ACL Tears in Female Athletes

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Case Overview

Female athletes experience ACL tears at a higher rate than their male counterparts. Elucidating the most pertinent factors that contribute to this discrepancy is important for designing effective prevention and intervention for female athletes to reduce, and thereby equalize, injury rate.

Patient Profile

- Initials: CR
- Age: 16
- Sex: Female
- Medical History: No pertinent positives; no prior knee or lower extremity injury.
- Surgical History: None
- Social History: Patient is in 10th grade. She lives at home with her parents. She plays soccer (since age 6) and softball (since age 10). She denies use of alcohol, tobacco, or illicit drugs.
- Prescribed Medication: None

Presenting Complaint

CR presents to the Emergency Department with pain and swelling in the right knee. Patient reports immediate pain, followed by swelling, after another player slid into her right shin during her soccer game, approximately 1 hour prior to arrival. She notes that it felt like her knee “shifted”. Patient reports the pain was initially 9/10 in severity, but is currently a 5/10. She reports difficulty bearing weight on her right leg. Patient denies other trauma, numbness, or paresthesias.

Evaluation

Vital signs: BP 110/60, HR 90, RR 16, Temp 37° C, pO2 100% on room air

On exam, CR is awake, alert, and appearing in mild painful distress. Right knee markedly swollen compared to left, moderately tender to palpation at joint lines. Active flexion limited secondary to pain. (+) Lachman test, (+) hemarthrosis. Left knee exhibits full active range of motion without swelling, tenderness, or deformity. Full active range of motion of hips, ankles, and toes bilaterally without swelling, tenderness, or deformity. DP and PT pulses intact bilaterally. Sensation to light touch intact proximally and distally.

Right knee X-ray: (-) fracture

Hospital Course

MRI confirmed complete ACL rupture. CR underwent ACL graft reconstruction 2 weeks later without complications. Rehabilitation therapy arranged upon discharge.

Discussion

Female athletes exhibit higher rates of anterior cruciate ligament (ACL) tears compared to male athletes. There appears to be a significant role in knee biomechanics that may attribute to this discrepancy, and specifically the higher rate at which female athletes experience noncontact ACL tears compared to male athletes.[1] Two important properties that appear to increase the rate of ACL tears is knee abduction, as well as knee extension. Females exhibit greater knee abduction and greater knee extension during running.[2] In sports such as basketball and volleyball, females exhibit greater knee abduction during double-leg stop jump (deceleration followed by rapid acceleration in the form of a jump, which mimics movement in basketball or volleyball[3] and greater knee extension during side-cutting at and above 90-degrees.[4]

Differences in biomechanics are thought to, in part, be due to proximal control, in that females favor use of knee extensors greater than hip extensors during landing, while males exhibit a more-equal distribution.[5] With this in mind, there have been numerous training programs centered on enforcing proper landing and appropriate neuromuscular activity, which have significantly decreased the incidence of ACL injury in female athletes.[6] There is also potential for biomechanical properties being used to identify those at-risk for ACL tears.

While it is encouraging to see initiatives that seek to address modifiable factors of sex differences in ACL tears, there also appears to be a role of normal maturation and physiology underlying the discrepancy. The divergence in ACL tears between male and female athletes seems to appear after puberty, in high school and collegiate athletes.[7] Peak height velocity is defined as the period when adolescents are at approximately 91% of adult height, and maturation is defined as >92% of adult height. It has been shown that both of these stages are associated with greater knee abduction moment and angle during drop vertical jump (which resembles taking a rebound shot in basketball, or blocking or spiking in volleyball in female athletes, but not their male counterparts.[8]

It is not clear what role hormonal changes, and specifically estrogen, play in mediating ligament function and failure. Studies have found that there is no acute difference in ligamentous laxity throughout three phases of the menstrual cycle[9], while other studies have found increased laxity during ovulation due to decreased fiber crosslinking.[10,11] Changes in ligamentous laxity may contribute to female athletes adopting compensatory activity in leg muscles, leading to the observed differences in knee biomechanics mentioned above.

Intrinsic differences in ACL properties and structure may predispose female athletes to ACL tears over male athletes. Studies have suggested that female ACLs have lower strain at failure, lower strain-energy density, and lower modulus of elasticity, after accounting for differences in ACL size, length, and age.[12] Female ACLs also exhibit lower fibril concentration compared to males, which is significantly correlated with stiffness and modulus of elasticity.[13]

Sex differences in ACL tears extend beyond the moment of failure, to differences in outcomes after ACL reconstruction. Following reconstruction, women report more frequent and intense pain.[14] They also exhibit significantly greater deficiency in extensor strength and range of motion.[14,15] This may contribute to female patients being less likely to return to pre-injury activity level, and more likely to experience repeat failure following reconstruction.[14]

Conclusion

This case highlights the complexity that underlies sex differences in ACL tears. Current literature highlights the roles of anatomy, injury mechanism, and neuromuscular activity. The latter two have been recognized as modifiable risk factors, and initiatives have been taken to raise awareness and properly train athletes to avoid injury. However, wide differences in rates of ACL injury between female and male athletes still exist. Building consensus in attributable factors and identifying persistent differences will continue to be important for designing targeted prevention.

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For further study of women's sports injuries, see: Templeton KJ. Women's Sports Injuries. 1st ed. Rosemont, IL: AAOS; 2013.

Key Words: ACL tear, Case Study, Female Athlete, Sex and Gender Medicine