MAXIMUM HIP FLEXION POWER IN YOUNG ADULTS:
EFFECTS OF INITIAL JOINT ANGLE AND ALLOWABLE RANGE OF MOTION

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INTRODUCTION

The ability to complete a compensatory step in time to arrest an on-going forward fall can require the hip flexor muscles to maximize hip flexion power (Schultz, 1997). Measurements of maximum hip flexor muscle power have been reported for hip velocities up to 210 °/sec (Cahalan, 1989), but higher peak velocities are required to arrest actual falls (Thelen, 1997). We are not aware of data on maximum hip flexor power capacity at these higher velocities. In addition, the effects of initial hip joint angle and the allowable range of hip joint motion on torque, velocity and power are unknown. Using a custom dynamometer, we tested the hypotheses that neither the initial hip joint angle nor the allowable range of motion would influence the maximum instantaneous hip flexion power or torque at velocities over 210 °/sec.

METHODS

Maximum instantaneous hip flexion power was measured in 10 healthy young subjects (18 to 23 years old), with equal numbers of males and females, on a custom dynamometer. Because measurements of maximum muscle power are prone to gravitational and inertial artifacts (Winter, 1981; Sapecia, 1982), the calculations of the net joint torque and power compensated for gravitational and inertial effects. Subjects were asked to attempt to maximize hip torque, velocity and power in seven distinct leg movements. Each movement was performed by the dominant leg with an extended knee. Subjects were instructed “to swing their leg as fast and as hard as they could”, until their leg angular momentum was arrested by an external device. Hip flexion angle was referenced to the neutral posture (denoted as 0º flexion). Subjects performed up to three trials for each of the seven combinations of initial joint angle (ANG) and range of motion (ROM) (Table 1), presented in a randomized sequence. For each ANG*ROM combination, the trial with the highest maximum power was found. After the data were normalized to each individual’s maximum value in the 0º - 90º test condition (Table 1), the hypotheses were tested using repeated measures analyses of covariance (covariates: height, mass, age, and physical activity). A p<0.05 value was considered significant.

RESULTS AND DISCUSSION

The combinations of ANG*ROM significantly affected the maximum hip flexor muscle power (p < 0.0005, Table 1). As initial joint angle increased from 0º to 60º, maximum power decreased (p < 0.0005). For 30º ROM movements this decrease was 35%. As the allowable range of motion was decreased from 90º to 15º, maximum power decreased by 19% (p = 0.003). This was principally due to the decrease in the maximum velocity attained.

The ANG*ROM combinations significantly
affected maximum angular velocity (p < 0.0005). For a 30° ROM, as initial joint angle increased from 0° to 60° maximum velocity decreased by 19% (p < 0.0005); but as range of motion decreased from 90° to 15° maximum velocity decreased by 61% (p < 0.0005). Maximum velocity ranged from 359 to 504 °/sec across all subjects.

The ANG*ROM combinations significantly affected maximum torque (p = 0.001, Table 1). The initial joint angle did not affect the maximum torque (p = 0.588), but the effect of the range of motion was significant (p < 0.0005). However, this latter result was mostly due to the 0 -15° test movement result, and to some extent to the 0 - 30° test movement result. Because preliminary results from subsequent blindfolded tests did not show this effect, we surmise that the original results were due to a priori knowledge of the next ROM to be tested and greater motivation at the small ROM angles.

The overall outcome values are consistent with trends reported by Cahalan (1989). In this study, the effect of gender on ANG and ROM effects was removed by the normalization procedure and repeated measures design. However, significant age and gender effects on the absolute values of torque, velocity and power have been found in a larger sample of young and old subjects using similar methods (Smeesters 2001).

<table>
<thead>
<tr>
<th>ANG*ROM</th>
<th>Power</th>
<th>Velocity</th>
<th>Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>0° to 90°</td>
<td>205±69 (Watts)</td>
<td>398±43 (°/sec)</td>
<td>46±11 (Nm)</td>
</tr>
<tr>
<td>0° to 90°</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>0° to 60°</td>
<td>0.99±.24</td>
<td>0.93±.09</td>
<td>0.99±.16</td>
</tr>
<tr>
<td>30° to 90°</td>
<td>0.78±.17</td>
<td>0.84±.05</td>
<td>0.90±.11</td>
</tr>
<tr>
<td>0° to 30°</td>
<td>0.92±.20</td>
<td>0.76±.06</td>
<td>1.07±.18</td>
</tr>
<tr>
<td>30° to 60°</td>
<td>0.73±.17</td>
<td>0.69±.06</td>
<td>0.99±.21</td>
</tr>
<tr>
<td>60° to 90°</td>
<td>0.60±.09</td>
<td>0.62±.06</td>
<td>0.90±.13</td>
</tr>
<tr>
<td>0° to 15°</td>
<td>0.81±.23</td>
<td>0.59±.07</td>
<td>1.20±.22</td>
</tr>
</tbody>
</table>

**SUMMARY**

(1) A greater initial hip flexion angle limited the maximum power attained, principally by limiting the maximum achieved velocity.

(2) Smaller ranges of motion also limited maximum power, again by limiting the maximum achievable velocity.

(3) Maximum torque was unaffected by initial joint angle and, quite probably, by range of motion.

(4) In order to maximize hip flexion power, initial flexion of the hip joint should be minimized and a sufficiently large range of motion allowed for the individual to reach their maximum angular velocity.

**REFERENCES**


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