DO KNEE ECCENTRIC STRENGTH AND KNEE JOINT KINETRICS DIFFER BETWEEN JUMPERS AND NON-JUMPERS IN LANDING ACTIVITIES?

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INTRODUCTION

Landing is a common movement task used in investigating impact attenuation and mechanisms of impact related lower extremities injury [1-5]. In the literature, there is limited biomechanical information regarding the relationship between eccentric strength of lower extremities and impact related biomechanics in landing. It is still unclear what roles of lower extremity eccentric strength plays in impact force attenuation during landing activities. Therefore, the main purpose of this study was to investigate the differences of knee eccentric strength and impact related knee biomechanics between jumpers and non-jumpers during step-off landing tasks.

METHODS

A total of 20 male college swimming athletes (non-jumper) and track and volleyball athletes (jumper) were recruited to participate in the study: 10 jumpers (age: 21.0±1.5 years, height: 185.3±5.2cm & weight: 712.7±66.7N) who received regular training on jumping/landing and lower extremity eccentric strength, and 10 age, height and weight matched non-jumpers (age: 20.2±1.4 years, height: 181.6±4cm & weight: 731.0±64.9N) who rarely received regular training on jumping/landing activities and lower extremity eccentric strength. The concentric and eccentric knee muscle strengths of dominant leg were tested at 60 deg/s on an isokinetic dynamometer (CON-TREX, MJ). The step-off landing trials were tested in a separate testing session. The participant performed five trials in each of four step-off landing conditions: soft and stiff landing from 0.4 m and 0.6 m landing heights. To ensure consistent and reliable landing techniques in the four landing conditions, the maximum knee flexion angle (2D angle) during testing were monitored using these criteria: 95-105 deg and 60-70 deg for soft and stiff landing at 0.4 m, and 100-110 deg and 65-75 deg for soft and stiff landing at 0.6 m, respectively. All participants wore a pair of standard lab running shoes (ALCE007-4, Li Ning) during landing trials. Anatomical and tracking reflective markers were placed on the pelvis and the dominant side of the lower extremity segments/joints. Three-dimensional kinematic (250 Hz, 8-camera Vicon) and ground reaction force (1250 Hz, Kistler) data were recorded simultaneously. 3D kinematic and kinetic variables were computed using Visual 3D (C-Motion, Inc). A right-hand rule was used to define the conventions of kinematic and kinetic variables. Additional data processing and analyses were performed using customized software (VB_V3D). A 3-way (group x height x stiffness) mixed design analysis of variance was used to detect group, height and landing stiffness differences for selected 3D variables. A 2-way (group x contraction) mixed design analysis of variance was used to detect group and contraction difference for max knee extension torques. The alpha level was set at 0.05.

RESULTS AND DISCUSSION

The isokinetic strength result showed that the jumper had significantly greater peak concentric and eccentric knee extension torques compared to the non-jumpers (p = 0.002, Figure 1). However, the group by contraction interaction was not significant (p = 0.063).

No significant group effects were found for the 1ˢᵗ or 2ⁿᵈ peak vertical ground reaction force (Fz_Max1 and Fz_Max2, Table 1). The jumpers had significantly larger knee flexion angle (KA_On_X, p = 0.017) and abduction angle (KA_On_Y, p = 0.037) at initial contact and larger maximum knee flexion angle (KA_X_Max, p = 0.018) compared to the non-jumpers. However, no significant group difference on knee flexion ROM (KA_X_ROM) was observed. The jumpers had significantly larger
1st peak knee extensor moment (KM_Max1_X, p = 0.033) and 1st peak power (KP_Min1_X, p = 0.012). In addition, no significant group related interactions were found for those selected variables. As expected, all kinetic variables increased significantly from 0.4 to 0.6 m and from soft to stiff landing whereas significant decreases were observed for knee kinematic variables (Table 1).

Although the knee eccentric strength was different between the groups, no differences on the vertical GRFs during landing were found. These results may be related to the similar knee flexion ROM across four landing conditions between the two groups. This similarity in knee flexion ROMs is more related to the experimental control of the landing stiffness employed in this study and less related to the knee eccentric strength. The jumpers tended to land with the knee in a more flexed position at touchdown. This result may indicate the athletes with more training in jumping and eccentric strength activities positioned the knee joint in a more favorable (flexed) position and pre-stretched the knee extensors to attenuate impact force compared to those athletes lacking jumping and eccentric training experience. As a result the peak knee extensor moment and power were greater for the jumpers compared to the non-jumpers.

**CONCLUSIONS**

No differences on the vertical GRFs were found between the two athlete groups although the jumper group had greater eccentric and concentric knee extension strength. However, the more experienced athletes adopted an impact attenuation strategy with greater knee flexion angle at initial contact that increased pre-stretching of knee extensors and increased peak knee extensor moment and power. It is still unclear whether there would be differences in the landing strategy, impact forces, and impact attenuation related variables if the participants chose their own landing technique during landing activities.

![Figure 1. Peak concentric and eccentric knee extension torques at 60 deg/s.](image)

**REFERENCES**


**Table 1.** Kinematic and kinetics variables in the four landing tasks: mean ± STD.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Unit</th>
<th>Non-jumpers 40soft</th>
<th>Non-jumpers 40stiff</th>
<th>Non-jumpers 60soft</th>
<th>Non-jumpers 60stiff</th>
<th>Jumpers 40soft</th>
<th>Jumpers 40stiff</th>
<th>Jumpers 60soft</th>
<th>Jumpers 60stiff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fz_Max1”**</td>
<td>(BW)</td>
<td>0.89±0.20</td>
<td>1.38±0.28</td>
<td>1.39±0.32</td>
<td>2.01±0.38</td>
<td>0.93±0.10</td>
<td>1.33±0.28</td>
<td>1.31±0.28</td>
<td>1.99±0.40</td>
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<tr>
<td>Fz_Max2”**</td>
<td>(BW)</td>
<td>3.24±0.53</td>
<td>4.02±0.80</td>
<td>4.03±0.95</td>
<td>4.84±0.94</td>
<td>3.29±1.29</td>
<td>4.66±1.95</td>
<td>3.77±1.00</td>
<td>5.00±1.68</td>
</tr>
<tr>
<td>KA_On_X”**</td>
<td>(deg)</td>
<td>-26.3±3.6</td>
<td>-16.8±4.4</td>
<td>-29.2±3.3</td>
<td>-18.4±4.0</td>
<td>-32.3±4.6</td>
<td>-21.1±4.0</td>
<td>-34.1±7.2</td>
<td>-21.2±3.6</td>
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<tr>
<td>KA_On_Y”**</td>
<td>(deg)</td>
<td>2.7±3.0</td>
<td>1.5±3.4</td>
<td>3.0±3.5</td>
<td>1.7±3.6</td>
<td>4.7±3.6</td>
<td>5.0±3.7</td>
<td>6.4±3.6</td>
<td>5.9±3.1</td>
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<tr>
<td>KA_Max_X”**</td>
<td>(deg)</td>
<td>-95.3±4.6</td>
<td>-59.2±4.2</td>
<td>-101.2±3.9</td>
<td>-66.8±4.8</td>
<td>-101.2±5.7</td>
<td>-64.9±3.9</td>
<td>-106.7±5.6</td>
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<td>KA_ROM_X”**</td>
<td>(deg)</td>
<td>-69.0±5.1</td>
<td>-42.4±4.7</td>
<td>-72.0±5.3</td>
<td>-48.4±6.1</td>
<td>-68.9±4.4</td>
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<td>-72.6±6.1</td>
<td>-48.9±4.1</td>
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<td>KM_Max1_X”**</td>
<td>(Nm/kg)</td>
<td>1.77±0.31</td>
<td>2.22±0.43</td>
<td>2.78±0.61</td>
<td>3.17±0.60</td>
<td>2.27±0.60</td>
<td>2.91±0.78</td>
<td>3.04±0.57</td>
<td>3.64±0.83</td>
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<tr>
<td>KP_Min1_X”**</td>
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<td>-14.9±2.8</td>
<td>-17.2±3.9</td>
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<td>-24.7±8.4</td>
<td>-29.9±6.9</td>
<td>-36.8±7.5</td>
</tr>
</tbody>
</table>

Note: **: significant difference on Height, *: significant difference on Stiffness, #: significant difference on Group.