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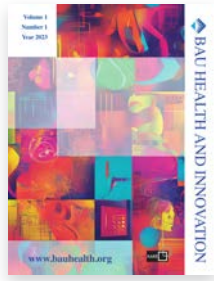

Review

Anterior Cruciate Ligament Injuries in Female Soccer: A Gender-based Approach to Pain Assessment and Clinical Applications from the Perspective of Anxiety Disorder and Kinesiophobia

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Abstract

In recent years, the frequency of sports injuries has been extensively investigated in terms of risk factors and preventive measures. Players engaged in team sports are at a higher risk of injury because the games typically involve various movements and interactions with the ball, teammates, and opponents. Although the mechanism of injury is common among professional football players, it represents a heterogeneous group with different types of injuries and widespread terminology. Traditionally, it has been categorized as delayed onset muscle soreness, strains, and contusions. The initial step in injury prevention is the assessment of injury epidemiology and the elimination of injury risk. This review addresses the importance of a gender-based approach in the assessment of pain and clinical practices for anterior cruciate ligament injuries commonly seen in female soccer players. Specifically, the effects of psychological factors such as anxiety disorders and kinesiophobia (fear of movement) on anterior cruciate ligament injuries are examined. It highlights gender-based differences in anterior cruciate ligament injuries suffered by female soccer players and discusses how these differences should be taken into account in pain assessment and treatment processes.

Keywords: Anterior cruciate ligament injuries, anxiety disorders, kinesiophobia, sex characteristics, soccer.

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Women's soccer has gained increasing global attention in recent years, being officially played in over 100 countries with an estimated 30 million players worldwide. The sport has experienced rapid growth globally, with more women actively participating.[1] However, this surge in participation has also led to a higher incidence of sports-related injuries among female players, particularly anterior cruciate ligament (ACL) injuries.[2] ACL injuries are notably more common in female athletes, and understanding the underlying causes is essential for developing both preventive and therapeutic strategies.[3] Research on injury epidemiology in female soccer players indicates that 51–83% of injuries result from physical contact with opponents, whereas 19–39% are due to fouls. Studies on injuries reveal that 48–70% of female soccer players experience at least one injury per season, with injury rates affected by factors such as age and competition level.[4] ACL injuries can have a detrimental impact on female players' careers, often requiring prolonged rehabilitation. Consequently, gender-based approaches to assessing and treating these injuries are essential.[5,6]

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Women differ from men in terms of physiological, anatomical, and psychological characteristics, as well as specific needs. These structural differences can sometimes place female athletes at either an advantage or disadvantage in sports contexts. Anatomical differences are estimated at 5–10%, whereas physiological differences may range from 10 to 20%. The anatomical, hormonal, and biomechanical differences of female soccer players may contribute to the higher prevalence of ACL injuries compared to their male counterparts. Consequently, gender-specific approaches can help reduce injury risk and support the development of more effective treatment strategies for female players.[7] One of the most significant distinctions between men and women is the menstrual cycle and its regulation by the hormonal system. Intense training and competition can cause physiological and emotional stress in women, leading to menstrual cycle disruptions.[7,8]

Athletes experiencing pain following an ACL injury often face negative physical and psychological consequences. Kinesiophobia (fear of movement) may alter cortical networks responsible for perceiving and regulating movement, potentially disrupting motor functions and evidence-based therapies. Many athletes report recurring and persistent symptoms over time.[9] In addition, psychological factors significantly influence the rehabilitation process of players experiencing pain after an injury. Fear of reinjury can negatively affect the recovery of physical dysfunctions, potentially delaying a successful return to the sport.[10–12]

This review aims to examine gender-specific approaches to pain assessment and clinical applications for ACL injuries in female soccer players. In addition, it explores the role of psychosocial factors, such as anxiety and kinesiophobia (fear of movement), in managing ACL injuries. Integrating these perspectives may improve our understanding of the injury processes female soccer players experience and support the development of effective treatment strategies.

First, this review will explore the prevalence and etiology of ACL injuries among female soccer players. Next, it will discuss the impact of gender-specific approaches on pain assessment and clinical applications. Finally, the role of psychosocial factors – including anxiety and kinesiophobia – in managing ACL injuries and the integration of these factors into treatment strategies will be examined.

The goal of this review is to contribute to the development of more effective gender-based approaches for managing ACL injuries in women's soccer.

ACL Injuries and Women's Soccer

Due to the knee joint being the largest synovial joint in the human body, it is particularly susceptible to injuries, especially ACL injuries. The ACL is one of the key structures connecting the femur and tibia in the knee, playing a critical role in maintaining normal knee function by preventing abnormal forward displacement of the tibia. Its anatomical position makes it vulnerable to sudden rotational forces between the femur and tibia.[13] The ACL resists anterior forces applied at 30° of flexion by 82–90%, though this resistance decreases to 74–85% at 90° of flexion. Its primary function is to limit rotational movements of the knee, prevent excessive tibial motion, and ensure knee stability.[14] The typical mechanism of ACL injury involves knee hyperextension, adduction, and rotation, often occurring during sudden deceleration or directional changes when excessive tensile forces are applied to the ligament.

Causes of ACL Injuries

- Sudden directional changes
- Abrupt stops
- Uncontrolled deceleration
- Knee rotation upon landing after jumps
- Collisions, particularly in contact sports such as soccer
- Sudden knee twisting due to foot getting caught on the ground.[15–17]

Most studies on injury prevention focus on non-contact ACL injuries caused by sudden deceleration during landing or directional changes. The ACL injury mechanism is influenced by anatomical, neuromuscular, biomechanical, genetic, hormonal, and other risk factors. Given the increased likelihood of these risk factors in female soccer players, gender-specific approaches to ACL injury prevention have been examined, as these factors differ between men and women.[18]

Several fundamental reasons exist for the higher prevalence of ACL injuries among female soccer players:

Anatomical Differences

Structural differences in the knee and ligaments in women can elevate the risk of ACL injuries. For instance, a greater pelvic width and distinct leg angles in women increase stress on the knee.

Hormonal Influences

Female hormones, particularly estrogen and progesterone, affect the elasticity and strength of ligaments. Hormonal fluctuations may make women more susceptible to ACL injuries during specific phases of the menstrual cycle.

Muscle Strength and Control

Female soccer players generally have lower muscle mass and strength than males, which can decrease

knee stability and increase ACL injury risk. In particular, quadriceps and hamstring imbalances contribute to this risk vulnerability.

Game Dynamics

The nature of soccer – characterized by sudden stops, directional changes, and jumps – places stress on the ACL. Biomechanical differences in how female players perform these actions may further heighten injury risk.[19–21]

Anatomical risk factors for ACL injury include reduced ligament size, decreased femoral notch width, increased posterior slope of the lateral tibial plateau, and higher body mass index. These factors are more prevalent in athletes than in males.[22] Research on gender differences has shown that females exhibit greater knee valgus and a higher quadriceps-to-hamstring ratio during landing.[23] Furthermore, the relationship between female hormones and neuromuscular control has been explored, indicating that injury risks vary due to differences in motor control patterns and hormonal effects during adolescence. ACL injuries are more common during the follicular and pre-ovulatory phases of the menstrual cycle, likely due to the presence of sex hormone receptors in the ACL. Estrogen and relaxin have synergistic effects, regulating collagen turnover and cross-linking, which increase ligament laxity, decrease ACL load tolerance, and reduce tendon stiffness.[24,25]

Pain Assessment and Clinical Applications

Pain

Pain is an unpleasant sensory and emotional experience. Pain signals indicate potential or existing danger, making clinical assessment and treatment challenging. Clinicians need to understand where and how athletes perceive pain, how they describe it, its characteristics and duration, and if prior treatment has been received. Female soccer players experience knee pain more frequently than their male counterparts, which may be related to anatomical differences such as the Q-angle. Research suggests that men are less likely to miss training or matches due to pain. Numerous cases of knee pain in female players exist, though its morphological origins remain unclear; it might be linked to the Q-angle of the knee.[26]

Clinical Applications: ACL

Physical examination is essential for diagnosing ACL injuries and evaluating knee pain, movement dysfunction, or hemarthrosis. Common tests for ACL injuries include the Lachman test, anterior drawer test, and pivot shift test:

Lachman test

In a sensitive test for ACL injuries, with one hand stabilizing the femur, the knee is positioned at 30° of flexion while an anterior force is applied to the tibia. Excessive movement compared to the other knee indicates a positive result.

Anterior drawer test

The patient lies supine with the knee at 90° of flexion. An anterior force is applied to the tibia, and greater displacement compared to the unaffected knee indicates a positive result.

Pivot shift test

The patient lies supine, and an internal rotation is applied to the ankle along with valgus stress on the tibia while the knee is flexed. If the lateral tibial plateau subluxates forward at 20–30° of flexion, the test is positive.

In addition to a patient's medical history, magnetic resonance imaging or arthroscopy can provide a definitive diagnosis, and ultrasonography can assist in detecting hemarthrosis within the intercondylar space.[27]

The Importance of a Gender-based Approach

Although numerous scientific studies focus on women's soccer, the gender-specific aspects of physiology, especially the menstrual cycle and its effects on physical performance, remain largely unknown.[28] Known physical, psychological, and pain-related factors in sports may be correlated with an increased risk of injury. Lower extremity injuries (e.g., knee, ankle, hip/groin, and hamstring) are common in soccer and have a high recurrence risk for players with prior injuries. Injuries, anxiety disorders linked to them, and subsequent kinesiophobia can hinder physical skill, strength, and engagement in sports and physical activities.

The injury profile of female athletes differs from males, with serious knee injuries (such as ACL injuries) at least twice as common in females than in males, regardless of exposure or participation level. Women are at higher risk for knee and ankle injuries, whereas males more frequently experience muscle and groin injuries.[29]

Despite the growing research on women's soccer, the gender-specific aspects of physiology, particularly the menstrual cycle's impact on physical performance, remain unclear.[30] The menstrual cycle consists of two main phases: The follicular phase (FP) and luteal phase (LP), with FP further divided into two subphases:

- Early FP: Characterized by low estrogen and progesterone concentrations
- Moderate FP: In which estrogen is highly independent of progesterone.[31]

LP is defined by elevated estrogen and progesterone levels, with the two main phases separated by a sharp rise in hormones triggering ovulation. These periodic hormonal changes are generally considered predictable and are known to influence cardiovascular, respiratory, thermoregulatory, and metabolic functions. Recent studies examining these effects on endurance performance have yielded compelling findings.[32] The cyclic fluctuations in reproductive hormones such as estrogen and progesterone can impact musculoskeletal tissues, such as muscles, tendons, and ligaments, suggesting that the menstrual cycle may influence injury risk among female soccer players. This risk may stem from effects on post-exercise recovery, postural control, kinesthetic sense, and neuromuscular coordination.[33]

The Q-angle is formed by the intersection of two anatomical lines on the anterior thigh: one from the anterior superior iliac spine to the center of the patella and the other from the tibial tubercle to the center of the patella. Tibial torsion (hip joint rotation), foot pronation/supination, and femoral anteversion influence the Q-angle. Clinically, the patella must be centered within the trochlear groove to measure the Q-angle.[34]

The Q-angle is generally greater in females than in males due to their broader pelvises. Factors such as the wide pelvis, external tibial rotation, and varus and valgus deformities affect the Q-angle. An increased Q-angle is considered a risk factor for several injuries. Injury mechanisms in sports are more strongly associated with dynamic loading conditions, and high Q-angles in women have been reported to influence knee injuries during sports activities.[35] The mean Q-angle is 15.8±4.5° in women and 11.2±3.0° in men. A larger Q-angle may increase patellofemoral joint contact pressure, thereby contributing to a higher risk of knee injuries. A potential contributing factor to knee injury is the configuration of the intercondylar notch. Research indicates that athletes with smaller notches are at higher ACL injury risk due to limited ACL adaptations.[36]

Perspective of Anxiety and Kinesiophobia

Anxiety and kinesiophobia play a significant role in managing ACL injuries among female football players. This perspective addresses the combined impact of physical and psychological factors on injury management.

Anxiety disorder refers to an individual's excessive worry and fear response to typically encountered situations. This disorder is common among athletes, as expectations and pressures associated with sports performance can elevate anxiety levels.[37,38] Often seen in athletes, anxiety can significantly influence pain and rehabilitation following an ACL injury. Post-injury anxiety may adversely affect athletes' physical recovery process and delay their return to sports. Moreover, concerns about reinjury can increase anxiety levels and impair an athlete's ability to perform movements.[39]

Kinesiophobia, defined as the fear or apprehension of movement, is frequently observed following ACL injuries. Athletes may avoid movement due to fear of reinjury, which can reduce their participation in essential rehabilitation exercises and prolong the recovery process. In addition, athletes experiencing kinesiophobia may have decreased engagement in physical activity, adversely affecting their performance.

ACL injuries are quite prevalent among female football players, often necessitating an extended rehabilitation period. During this process, athletes' anxiety levels may increase, as both injury-related concerns and the uncertainty of the recovery process contribute to heightened anxiety.

Pain experienced by athletes should be assessed from both physical and psychological perspectives. High anxiety levels can intensify pain perception and negatively impact the recovery process. Clinical practices require a comprehensive approach that supports athletes' physical and mental health, including physical therapy, psychological support, and sports coaching.[40]

Conclusion

The question of whether menstrual pain is more or less intense among female athletes remains a topic of debate. While some studies suggest that exercise performance influences menstruation, others argue that this effect is negligible. For example, a study by Vaiksaar et al. found that the phase of the menstrual cycle did not impact oxidation and lactate concentrations among exercising women (2015).[32,41]

Various studies have found that the risk of ACL injury increases during the late follicular/ovulatory phase, when estrogen levels are highest, likely due to increased ACL laxity. Other studies report higher incidences of ACL injuries during the early follicular or late LPs.[42] However, there are frequent discrepancies in defining and predicting these phases. For instance, some studies only compare pre- and post-ovulation injury incidence without considering the approximately tenfold rise in estrogen concentrations from early to late FPs. Interpreting published injury rates is further complicated by the inclusion of hormonal contraceptive users in datasets.[43]

This review underscores the importance of a gender-based approach in pain assessment and clinical applications for ACL injuries, which are prevalent among female football players. It highlights the gender-specific differences in ACL injuries among female football players and discusses how these differences should be considered in pain assessment and treatment processes.

The research begins by focusing on the risk factors and mechanisms of ACL injuries in female football players, particularly noting that movements commonly seen in sports, such as landing or changing direction, increase the risk of ACL injuries in women. Anatomical, hormonal, and biomechanical differences are also emphasized as contributing factors to female football players' susceptibility to such injuries.

The pain assessment and clinical applications section discusses the importance of tests and imaging methods used in diagnosing ACL injuries. It also notes that knee pain is more frequent in female football players than in males, which may be related to morphological factors. This section further emphasizes the need to evaluate physical examination findings and medical history in athletes with ACL injuries.

The importance of a gender-based approach section underscores the need for gender-specific approaches, as female football players have injury profiles distinct from males. It also points out that the menstrual cycle may influence injury risk among female football players and that hormonal changes can affect musculoskeletal tissues. This section highlights that understanding gender-based factors is crucial to developing effective treatment strategies for reducing injury risk.

In conclusion, this review emphasizes the necessity of gender-based approaches in evaluating and treating ACL injuries among female football players. It brings attention to how female football players' physiological, anatomical, and hormonal differences influence injury risk, making gender-specific treatment strategies essential. This approach may help better understand the sports lives of female football players and develop more effective treatment strategies.

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