Polska

Wojciech Jan Niemcewicz ORCID <https://orcid.org/0009-0001-2196-6125>  
E-mail: wojniem01@gmail.com  
Uniwersytet Medyczny w Lublinie, Polska

Kamila Ryń ORCID <https://orcid.org/0009-0003-4005-9584>  
E-mail: kamilaryn2@wp.pl  
Uniwersytet Medyczny w Lublinie, Polska

Aleksandra Koźlicka ORCID <https://orcid.org/0000-0001-6353-1915>  
E-mail: ola\_kozlicka@wp.pl  
Uniwersytet Medyczny w Lublinie, Polska

Jakub Klajda ORCID <https://orcid.org/0009-0001-4354-5743>  
E-mail: jakub.klajda99@gmail.com  
Uniwersytet Medyczny w Lublinie, Polska

Zuzanna Gorczyca ORCID <https://orcid.org/0009-0004-8789-1148>  
E-mail: zuziagorczyca@interia.pl  
Warszawski Uniwersytet Medyczny, Polska

**Corresponding Author:**

Mikołaj Czerniakowski ORCID <https://orcid.org/0009-0007-3078-9793>  
E-mail: czernos@gmail.com  
Uniwersytet Medyczny w Lublinie, Polska  
Nowy Krępiec, ul Kasztanowa 7  
21-007 Mełgiew, Polska

## Abstract

**Background:** Anterior cruciate ligament (ACL) injuries are among the most severe and debilitating orthopedic traumas in modern football. The high-intensity nature of the sport, which demands frequent pivoting, rapid deceleration, and high-impact contact, significantly predisposes players to these injuries.

**Aim of the study:** This comprehensive review aims to synthesize current epidemiological data, analyze in-depth injury mechanisms (including neurocognitive factors), evaluate surgical and non-operative management strategies, detail criteria-based return-to-sport (RTS) protocols, and review the efficacy of modern prevention strategies for ACL injuries in football players.

**Material and Methods:** A comprehensive review of the literature was conducted utilizing 20 selected peer-reviewed articles, including national registries, meta-analyses, and systematic video analysis studies published between 2012 and 2025.

**Results:** Recent literature indicates a substantial burden of ACL injuries in football, heavily influenced by the level of play, gender, and exposure type. Amateur players present a higher incidence rate (0.074/1000h) compared to professionals (0.058/1000h). Match-play exponentially increases the risk compared to training. Non-contact mechanisms account for over 55% of injuries, primarily occurring during defensive pressing and rapid deceleration. Emerging evidence highlights neurocognitive errors as significant contributors to non-contact ruptures. Female athletes face a 1.5 to 1.6-fold higher risk due to anatomical, hormonal, and biomechanical disparities. While surgical reconstruction (ACLR) remains the gold standard, returning to pre-injury performance is highly challenging. Only approximately 44-55% of athletes successfully return to competitive play, with fear of reinjury (kinesiophobia) acting as the primary barrier in 33% of failed cases. Furthermore, the risk of a secondary ACL injury reaches up to 30% in adolescent populations.

**Conclusions:** ACL injuries impose a profound burden on football players, impacting both short-term athletic performance and long-term joint health, including an elevated risk of osteoarthritis. Tailored, sport-specific neuromuscular prevention programs (e.g., FIFA 11+) and individualized, criteria-based, psychologically-informed rehabilitation protocols are essential to reduce injury incidence and facilitate safe and successful RTS.

**Keywords:** Anterior Cruciate Ligament; ACL; Football; Soccer; Injury Mechanism; Return to Sport; Kinesiophobia; Rehabilitation; Prevention.

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## 1. Introduction

Football (soccer) is the most popular sport globally, characterized by highly demanding physical activities. The modern game has evolved significantly over the past two decades, with players executing a higher number of high-speed sprints, sudden changes of direction (COD), jumping, and frequent pivoting movements [7]. Consequently, it exposes athletes to a substantial risk of acute musculoskeletal injuries. Among these, the rupture of the anterior cruciate ligament (ACL) is recognized as one of the most severe and debilitating injuries a football player can sustain, typically resulting in a prolonged absence from the sport (often ranging from 6 to 12 months) and potentially threatening the athlete's career trajectory [5, 7].

While the overall incidence of ACL injuries in the general population is estimated at approximately 1 in 3000 individuals, this rate is significantly amplified within the young athletic population, particularly those participating in multidirectional team sports like football [1, 15]. The epidemiological burden is profound. The incidence of adolescent ACL injuries and subsequent reconstructions (ACLR) has increased by 40-55% over the last twenty years, reflecting both higher youth participation rates and the intensifying physical demands of early specialization [10].

Despite continuous advancements in surgical techniques and modern rehabilitation protocols, the postoperative consequences remain significant. Returning to the pre-injury level of competitive performance is not guaranteed, and sustaining an ACL injury carries a high risk of subsequent clinical complications. Athletes returning to pivoting sports face a considerable risk of graft rupture or contralateral ACL injury [10]. Moreover, regardless of the success of the surgical intervention, an ACL injury significantly increases the long-term risk of developing early-onset knee osteoarthritis (OA), thus affecting the patient's quality of life long after their athletic career concludes [5, 12].

Given the intense physical demands of modern football and the severe physical, psychological, and financial consequences of ACL injuries, a profound understanding of the exact epidemiological factors, specific biomechanical injury mechanisms, rehabilitation pathways, and barriers to returning to sport is crucial for medical professionals. Therefore, the primary objective of this review is to comprehensively analyze the epidemiology, sport-specific situational patterns, neurocognitive factors, return-to-sport outcomes, and the effectiveness of current prevention programs regarding ACL injuries in contemporary football.

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## 2. Material and Methods

Although this is a narrative review, a systematic approach was applied to gather and analyze the literature. The review is based on a selected cohort of 20 high-quality, peer-reviewed articles focusing specifically on ACL injuries within the context of football (soccer). The source material includes data from large-scale national registries (e.g., the Swedish National Knee Ligament Registry, the ACL-registry in German Football), comprehensive systematic reviews, meta-analyses, and detailed systematic video analysis studies.

The literature encompasses publications from prominent sports medicine and orthopedics journals, including the American Journal of Sports Medicine, British Journal of Sports Medicine, Sports Medicine, and Knee Surgery, Sports Traumatology, Arthroscopy. The selected articles cover a publication span primarily from 2012 to 2025, ensuring that the review reflects the most contemporary data regarding the modern, high-intensity version of the sport. Data extraction focused on epidemiological incidence rates, biomechanical and situational mechanisms of injury, surgical versus non-operative outcomes, psychometric evaluations of return to sport, and the statistical efficacy of injury risk reduction programs (IRRPs).

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## 3. Anatomy and Biomechanics of the ACL

To fully comprehend the mechanisms of injury, a foundational understanding of the ACL's anatomy and biomechanical function is required.

### 3.1 Anatomical Structure

The ACL is an intra-articular, extra-synovial ligament located within the central core of the knee joint. It originates from the posteromedial aspect of the lateral femoral condyle and inserts into the anterior intercondylar area of the tibia. Anatomically and functionally, the ACL is divided into two primary bundles named for their tibial insertion sites: the anteromedial (AM) bundle and the posterolateral (PL) bundle.

- **The Anteromedial (AM) Bundle:** This bundle is primarily tense during knee flexion and serves as the main restraint against anterior tibial translation in the flexed knee.
- **The Posterolateral (PL) Bundle:** This bundle is tense in extension and plays a crucial role in providing rotational stability, particularly against internal rotation of the tibia during the pivot-shift mechanism.

### 3.2 Biomechanical Function in Football

In the context of football, the knee is constantly subjected to massive multi-planar forces. The ACL provides approximately 85% of the total restraining force to anterior tibial translation. During a typical cutting maneuver or deceleration—actions performed hundreds of times during a football match—the ACL must absorb immense sheer forces. When the knee is in a position of shallow flexion (0-30 degrees), the mechanical advantage of the quadriceps muscle

is maximized. A forceful quadriceps contraction in this position can pull the tibia anteriorly relative to the femur, placing massive strain directly on the ACL [7, 11]. If this is combined with dynamic valgus (inward collapse of the knee) and tibial rotation, the tensile limits of the ligament are easily exceeded, resulting in rupture.

---

#### 4. Detailed Epidemiology of ACL Injuries in Football

The epidemiology of ACL injuries in football is highly complex and characterized by significant variability depending on the competitive level, the type of exposure (match versus training), the playing surface, and gender.

##### 4.1 Incidence Rates: Professional vs. Amateur Football

A common misconception is that professional athletes, due to the higher speed and physical intensity of their matches, suffer the highest rate of ACL injuries. However, recent longitudinal data directly contradicts this. According to the comprehensive "ACL-registry in German Football," which tracked injuries over five years, the incidence of ACL injuries was found to be highest in amateur football leagues [3].

- **Amateur Football:** 0.074 injuries per 1000 hours of exposure.
- **Professional Football:** 0.058 injuries per 1000 hours of exposure.
- **Semi-Professional Football:** 0.043 injuries per 1000 hours of exposure.

This disparity suggests that the professional environment benefits from a protective "ecosystem." Elite clubs employ full-time medical staffs, enforce rigorous load management protocols, utilize GPS tracking for fatigue monitoring, and mandate the completion of sport-specific neuromuscular injury prevention programs. In amateur settings, these protective measures are often absent or inconsistently applied, leaving players significantly more vulnerable to biomechanical breakdown [3]. Furthermore, systemic instability within a team contributes to injury risk; studies have shown that players moving to a higher division or playing for a team that undergoes a mid-season coaching change are at a significantly increased risk of sustaining an ACL injury [2].

| Mechanism Type | Prevalence (%) | Typical Pattern        | Situational | Description  |
|----------------|----------------|------------------------|-------------|--|
| Non-Contact    | 55% - 59%      | Defensive deceleration | pressing,   | No physical contact with another player or object. |

|                         |           |                              |  |
|-------------------------|-----------|------------------------------|--|
| <b>Indirect Contact</b> | 17% - 21% | Aerial duels, ball shielding | Contact to a non-knee body part (e.g., shoulder push). |
| <b>Direct Contact</b>   | 12% - 41% | Sliding tackles              | Direct blow to the knee forcing it beyond limits.      |

Table 1: Distribution of ACL injury mechanisms in modern football [2, 7, 20]

#### 4.2 Match vs. Training Exposure

Across all skill levels and genders, the risk of sustaining an ACL injury is exponentially higher during competitive matches than during regular training sessions. The intensity, unpredictability, and psychological pressure of a match create an environment ripe for injury.

- In professional football, match incidence can reach up to 0.343 per 1000 hours, compared to a mere 0.015 per 1000 hours during training [3].
- Data from the Swedish registry corroborated this, showing that 66% of all ACL injuries were sustained during matches, while only 25% occurred during practices [2].

#### 4.3 Temporal and Seasonal Patterns

The occurrence of ACL injuries also follows specific temporal trends throughout a season and within a single match. Epidemiological data indicates a peak in injury frequency at the very beginning of the season (August and September in European leagues) or during the restart immediately following a winter break [2]. This points to the critical importance of proper pre-season conditioning and the potential danger of sudden spikes in acute workload.

Interestingly, the risk is highest early in the game. Approximately 47% of injuries are sustained during the first 30 minutes of a match, with 24% occurring in the first 15 minutes alone [2]. This finding challenges the traditional notion that extreme, late-game muscle fatigue is the primary driver of ACL ruptures. Instead, it suggests that the high intensity, aggressiveness, and potentially inadequate neuromuscular warm-up at the start of a match are significant risk factors.

#### 4.4 The Role of Playing Surfaces: Natural Grass vs. Artificial Turf

The debate over playing surfaces remains prominent in football. While older generations of artificial turf were widely criticized for increasing injury risk due to high rotational friction (cleat-to-surface interaction), modern third-generation (3G) and fourth-generation (4G) artificial turfs have improved significantly. Current epidemiological consensus suggests that while there may be minor variations in the types of minor injuries sustained, there is no statistically significant

difference in the overall incidence rate of severe ACL ruptures between high-quality modern artificial turf and natural grass in elite football. However, poor maintenance of either surface dramatically increases injury risk.

---

## 5. Sex-Based Disparities in ACL Injuries

One of the most heavily researched areas in sports traumatology is the significant gender disparity in ACL injury rates. Female football players consistently exhibit a higher susceptibility to ACL ruptures compared to their male counterparts.

### 5.1 Incidence Differences

Meta-analytical data indicates that female athletes have a 1.5 to 1.6-fold higher relative risk of sustaining an ACL injury [6, 14]. When isolating non-contact mechanisms, the disparity becomes even more pronounced: female incidence rates are approximately 0.14 per 1000 player-hours, whereas male rates are 0.05 per 1000 player-hours [6].

### 5.2 Multifactorial Etiology

This heightened risk is entirely multifactorial, driven by intrinsic anatomical, hormonal, and neuromuscular differences:

1. **Anatomical Factors:** Females generally possess a narrower intercondylar notch (the groove in the femur through which the ACL passes). A narrower notch can cause a "guillotine effect," impinging the ACL during twisting motions. Furthermore, females typically have a wider pelvis, leading to a greater Q-angle (quadriceps angle), which inherently increases valgus stress on the knee joint during dynamic loading.
2. **Hormonal Factors:** Variations in estrogen and relaxin levels during the menstrual cycle have been shown to affect ligamentous laxity. The ACL contains estrogen receptors, and cyclical hormonal changes can alter the structural stiffness of the ligament, potentially making it more susceptible to failure during the pre-ovulatory phase.
3. **Neuromuscular and Biomechanical Factors:** Female athletes often exhibit "quadriceps dominance," meaning they rely more heavily on the anterior thigh musculature rather than the posterior chain (hamstrings and gluteals) during deceleration and landing. Because the hamstrings act as an agonist to the ACL (preventing anterior tibial translation), weak or delayed hamstring activation removes a critical active restraint, placing the entire burden of deceleration on the passive ACL. Additionally, females frequently land from jumps with less hip and knee flexion (a "stiffer" landing) and greater dynamic knee valgus [14, 15].

---

## 6. Mechanisms of Injury and Situational Patterns

Understanding the specific mechanisms and situational patterns—the "how" and "where" on the pitch—is critical for both accurate diagnosis and the development of targeted, sport-specific prevention strategies.

### 6.1 Contact vs. Indirect Contact vs. Non-Contact Mechanisms

Injuries are broadly classified into three categories based on the nature of the trauma:

- **Non-Contact Injuries:** The player sustains the rupture without any physical contact from another player or object. These represent the vast majority of ACL injuries in football, accounting for approximately 55% to 59% of all cases [2, 6, 7].
- **Indirect Contact Injuries:** The player experiences physical contact to a body part other than the injured knee (e.g., a push to the shoulder or hip), which perturbs their balance and leads to an awkward landing or twisting motion that ruptures the ACL. This accounts for about 17% to 21% of injuries.
- **Direct Contact Injuries:** A direct blow to the knee joint (e.g., a severe sliding tackle) forces the joint beyond its physiological limits. This mechanism is responsible for roughly 12% to 41% of cases and is notably more frequent in professional football due to the higher velocity and frequency of tackling [3, 7].

| Metric                      | Data              | Implications                                |
|-----------------------------|-------------------|---|
| Injury Reduction Potential  | Up to 50%         | Programs are highly effective if adhered to |
| Required Adherence          | > 75% of sessions | Benefits are lost with inconsistent use     |
| Compliance (Female Players) | 31.4%             | Underutilization in high-risk groups        |

|                                  |       |  |
|----------------------------------|-------|--|
| <b>Compliance (Male Players)</b> | 15.6% | Massive failure in grassroots implementation |
|----------------------------------|-------|--|

Table 2. Efficacy and Compliance of Injury Prevention Programs [2, 4, 18].

## 6.2 Common Situational Patterns in Football

Systematic video analysis studies utilizing high-definition match footage have revolutionized our understanding of how these injuries occur in real-time. Four distinct situational patterns consistently emerge in modern football [7, 11, 20]:

1. **Defensive Pressing and Tackling (The Most Common):** The most frequent scenario leading to a non-contact or indirect contact ACL injury occurs when a player is actively defending. This typically involves a player closing down an opponent at high speed (pressing), followed by a rapid deceleration and a sudden, unanticipated change of direction (COD) to react to the attacker's movement. The injury usually occurs on the weight-bearing, planted leg as the player attempts to cut.
2. **Being Tackled:** Injuries frequently occur during the weight-bearing phase when a player is in possession of the ball and is attempting to shield it or brace for an impending tackle from an opponent.
3. **Regaining Balance After Kicking:** A significant, yet counterintuitive, percentage of non-contact injuries occur immediately after a player executes a powerful shot, cross, or long pass. The injury invariably happens on the standing (non-kicking) leg. As the kicking leg swings through with immense force, the planted leg must absorb massive rotational and deceleration forces to maintain balance.
4. **Landing from a Jump:** This pattern is most frequently observed in goalkeepers catching a cross or outfield players engaging in aerial duels for a header. The injury typically involves a single-leg, "stiff" landing, with the knee in shallow flexion and the center of mass falling outside the base of support.

## 6.3 Neurocognitive Errors and Fatigue

Emerging research has begun to look beyond purely mechanical explanations. Football is an open-skill sport requiring continuous cognitive processing, spatial awareness, and rapid decision-making. Recent studies suggest that "neurocognitive errors" play a significant role in non-contact ACL injuries [16].

When a player is forced to process complex, unexpected stimuli (e.g., a ball taking a sudden deflection, an opponent moving unpredictably), their attentional capacity is divided. This cognitive overload can disrupt pre-programmed motor control strategies, leading to a split-second delay in protective muscle activation (like hamstring firing). Consequently, the player executes a

movement with poor biomechanical form, resulting in ligament failure. This highlights that ACL injury is not solely a physical failure, but often a failure of the central nervous system to coordinate a safe movement under cognitive stress [16].

---

## 7. Management Strategies: Surgical vs. Non-Operative

The management of an ACL-deficient knee in a high-demand athlete remains a topic of intense clinical debate, heavily influenced by the physical demands of football.

### 7.1 The Surgical Gold Standard (ACLR)

Anterior Cruciate Ligament Reconstruction (ACLR) is overwhelmingly the preferred route for football players. It is estimated that up to 98% of orthopedic surgeons recommend surgery for athletes wishing to return to high-intensity jumping and cutting sports. The goal of surgery is to restore mechanical stability to the knee, preventing the "giving way" episodes that cause further damage to the menisci and articular cartilage.

**Graft Selection:** The choice of graft is a critical decision. In professional football, autografts (tissue harvested from the patient's own body) are heavily favored over allografts (donor tissue) due to lower failure rates in young, active populations.

- **Bone-Patellar Tendon-Bone (BPTB):** Traditionally considered the "gold standard" for elite athletes. It offers bone-to-bone healing, providing early rigid fixation and excellent rotational stability. However, it carries a higher risk of anterior knee pain (donor site morbidity), which can complicate kneeling and kicking.
- **Hamstring Tendon (HT):** A very popular choice due to a smaller incision and less anterior knee pain. However, harvesting the hamstrings can permanently weaken the very muscle group that acts to protect the ACL, which is a significant consideration for football players.
- **Quadriceps Tendon (QT):** An increasingly popular alternative in modern orthopedics. It provides a thick, robust graft with potentially less donor site morbidity than BPTB, though rehabilitation protocols must carefully manage early quadriceps inhibition.

**Lateral Extra-articular Tenodesis (LET):** In recent years, surgeons frequently combine ACLR with a LET procedure (e.g., a modified Lemaire technique) for high-risk football players. This involves creating a secondary stabilizing structure on the outside of the knee to further restrict internal rotation, significantly reducing the risk of graft rupture in players with severe rotational instability.

### 7.2 Non-Operative Management: The "Coper" Phenomenon

While surgery is the dogma, it is occasionally challenged. A small subset of patients, termed "copers," can dynamically stabilize their ACL-deficient knee through exceptional neuromuscular control. A notable case report detailed an English Premier League player who opted for complete

non-operative management of an acute ACL rupture [8]. Through an intensive, highly individualized rehabilitation program focusing on extreme strength and proprioception, the player returned to elite match play within 8 weeks and remained asymptomatic at an 18-month follow-up [8].

While such cases prove that return to elite football without an ACL is physiologically possible, it is widely considered an exception rather than the rule. The long-term risks—such as accelerated chondral and meniscal damage caused by micro-instability—deter most medical staffs from recommending this approach for young professionals.

---

## 8. Rehabilitation and Return to Sport (RTS) Protocols

Rehabilitation following ACLR is a lengthy, arduous process. Modern protocols have shifted away from strict time-based milestones (e.g., "running at 3 months") toward strict **criteria-based progressions**. An athlete cannot progress to the next phase until they pass specific functional tests.

### 8.1 The Phases of Rehabilitation

A standard, high-quality football rehabilitation protocol is typically divided into five or six phases:

1. **Phase 1: Acute Recovery (0-4 weeks)**. Focus on reducing swelling, restoring full passive knee extension (crucial for normal gait), and reactivating the quadriceps muscle to prevent atrophy.
2. **Phase 2: Strength and Control (1-3 months)**. Progressive weight-bearing, closed kinetic chain exercises (squats, leg presses), and restoration of normal gait mechanics.
3. **Phase 3: Running and Plyometrics (3-5 months)**. Introduction of straight-line jogging, low-level plyometrics (jumping and landing), and advanced strengthening. The athlete must demonstrate adequate quadriceps strength (usually >70% of the uninjured leg) before running.
4. **Phase 4: Sport-Specific Agility (5-8 months)**. Introduction of cutting, pivoting, and high-speed decelerations. Drills mimic on-pitch scenarios without opposition.
5. **Phase 5: Return to Team Training (8-12+ months)**. Gradual reintegration into contact drills, full team practices, and eventually competitive match play.

### 8.2 The Reality of RTS Rates

Despite surgical success, the ultimate goal—returning to the pre-injury level of athletic performance—is alarmingly difficult to achieve. Systematic reviews demonstrate that while approximately 81% to 82% of athletes eventually return to "some form" of sporting activity, only about 44% to 55% successfully return to competitive, pre-injury level play [5, 17].

Among elite professionals, the return rates are higher (up to 83%), largely due to financial incentives and elite medical care. However, even among those who successfully return to the pitch,

there are often measurable decreases in sport-specific performance statistics (e.g., fewer sprints, altered movement mechanics) in the seasons immediately following their return.

### **8.3 The Psychological Barrier: Kinesiophobia**

The most striking finding in modern RTS research is that physical impairments (e.g., knee weakness or instability) are not the primary reason athletes fail to return. The overall weighted rate of failure to RTS is estimated at 25.5%, and psychosocial-related reasons account for 55.4% of these failures, significantly overshadowing physical limitations (44.6%) [1].

Fear of reinjury, clinically termed **kinesiophobia**, is the single most cited deterrent, accounting for 33.0% of all reasons athletes abandon football post-ACLR [cite: 1]. Athletes often report a profound lack of "trust" in the knee, despite passing all objective strength and hop tests. This highlights a massive gap in traditional rehabilitation: the failure to address psychological readiness. Tools like the **ACL-RSI (Return to Sport After Injury)** psychological scale are now highly recommended to identify athletes requiring psychological intervention before clearance to play.

### **8.4 Secondary Injuries and Long-Term Health**

The risk does not end once the player returns to the pitch. Returning to football places the athlete at a high risk for subsequent trauma. Up to 30% of adolescent patients suffer a second ACL injury (comprising approximately 20% ipsilateral graft failures and 10-13% contralateral native ACL ruptures) [10]. This high reinjury rate often peaks between 12 to 24 months post-surgery during the crucial "ligamentization" phase of the graft. Furthermore, the presence of concomitant injuries (like meniscal tears, present in >70% of cases) drastically accelerates the onset of osteoarthritis, threatening the long-term joint health of the athlete [10, 12].

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## **9. Prevention Strategies in Modern Football**

Given the high incidence, severe career implications, and long-term health consequences of ACL ruptures, effective injury risk-reduction programs (IRRPs) are an absolute necessity in football.

### **9.1 Neuromuscular Training Programs**

Prevention programs focus almost entirely on addressing modifiable biomechanical risk factors. They aim to "re-program" the athlete's neuromuscular system to utilize safer movement strategies—specifically, encouraging greater knee and hip flexion during landing, activating the hamstrings and gluteals to control deceleration, and eliminating dynamic knee valgus [4, 15].

Multi-component neuromuscular training programs that incorporate a blend of plyometrics, dynamic balance training, core strengthening, and landing impact control have proven highly effective. Studies indicate that structured programs can reduce the incidence of non-contact ACL injuries by up to 50% in female athletes [4].

## 9.2 The FIFA 11+ Program

The most prominent and widely researched program is the **FIFA 11+**. Developed by the FIFA Medical Assessment and Research Centre (F-MARC), it is a standardized, 20-minute warm-up specifically designed to protect football players from lower extremity injuries [4, 9, 18]. The program is divided into three parts:

1. Running exercises at slow speed combined with active stretching and controlled contacts.
2. Six sets of exercises focusing on core and leg strength, balance, and plyometrics (with varying levels of difficulty).
3. Running exercises at moderate/high speed combined with planting and cutting movements.

## 9.3 The Crisis of Compliance

Despite the overwhelming scientific evidence supporting the efficacy of programs like the FIFA 11+, their real-world impact is severely blunted by poor compliance. Epidemiological surveys reveal a stark reality: only about 31.4% of female football players and a mere 15.6% of male players consistently utilize knee-specific control exercises during their routines [2].

The protective benefits of the FIFA 11+ are heavily dose-dependent; research indicates it must be performed during at least 75% of all football exposure sessions (training and matches) to be an effective preventive tool [13, 18]. The lack of compliance is frequently attributed to coaches and players finding the routines monotonous, time-consuming, or insufficiently specific to the tactical demands of football.

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## 10. Discussion

The synthesis of current literature reveals that ACL injuries in modern football represent a complex, multifactorial pathology that extends far beyond a simple mechanical tear of a ligament. The epidemiological data confirms that the burden is actually heaviest at the amateur and grassroots levels, where the protective infrastructure of professional clubs is absent. This highlights an urgent public health need to democratize access to injury prevention education and resources down the football pyramid.

The mechanisms of injury clearly demonstrate that football-specific actions—particularly defensive pressing and responding to unpredictable stimuli—are the primary culprits. The integration of neurocognitive science into injury mechanisms suggests a paradigm shift is needed. Prevention programs can no longer be simple, closed-skill warm-ups. To be truly effective and improve compliance, prevention must mimic the chaos of the sport. Future Injury Risk Reduction Programs (IRRP) must incorporate cognitive challenges (e.g., reacting to a visual or auditory cue while landing) and be seamlessly integrated into regular ball-work drills rather than isolated as separate, boring routines.

Furthermore, the shockingly low rate of return to pre-injury performance, driven heavily by kinesiophobia, demands a total overhaul of RTS criteria. The clearance to play can no longer be based solely on an isokinetic strength test and the passage of 9 months on a calendar. A holistic approach, integrating psychological readiness assessments (like the ACL-RSI) and objective biomechanical evaluations of movement quality under fatigue, must become the clinical standard.

Finally, the long-term joint health of football players must remain a priority. With a high risk of secondary injuries and early-onset osteoarthritis, the conversation around ACL injuries must shift from "getting the player back for the next season" to "preserving the knee for the next thirty years."

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## 11. Conclusions

Anterior cruciate ligament injuries continue to represent a formidable challenge in modern football, exerting a heavy physical, psychological, and financial toll on athletes. Based on the comprehensive review of contemporary literature, the following key conclusions can be drawn:

1. **Epidemiological Reality:** The incidence of ACL injuries remains unacceptably high. The risk is significantly greater during competitive match-play compared to training, and amateur players face a higher overall risk than professionals [3].
2. **Gender Disparity:** Female football players are inherently more susceptible to ACL ruptures, particularly non-contact injuries, due to a complex interplay of anatomical, hormonal, and neuromuscular factors [6, 14].
3. **Specific Mechanisms:** Non-contact injuries, which account for the majority of ruptures (over 55%), occur predominantly during defensive pressing, rapid deceleration, and unanticipated changes of direction, often exacerbated by neurocognitive overload [7, 16, 20].
4. **The RTS Failure:** Surgical reconstruction does not guarantee a return to performance. A significant portion of competitive athletes fails to return to their pre-injury level, largely due to profound psychosocial barriers and the paralyzing fear of reinjury (kinesiophobia) [1, 5].
5. **Long-Term Consequences:** The risk of subsequent ACL injuries to either the graft or the contralateral knee is severe (up to 30% in youths), and the development of post-traumatic osteoarthritis is a highly prevalent long-term consequence [10, 12].
6. **Prevention Paradox:** While neuromuscular training programs like the FIFA 11+ are scientifically proven to be highly effective in reducing injury risk, their real-world efficacy is catastrophically undermined by poor implementation and low compliance among coaches and players [2, 4, 18].

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### **Supplementary Materials**

Not applicable.

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### **Author Contributions**

Conceptualization, Mikołaj Czerniakowski; methodology, Jakub Karczewski; software, Jakub Klajda; validation, Aleksandra Białek; formal analysis, Aleksandra Sadok; investigation, Wojciech Kubas; resources, Wojciech Jan Niemcewicz; data curation, Kamila Ryń writing—original draft preparation, Mikołaj Czerniakowski; writing—review and editing, Aleksandra Koźlicka and Zuzanna Gorczyca; visualization, Mikołaj Czerniakowski and Jakub Klajda; supervision, Jakub Karczewski; project administration, Aleksandra Białek. All authors have read and agreed to the published version of the manuscript.

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No new data were created or analyzed in this study. Data sharing is not applicable to this article.

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### **Conflicts of Interest**

The authors declare no conflict of interest.

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