Lower Extremity Stiffness Pre-Competition and Post-Competition

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Lower Extremity Stiffness Pre and Post Competition

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ABSTRACT

Objective: To track leg stiffness in collegiate cross-country runners in response to a cross country race. Methods: Twenty-five collegiate cross-country runners were recruited for this study. They were assessed for leg stiffness 24 hours before and after a race as well as 48 hours after the race. Three jumping protocols were conducted: 1) static jump, 2) countermovement jump, 3) vertical hopping test. Each test was performed on two force plates and vertical ground reaction force data was collected. Results: No significant differences were found in post-hoc analysis for CMJ and EUR. SJ height increased significantly between 24 and 48 hours post-race. A significant main effect was found for SJ, CMJ and K. K decreased significantly 24 hours after the race (33.11 kN/m) compared to 24 hours before (38.84 kN/m). 48 hours after the race K increased significantly (36.30 kN/m) compared with 24 hours after the race. Conclusion: Leg stiffness appeared to decrease 24 hours following the race and then increase back to resting values 48 hours following the race.

PARTICIPANTS

Twenty-five active Division 1 collegiate cross-country runners were recruited and volunteered to participate in this study. Individuals who had surgery or an injury that prevented participation in physical activity within the last six months of the study were excluded. Three participants dropped out due to race related injuries.

Table 1. Participant demographics expressed as mean ± standard deviation

<table>
<thead>
<tr>
<th>Sex</th>
<th>Age (y)</th>
<th>Weight (kg)</th>
<th>Height (m)</th>
<th>Weekly Volume (km/week)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male (14)</td>
<td>19.1 ± 10</td>
<td>63.7 ± 5.3</td>
<td>1.7 ± 0.1</td>
<td>95.4 ± 14.9</td>
</tr>
<tr>
<td>Female (11)</td>
<td>20.2 ± 1.3</td>
<td>55.8 ± 5.2</td>
<td>1.7 ± 0.1</td>
<td>72.4 ± 15.3</td>
</tr>
</tbody>
</table>

METHODS

- **Static Jump (SJ):** participant flexes the knees to 90° and holds for about three seconds prior to maximally jumping on command.
- **Countermovement Jump (CMJ):** participant jumps immediately following knee flexion, invoking the SSC.
- **Vertical Hopping Test (HT):** participant hops as high as possible in place without pausing in between jumps. Leg stiffness (K) can be calculated from the vertical force exerted on a force platform during ground contact time of the HT.

<table>
<thead>
<tr>
<th>Force Plates:</th>
<th>All tests were done on two AMTI optima force plates (Watertown, MA) and were sampled at 1000Hz.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Processing:</td>
<td>Data was exported to GNU Octave (John W. Eaton, 2018) and vQSP data was filtered using a 4th order Butterworth lowpass filter to find mass, peak force, rate of force development, impulse, takeoff velocity, peak power, peak landing force, and jump height.</td>
</tr>
<tr>
<td>Statistics:</td>
<td>Repeated measures ANOVA was run on SJ, CMJ, EUR and K. No significance was found in the post-hoc analysis for CMJ, p &gt; 0.05.</td>
</tr>
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</table>

RESULTS

- **SJ & CMJ:** Mauchly’s test for sphericity indicated that the assumption of sphericity for the SJ (X²(2) = 3.54, p > 0.05) and CMJ (X²(2) = 2.12, p > 0.05) has been met. There was a significant main effect on SJ height over the three days F(2, 42) = 3.89, p = 0.028. Post-hoc analysis only showed that SJ height increased significantly from the second to third testing day, p = 0.048. There was also a main effect on CMJ height, F(2, 42) = 3.85, p = 0.035. No significance was found in the post-hoc analysis for CMJ, p > 0.05.
- **K:** Mauchly’s test indicated that the assumption of sphericity was met for leg stiffness, X²(2) = 4.42, p > 0.05. There was a significant main effect on leg stiffness over the three days F(2, 42) = 4.488, p = 0.017. K decreased significantly from 36.84 kN/m to 33.11 kN/m across days one and two (p = 0.08) and then increased significantly between day two and three (36.30 kN/m), (p = 0.018).

DISCUSSION

- The results support our hypothesis: K decreased 24 hours following the race and increased 48 hours after.
- Fatiguing SSC exercises may elicit decreased neuromuscular performance.
- Decreased pre-activation of the lower extremity muscles.
- During the HT there may have been decreased pre-activation leading to a less rapid rebound and decreased K.
- SSC exercise results in a two phases of recovery.

TAKE HOME MESSAGES

- **Coaching Implications:**
  - Practical field based procedures for finding leg stiffness.
  - SSC is feasible and non-invasive.
  - Coaches can track leg stiffness frequently during a training cycle to appropriately schedule workouts and rest days.
- **Conclusion:**
  - SJ, CMJ, and EUR were not sensitive, but significant changes in K in this study suggest that leg stiffness may be a valuable tool in coaching distance runners.
  - Future research: track leg stiffness throughout a day, or throughout a micro cycle in response to different types of workouts.
- **Limitations:**
  - Men’s race distance – 8km, Women’s race distance – 5km
  - Terrain and distance the participants ran following day two of testing
  - Responders and non-responders

REFERENCES