INTRODUCTION

It is imperative, when designing a test to detect an athlete’s vulnerability to injury, that the test should be valid in both non-fatigued and fatigued situations. Detecting an athlete’s potential for injury during later stages of athletic performances would allow coaches to make important decisions concerning whether or not to take a certain player out of a game.

Knee valgus has been identified as a non-favorable position during landing as it has been linked to ACL injuries [1]. In a recent study we found the change in distance between the knees experienced during landing could be predicted from that experienced during a squat in a group of active college students [2]. The distance between the knees was used as an indicator of knee valgus as it is a more practical measuring method if a field test is to be developed [3]. This was a good first step in an attempt to develop a field test to identify athletes with greater potential for ACL injuries. However, this was not tested in post-fatigue situations nor was a measure of true knee valgus used.

Thus, the purpose of this study was to establish if the quantity of true knee valgus observed after landing (Land) could be predicted from the valgus measurements during the downward movement of the takeoff (TO) phase of a jump and the downward movement of a squat (Squat) during both pre- and post-fatigued conditions.

METHODS

Twenty active college students (10 male, 10 female) participated in this study. Prior to testing participants read and signed an informed consent, which was approved by the Arizona State University Research Compliance Office. Participants were excluded if they had any orthopedic condition that would prevent them from performing a maximal vertical jump.

Position and orientation of all segments were recorded using 12-camera Vicon motion-capture system (240 Hz, Vicon, Oxford, UK). All participants were asked to perform three squats during which they squatted down and then back up to standing. Subjects were instructed to squat as if about to jump but to return to standing with the feet remaining in contact with the ground in order to replicate the first half of the takeoff phase of the jump. Subjects also performed three maximal countermovement vertical jumps while raising both arms as if to block a volleyball shot and land on both feet. Following the jumping and squatting tasks, participants underwent a fatiguing protocol, which consisted of the participants running on a treadmill at 10 km/h at a 10% uphill grade for 5 min.

Pearson product correlations were used to identify the relationship between knee valgus during Land, TO, and Squat. Linear regression analyses were conducted to identify the predictability of the knee valgus during Land from knee valgus during the TO and Squat.

RESULTS AND DISCUSSION

In the pre-fatigue condition, Pearson product correlations showed significant positive correlation between knee valgus experienced during TO, Land, and squat from both the right and left sides (Table 1). The strongest correlations were between TO and squat (r = .948 and r = .860, for the right and left sides, respectively). Similar results were seen in the post-fatigue condition as significant positive
correlations between knee valgus experienced during TO, Land, and squat from both the right and left sides were also observed (Table 2). The strongest correlations were also between TO and squat (r = .988 and r = .882, respectively).

Table 1 Relationship Between Knee Valgus Measured During TO, Land, and Squat (Pearson Product Moment Correlations) in the Pre-Fatigue Condition.

<table>
<thead>
<tr>
<th></th>
<th>Take off</th>
<th>Landing</th>
<th>Squat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Take off</td>
<td>1</td>
<td>.782*</td>
<td>.948*</td>
</tr>
<tr>
<td>Landing</td>
<td>.595*</td>
<td>1</td>
<td>.805*</td>
</tr>
<tr>
<td>Squat</td>
<td>.611*</td>
<td>.860*</td>
<td>1</td>
</tr>
</tbody>
</table>

Right side shown above the diagonal, Left side shown below the diagonal, * p ≤ .01 level (2-tailed)

Table 2 Relationship Between Knee Valgus Measured During TO, Land, and Squat (Pearson Product Moment Correlations) in the Post-Fatigue Condition.

<table>
<thead>
<tr>
<th></th>
<th>Take off</th>
<th>Landing</th>
<th>Squat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Take off</td>
<td>1</td>
<td>.866*</td>
<td>.988*</td>
</tr>
<tr>
<td>Landing</td>
<td>.846*</td>
<td>1</td>
<td>.859*</td>
</tr>
<tr>
<td>Squat</td>
<td>.882*</td>
<td>.686*</td>
<td>1</td>
</tr>
</tbody>
</table>

Right side shown above the diagonal, Left side shown below the diagonal, * p ≤ .01 level (2-tailed)

Knee valgus during Land showed correlations with knee valgus during Squat and TO for both the right and left sides that persisted during pre and post-fatigue conditions. As anticipated, correlations were not as strong as the Squat and TO correlations were for all but one measure (left knee Squat and TO had an r = .611, which is less than that between Squat and Land).

We believe there are two reasons why knee valgus during Squat and TO had a stronger relationship with each other than with Land. First, the start position for the Squat and TO was standing with the feet at shoulder width apart. Thus, the starting positions were almost identical. Although participants landed on two feet, the distance between the feet upon landing is not fully controlled considering the different possibilities of landing on any particular spot. The second reason is related to landing speed. The instructions given for the squat was to squat as if to jump but to return to stance without the feet leaving the ground. This assumes that the downward phases of each condition are performed at similar speeds. There may have been an inability to control the velocity of the upward phase in squatting and during the countermovement due to the different endpoints (airborne phase in the jump vs. stand in the squat) but that is irrelevant when comparing the downward phase. Land on the other hand was functionally different as maximum speed is reached just after the instant of touchdown and there is a continuous decrease in speed until a stop is reached. Despite these differences enough similarities existed between the three tasks to result in the significant positive correlations we found in both the right and left sides during the pre-fatigue and post-fatigue conditions.

A multiple step-wise linear regression analysis showed knee valgus during Squat to be the single best predictor for that during Land for both knees in the pre-fatigue condition with adjusted R² values of .648 and .374 for the right and left knees, respectively. Similar results were observed in the post-fatigue condition as right knee valgus during Squat was the single predictor with an R² value of .738. For the left side, knee valgus during the TO was the single predictor with an R² value of .715.

Regression analysis revealed that knee valgus experienced during landing is best predicted by either that observed during the downward phases of squatting or the takeoff prior to jumping with squatting being the better predictor.

CONCLUSIONS

Relationships found in this study have been consistent in both pre- and post-fatigue conditions. This suggests the ability of using knee valgus angle during squatting to predict the quantity of valgus that potentially may be experienced during landing which may prove to be a useful screening tool in determining which athletes would benefit from an ACL injuring prevention program. However, measuring knee valgus in a field setting may prove difficult. Future studies should investigate the relationship between true knee valgus during landing and the distance between the knees where participants would be allowed to land freely.

REFERENCES