EVALUATION OF LOWER EXTREMITY MUSCULOSKELETAL MODEL USING SIT-TO-STAND MOVEMENT

Mark S. Thompson1, Michael Voigt2, and Mark de Zee3

1Department of Orthopaedics, Lund University Hospital, Lund, Sweden, mark.thompson@ort.lu.se
2Center for Sensory-Motor Interaction, Department of Health Science and Technology, Aalborg University, Denmark
3The AnyBody Group: http://anybody.auc.dk, Institute of Mechanical Engineering, Aalborg University, Denmark

INTRODUCTION
In this work, we have evaluated the lower extremity model by comparing predicted muscle activation and ground reaction forces with EMG activity and force plate measurements.

MATERIALS AND METHODS
The sit-to-stand (STS) movement was chosen for the evaluation due to its relative simplicity, its importance for daily life and the number of other studies in the literature. STS movements of two subjects (MST: height 1.82 m, mass 72 kg and MdZ, height 1.85 m, mass 70 kg) were captured by a 120 Hz seven camera Qualisys system with three force plates (left and right feet, seat). The marker set defined head, upper body, pelvis, thigh, Shank and foot body segments. Data from 10 EMG surface electrodes were recorded at 1200 Hz. The signals were normalised by peak activity during a maximal voluntary dynamic contraction and processed using zero phase shift filters (band pass 20 – 200 Hz, rectification). Muscle activity onset and offset was determined automatically using a 50 Hz low pass filter, 25 ms window and 3 standard deviations above background as the threshold (Hodges and Bui 1996). An activity “envelope” was obtained using a 5 Hz low pass filter. To ensure synchronisation between motion capture and EMG, the seat force plate signal was recorded with both data sets. The inverse dynamic analysis took approximately 20 s on a 1.3 GHz PC. The results of the muscle comparisons for preferred speed trial 1 for subject MST are shown in Table 1. Figure 2 shows a plot comparing rectified EMG, EMG envelope and AnyBody activity (the sum of three separate parts) for Gluteus medius, also for subject MST. The mean success ratio for trial 1 at all speeds for subject MST was 0.67. The poor success ratios for the quadriceps arise because AnyBody switches them “off” after 1 s while measurable muscle EMG continues. Gluteus medius has a good success ratio but poor correlation, which may be due to the EMG signal being specific to one part of the muscle. The correlation coefficient is a useful measure although EMG amplitude is not directly related to muscle force and so a low correlation coefficient is a useful measure although EMG amplitude is not directly related to muscle force and so a low correlation does not necessarily signify poor modelling. It is planned to use ground reaction centre of pressure and hip joint force for further evaluation of the model.

In conclusion the evaluation has highlighted muscles which need attention before the model may be used predictively.

REFERENCES

Table 1 Preferred speed results: success ratio and correlation coefficient for predicted muscle activity.

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Soleus</th>
<th>Gastrocnemius</th>
<th>Tibialis anterior</th>
<th>Rectus femoris</th>
<th>Vastus medialis</th>
<th>Vastus lateralis</th>
<th>Biceps femoris</th>
<th>Semitendinosus</th>
<th>Gluteus maximus</th>
<th>Gluteus medius</th>
</tr>
</thead>
<tbody>
<tr>
<td>success</td>
<td>0.97</td>
<td>0.89</td>
<td>0.85</td>
<td>0.17</td>
<td>0.33</td>
<td>0.33</td>
<td>0.99</td>
<td>0.44</td>
<td>0.99</td>
<td>0.75</td>
</tr>
<tr>
<td>correlation</td>
<td>0.55</td>
<td>0.27</td>
<td>-</td>
<td>0.03</td>
<td>0.62</td>
<td>0.74</td>
<td>0.44</td>
<td>-0.28</td>
<td>0.43</td>
<td>0.11</td>
</tr>
</tbody>
</table>