

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

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## 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<sup>1,2</sup>
  - 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**

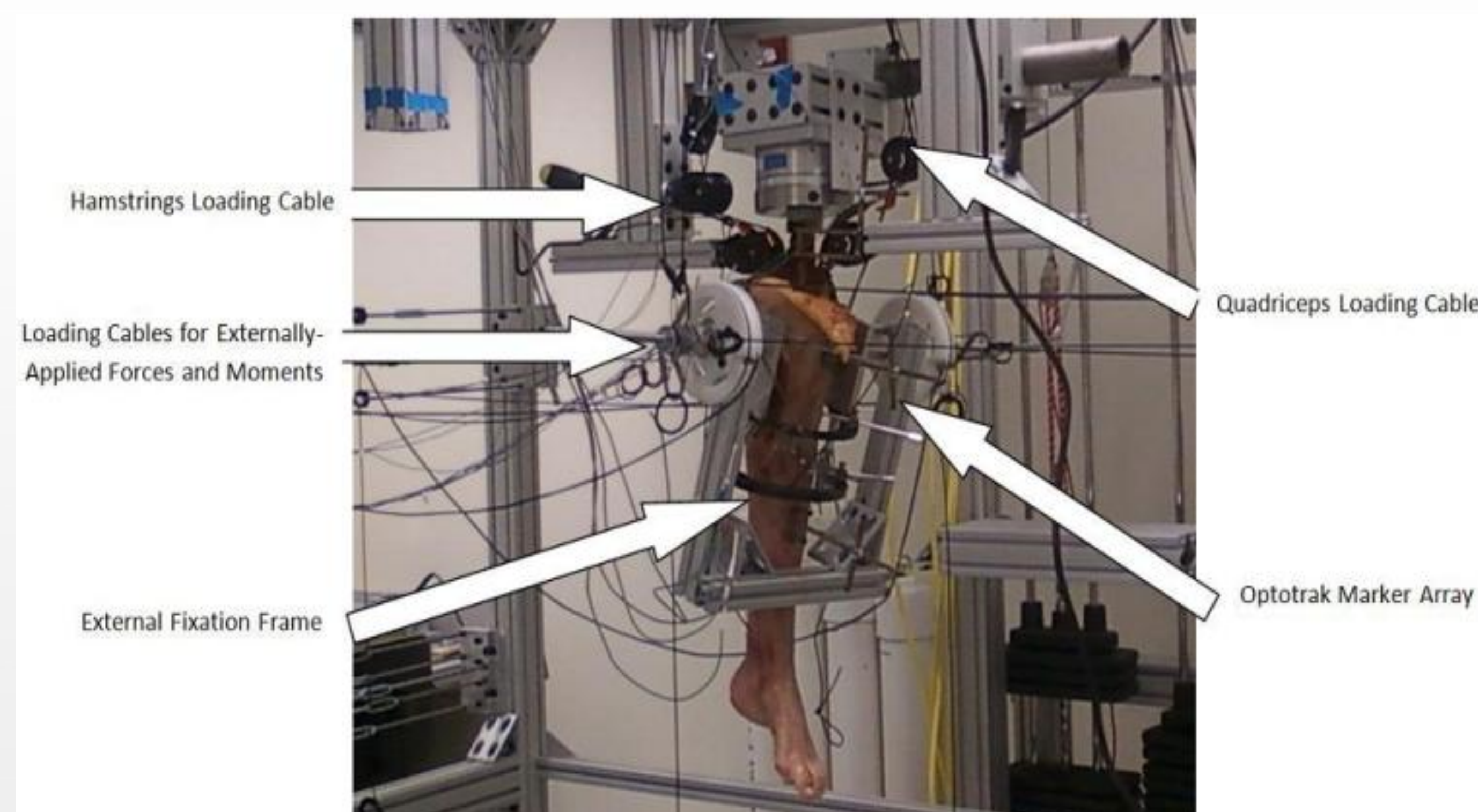


Figure 1: Custom force couple testing system with fixed potted limb

- 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

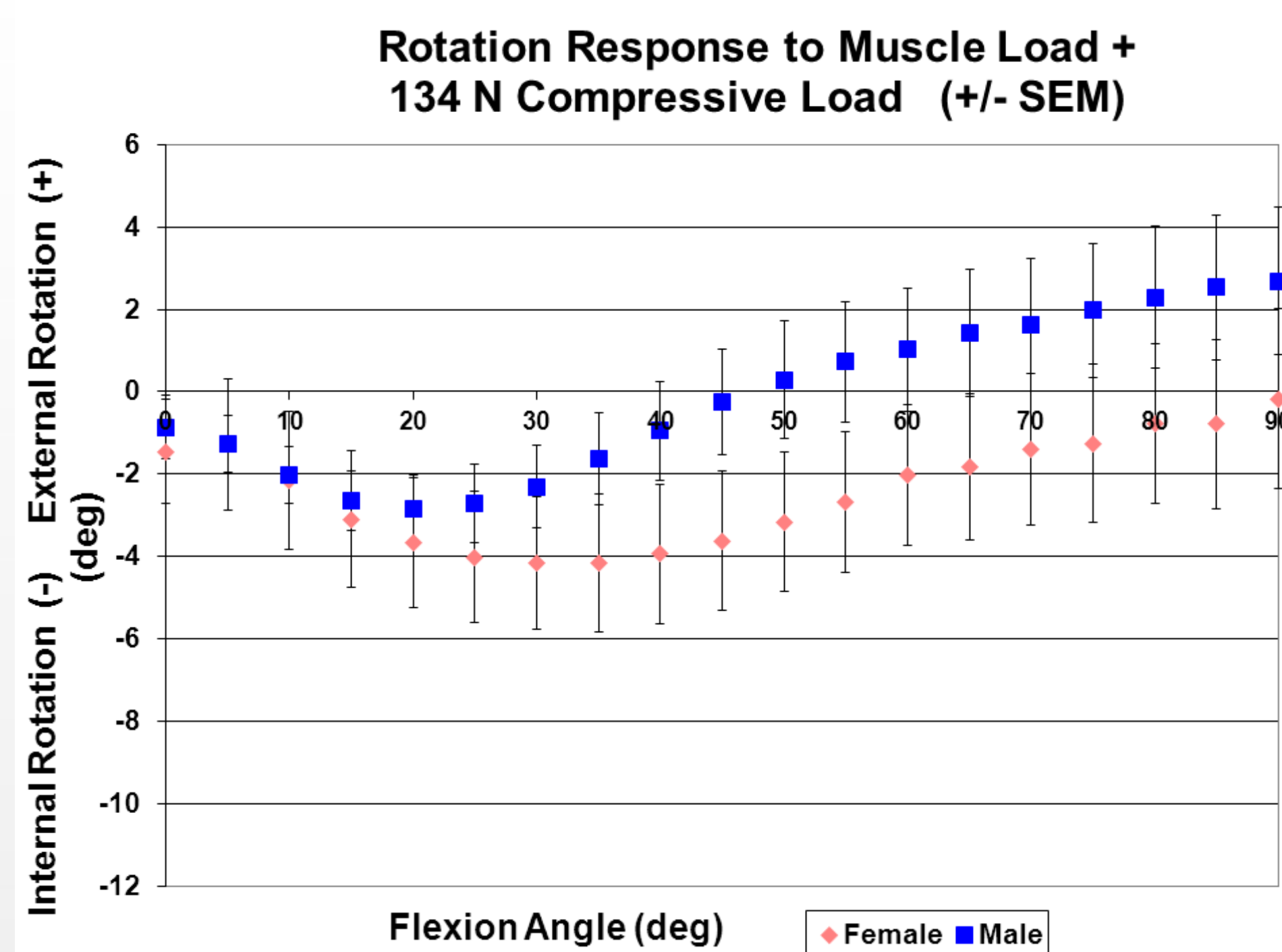
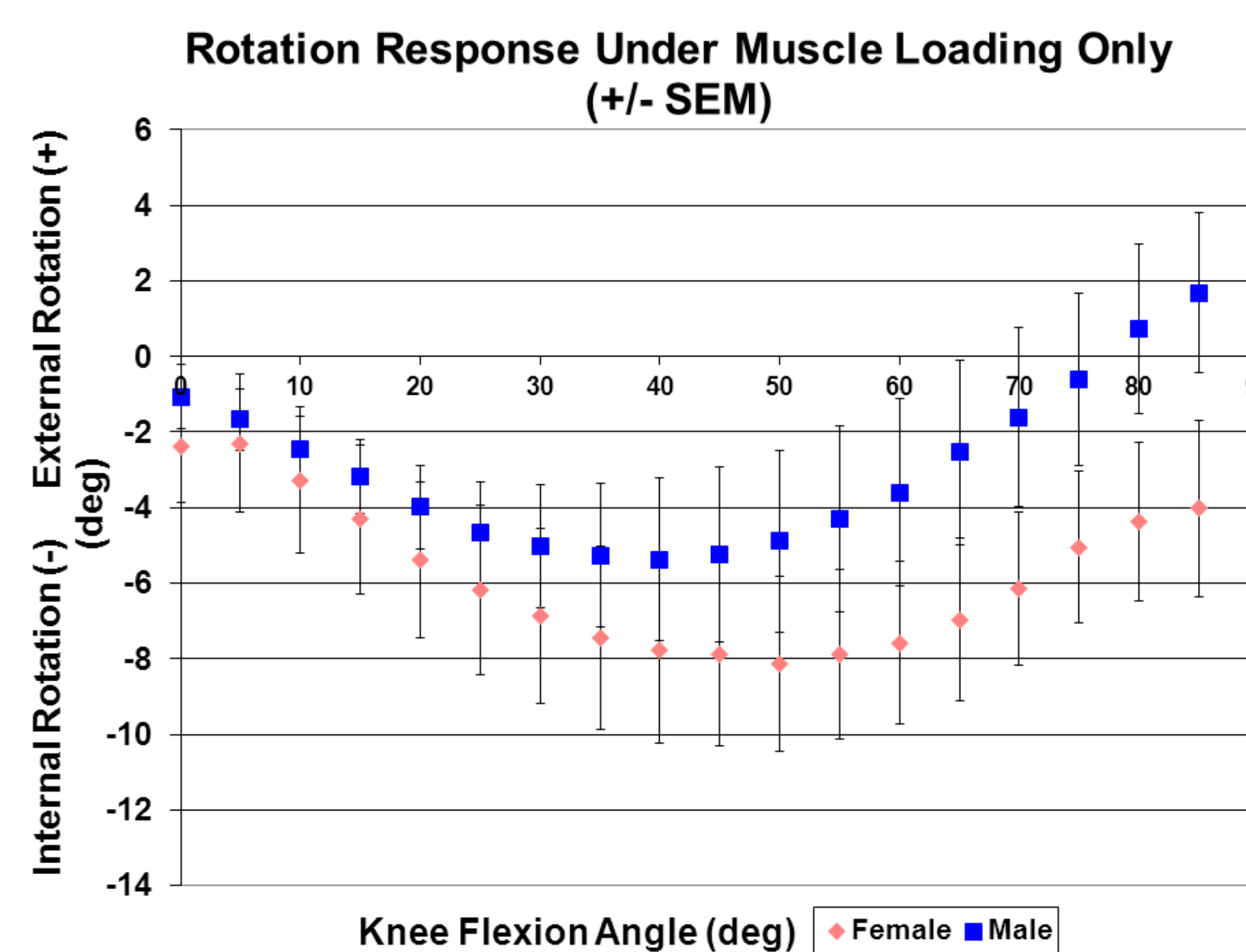


Figure 2: Transverse plane alignment of cadaveric specimens under muscle forces (top) and muscle forces + compressive load (bottom)

## 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<sup>3</sup>
- 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 Traumatol Arthrosc*
- [3] Chandrashekar et al., 2006 *J Biomech*

## ACKNOWLEDGEMENTS

The authors acknowledge their collaborators at the University of Toledo and Cincinnati Children's Hospital Medical Center. The authors would like to acknowledge funding support from National Institutes of Health/NIAMS Grants R01-AR049735, R01-AR05563 and R01-AR056259.