MOTION ANALYSIS REPORT

Using OpenSim & Kinovea

Team 10

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***Abstract*—The goal of this paper is to study the causes of non-contact ACL injuries in female football players, especially as these injuries have been increasing at a higher rate in women compared to men. To explore this, we investigated three common movements associated with ACL injuries: stopping, jumping, and pivoting. Motion data was collected and analyzed from seven different female and male players to compare joint angles and movement patterns. Our results showed that female players generally exhibited greater knee valgus angles, less knee flexion during landing, and a more upright trunk posture during deceleration all of which are linked to higher ACL strain. These findings support the need for more female-centered research and training approaches to reduce injury risk in women's football.**

I. Introduction

ANTERIOR cruciate ligament (ACL) injuries are a common issue in sports, especially in fast-paced games like football. These injuries often happen without contact, during sudden stops, quick turns, or landings. While both male and female athletes are affected, females are reported to be 2 to 8 times more likely to experience an ACL injury.

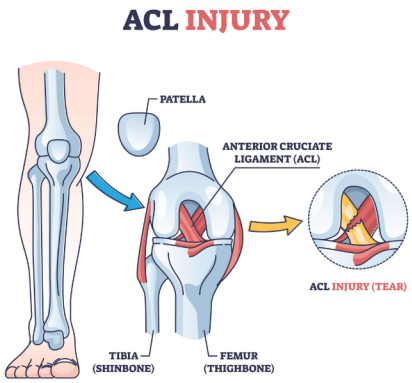


Fig. 1. ACL ligament.

This higher risk is linked to factors like body structure and movement mechanics. For example, female athletes generally have less bow-legged (varus) alignment than males (see Fig. 1). This can lead to greater inward knee motion (valgus) during high-impact actions, increasing strain on the ACL. As a result, female football players are especially vulnerable during quick, dynamic movements.

Understanding the causes of these injuries is key to developing better prevention strategies. This report focuses on the reasons behind the higher ACL injury rates in female football players, particularly the biomechanical factors involved.

II. Methodology And Data Collection

To investigate the biomechanical differences contributing to ACL injury risk, particularly between male and female athletes, our team designed an observational study focusing on lower limb motion and joint loading during athletic movements.

First, recruiting a group of male and female participants and recording video footage of each subject performing common football-related actions, such as sudden stops, directional changes, and jump landings. Reflective markers or visual trackers were placed on key joints of the lower limbs—such as the hips, knees, and ankles—to accurately capture joint angles and limb alignment throughout the movements.

Fig. 2. Marker placement on lower limb joints for angle analysis.

III. Development of Analysis

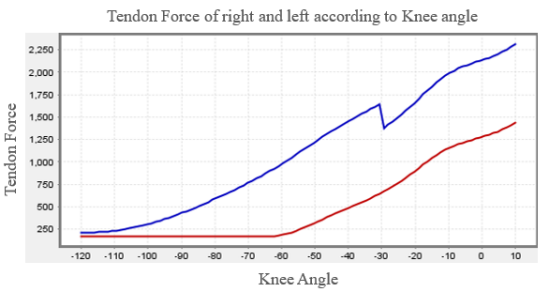
Using **Kinovea**, a motion analysis software, extracting joint angle data from the recorded videos. This enabled us to assess the alignment and angular changes of the lower extremities during high-impact movements, with a particular focus on knee valgus and varus tendencies.

To further analyze the internal forces acting on the joints, biomechanical model is derived from existing research and processed our motion data using **OpenSim**, a musculoskeletal simulation software. By inputting the tracked joint movements, generating force graphs that illustrate the variation in joint loads across different phases of motion.

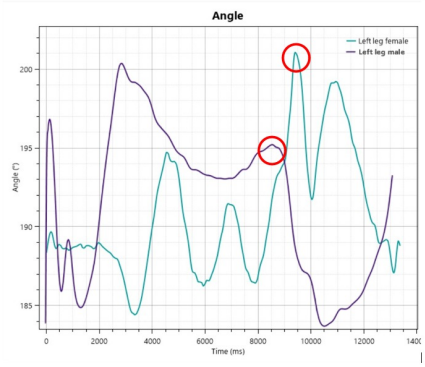
This combined approach allowed us to compare biomechanical patterns between male and female subjects. Specifically, aimed to identify whether female participants exhibited less natural varus (bow-legged) alignment and if their joint forces varied significantly with joint angles during motion—factors believed to contribute to increased ACL injury risk.

IV. Results

1. Landing from a jump:

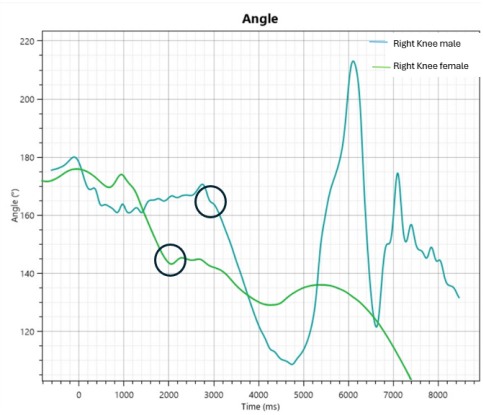


Graph (1) shows the relation between knee angles and tendon force for Landing from a jump movement, the knee angle moves from high flexion (–120°) toward extension at the end (+10°),the tendon force increases progressively in both ACLs.



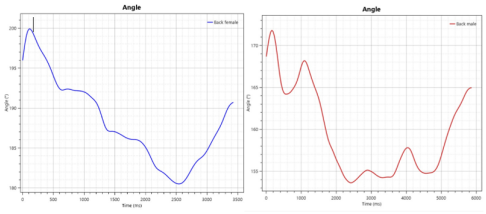
Graph (2) shows the variation in the angle between the hip and ankle at the knee joint of the left leg for both genders over time from front view; the highlighted section indicates that the female tends to land with greater inward knee motion .

2. Pivoting and twisting:



Graph (3) shows the variation in the angle between the hip and ankle in the knee joint of the left leg for both genders over time from side view; the highlighted section indicates that the male extended his knee more while pivoting.

2. Decelerating and Stopping:



Graph (4) shows the variation in back extension angle for both genders over time, viewed from the side. The angle ranges from 180° to 190° for the female, and from 150° to 160° for the male.

V. Discussion and Summary

Our analysis highlighted some important differences in how male and female athletes move during key actions like landing, pivoting, and stopping all of which are commonly linked to ACL injuries. These differences aren't just about strength or skill they also come from how the body works and what kind of gear the players use.

In the landing phase, data showed that the knee angle transitions from deep flexion toward near extension. As this happens, tendon forces in the ACLs progressively increase. This is especially concerning for females, who landed with greater knee valgus on average 7° to 12° higher than their male counterparts, which is an inward collapse of the knee amplifying internal joint stresses and making the ACL more vulnerable. The force-angle relationship in our data further supports this, indicating heightened ligament loading during this phase.

In pivoting and twisting movements, we observed that females again showed more inward knee motion while filming. From the side view, male athletes tended to extend their knees more during the turn, while females kept their knees slightly more flexed. While flexion isn't necessarily negative, combined with valgus positioning and a planted foot, it creates a risky configuration where the knee may lack rotational control precisely when ACL strain is at its peak.

Deceleration and stopping revealed another important difference. Female athletes displayed more upright posture, compared to males.This altered posture shifts the center of gravity backward, reducing gluteal and hamstring activation by 20–30 %‘, reduces the engagement of protective muscles like the glutes and hamstrings, and increases reliance on passive structures like ligaments especially the ACL for shock absorption and balance during abrupt stops.

We also explored the potential hormonal influences on injury risk to see if they played a contributing role. We found that when estrogen levels rise during certain phases of the menstrual cycle (typically days 12–14 of the cycle) this can increase ligament laxity, making joints feel less stable.

Finally, footwear design is a contributing factor. Most cleats are made with male foot shapes and biomechanics. Studies show that more than 60 %‘ of female players report discomfort or instability in standard cleats, which can lead to up to 20%‘ reduced traction

To conclude, female athletes in our study demonstrated movement patterns that increase ACL strain greater knee valgus, less trunk lean, and altered joint kinematics during high-risk maneuvers like jumping, stopping, and pivoting. Combined with the effects of hormone-driven ligament laxity and gear not designed for their biomechanics, these findings help explain the significantly higher injury rates seen in female football players.Combined, these biomechanical, hormonal, and equipment-related factors contribute to the 2–8 times higher ACL injury risk observed in female football players compared to males.

References

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