**Simulation Lab #2:**

**Kinematic and Geometric Modeling of the Hip, Knee, and Associated Muscles**

Modeling and Simulation of Human Movement

BME 599

Laboratory Developers: Jeff Reinbolt, Hoa Hoang, B.J. Fregly,   
Silvia Blemker, Allison Arnold

# VII. Create a Kinematic Model of the Lower Extremity

***Table 1. Femur Landmarks***

|  |  |  |  |
| --- | --- | --- | --- |
|  | X | Y | Z |
| Hip center |  |  |  |
| Medial epicondyle |  |  |  |
| Lateral epicondyle |  |  |  |

***Table 2. Rotation Matrix,***

|  |  |  |
| --- | --- | --- |
|  |  |  |
|  |  |  |
|  |  |  |

***Table 3. Rotation Matrix,***

|  |  |  |
| --- | --- | --- |
|  |  |  |
|  |  |  |
|  |  |  |

***Table 4. Rotation parameters that describe***

|  |  |  |
| --- | --- | --- |
| Euler angles | Degrees | Radians |
| *φ* |  |  |
| *θ* |  |  |
| *ϕ* |  |  |

Is the center of the femoral head at the origin of the femur segment reference frame? Do the axes for the femur body correspond to Fig. 1? Where is the femur’s reference frame relative to the pelvis? Is the position of the femoral head in the acetabulum?

# VII-C.1 Create Knee Joint #1

Inspect how the tibia moves about the femur for different angles. Does the tibia have rolling and sliding motion? Does it exhibit any gapping between the tibial plateau and the femoral condyles?

# VII-C.2 Create Knee Joint #2

Inspect how the tibia moves about the femur. Does the tibia have rolling and sliding motion? Does it exhibit any gapping between the tibial plateau and the femoral condyles? How does motion of Knee Joint #2 differ from the motion of Knee Joint #1? Does Knee Joint #2 look better than the hinge knee? Briefly answer these questions in your written report.

# VII-D.1 Create and Evaluate Muscle Path #1

***Table 5. Semitendinosus Origin and Insertion***

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Type of point | X | Y | Z | Reference Body |
| Origin1 | Fixed |  |  |  |  |
| Insertion2 | fixed |  |  |  |  |
| 1 coordinates should be defined with respect to the pelvis  2 coordinates should be defined with respect to the tibia | | | | | |

Visually inspect your muscle. Does it look anatomical? Does it penetrate any bones?

Plot the experimental data superimposed on your curves.

Comment on the validity of representing the semitendinosus path geometry as a straight line from the origin to the insertion.

# VII-D.2 Create and Evaluate Muscle Path #2.

***Table 6. Semitendinosus Muscle #2***

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Type of point | X | Y | Z | Reference Body |
| Origin |  |  |  |  |  |
| ? |  |  |  |  |  |
| Insertion |  |  |  |  |  |

Plot the hip and knee flexion moment arms superimposed on the experimental data plot. Compare these plots. Summarize your method for representing the muscle path geometry. How did you define the attachments?

What was your rationale for locating the wrapping surface and/or via points? Which of these parameters are the moment arms most sensitive to? If you didn't have experimental data for reference, how confident would you be in the moment arms predicted by a kinematic musculoskeletal model?

# VII-D.2.4 Analyze the sensitivity of the semitendinosus moment arms to knee kinematics.

Summarize your knee kinematics-moment arms sensitivity study by answering the following questions:

* How and why are the moment arms of the two muscles different?
* Do you think the differences in the knee kinematics affect the muscle moment arms enough to matter?
* For what applications might a hinge joint knee be sufficient? When would a hinge knee not be sufficient?

# VII-E Discussion

Comment on the factors that influence the accuracy of muscle moment arms computed with a kinematic musculoskeletal model.

What techniques might you use (computational or experimental) to increase the accuracy of a model if necessary?