Acute effects of passive static stretching on explosive force output of leg extensor muscles

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Introduction
The acute effects of stretching on muscular performance are currently under debate. Previous studies showed that acute bouts of passive muscle stretching can reduce performance during movements which require maximal muscle power output. The purpose of this study was to compare the effects of static stretching on leg extensor muscles during squat jumps at different knee starting angles.

Methods
Fourteen healthy male subjects (age [mean (SD)] 23.2 (2.0) years; height 1.80 (0.05) m; body mass 74.9 (6.6) kg) participated in this study. The subjects performed 2 series of vertical jumps (squat jump) starting at different knee angles: 50°, 70°, 90°, 110° (5 jumps/angle) in a randomized order. The first series was preceded by a 10 min warm-up (No Stretching, NS), whereas in the second series the warm-up was followed by a passive static stretching (SS) (6 min) of quadriceps and triceps surae muscles. Each knee starting angle was monitored by means of an electro-goniometer. All the jump series were executed on a force platform (4-Jump, Kistler, USA) and each jump was analyzed by a custom software (developed with LabView, National Instrument, USA), to calculate force, fly time, acceleration and power. The 3 best jumps for each starting angle were considered for statistical analysis (Two-Way ANOVA).

Results
Flight time significantly increased with knee starting angles (p<0.05)(see Table 1), without significant differences between ST and SS conditions. The peak force significantly decreased with knee starting angles (p<0.05), being significantly lower in ST condition (p=0.03).

Table 1: Flight time and peak force during squat jump at different knee starting angles with and without stretching

<table>
<thead>
<tr>
<th>Knee starting angle (deg)</th>
<th>50° m±SD</th>
<th>70° m±SD</th>
<th>90° m±SD</th>
<th>110° m±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flight time NS</td>
<td>284.89</td>
<td>370.78</td>
<td>429.49</td>
<td>438.18</td>
</tr>
<tr>
<td>(ms) ST</td>
<td>262.17</td>
<td>363.83</td>
<td>428.29</td>
<td>441.80</td>
</tr>
<tr>
<td>peak force NS</td>
<td>2416.42</td>
<td>2244.31</td>
<td>1966.87</td>
<td>1632.28</td>
</tr>
<tr>
<td>(N) ST</td>
<td>2246.55</td>
<td>2205.12</td>
<td>1846.83</td>
<td>1595.86</td>
</tr>
</tbody>
</table>

The maximal power output was obtained at 90° knee starting angle (see Figure 1) in both ST and SS conditions, and was significantly lower (p=0.05) during ST, especially at lower starting angles.

Conclusions
This study confirms that a static stretching bout seems to reduce power and force output during a vertical jump, as previously reported. Interestingly, such effect is more pronounced at lower knee starting angles, suggesting that stretched muscle fascicles could be placed in a less optimal portion of the torque-length relationship than non-stretched muscles. Finally, the use of static stretching during the warm-up procedures prior of power activities remains questionable.

References