

ANATOMICAL AND STRUCTURAL FACTORS

What We Know

1. The female ACL is smaller in length, cross-sectional area, and volume compared with the male ACL, even after adjusting for body anthropometry.¹
2. The female's femoral notch height is larger, but the femoral notch angle is smaller than in males, which may influence femoral notch impingement theory. Femoral notch width is a good predictor of ACL size (area and volume) in males but not in females. Femoral notch angle is a good predictor of ACL size in females but not in males.¹
3. The female ACL is less stiff (has a lower modulus of elasticity) and fails at a lower load level (lower failure strength), even after adjusting for age, body anthropometrics, and ACL size.²
4. The ultrastructural analysis of the ACL shows that the percentage of area occupied by collagen fiber (area of collagen fibers/total area of the micrograph) is lower in females than in males when adjusted for age and body anthropometrics.³
5. Adult females have greater anterior pelvic tilt,^{4,5} hip anteversion,⁵ tibiofemoral angle⁵, quadriceps angle,^{4,5} genu recurvatum,^{5,6} anterior knee laxity,⁷⁻¹¹ and general joint laxity¹²⁻¹⁴ than adult males.
6. In adults, no sex differences have been observed in measures of tibial torsion,⁵ navicular drop,⁴⁻⁶ or rearfoot angle.^{5,15}
7. Lower extremity alignments are different among maturational groups and also develop at different rates in males and females.¹⁶

What We Don't Know

1. Do variations in tibial slope (anterior-posterior and medial-lateral), ACL volume, ultrastructure, and laxity and femoral notch geometry, condylar geometry, and lower extremity alignment or the interaction among these variables increase the likelihood of ACL strain and failure?
2. Can physical activity influence these anatomical and structural factors and, if so, when, how, and for how long do the changes occur as a result of physical activity?

3. What effect does meniscal geometry have on ACL strain and failure during activity?
4. Do variations in anatomical and structural factors influence neuromuscular and biomechanical function?

Where We Go From Here

1. In a retrospective comparison of ACL-injured and healthy knees, smaller ACL volumes were noted in those with ACL injury (abstract 20). Further research is needed to examine whether decreased ACL volume predicts ACL injury.
2. Early evidence suggests an association between (1) posterior-inferior tibial slope and ACL insufficiency,¹⁷ and (2) elevated posterior-inferior tibial slope and increased ACL strain (abstract 23). More studies examining the influence of posterior tibial slope on ACL strain and failure are needed.
3. Early evidence suggests a difference between medial and lateral tibial slopes and that females have greater tibial slopes than males (abstract 23). Further research is needed to understand the relationship of these sex differences in tibial plateau geometry to ACL injury risk.
4. Early evidence (computational work) suggests that individual tibiofemoral joint geometry (including articular morphology and ligament insertions) influences ACL strain (abstract 22). Further work is needed to identify participant-specific tissue properties via laxity testing and to validate the computational models.
5. Future authors should also consider case-control study designs for examining structural factors because they are not acutely affected by ACL ruptures.
6. We should continue studying ACL injury mechanisms by simulating physiologic conditions in laboratory environments.
7. Interactions among tibial slope (anterior-posterior, medial-lateral), ACL volume, ultrastructure, and laxity and femoral notch geometry, condylar geometry, and lower extremity alignment should be examined for their potential to increase the likelihood of ACL strain and failure.
8. The influence of physical activity during maturation and across the life span on anatomical and structural factors should be addressed.

9. The role of meniscus geometry in ACL strain and failure during activity should be examined.
10. The influence of anatomical (eg, posture, structure, body composition) and structural (eg, tibial slope, condylar geometry) factors on neuromuscular and biomechanical function should be identified, both in adults and in maturing youth.

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