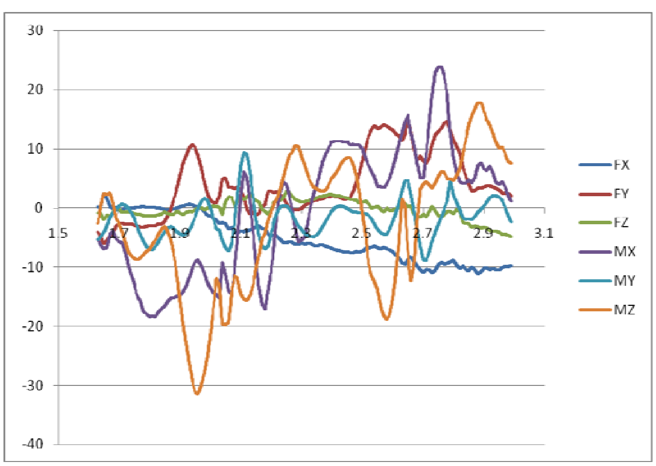
BioE/ME 485
Homework 2
4/17/08
Melanie Fox

a. Comments on validation of simulation
    i. I evaluated the final simulation by plotting some of the generalized coordinates of the model after each step of the workflow to observe how the kinematics changed, and to determine whether this change was acceptable. For example, I plotted the torso rotations, back angles, knee, hip, and ankle angles after RRA to see how much they were adjusted from the IK solution, and again after CMC to see how well they were tracked. Since the model doesn't have arms some inconsistencies, such as exaggerated rotation of the trunk may be more acceptable than large deviations in joints of interest, such as knee angles for example.

    I also compared the muscle excitations for several major lower extremity muscles (vasti, BFSH, soleus) with EMG timing of muscles during walking found in the literature (Perry, 1992). The vasti are generally on at the end of swing phase through early stance, which is consistent with both legs in the simulation. Biceps femoris short head is generally on during late-mid single limb stance phase and early swing. In my simulation for both legs, the muscle tends to come on early (around terminal swing and intial contact) and stay on late (throughout swing). This could be an effort to make up for the medial hamstrings, which are not modeled. Soleus is generally off during swing and on during stance and push-off. The muscle excitations in my simulation are generally consistent with this pattern.

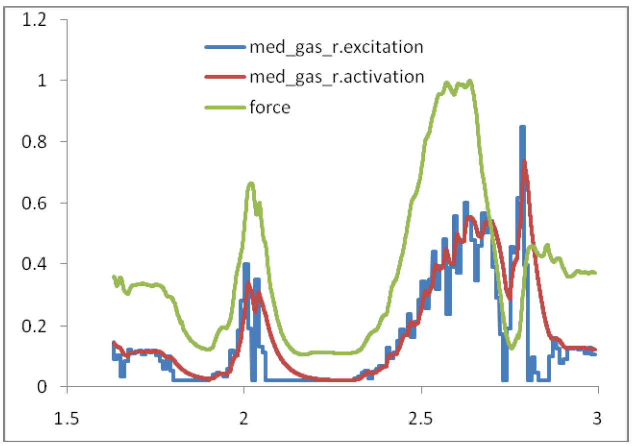
    ii. See attached kinematic plots and muscle excitations.

b. Comments on RRA
    i. Residual forces & moments. Yes, I think they are reasonably small compared to muscle forces.



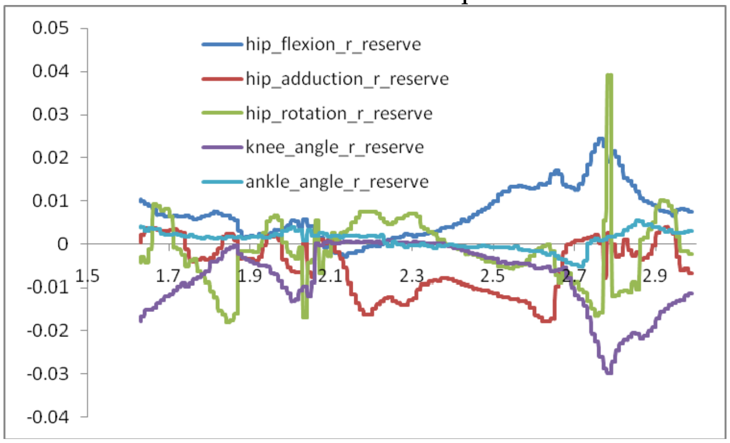
ii. I did not change the default values in the Task, ControlConstraints, or Actuator files. I did not need to because the simulation tracked well and no actuators saturated.

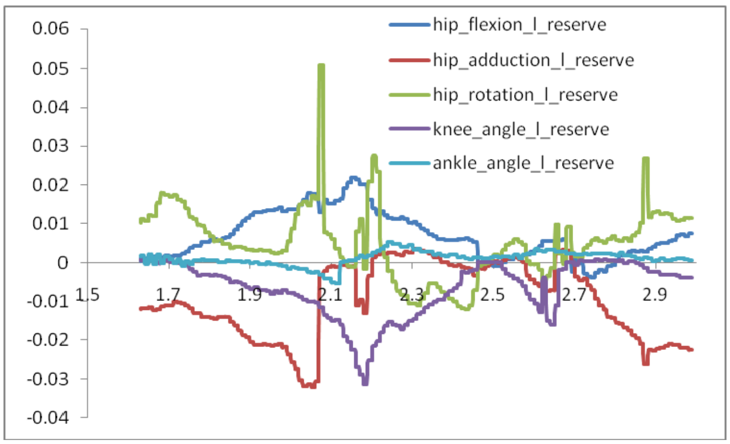
c. Comments on CMC
   i. Yes, I used the model with the adjusted torso mass parameters in CMC. It probably wouldn't have made much difference in this walking simulation, but in general it seemed like a good idea to use the model that makes the kinetics more dynamically consistent so that CMC would be more likely to produce a good result.
   ii. Gastroc excitation, activation, and force (scaled by % of maximum)



Excitation and activation are different because they are related by a first order differential equation. There is a time constant associated with activation ramping up or down to the excitation level. Gastroc force looks most like activation. A control algorithm, such as the one used in CMC, could account for this time delay when choosing excitations by predicting what the muscle activation (which is directly related to the force) will be. Also, as emphasized in class, when choosing the time step for the control algorithm, there is a trade-off between choosing a window that is small enough to allow accurate numerical differentiation/integration and choosing a window that is large enough to allow sufficient time for muscle activations to ramp up to the excitations. The choice of time step size is related to the choice of the muscle activation and deactivation time constants prescribed in the muscle model.

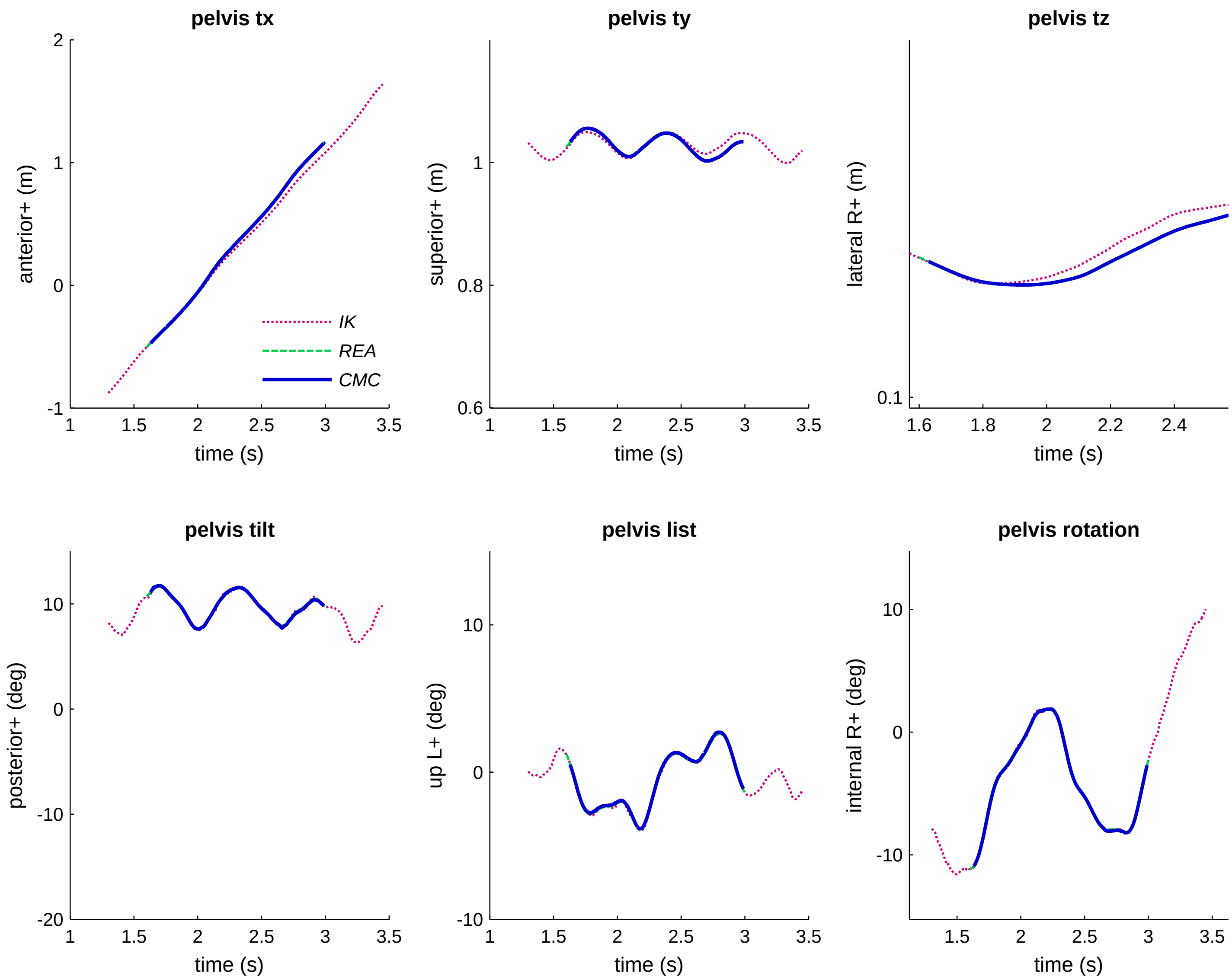
iii. Reserve actuator torques

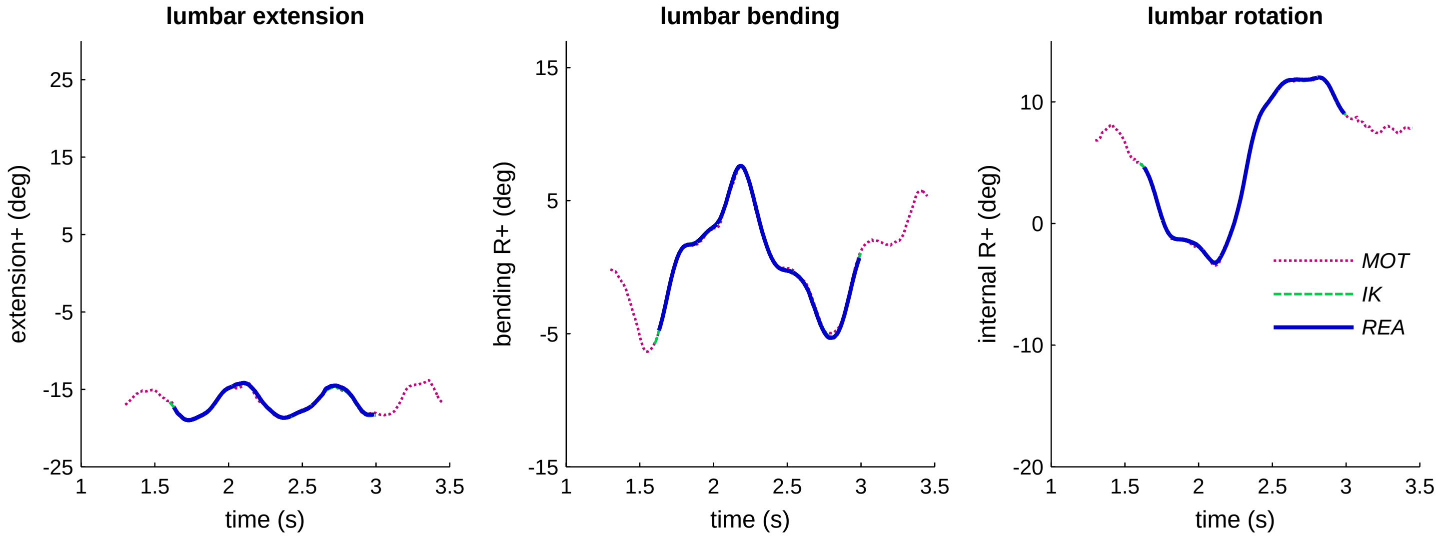




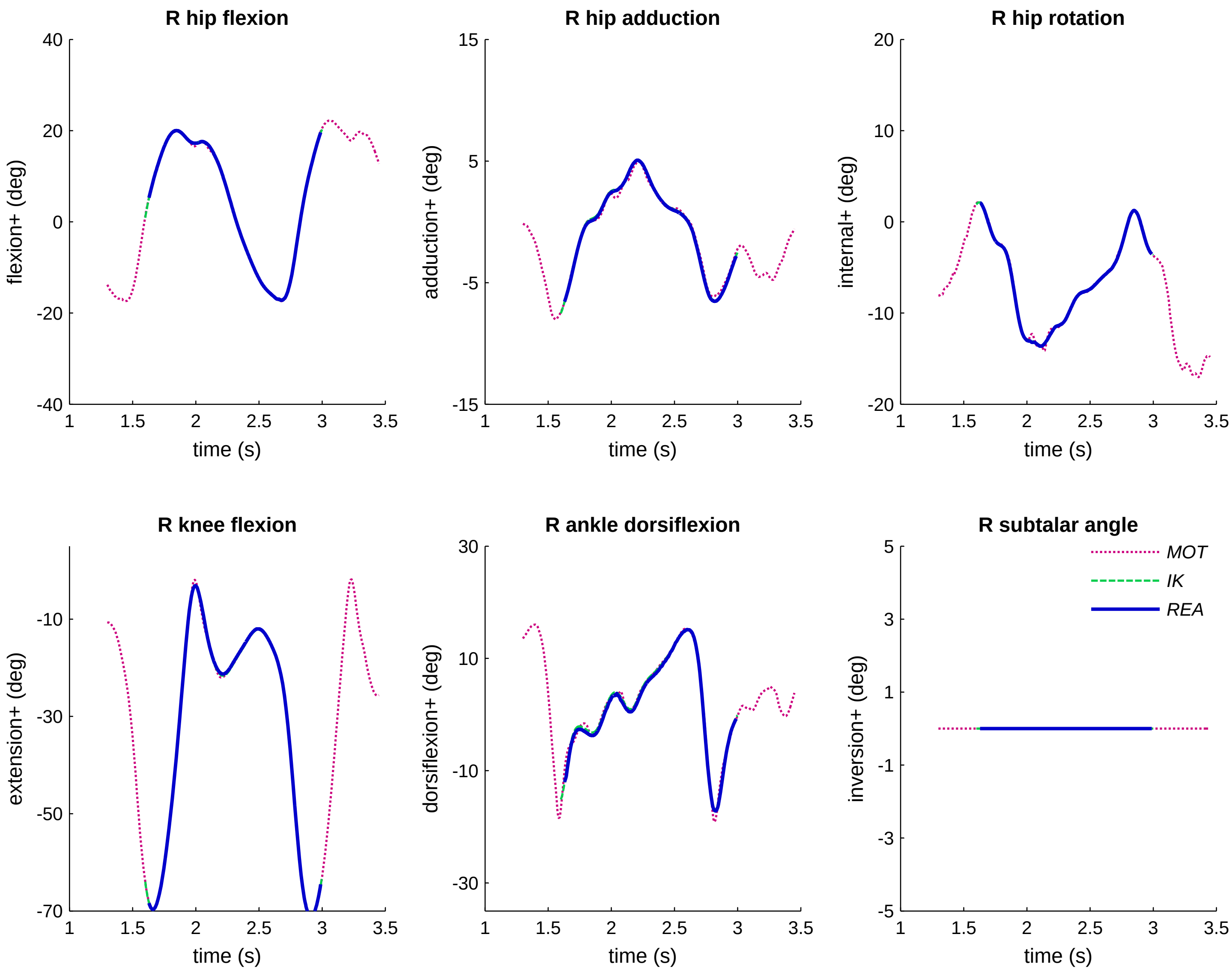
The largest reserve actuator forces are hip rotation forces which spike around toe-off for each leg. Hip flexor muscles at this point (such as psoas and iliacus) have fairly high excitations, so it is possible that the muscles in the model are a little weak. But overall, the reserve actuator forces are very low compared to muscle forces.

iv. I did not change the default values in the Task, ControlConstraints, or Actuator files. I did not need to because the simulation tracked well and no actuators saturated. I did change the pelvis COM in the CMC Actuators .xml file.

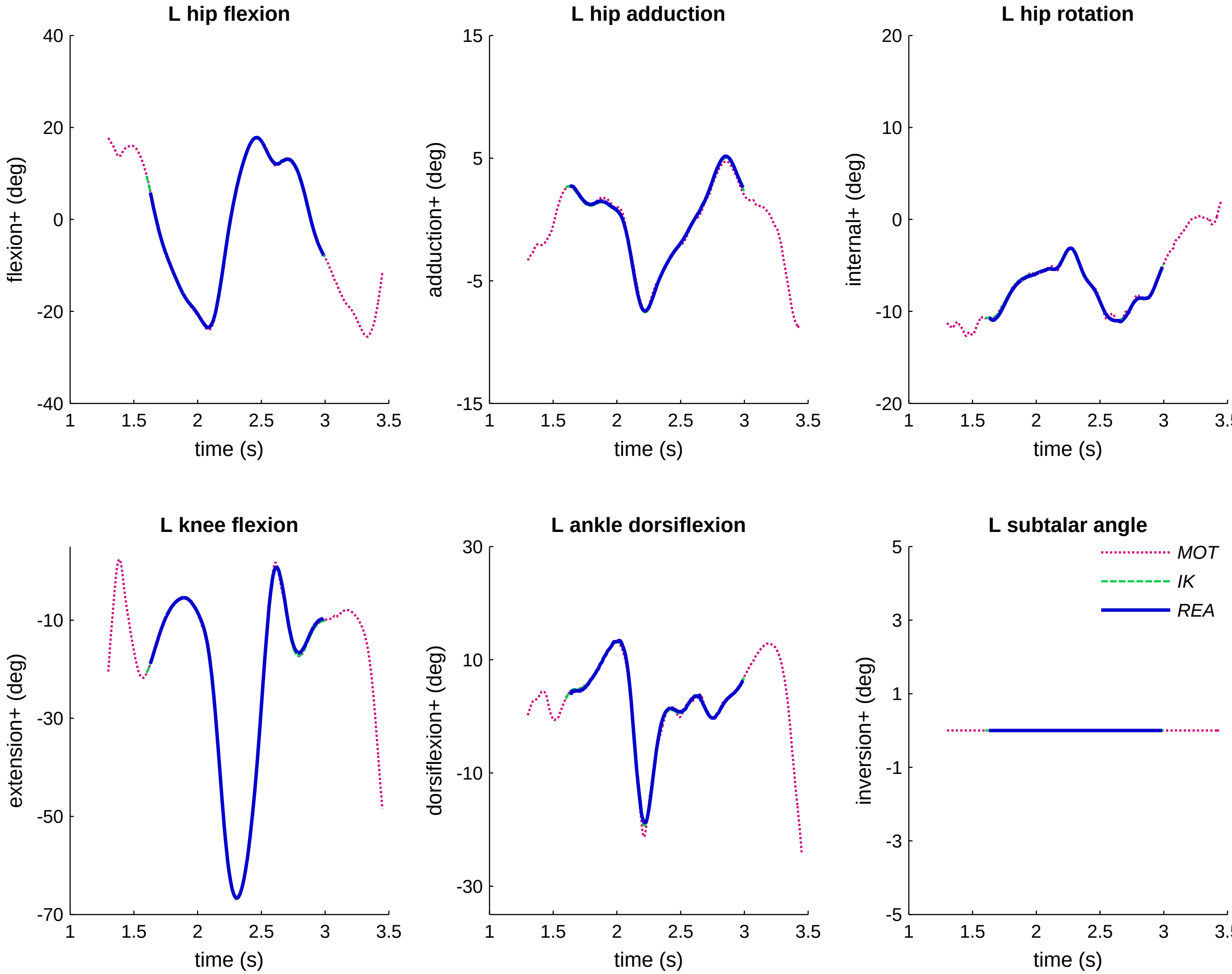

pelvis tx
anterior+ (m)
time (s)
IK
REA
CMC
pelvis ty
superior+ (m)
time (s)
pelvis tz
lateral R+ (m)
time (s)
pelvis tilt
posterior+ (deg)
time (s)
pelvis list
up L+ (deg)
time (s)
pelvis rotation
internal R+ (deg)
time (s)



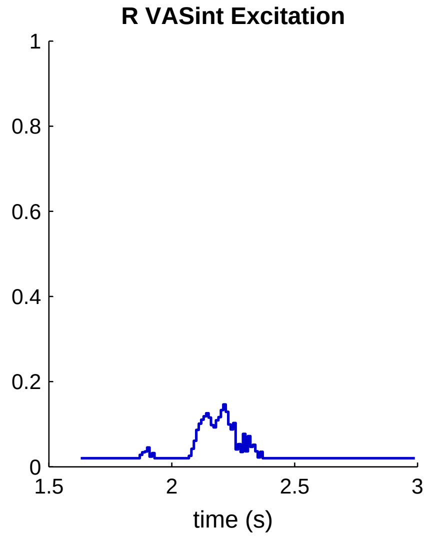
lumbar extension
extension+ (deg)
25
15
5
-5
-15
-25
1
1.5
2
2.5
3
3.5
time (s)
lumbar bending
bending R+ (deg)
15
5
-5
-15
1
1.5
2
2.5
3
3.5
time (s)
lumbar rotation
internal R+ (deg)
10
0
-10
-20
1
1.5
2
2.5
3
3.5
time (s)
MOT
IK
REA

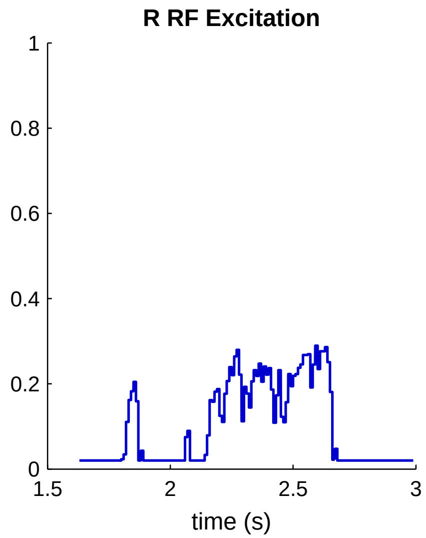


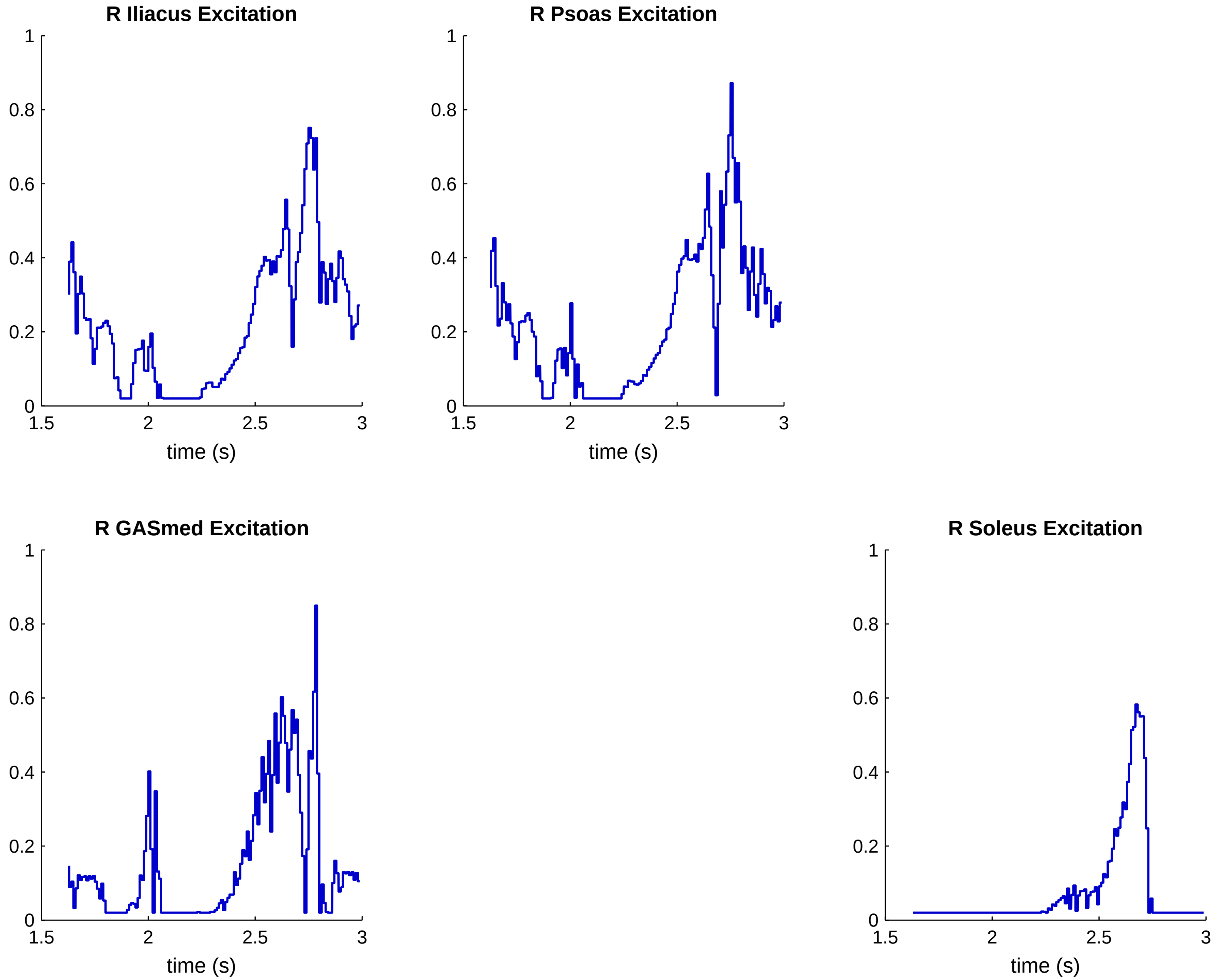
R hip flexion
flexion+ (deg)
time (s)
R hip adduction
adduction+ (deg)
time (s)
R hip rotation
internal+ (deg)
time (s)
R knee flexion
extension+ (deg)
time (s)
R ankle dorsiflexion
dorsiflexion+ (deg)
time (s)
R subtalar angle
inversion+ (deg)
time (s)
MOT
IK
REA

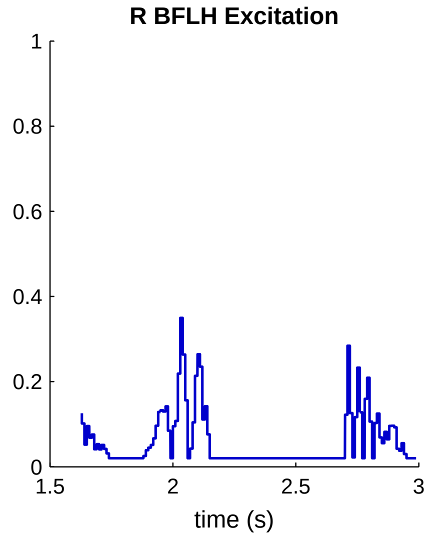


L hip flexion
flexion+ (deg)
L hip adduction
adduction+ (deg)
L hip rotation
internal+ (deg)
L knee flexion
extension+ (deg)
L ankle dorsiflexion
dorsiflexion+ (deg)
L subtalar angle
inversion+ (deg)
time (s)
MOT
IK
REA


R VASint Excitation
1
0.8
0.6
0.4
0.2
0
1.5
2
2.5
3
time (s)


R RF Excitation
1
0.8
0.6
0.4
0.2
0
1.5
2
2.5
3
time (s)


R Iliacus Excitation
R Psoas Excitation
R GASmed Excitation
R Soleus Excitation
0
0.2
0.4
0.6
0.8
1
1.5
2
2.5
3
time (s)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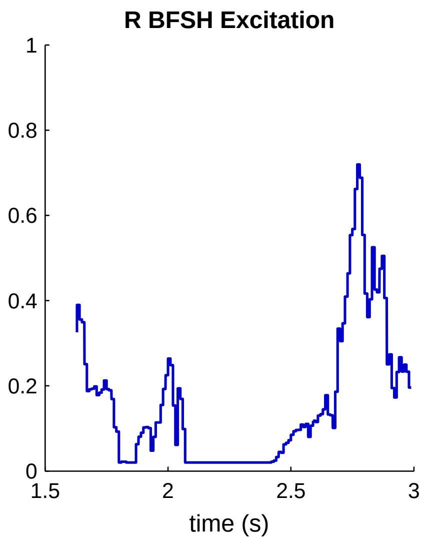
1.5
2
2.5
3
time (s)


R BFSH Excitation
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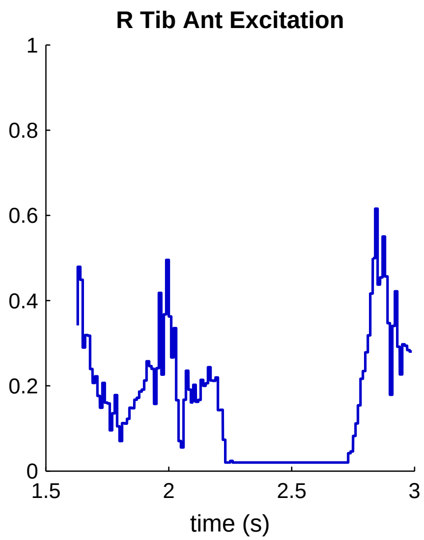
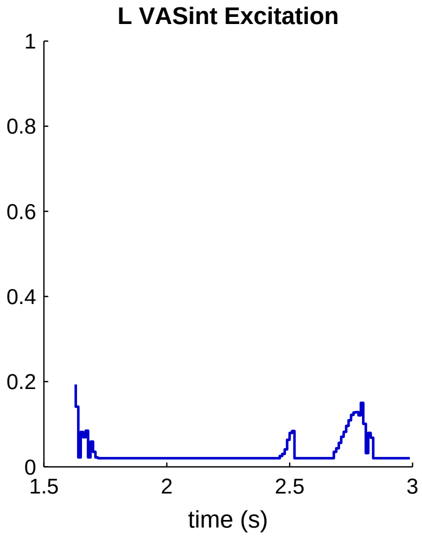
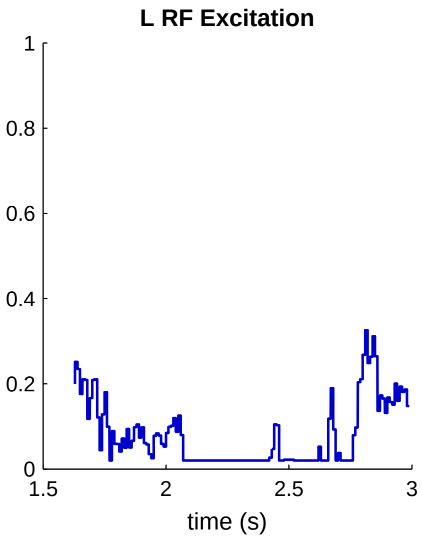
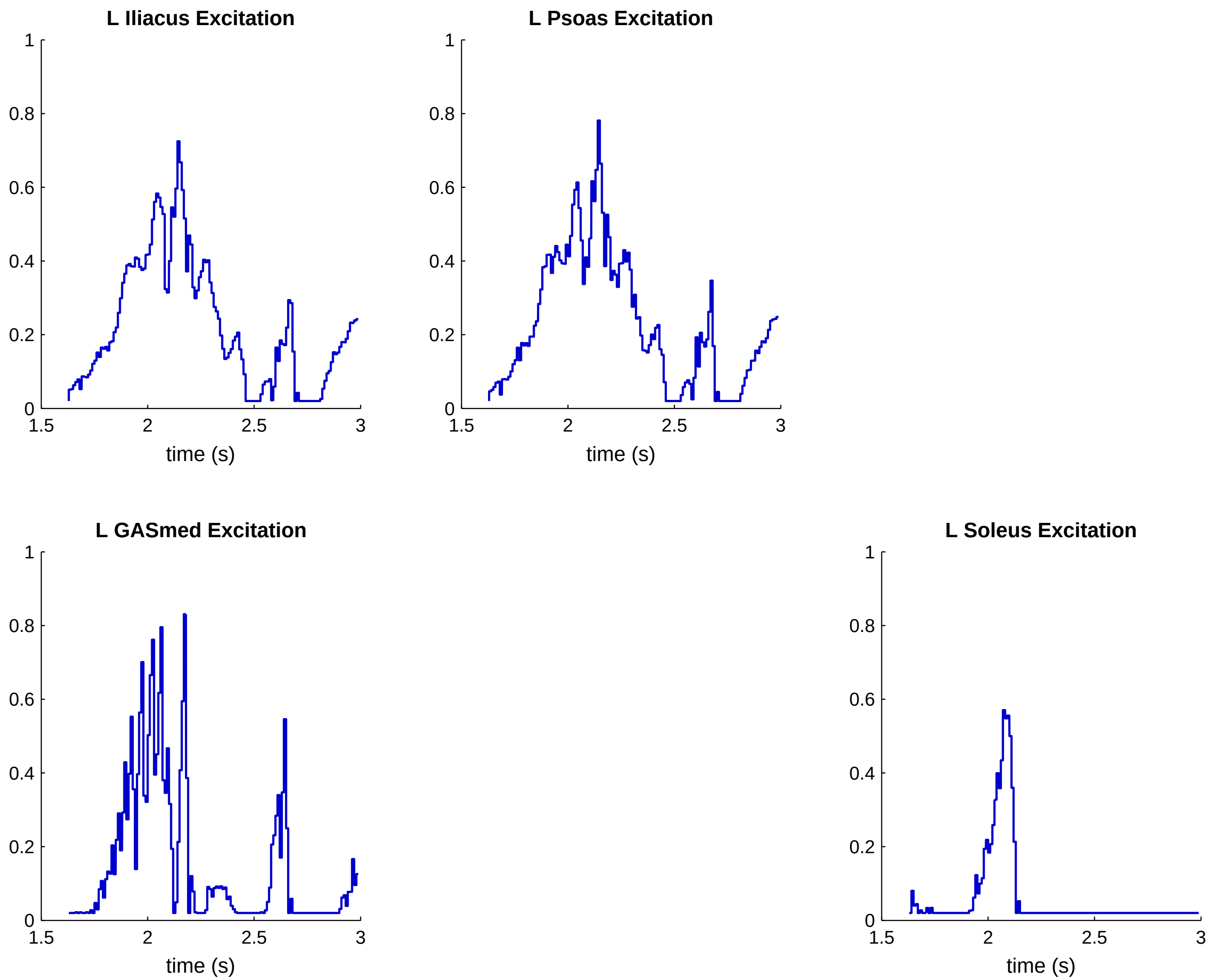
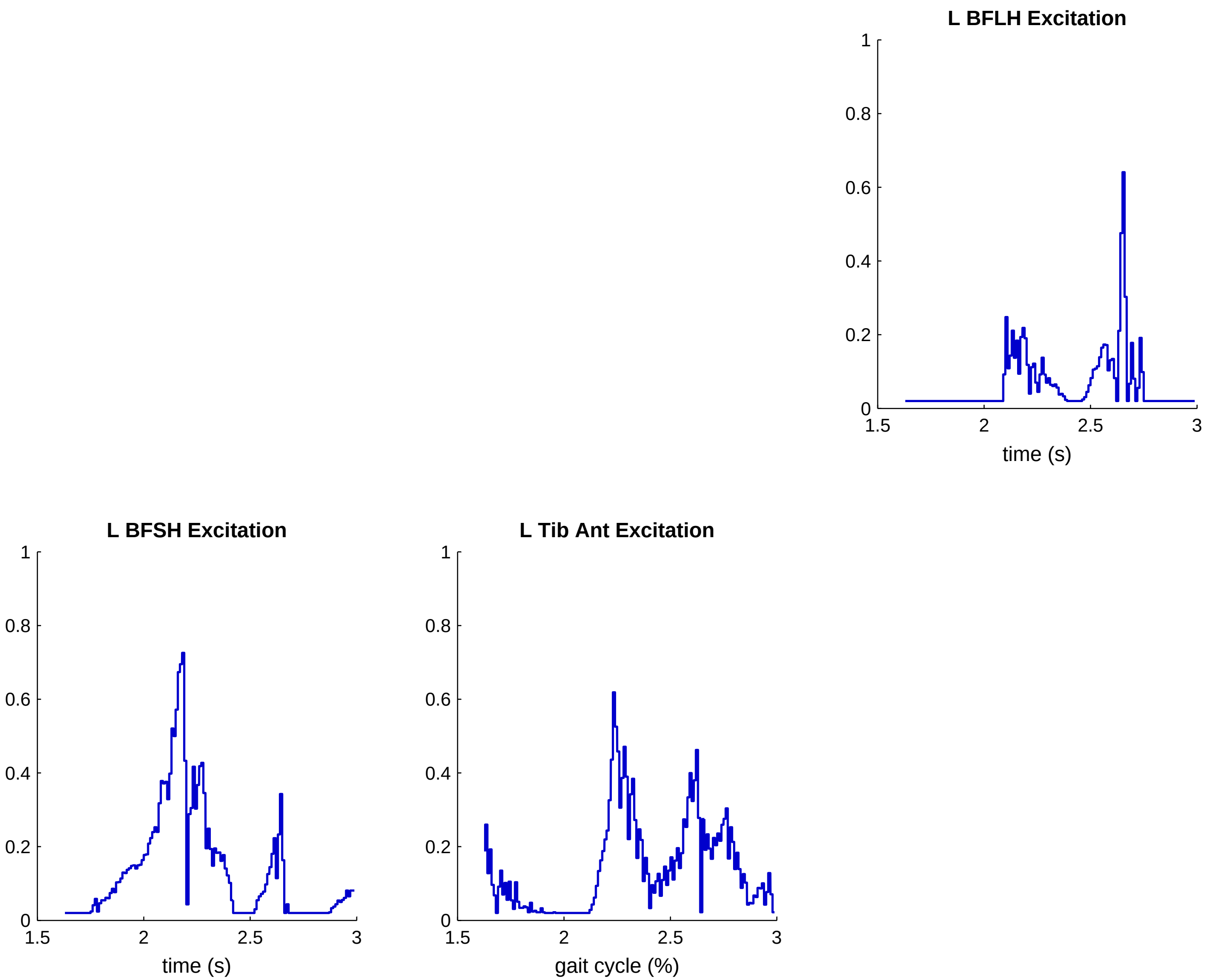
0.2
0
1.5
2
2.5
3
time (s)


R Tib Ant Excitation
1
0.8
0.6
0.4
0.2
0
1.5
2
2.5
3
time (s)


L VASint Excitation
1
0.8
0.6
0.4
0.2
0
1.5
2
2.5
3
time (s)


L RF Excitation
1
0.8
0.6
0.4
0.2
0
1.5
2
2.5
3
time (s)


L Iliacus Excitation
L Psoas Excitation
L GASmed Excitation
L Soleus Excitation
0
0.2
0.4
0.6
0.8
1
1.5
2
2.5
3
time (s)


L BFLH Excitation
time (s)
L BFSH Excitation
time (s)
L Tib Ant Excitation
gait cycle (%)