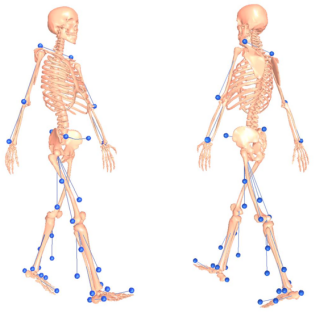
BIOMENG771: OpenSim Lab 2: Kinetic Modelling of the Musculoskeletal System



Aim: In this lab you will learn how to perform inverse dynamic analyses in OpenSim.

This lab is due September 16 at 12:00pm and is worth 10% of your final grade.

Problem: You want to investigate the influence of using walking poles to alter the walking gait of a patient who has had a joint replacement. You read somewhere in a magazine that the use of walking poles alleviates the loads placed on the knee. After performing inverse kinematics to investigate the changes in lower limb joint angles (Lab 1) the next step is to calculate knee joint loads for this subject. You will perform an inverse dynamic analysis and adjust the default OpenSim model to enable the calculation of the knee adduction moment. You will use this as a 'surrogate measure' of the medial-lateral force balance at the knee and then compare these findings with the actual *in vivo* joint contact force data.

Task 1: Prepare the ground reaction force data for OpenSim. The data for this lab are in the KineticsLabData.zip file on Canvas, and includes the raw .c3d files from two gait trials…a normal walking gait trial (*jw_ngait_og1.c3d*) and a walking gait trial with long walking poles (*jw_wpgait_ln4.c3d*). The tracked markers (.trc) and ground reaction forces from each plate have already been exported in an OpenSim .mot format (See the opensim confluence website for more details about the .mot file format and how to represent your grf and trc data). Note: The force plate data are NOT filtered, so you might need to write a script to filter these forces at an appropriate frequency.

View the C3D file in Mokka to determine which feet strike each force plate in each trial (the plates are conveniently numbered in Mokka and these numbers coincide with the .mot file names). Analyse ONLY the FIRST right foot strike for each trial.

Task 2: Add two more dofs to the knee model. The default knee in this model has only one degree of freedom (flexion-extension). If we want to calculate the net joint moment about other axes (abduction-adduction or internal-external rotation) we will have to include these DOFs in the model. Modify the scaled *gait2354_simbody.osim* model using Notepad++ to include knee internal-external rotation and adduction-abduction (as shown during Tutorial 4). Place appropriate constraints on these new DOFs. Note: you can also 'clamp' these DOFs so that they don't adjust during the IK solution, but OpenSim will still calculate the net joint moment about these axes.

Task 3: Perform Inverse Dynamics. Use the scaled model from Lab 1 with updated knee DOFs (from

Task 2 above) to perform inverse kinematics (IK) on the .trc files and then inverse dynamics on both of the walking trials. You might need to re-run the IK for these trials if you had not previously rotated the marker data to the correct OpenSim coordinate system. Once you have performed IK on these trials you can check to make sure your ground reaction forces and motion are in the same coordinate system by 'associating' the Force Plate.mot file to the IK solution. You should see a green force vector visualised going through the feet. You will need to identify which segment in the model will be associated to the reaction force (in the External Loads tab of the Inverse Dynamics tool). For walking this body should be the calcaneus.

Task 4: Calculate medial-lateral contact forces. You will be provided with two files containing the raw data from the four load cells embedded in the instrumented tibial tray (*jw_ngait_og1_knee_forces.csv* and *jw_wpgait_ln4_knee_forces.csv*). Use the regression equation below to convert the raw data into medial and lateral contact forces.

$$c_1 = 0.9871$$
$$c_2 = 0.9683$$
$$c_3 = 0.0387$$
$$c_4 = 0.0211$$
$$F_{medial} = c_1 F_{AM} + c_2 F_{PM} + c_3 F_{AL} + c_4 F_{PL}$$
$$F_{lateral} = (1 - c_1) F_{AM} + (1 - c_2) F_{PM} + (1 - c_3) F_{AL} + (1 - c_4) F_{PL}$$

Prepare a report that answers the following questions. Include tables or figures with appropriate axes and labelling to highlight your findings (note: you will lose marks for figures and tables that do not have labels, units, or captions!).

1. The ground reaction forces during walking might vary between normal walking and the pole walking trial. Plot the vertical ground reaction forces for the normal walking gait trial and the walking pole gait trial, time-normalised to the stance phase. Comment on the difference in the peak vertical ground reaction force and why you think this difference exists. **(3 marks)**

2. When you performed inverse dynamics did you pre-filter the ground reaction forces? Describe whether or not this step is necessary. Justify your answer. **(2 marks)**

3. Plot the three hip joint moments for the normal walking trial normalised to the stance phase and comment on how the optimal joint centre location vs OpenSim hip centre prediction might alter the moments calculated. **(3 marks)**

4. Plot the knee adduction moment for the two walking trials (again, time-normalised over stance phase) and briefly comment on the difference between the normal walking trial and the walking pole trial in the figure caption. **(3 marks)**

5. Plot the medial-lateral joint contact forces across the stance phase for the two walking trials and briefly comment on the difference between the normal walking trial and the walking pole trial in a figure caption. **(3 marks)**

6. Comment on whether you think it would be a good idea to constrain (or clamp) the varus-valgus (abduction-adduction) or internal-external rotation degrees of freedom at the knee when you perform IK. Use your knowledge of normal knee motion to justify this answer. **(2 marks)**

7. Is the knee adduction moment calculated from inverse dynamics a reasonable estimate of the knee contact forces for these two trials? Justify your answer. **(2 marks)**

8. Using the data from your analysis make a recommendation to a patient who has medial tibiofemoral osteoarthritis whether or not they should use walking poles to potentially reduce the progression of the disease. Justify your response. **(2 marks)**

Upload your report to Canvas prior to 12:00PM September 16.

Total is 20 marks