Correlation of Tibial Accelerations with Knee Kinematics and Kinetics During Single-Leg Landings

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BACKGROUND

• Anterior cruciate ligament (ACL) injuries remain a serious problem in competitive and recreational sports.
• There have been many studies investigating potential risk factors for this injury, however, there has not been any documentation of a decline in ACL injury rates.
• A portable, cost effective, and easy to use device that is correlated to biomechanical measures of ACL risk factors will be helpful in the prospective examination of risk factors for ACL injury and injury preventative measures.

METHODS

INTERVENTIONS:
• Each subject completed three successful trials of a single-leg stop-jump (Figure 1) and a single-leg drop-landing task on their dominant leg (Figure 2).
• The single-leg stop-jump tasks required subjects to perform a single-leg broad jump to a target area 40% of their height away and immediately perform a maximum single-leg vertical jump upon landing.
• The single-leg drop-landing required subjects to drop off a 12 inch box onto a force platform using a single-leg.

EQUIPMENT:
• High-Speed Dynamic Stereo X-ray (DSX, Figure 3)
• 3D Video Based Motion Analysis System (Vicon Motion Systems Inc.)
• Force Platform (Bertec Corp.)
• 3D Accelerometer (+/- 18g, ZeroPoint inc., Figure 4)

MAIN OUTCOME MEASURES:
• Accelerometer (Affixed to the medial tibial plateau)
  • Peak accelerations in all three orthogonal planes were measured along with the peak resultant accelerations in the transverse plane and resultant accelerations from all three axes.
• 3D Video Based Motion Analysis
  • Peak angles were measured for knee flexion and knee valgus during landing.
  • Peak ground reaction force (GRF) and proximal anterior tibial shear force (PATSF) was also measured during landing.
• Dynamic Stereo X-ray (DSX)
  • Peak tibial translation was measured during landing.

STATISTICAL ANALYSIS:
• Pearson product moment correlation coefficients were used to analyze the linear relationship between tibial accelerations and kinematics and kinetics measured using the 3D video based motion analysis system and arthokinematics measured using the dynamic stereo x-ray system during landing.
• Alpha was set at p=0.05 set for statistical significance a priori.

RESULTS

• Peak TA was significantly correlated to peak knee flexion in axis three but not in the transverse resultant during the stop-jump task.
• Peak TA was significantly correlated to peak vertical GRFs (pVGRF) in the vertical axis during the stop-jump and drop-landing task.
• Vertical GRFs during the stop-jump task were also correlated to peak TA in the transverse plane and resultant of all directions (Total Res.)
• Among DSX measures, peak tibial translation magnitude (pTTmag) was correlated with vertical and resultant directions of the accelerometer.

SUMMARY AND CONCLUSIONS

The results of this study demonstrate that TAs have moderate correlations with landing GRFs, knee flexion, and tibial translation. Tibial acceleration may be a good measure of landing impact at the knee and may provide some information related to knee flexion and tibial translation magnitude during landing. The use of an accelerometer may help facilitate the prospective evaluation of ACL risk factors. More studies are needed to further investigate these relationships in different populations and during different tasks.

SUBJECTS

Ten highly active varsity and club level college female athletes were recruited to participate in this study. Subjects were excluded if they reported any previous knee injury.

Table 1. Subject Demographics

<table>
<thead>
<tr>
<th>n</th>
<th>Age (years)</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>20.3 ± 0.8</td>
<td>168.6 ± 9.0</td>
<td>63.3 ± 6.2</td>
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Table 2. Accelerometer Correlations

<table>
<thead>
<tr>
<th>Accl Axis</th>
<th>pfF</th>
<th>pfV</th>
<th>pfVT</th>
<th>pfGRF</th>
<th>pfPGRF</th>
<th>pfATT</th>
<th>pTTmag</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical</td>
<td>0.919</td>
<td>0.363</td>
<td>0.526</td>
<td>0.796*</td>
<td>0.696*</td>
<td>-0.372</td>
<td>0.006</td>
</tr>
<tr>
<td>Trans. Res.</td>
<td>-0.430</td>
<td>0.205</td>
<td>0.352</td>
<td>0.783*</td>
<td>0.209*</td>
<td>-0.058</td>
<td>0.373</td>
</tr>
<tr>
<td>Total Res.</td>
<td>0.059</td>
<td>-0.270</td>
<td>0.467</td>
<td>0.778*</td>
<td>0.593*</td>
<td>-0.388</td>
<td>0.042</td>
</tr>
</tbody>
</table>

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