Asymmetry in Young Healthy Adult Knee Kinematics Revealed Through Biplane Radiography of the Full Gait Cycle

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Introduction

Symmetry of Knee Kinematics
- Bilateral symmetry is a common criterion in evaluating a patient's response to knee surgery or rehabilitation
- Assumption of perfect symmetry implies that kinematic differences are related to the injury, surgical procedure or rehabilitation
- Expected symmetry in uninjured healthy knees remains unknown

Aims
- Evaluate side-to-side difference (SSD) in knee kinematics of young healthy adults
- Evaluate the use of biplane radiography to calculate kinematics of full gait cycle

Methods

Subjects
- 19 healthy young adults with IRB approval and informed consent were enrolled (9 female, 10 male; age: 30.4 ± 6.3 years)

Data Collection
- Biplane radiographs were collected during level walking (self selected speed; average 1.4 m/s) with Dynamic Stereo X-ray system (DSX)
- Full gait cycle captured in 2 separate segments, with 2 trials each; (1) before foot strike to mid-stance (2) mid-stance to second foot strike
- High resolution computed tomography (CT) acquired and used to build subject specific femur and tibia models (± 10 cm from joint line)
- Foot strike recorded using instrumented treadmill

Data Processing
- Knee kinematics were determined using a validated volumetric model-based bone tracking technique (Figure 1)
- Right femur and tibia anatomical coordinate systems determined using anatomical landmarks, then were mirrored to the left side bones using iterative closest point to match the bone surfaces
- Kinematic parameters calculated using Grood and Suntay convention
- Custom MATLAB code used to interpolate kinematic results as a function of percent gait cycle
- Average kinematic curve for each subject found by averaging kinematic results from all trials (Figure 2)
- SSD found by calculating absolute difference between left and right knee kinematics per subject

Results

- Peak average translation SSD: anterior-posterior 2.3 mm, lateral-medial 1.0 mm, proximal-distal 1.6 mm
- Peak average rotation SSD: flexion/extension 8.2°, internal/external 5.2°, ab/adduction 2.8°

Discussion

- Largest SSD observed between double support (Figure 3: *DS) and beginning of swing phase (Figure 3: *SP) for flexion/extension and abduction/adduction rotations
- Translations and Int/Ext rotation SSD was overall constant across entire gait cycle
- This study was able to evaluate in vivo native knee kinematics for the entire gait cycle using a biplane imaging technique

Significance
- Provided valuable baseline data indicating the amount of kinematic asymmetry that is present in healthy young adults during gait
- Surgical and rehabilitation procedures that result in kinematic symmetry as good or better than these bounds may be considered to have returned the knee kinematics to “normal,” despite any statistically significant differences that may exist between knees

References and Acknowledgement


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