The Relationship of Lower Extremity Alignments, Knee Laxity and Anterior Tibial Translation During Drop Landings: A Bi-Plane Fluoroscopy Study

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INTRODUCTION:
The rate of injury to the anterior cruciate ligament (ACL) in the United States is reported to be above 1 in 3000 [1]. Several factors including anatomical structure, movement patterns and neuromuscular recruitment patterns have been identified as risk factors for the non-contact ACL injury. Prior investigations have implicated lower extremity alignments including rearfoot angle, tibial torsion, quadriceps angle (Q-angle), pelvic tilt, navicular drop, femoral antever sion and genu recurvatum as significant contributory factors in the non-contact ACL injury because they may place the knee and ACL in vulnerable positions [2-5]. Specifically, rear foot angle and navicular drop may allow for increased tibial torsion forcing greater knee rotation and anterior tibial translation; and, large pelvic tilt, femoral antever sion and Q-angles would be associated with increased knee valgus [2-5]. Thus, these lower extremity alignments are often cited as risk factors for ACL injury, but how they may affect or are related to knee joint function during a function activity such as landing from a jump is not known.

Since functional knee stability is affected by both active and passive knee joint restraints, increased risk of ACL injury may also occur in the absence of sufficiently taut ligaments. Previous studies have suggested static KT-1000/2000 knee laxity measures are predictive of ACL injury [3,5]. Woodford-Rogers et al., (2007) found greater measures of knee laxity in the non-injured limb of ACL injured patients; and, Uhrochak et al. (2003) found athletes with higher knee laxity scores to be more likely to injure their ACL.

The purpose of this study was to determine the relationship between select lower extremity alignments, knee laxity and anterior tibial translation (ATT) measured during a drop landing.

METHODS:
Eleven healthy subjects (6M, 5F; age 26.9±6.4yrs) completed 5 self-selected drop landings from a height of 40cm inside a biplane fluoroscopy system. Subjects also performed a seated, unloaded knee extension task. Fluoroscopy images were captured at 100 Hz for one landing and the knee extension task. Bone geometries reconstructed from CT scans were matched onto the calibrated fluoroscopy images after their contours were detected semi-automatically using mobel based RSA (Medis Specials, Leiden, Netherlands). Knee rotations and translations were calculated using methods described by Grood & Suntay [7].

Normalization to knee extension was achieved by subtracting the translation and rotation of the tibia during knee extension from data collected during the landing task at the same knee flexion. Anatomical alignment measures of rearfoot angle, navicular drop, femoral antever sion, pelvic tilt, tibial torsion, Q-angle and genu recurvatum were made with techniques described by Schultz and Nguyen (2007). Knee laxity was evaluated with KT-1000 testing.

Correlations were made between peak ATT and each of the measured alignment and knee laxity scores to determine their relationship during the drop land task.

RESULTS:
Alignment measures as well as knee laxity scores are presented in Table 1 and the correlation matrix with associated p-values for all variables are presented in Table 2. Significant findings were between femoral hip antever sion and time to maximal ATT (p = 0.01) where a negative correlation existed; and, between hip antever sion and tibial torsion (r = -.63; p = 0.03). No other alignment measure or knee laxity demonstrated a significant relationship with ATT during the drop landing (all p > 0.14).

<table>
<thead>
<tr>
<th>Alignment Measure</th>
<th>KT1000 Max ATT (mm)</th>
<th>KT1000 Max ATT (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tibial Torsion</td>
<td>1.22</td>
<td>3.81</td>
</tr>
<tr>
<td>Pelvic Angle</td>
<td>.68</td>
<td>.68</td>
</tr>
<tr>
<td>Femoral Antever sion</td>
<td>.11</td>
<td>.11</td>
</tr>
<tr>
<td>Q Angle</td>
<td>.47</td>
<td>.47</td>
</tr>
<tr>
<td>Genu Recurvatum</td>
<td>.03</td>
<td>.03</td>
</tr>
<tr>
<td>Navicular Drop</td>
<td>.21</td>
<td>.21</td>
</tr>
<tr>
<td>Rearfoot Angle</td>
<td>.18</td>
<td>.18</td>
</tr>
<tr>
<td>KT1000 Max ATT</td>
<td>.68</td>
<td>.68</td>
</tr>
</tbody>
</table>

DISCUSSION:
The results of this study suggest a direct relationship between select lower limb alignments and knee ATT. Specifically, a significant negative correlation was found between femoral antever sion and time to maximal ATT and a negative correlation between tibial torsion and hip antever sion. Collectively, increased femoral antever sion in conjunction with increased external tibial torsion results in increased knee valgus and this was apparent in this study with a moderate correlation between tibial torsion and maximal knee valgus angle (r = -.465). Clinically, higher knee valgus during landing has been attributed to higher ACL injury rates.

Considerable discussions have focused on how lower extremity alignment measures and knee laxity may relate to ACL injury [2-6]. However, the influence of these variables on ACL injury and knee function in general remains controversial. This is because it is assumed that these alignments and knee laxities have direct influence on knee function. To date, however, no study has been able to directly relate these variables to knee function (knee translations to be specific) as traditional optical motion capture techniques are limited in accuracy to make such relationships apparent. The present study has shown that some lower extremity alignments are directly related to knee ATT. Previous studies that have shown significant relationship between these factors and the risk of ACL injury have suggested that these alignment and knee laxity measures must be greater than 1 SD of normal values to have a significant ACL injury predictive value. We have found significant relationships even though our subjects were within normal values.

CONCLUSIONS:
Within the scope and limitation of this investigation, femoral antever sion and tibial torsion have been shown to be correlated to knee ATT during the drop land. These relationships were found in individuals who are not currently at risk for ACL injury. Clinically, this is valuable since lower limb alignment measures can be easily measured allowing for more centers to participate in ACL screening and preventive programs. Currently, gender disparities and individual considered outliers in these alignment measures are being tested to determine if these relationships can be stronger in “at risk” ACL injury groups.

REFERENCES:
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