Anterior Cruciate Ligament (ACL) injuries are one of the most common injuries in sport with 250,000 reported cases in the US annually. The peak age range for this injury is 16-17 years old.

ACL injuries can be categorized as either contact or non-contact injuries: Non-contact injuries typically occur as a result of valgus collapse of the involved lower extremity, which commonly occurs during a jump landing or cutting maneuver.

Cutting tasks are reported as the cause of 57% of non-contact ACL injuries in collegiate basketball and soccer players; despite the high percentage of ACL injuries that occur during a cutting task, there is no validated clinical measure to assess cutting injury risk factors.

Previous research has shown that knee abduction moments during a cutting task are significantly higher than during a Drop Vertical Jump (DVJ).

The purpose of this study is to determine the validity of a qualitative checklist used to identify ACL injury risk in the clinic during a 45 degree sidestep cut.

Methods
Subjects: A convenience sample of 23 subjects was taken from local male and female athletes, ages 12-18 with no medically treated lower extremity injuries in the last 6 months, no previous surgeries and all active participants in a cutting sport.

Methods: Athletes were given verbal instructions/demonstration and asked to perform a 45 degree side cut step cut towards the right and the left (3 trials of each) and 3 trials of a DVJ.

Data Collection: Kinematic data was collected and processed using VICON workstation software. Kinetic data was captured using the 8 cameras BTS SMART 700DV 3D Motion Analysis System and an iPad was used to record (anterior and lateral views) of these movements as well. Knee abduction moments were calculated using inverse dynamics.

Outcomes: One experienced clinician used the Dartfish application and a clinical established 45 degree cut qualitative checklist to independently view and score the cut. A separate experienced clinical evaluated biomechanical errors during the DVJ using the Landing Error Scoring System (LESS), a reliable and valid clinical assessment tool of jump landing biomechanics.

Statistical Analysis: Pearson correlation statistics were used to examine the relationship between the LESS, and the 45 degrees cut checklist total scores. Peak knee abduction moment (KAM) cut scores for ACL injury risk prediction are shown in a DVJ (>25.25 Nm and > 21.74 Nm). These known values were used to estimate KAM cut scores that may be predictive of ACL injury risk during a cutting task (>151.5 Nm and >130.44 Nm). Pearson correlation and Chi-square statistics were used to examine the relationship between the estimated KAM cut scores and the total 45 degree cut checklist score and individual 45 degree cut checklist items for each subject's right and left lower extremity.

Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>45 degree cut checklist</th>
<th>Modified 45 degree cut checklist</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spearman Correlation (r, p-value)</td>
<td>Spearman Correlation (r, p-value)</td>
<td></td>
</tr>
<tr>
<td>LESS</td>
<td>-0.1226, 0.5869</td>
<td>0.0678, 0.7645</td>
</tr>
<tr>
<td>KAM</td>
<td>0.3288, 0.01185</td>
<td>0.08192, 0.5971</td>
</tr>
</tbody>
</table>

Table 1: The Relationships Between the LESS Score, Peak KAM and the 45 Degree Cut Check List Scores

Table 3: The relationship between KAM cut off score (> 151.5Nm) and 45 Degree Cut Checklist Item

Clinical Relevance

Despite the high percentage of ACL injuries that occur during a cutting task, there is no validated clinical measure to assess cutting injury risk factors. The results of this pilot study suggest that a modified 45 degree cut qualitative checklist may be able to identify athletes who are at risk for suffering an ACL injury. However, more research is needed to determine true peak KAM cut off scores that are predictive of ACL injury risk during a cutting tasks in the adolescent athlete. Additionally, visual identification of certain cutting related faults may provide useful information in determining risk.

References

The effect of weight bearing dorsiflexion range of motion on lower extremity kinematics during a 45 degree cut.

Authors: Lauren Butler, Eryn K. Apanovitch, Amie DeVerna, Cheryl Gimenez, Moataz Eltoukhy, Jeonghoon Oh

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Background

- Anterior Cruciate Ligament (ACL) injuries are one of the most common injuries in sport with 250,000 reported cases in the US annually.
- Several sub-optimal movement patterns have been linked to ACL injury including, decreased knee flexion range of motion (ROM) and valgus collapse of the lower extremity (LE) during noncontact jumping and cutting tasks.²
- Limited weight bearing dorsiflexion (WBDF) has been associated with decreased knee flexion, increased knee valgus, and increased ground reaction forces during several functional tasks (squat, drop vertical jump and a lateral step down).³–⁴
- Despite the association of decreased WBDF and LE kinematics that have been linked to higher ACL injury risk, no study has examined the relationship between decreased WBDF and LE kinematics and kinetic compensations during a cutting task.
- The aims of this pilot study are to determine the relationship between WBDF and LE kinematics and kinetics during a 45 degree side cut.

Methods

A convenience sample of 23 subjects were taken from local male and female athletes. Ages 12-18 with no medically treated lower extremity injuries in the last 6 months, no previous surgeries and all active participants in a cutting sport. Athletes were given verbal instructions/demonstration and asked to perform a 45 degree side step cut towards the right and the left (3 trials of each).

Data Collection: Kinematic data was collected and processed using VICON workstation software. Kinetic data was captured using the 8 camera BTS SMART 7000DX 3D Motion Analysis System and an iPad was used to record (anterolateral and lateral views) of these movements. Knee abduction moments were calculated using inverse dynamic methods.

Outcomes: One experienced clinician used a gravity inclinometer to measure WBDF range of motion following the protocol for the Weight Bearing Ankle Dorsiflexion Test (WBADT), a reliable and valid measure of weight bearing ankle dorsiflexion range of motion.

Statistical Analysis: Pearson correlation statistics were used to examine the relationship between subjects WBDF range of motion and LE kinematics and kinetics during the 45 degree side step cut.

Results

The findings of this pilot study show that decreased WBDF range of motion is related to suboptimal movement pattern changes during performance of a 45 degree side step cut. Athletes with lower WBDF range of motion demonstrated a statistically significant increase in hip abduction angle at both initial contact and pvGRF, as well as a significant decrease in knee flexion angle at pvGRF.

Table 2: The Relationship Between WBDF and LE Kinematics

<table>
<thead>
<tr>
<th>LE Kinematics</th>
<th>WBDF Spearman Correlation (r,p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hip Adduction (pvGRF)</td>
<td>.48, .0013</td>
</tr>
<tr>
<td>Hip Adduction (initial contact)</td>
<td>.41, .0060</td>
</tr>
<tr>
<td>Knee Flexion Angle (pvGRF)</td>
<td>.37, .02</td>
</tr>
</tbody>
</table>

Clinical Relevance

Despite the high percentage of ACL injuries that occur during a cutting task, there is no validated clinical measure to assess performance of a 45 degree side step cut. A statistically significant inverse relationship was found between WBDF and hip adduction angle at peak vertical ground reaction force (pvGRF) (r=0.48, p=.0013) and initial contact (r=.41, p=.0060). There is also a statistically significant direct relationship between WBDF and knee flexion angle at pvGRF (r=.37,p=.02). No relationship was found between WBDF and knee valgus angle, trunk lateral flexion, or peak knee abduction moment during the 45 degree side step cut.

Conclusion:

Increased hip adduction and decreased knee flexion have both been identified as potential contributing factors of ACL injury during cutting tasks. The relationship found between decreased WBDF and these suboptimal movement pattern changes suggests that screening for decreased WBDF may be a critical component to ensuring safe cutting technique.

References

5. Amramgahi A, Herrington L, Jones R. Intratester, intertester and test-retest reliability of a qualitative scoring system of limb alignment during single leg squat. The Knee in Press.
Background

Asymmetrical lower extremity loading after ACL Reconstruction has been shown to persist for more than a year after ACL reconstruction and may be predictive of subsequent ACL injuries. Currently, there are no validated, objective clinical tools that can be used by the clinician to determine return to sport readiness.

Methods

A convenience sample of 23 subjects was taken from local male and female athletes, ages 12-18 with no medically treated lower extremity injuries in the last 6 months, no previous surgeries and all active participants in a cutting sport. Participants were excluded if they had any previous lower extremity (LE) surgery, any lower extremity injury in the last 6 months, a positive response on the PAR-Q or history of scoliosis. Athletes were given verbal instructions/demonstration and asked to perform an anterior view of the overhead squat.

Data Collection

Kinematic data was collected and processed using VICON workstations software. Kinetic data was captured using the 8-camera BTS SMART 7000DX 3D Motion Analysis System and an iPad was also used to record (anterior, lateral, and posterior views) these movements. Reflective markers were placed on the trunk and bilateral upper and lower extremities for quantitative analysis using Dartfish. Overhead Squat (2 trials) and a Drop Vertical Jump (3 trials).

Data Analysis

Statistical analysis was used to determine if a relationship between slope in degrees and the difference in timing to reach peak vGRF in seconds exists between the right and left LE during each task.

Discussion

The findings of this pilot study suggest that there is a moderate, positive relationship between the 2-D measurement of TT slope and the difference in timing to reach peak vGRF during an OH squat and a DVJ. When using a TT slope of ≤ 4° as the cut off for symmetrical LE loading, 89.5% of subjects were correctly identified as being symmetrical and 100% of subjects were correctly identified as being asymmetrical during the OH squat.

Clinical Relevance

A clinician friendly tool to evaluate asymmetrical loading can provide quantifiable data that can be used by the clinician to determine return to sport readiness.

TT Slope Off (degrees)

Subjects correctly identified as being asymmetrical

TT Slope Cut Off (degrees)

Subjects correctly identified as being symmetrical

Table 1: The Association Between Clinical (TT Slope) and Biomechanical Measures (timing difference) During a Drop Vertical Jump (DVJ) and Overhead Squat (OHS)

<table>
<thead>
<tr>
<th>TT Slope Cut Off (degrees)</th>
<th>DVJ Chi-square (p-value)</th>
<th>OH Chi-square (p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3°</td>
<td>0.0022</td>
<td>0.0355</td>
</tr>
<tr>
<td>4°</td>
<td>0.0346</td>
<td>0.0023</td>
</tr>
</tbody>
</table>

Table 2: The Relationship Between Tibial Tuberosity Slope and the Difference in Timing for the Drop Vertical Jump (DVJ) (.01 second) and the Overhead Squat (OHS) (1.5 seconds)

<table>
<thead>
<tr>
<th>TT Slope Off (degrees)</th>
<th>DVJ Spearman Correlation (r, p-value)</th>
<th>OH Spearman Correlation (r, p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3°</td>
<td>0.669, 0.0009</td>
<td>0.459, 0.0364</td>
</tr>
<tr>
<td>4°</td>
<td>0.461, 0.0354</td>
<td>0.669, 0.0009</td>
</tr>
</tbody>
</table>

References