Sex Differences in Unconstrained Transverse Plane Kinematic Response Under Compression and Simulated Muscle Forces

Samuel C. Wordeman[a,b], Carmen E. Quatman[a,c], Ata M. Kiapour[e], Richard C. Ditto[e], Vijay K. Goel[e], Constantine K. Demetropoulos[e], Timothy E. Hewett[a-d]

[a]Sports Health and Performance Institute (SHPI); [b]Department of Biomedical Engineering; [c]Department of Orthopaedic Surgery; [d]Departments of Physiology and Cell Biology, and Family Medicine, The Ohio State University; [e]The Engineering Center for Orthopaedic Research Excellence (ECORE), The University of Toledo

Wexner Medical Center

BACKGROUND

- Anterior cruciate ligament (ACL) injury affects nearly 250,000 Americans annually
- *In vitro* studies provide insight into tissue mechanics
- It is postulated that sex differences in tibial geometry alters biomechanics[1,2]
  - Few studies consider sex when interpreting *in vitro* biomechanical results and populating cadaveric studies
- PURPOSE: To examine sex differences in unconstrained kinematic response to simulated muscle forces and compressive loads
- HYPOTHESIS: Transverse plane kinematic response differs between male and female cadavers when a compressive load is applied across the knee joint

METHODS

- Sixteen cadaveric limbs tested in unconstrained
  - 10 female, 45.7 9.3 years old
  - 6 males, 41.5 7.1 years old
- Femur and tibia sectioned at mid-shaft and potted in polyester resin
  - Fixed in custom force couple testing system (FCTS), **Figure 1**

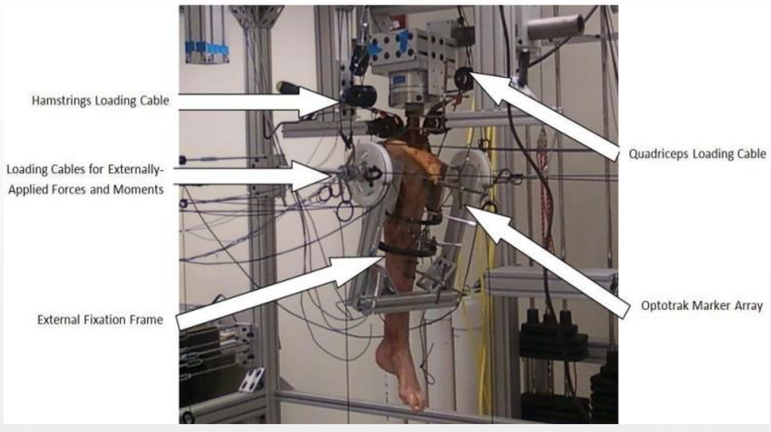
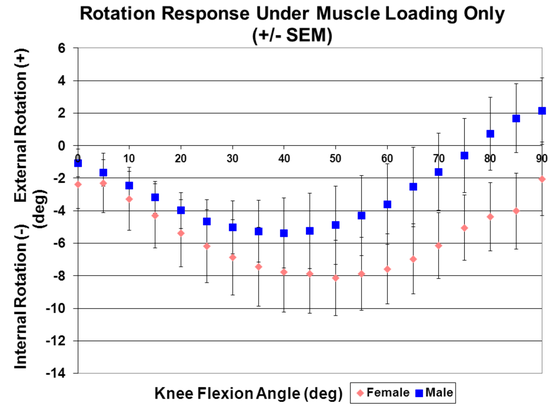


Figure 1: Custom force couple testing system with fixed potted limb

- Simulated muscle forces applied to stripped tendons via muscle clamps:
  - 400 Newton Quadriceps
  - 200 Newton Hamstrings
- Rigid body tibiofemoral kinematic measured at 100 Hz (Optotrak 3020 System, Northern Digital, Waterloo, Canada)
- Limbs cycled from 0°-90° of flexion using servo-electric actuators
- Compressive load of 134 Newton added, tests repeated
- Repeated measures mixed-model analysis of covariance (ANCOVA) used to assess differences in transverse plane knee alignment



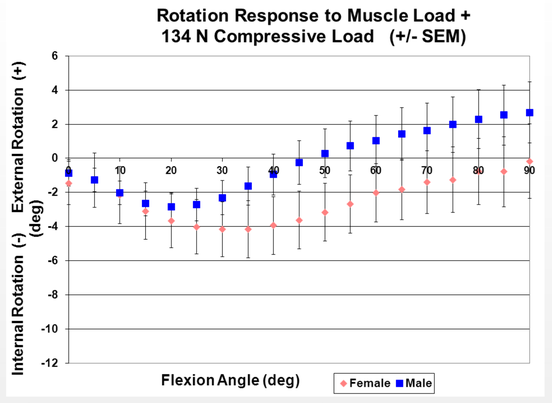


Figure 2: Transverse plane alignment of cadaveric specimens under muscle forces (top) and muscle forces + compressive load (bottom)

RESULTS

- Significant sex-by-flexion angle differences
  - Simulated muscle force condition (p=0.024)
  - Simulated muscle force + compression (p=0.007)
  - Within specimen effect of knee flexion angle (p=0.000)
- Figure 2 shows transverse plane alignment by knee flexion angle

DISCUSSION

- Female specimens experienced internal rotation through a greater range of flexion angles for both conditions
  - Internal rotation generates strain in the ACL
  - Differences could be explained by smaller soft tissue structures in females[3]
- Under compression, males decrease the magnitude of internal rotation at flexion angles greater than 20°
  - Females progressively increase internal rotation to 35°
- This study demonstrates that significant differences in unconstrained kinematics exist between the sexes
  - Under identical loading conditions, soft tissue strains may differ significantly
- Biomechanical studies should consider these differences when populating specimens and interpreting results

REFERENCES:

[1] Hashemi et al., 2010 *Am J Sports Med*
[2] Musahl et al., 2010 *Knee Surg Sports Trauatol Arthrosc*
[3] Chandrashekar et al., 2006 *J Biomech*

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