Regional difference in electromyographic activity of the rectus femoris muscle during maximal voluntary knee extension and hip flexion

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SUMMARY
This study examined whether the muscle activities of the distal and proximal portions of the bi-articular rectus femoris (RF) muscle differ during knee extension and hip flexion. Ten male subjects performed maximal voluntary isometric contractions of knee extension and hip flexion separately, with the hip and right knee flexed at 70° and 90°, respectively. Electromyographic (EMG) signals were recorded from the distal and proximal portions of the RF muscle. In both portions, the EMG amplitude was significantly lower during hip flexion compared with during knee extension. In addition, the muscle activation level during hip flexion relative to knee extension was significantly greater in the proximal portion than in the distal portion. The findings suggest that muscle activation is heterogeneous within the RF muscle and that the motor units in the proximal portion are activated at a higher level when the bi-articular RF acts as a hip flexor rather than as a knee extensor.

INTRODUCTION
Some human skeletal muscles are anatomically subdivided into neuromuscular compartments, according to their architecture and/or innervation patterns [1, 2]. The motor nerve of the bi-articular rectus femoris (RF) muscle is generally split from the femoral nerve trunk into two sub-branches just before it reaches the distal-middle and proximal portions of the muscle [3]. Thus, neuromuscular activities of both portions can vary depending on the task (knee extension or hip flexion). Therefore, this study compared EMG signals recorded from the distal and proximal portions of the RF muscle during maximal voluntary isometric contractions (MVCs) of knee extension and hip flexion.

METHODS
Ten healthy young male adults (27.1 ± 3.3 years, 1.74 ± 0.05 m, 67.3 ± 5.4 kg; mean ± SD) participated in this study. Subjects were seated on a dynamometer with the hip and right knee flexed at 70° and 90°, respectively. After warm-up contractions, they performed MVCs of knee extension and hip flexion for approximately 3 s, with a rest period of 2 min.

Bipolar Ag/AgCl surface electrodes with a diameter of 3 mm and an inter-electrode distance of 20 mm were placed along fascicles at two portions in the RF muscle; 40 mm distal and 40 mm proximal from the 50% level between the greater trochanter and the lateral intercondylar tuberculum. The EMG signals were bandpass-filtered (5-1000 Hz), differentially amplified (×500), and recorded with a sampling frequency of 2 kHz. The root mean square values of EMG (RMS-EMG) were calculated during a 1 s period with a steady torque output. Then, for EMG data of each portion, the relative muscle activation level during hip flexion MVC was calculated from the following equation: RMS-EMG during hip flexion / RMS-EMG during knee extension × 100 (%).

Student’s paired t-tests were used to compare the RMS-EMG of each portion between knee extension and hip flexion tasks, and compare the relative muscle activation levels during hip flexion between the distal and proximal portion of the RF muscle.

RESULTS AND DISCUSSION
In both distal and proximal portions, the RMS-EMG was significantly lower during hip flexion than during knee extension (Table 1, P < 0.01). The muscle activation level during hip flexion relative to knee extension was significantly higher in the proximal than in the distal portion (Distal: 51.4 ± 16.5 %, Proximal: 80.0 ± 26.9 %, P < 0.05). These findings indicate that muscle activation is heterogeneous within the RF muscle, and that the motor units in the proximal portion are activated at a higher level when the bi-articular RF acts as a hip flexor rather than as a knee extensor. It is suggested that neural inputs to the neuromuscular compartments in the RF depend on the tasks performed.

CONCLUSIONS
Muscle activation is heterogeneous within the RF muscle and motor units in the proximal portion are activated at a higher level when the RF acts as a hip flexor rather than as a knee extensor.

Table 1: Electromyographic activities (RMS-EMG) of each portion during MVC of knee extension and hip flexion.

<table>
<thead>
<tr>
<th>RMS-EMG (mV)</th>
<th>Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distal Portion</td>
<td>0.307 ± 0.206</td>
</tr>
<tr>
<td>Proximal Portion</td>
<td>0.243 ± 0.074</td>
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</tbody>
</table>

*Significant difference (P < 0.01) between tasks for each portion.
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REFERENCES

Figure 1: Relative muscle activation level during hip flexion (to knee extension). *Significant difference (P < 0.05) between the distal and proximal portions.