

ACL STRAIN DURING SIMULATED FREE-SPEED WALKING

ACL Study Group, March 2002

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Introduction

- **ACL critical to knee joint stability**
- **ACL is loaded during strenuous activities**
- **unclear whether ACL loaded during moderate activities like free-speed walking**
- **unclear whether compensation is needed in walking**

Purpose

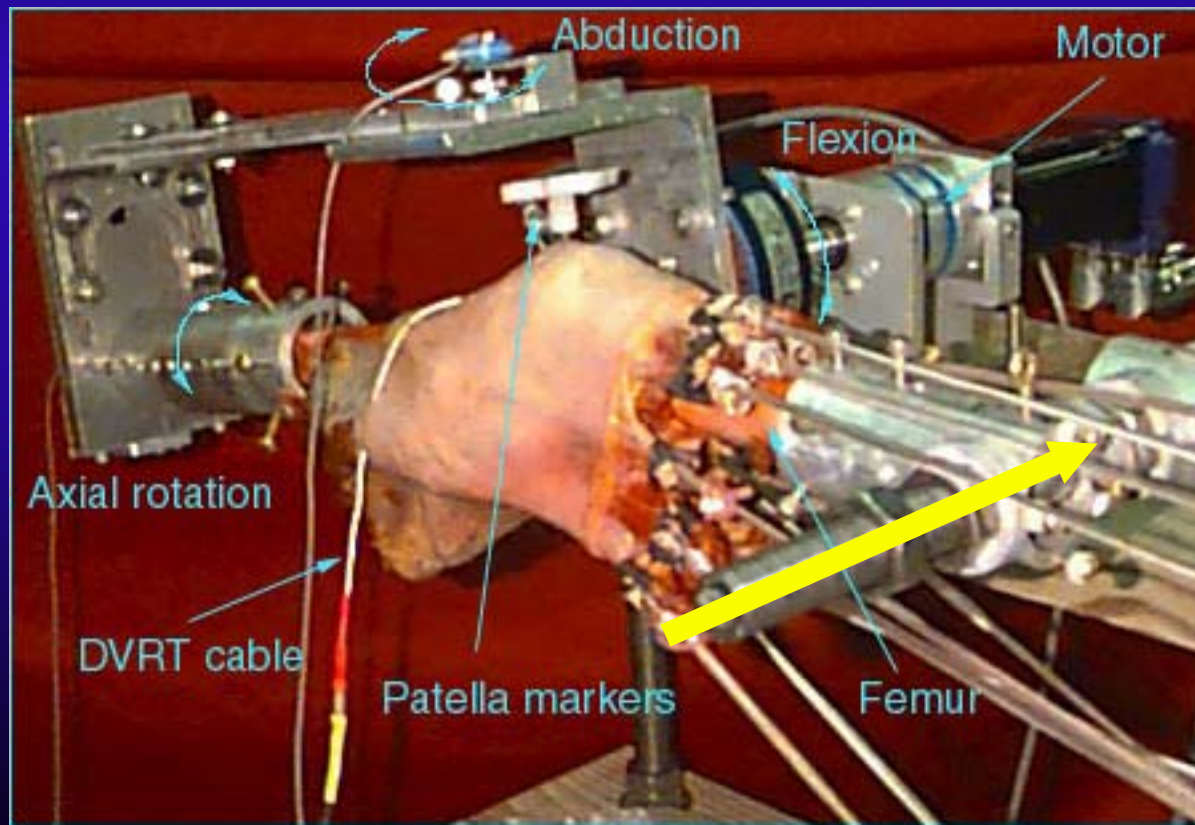
- **evaluate ACL strain during simulated walking with a cadaver model**
- **knee placed at various axial rotation and AP translational positions**
- **Knee flexion-extension controlled based on the averaged walking pattern of 30 normal subjects**

Materials and methods

- **fresh frozen human knees**
- **ACL exposed through parapatellar incision**
- **MicroStrain™ DVRT transducer was sutured onto the anteromedial band of the ACL**
- **Femoral inter-condylar notch was enlarged to avoid impingement**

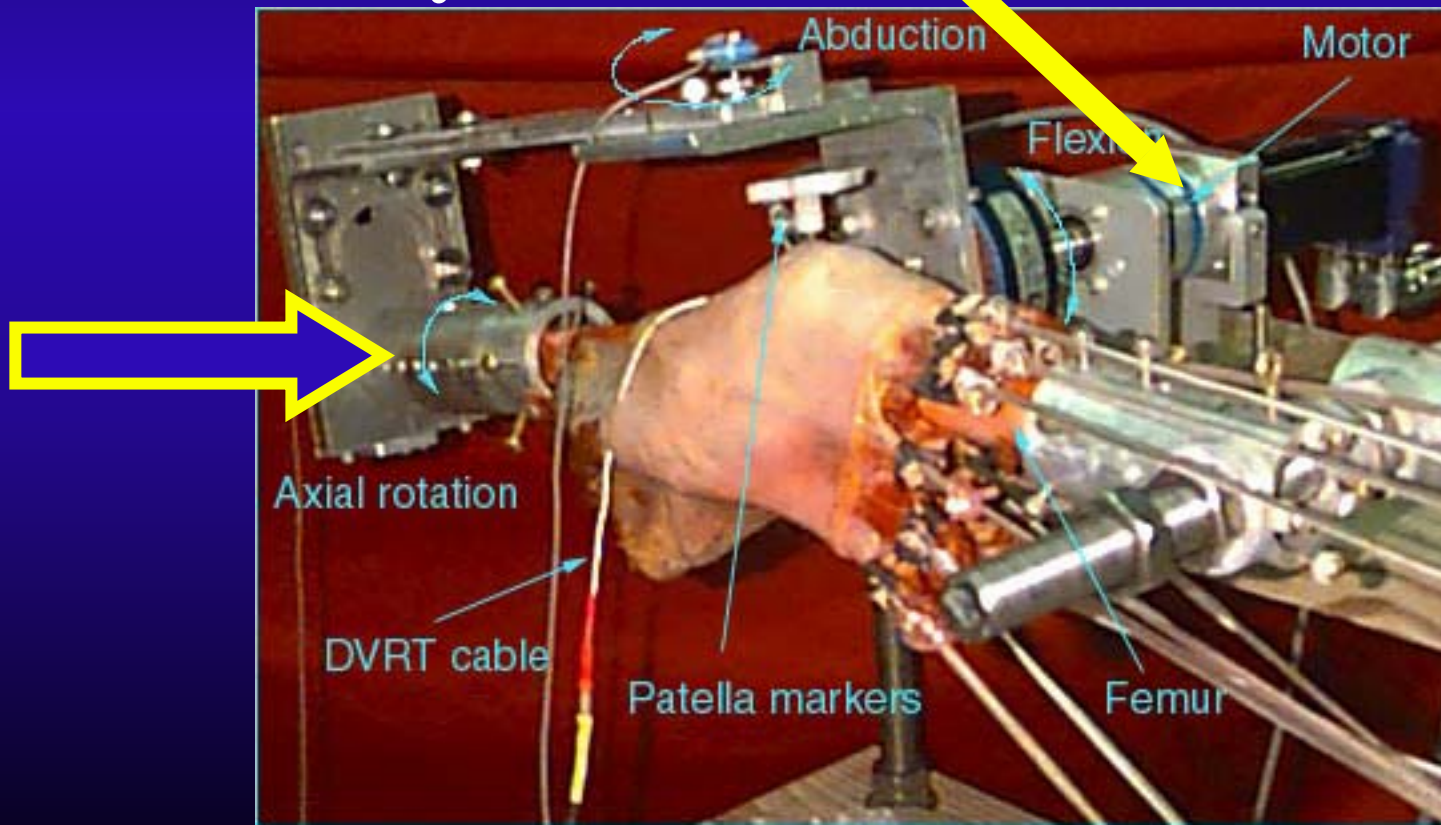
Experimental set up

- Femur fixed rigidly to the frame.



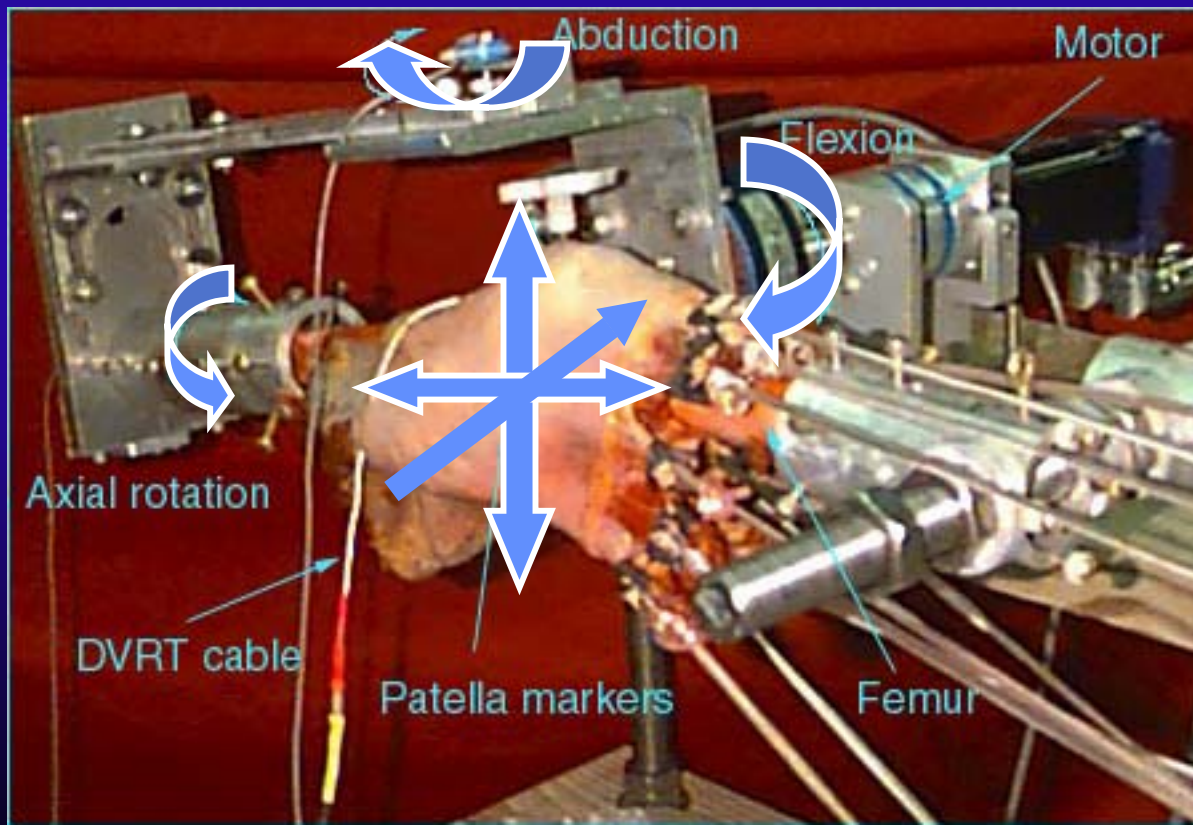
Experimental set up

- Tibia fixed to an attachment mechanism
- driven by servomotor



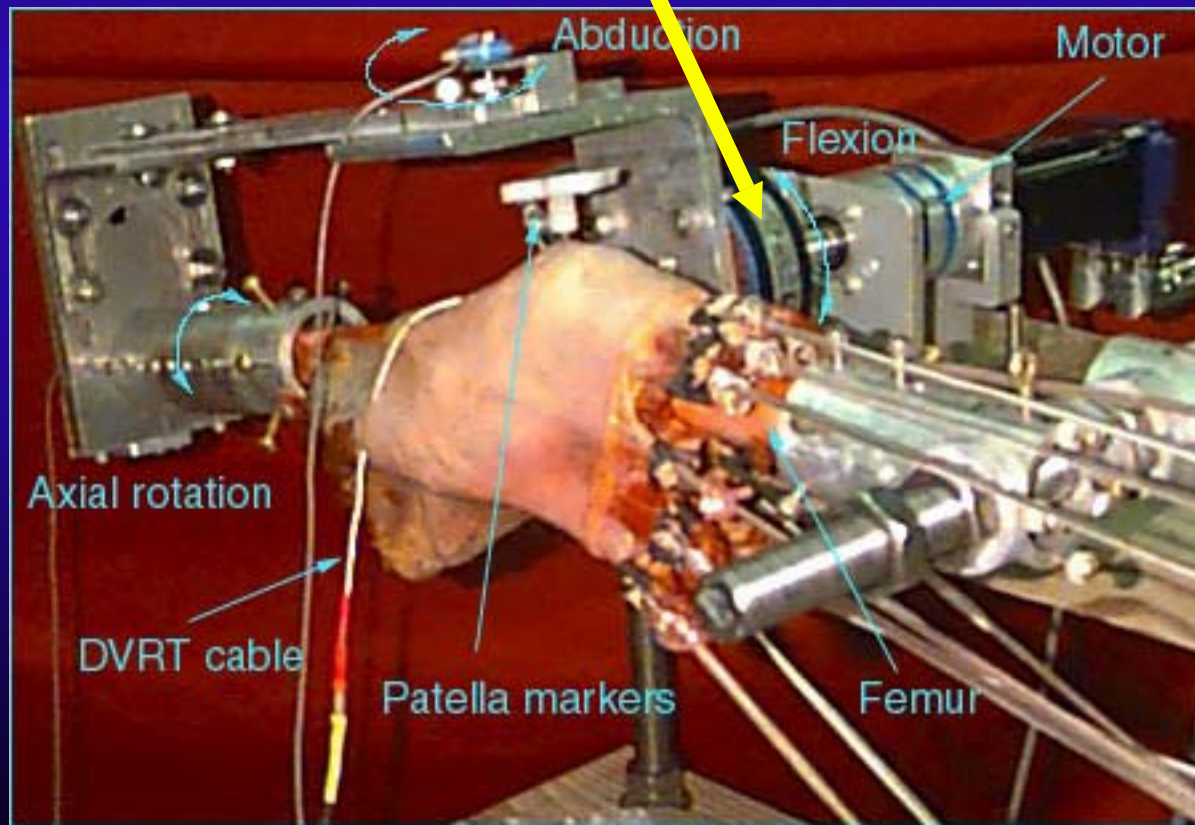
Experimental set up

- abduction, flexion, rotation, and 3 orthogonal translations of the tibia relative to femur



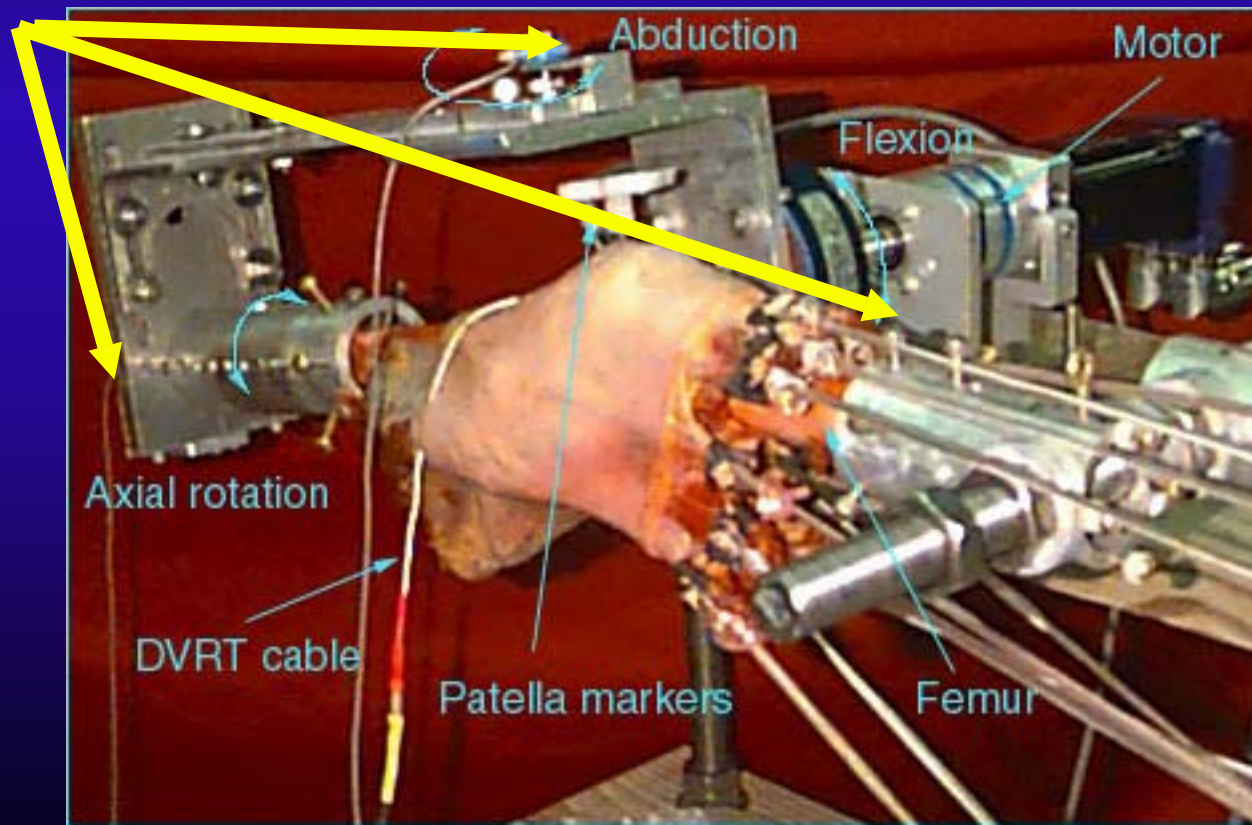
Experimental set up

- six-axis force sensor used to measure forces and moments



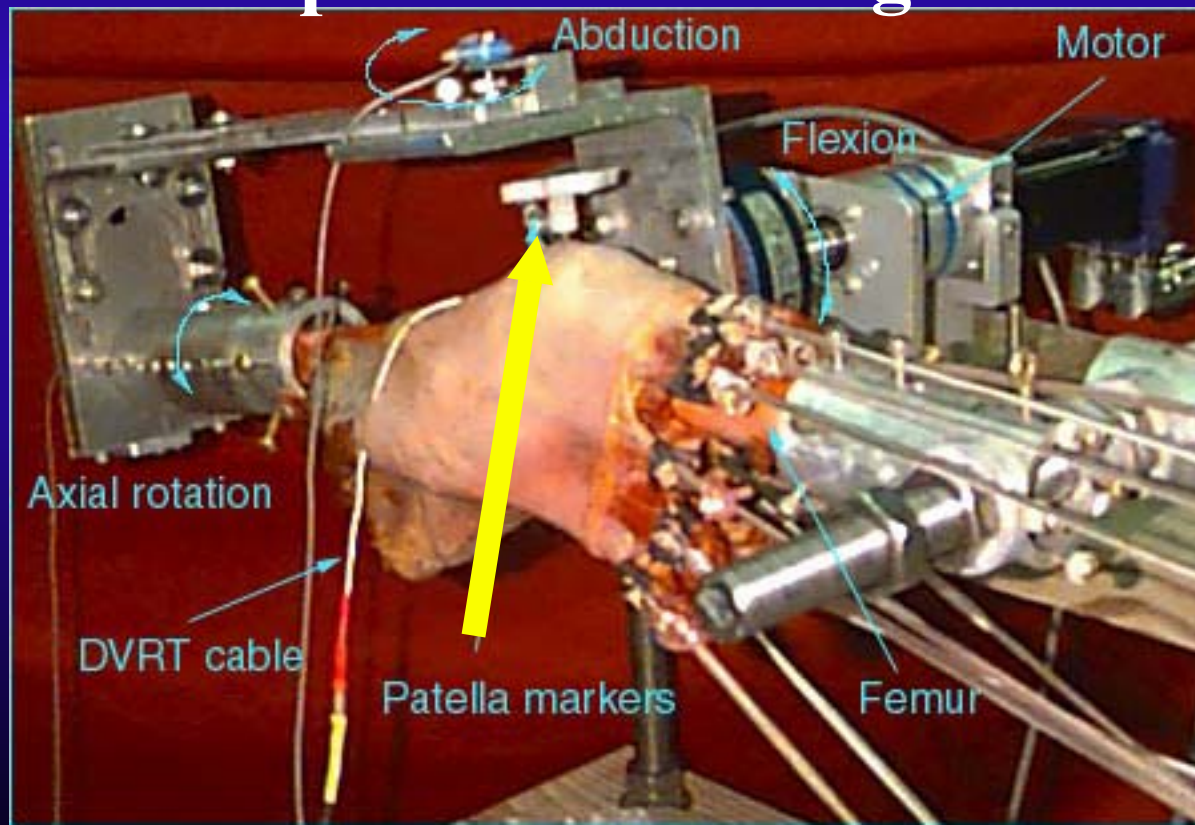
Experimental set up

- precision potentiometers to measure rotations/translations



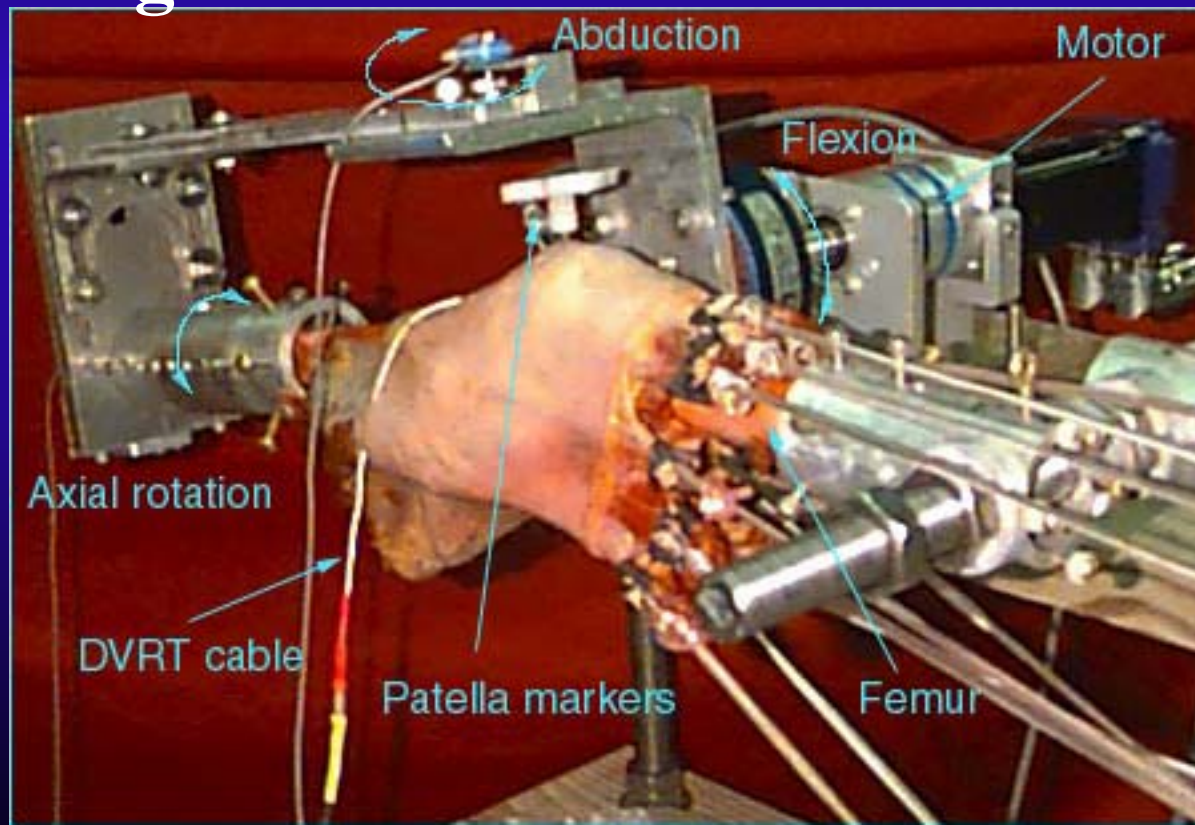
Experimental set up

- position sensor was placed on the patella to measure patellar tracking



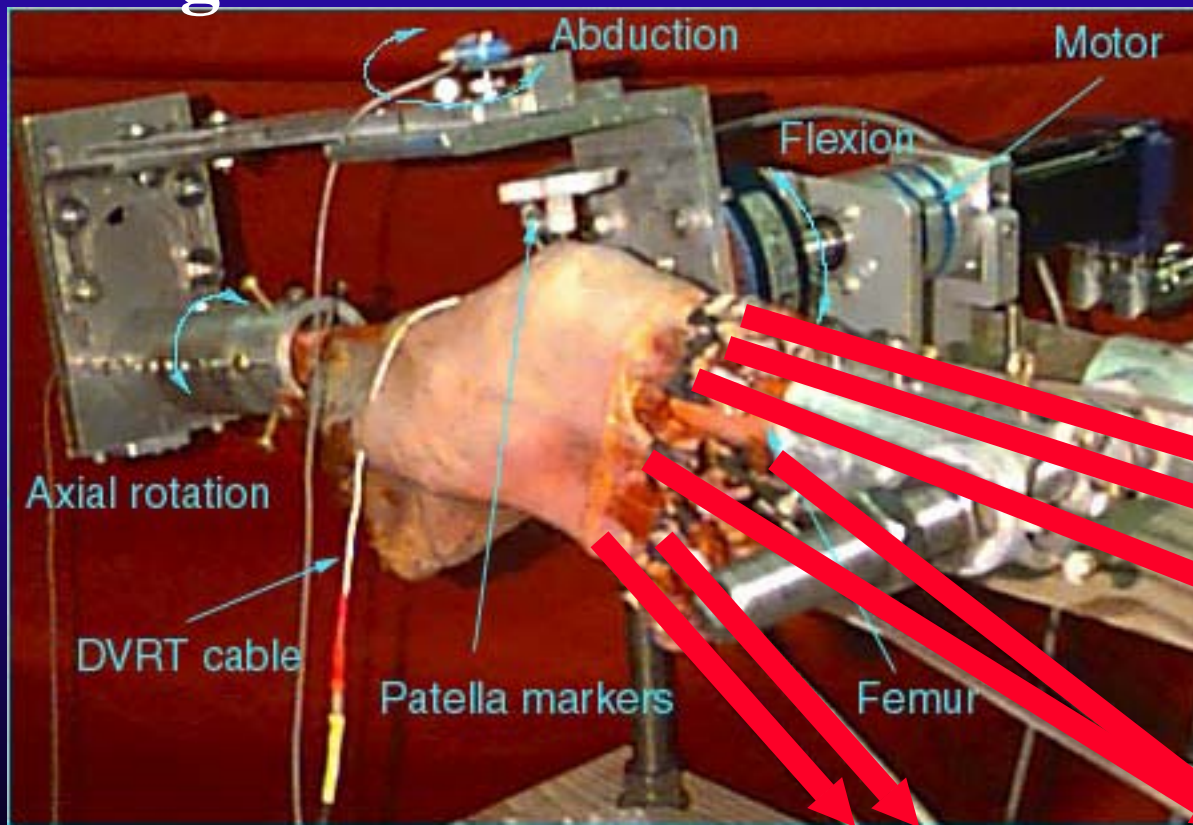
Experimental set up

- Ropes were sutured to individual muscles crossing the knee

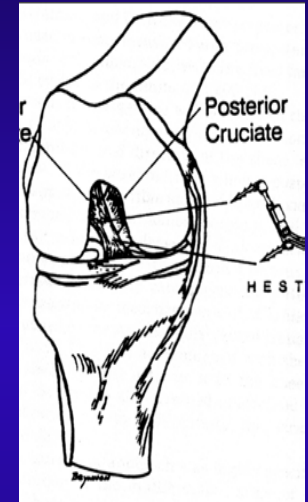
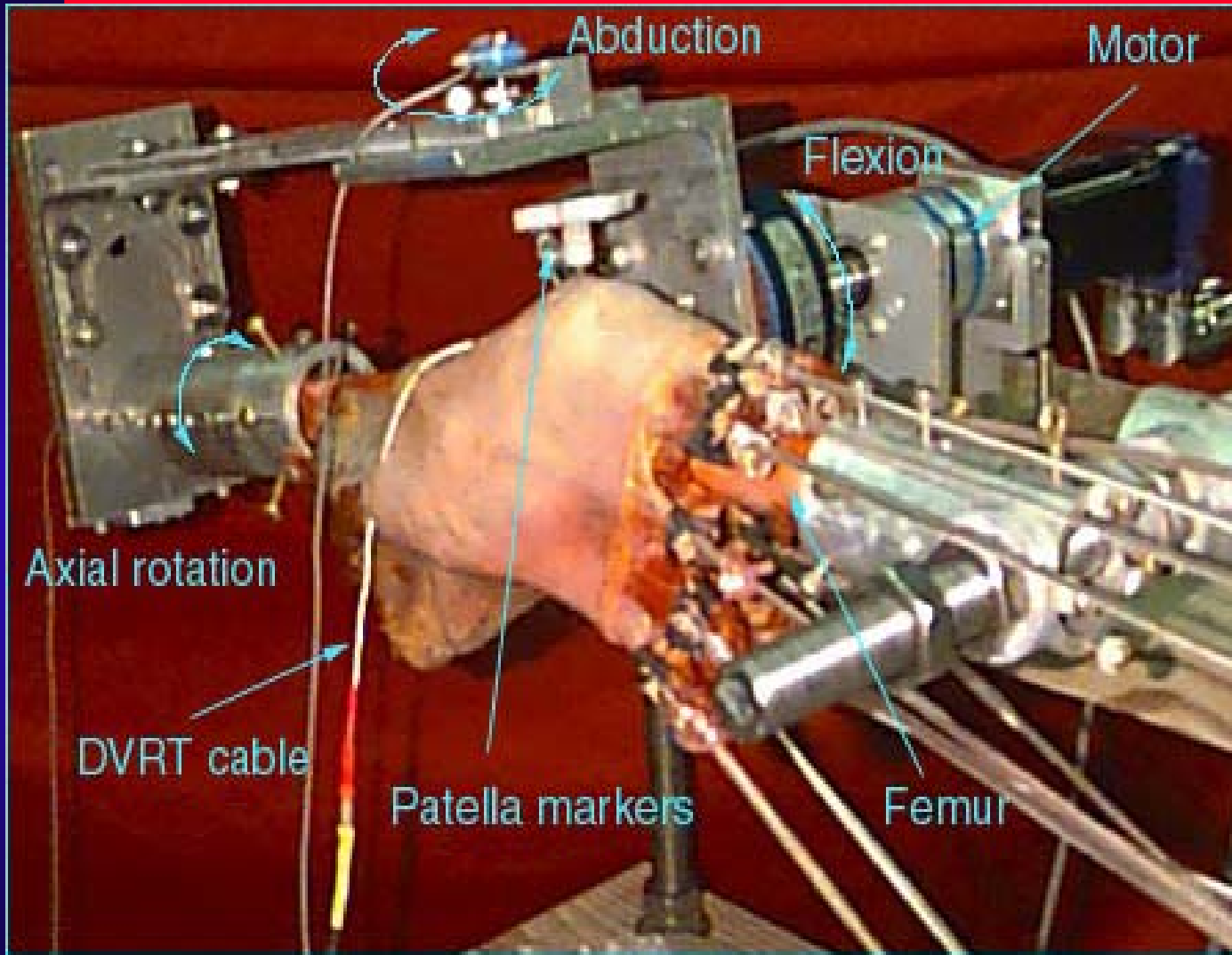


Experimental set up

- muscles loaded according to the physiological cross sectional area



ACL Strain in “Locomotion”

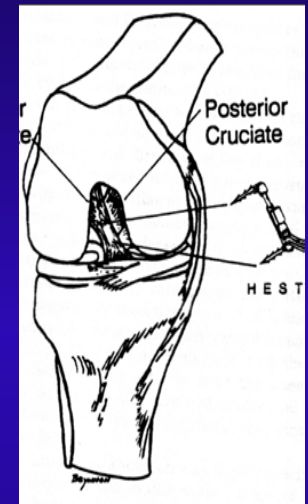


“Walk” with different IR/ER: 7°, A-P translation: 10 mm

Simulation of walking

- **Average knee flexion pattern during free speed walking obtained from 30 normal subjects**
- **servomotor used to simulate walking pattern on the cadaveric knee**
- **about 13 “strides” in each 16 second long trial**

ACL Strain in “Locomotion”

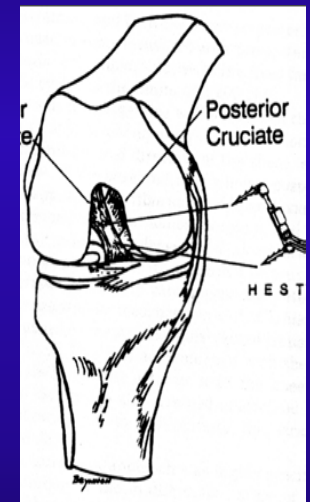
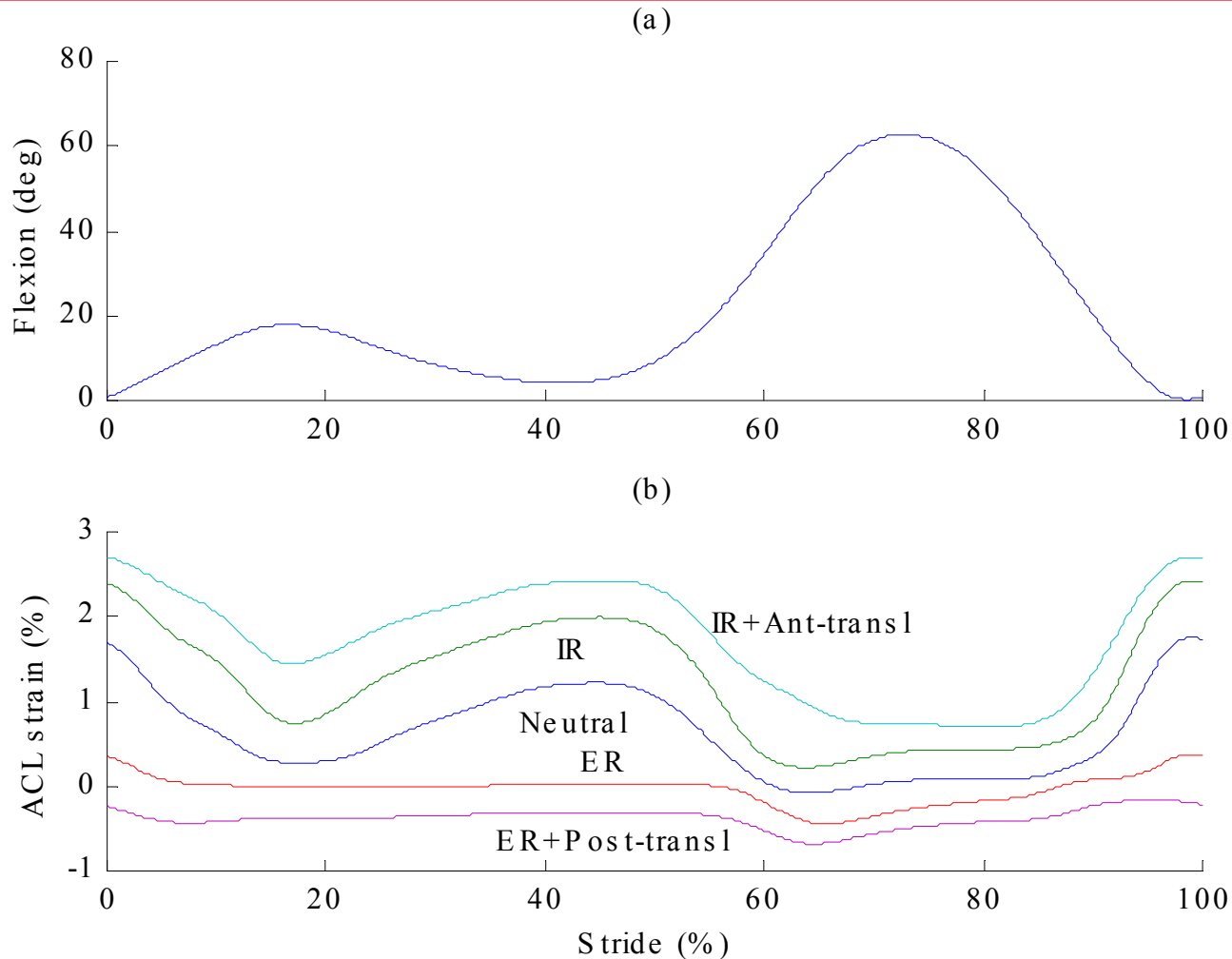


“Walk” with different IR/ER: 7°, A-P translation: 10 mm

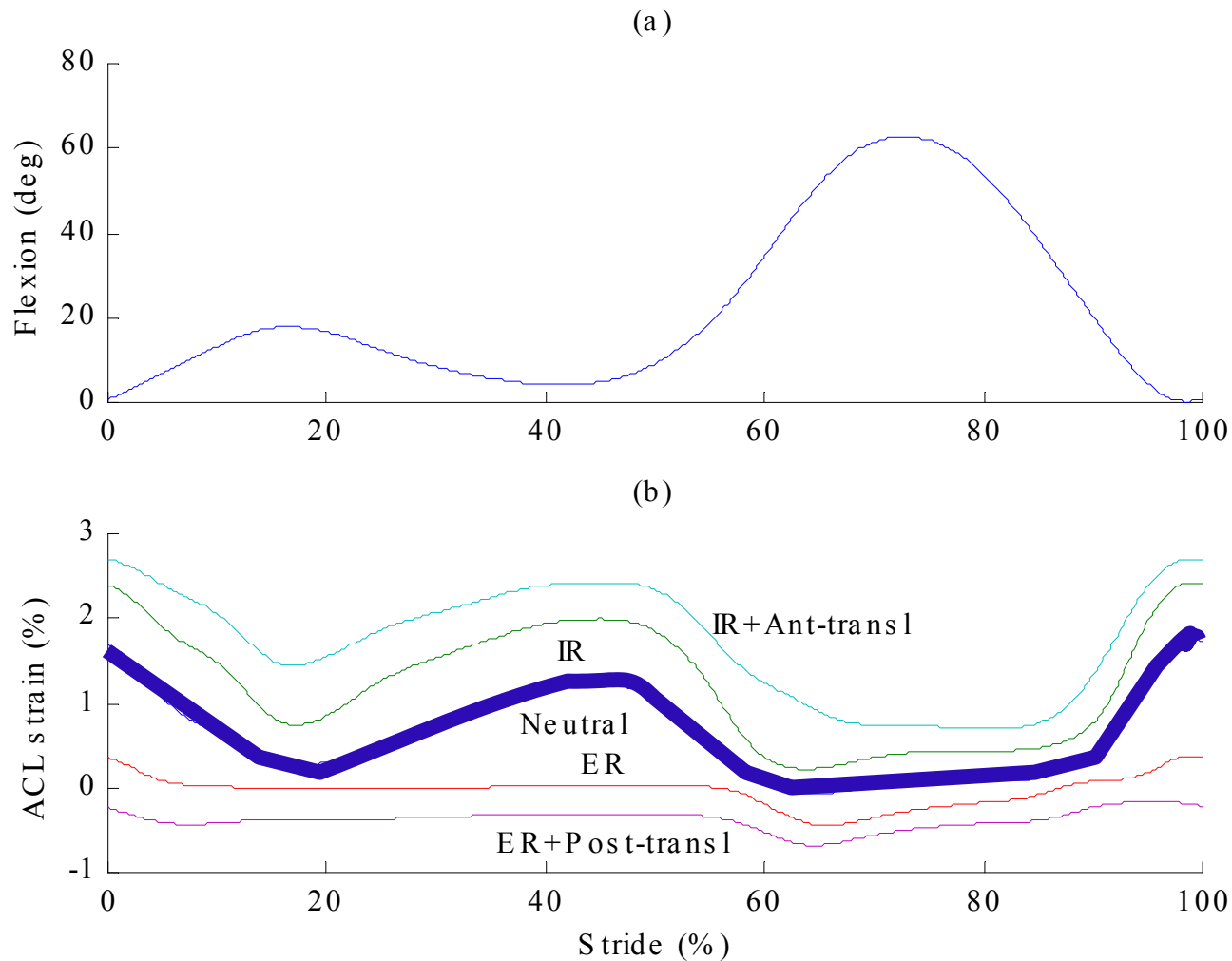
Simulation of walking

- repeated with the tibia placed at different axial rotations (-7° , 0° , and 7° internal rotation)
- tibia also placed at different anterior-posterior translation (-10 mm, neutral, and 10 mm)

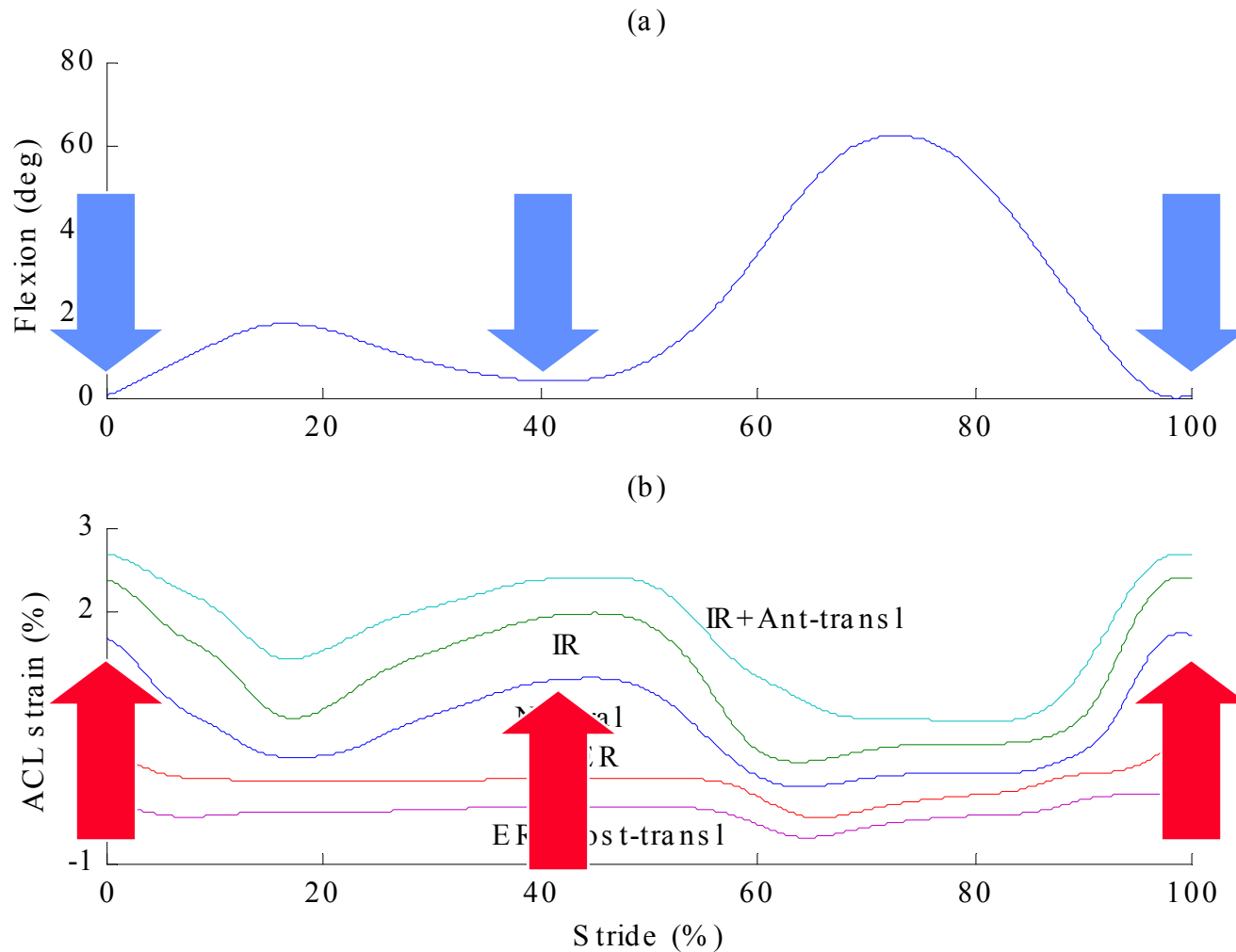
Results: ACL strain during simulated “free-speed walking”, averaged over 48 strides



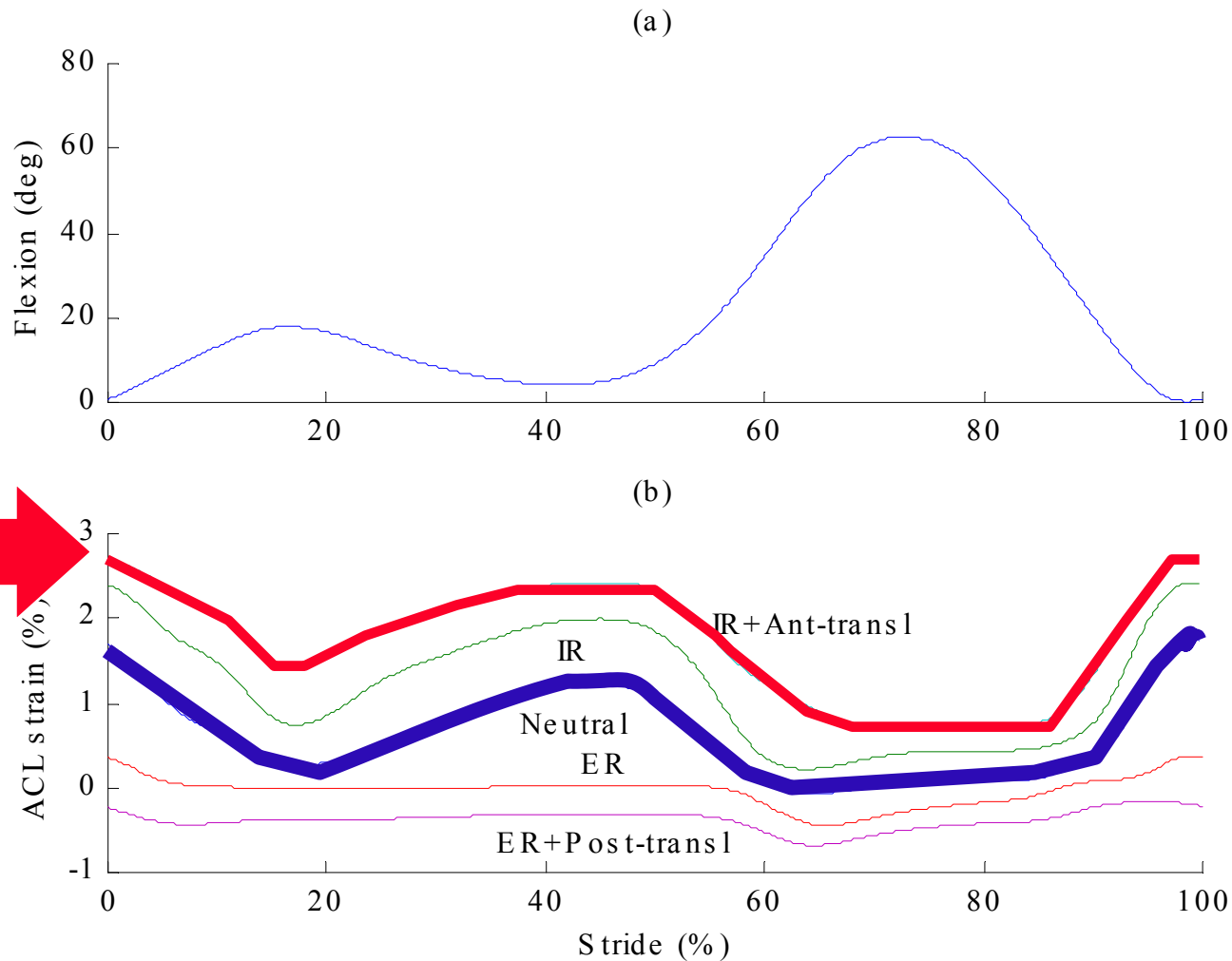
ACL strain varied systematically with knee position during the simulated “walking”.



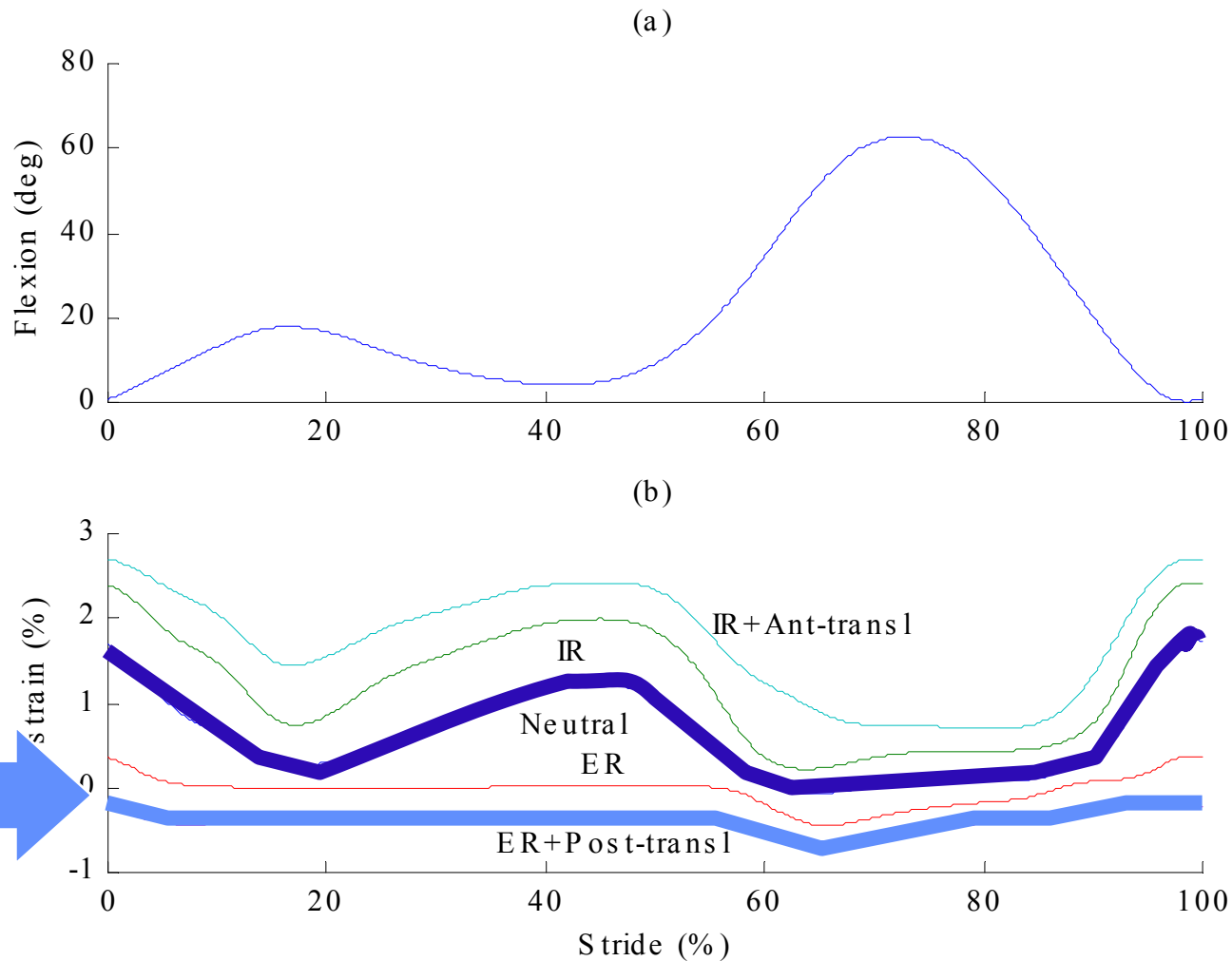
largest strain observed at near full knee extension



ACL strain increased markedly with tibial internal rotation and anterior translation



tibial external rotation and posterior translation reduced the ACL strain substantially



Results

- **Over multiple strides in a trial, the strain variation was usually larger during the first stride**
- **became smaller and more repeatable afterwards.**

DISCUSSION

- **allowed evaluation of ACL loading in well-controlled and systematically varied patterns**
- **cadaver setup allowed evaluation of ACL strain under conditions that were difficult to implement in an *in vivo* setup (e.g., ACL strain at full knee extension due to possible impingement).**

Discussion

- **ACL is loaded considerably during free-speed walking**
- **indicate need for compensation for ACL deficiency during locomotion**

Discussion

- **internal rotation of the tibia loads the ACL strongly (Markolf et al JOR 1995)**
- **a compensatory mechanism adopted by ACL deficient is to externally rotate the tibia**
- **this may avoid loading a partially torn ACL and/or to avoid unstable knee positions (Zhang et al Gait & Posture 1998)**
- **Further work needs to be done to test a larger sample at systematically varied knee positions in 3-D space.**

Acknowledgments

- **The authors acknowledge the partial supports of the NIDRR and NIH (LZ).**

Thank you.

