Leg Muscle Activation in Isokinetic Cycling versus Elliptical Stepping.

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Introduction

Cycling and elliptical stepping are common exercise modalities that involve slightly different leg movements. A distinct feature of cycling and elliptical stepping exercise is the smooth leg movements and the suggested low stress applied on the joints, compared to walking or running. When performed at a constant-velocity (‘isokinetic’) mode, such exercise can have a positive effect on leg muscle development. This study investigated the leg muscle activation between the two types of exercise movements. We hypothesized that the elliptical stepping might require greater leg muscle activation time compared to cycling due to the greater linear translation component of the movement.

Methods

10 healthy young adults subjects (8 males, 2 females) with average body mass index, performed two seated modalities of leg exercise – cycling and elliptical stepping. Written informed consent, approved by The University of Sydney Human Ethics Research Committee, was obtained from each subject. Subjects used a MOTOmed VIVA isokinetic cycle to perform cycling movement, and a Biodex BioStep Clinical Pro Semi Recumbent Elliptical stepping machine to perform elliptical stepping movement. Surface electromyography (EMG) measurements were recorded on the right leg muscles (rectus femoris, vastus lateralis, vastus medialis, gluteus maximus, biceps femoris, adductor longus, gracilis, gastrocnemius, tibialis anterior, and soleus). Leg joint kinematics was collected using 3D-motion analysis. Subjects performed both types of pedaling exercise at 50 rev•min, in isokinetic mode, at 45 W for 10 min. The order of leg exercise modes was randomized and statistical analysis was by independent t-test (p<0.05).

Results

The total muscle activation times for all 10 muscles were calculated using the equation:

\[
\text{Total activation} = \sum (\text{Mean} \pm c\times SD)
\]

where \(t_{\text{activation}}\) = activation time; \(t_{\text{activation}} \text{ satisfies Mean} \pm c\times SD; \text{Mean} \& SD = \text{EMG signal mean amplitude} \& \text{standard deviation}; \ c = \text{adjustable constant}

Table 1: Muscle activation times (s) for cycling and elliptical stepping. Data are mean ± SD.

<table>
<thead>
<tr>
<th>Muscles</th>
<th>Cycling</th>
<th>Elliptical Stepping</th>
</tr>
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<tbody>
<tr>
<td>Quadriceps</td>
<td>0.652 ± 0.075</td>
<td>0.713 ± 0.055</td>
</tr>
<tr>
<td>Hamstring</td>
<td>0.609 ± 0.073</td>
<td>0.627 ± 0.086</td>
</tr>
<tr>
<td>All Muscles</td>
<td>5.987 ± 0.375</td>
<td>6.265 ± 0.406</td>
</tr>
</tbody>
</table>

Table 1 portrays the total activation time for each muscle and the overall activation time of all muscles, with \(c = 2\) from the equation. The total activation time was measured over 10 s, i.e. 8.33 pedal revolutions. Statistical analysis revealed that the muscle activation times were significantly greater for two of the 3 quadriceps muscles; vastus lateralis (p=0.000) and vastus medialis (p=0.001). The total accumulated muscle activation time was greater for elliptical stepping but the difference did not reach significance (p=0.13).

From the temporal EMG signal, the signal amplitude and time duration were analysed with respect to the instantaneous ankle position, to indicate the muscle activation throughout the range of movement. Figure 1 portrays the quadriceps and biceps femoris muscle activations for each exercise mode, of one subject. Each muscle was activated for a longer duty cycle to produce the elliptical stepping movement compared to the cycling movement.

Discussion & Conclusion

An isokinetic exercise mode, where the angular velocity is constant, a longer activation time reflects greater rotation angle over which the muscles were recruited. From the tested exercise protocol, this study indicates that that elliptical stepping evoked greater overall muscle activation time compared to cycling. This is an original finding which potentially contributes towards leg exercise rehabilitation, whenever a greater muscle activation period is of benefit.