PURPOSE

To develop and validate a simple method to determine sagittal plane knee kinematics from frontal plane video during a box drop vertical jump.

INTRODUCTION

• Knee abduction moment is a known risk factor for anterior cruciate ligament (ACL) injury
• The box drop vertical jump (DVJ) is a commonly employed activity to assess the magnitude of knee abduction moment
• Current screening tools rely heavily on costly or impractical means of capturing video or kinematic and kinetic data from multiple angles
• Determining risk for increased knee abduction moment can be done using basic anthropometrics and frontal and sagittal knee kinematics during DVJ

METHODS

• Twenty (20) female high school athletes performed five (5) DVJ trials from a 31 cm high box
• Motion analysis data collected from a ten (10) camera motion capture system (Eagle Cameras, Motion Analysis Corp, Santa Rosa, CA)
• Frontal and sagittal plane video collected using camcorders
• Frontal plane video frames at initial contact and peak knee flexion were analyzed and hip, knee and ankle joint centers were digitized
• Vector analysis was used to derive third dimensional kinematics from frontal plane coordinates in the following manner:

\[
L_{3Y} = \sqrt{L_5^2 - L_{3Z}^2 - L_{5Z}^2} \quad \text{Eq 1}
\]

The depth component (y-axis) of each segment was estimated as shown in Equation 1

To determine knee flexion angle, the YZ plane projection vectors for each segment were expressed from knee to hip or knee to ankle as shown in Equation 2.

\[
\bar{\mathbf{S}}_{yz} = L_{3Z} \hat{e}_x + \sqrt{L_5^2 - L_{3Z}^2 - L_{5Z}^2} \hat{e}_y \quad \text{Eq 2}
\]

Where \( \bar{e}_y \) represents the unit vector in the Cartesian coordinate system in the direction of alpha.

Using the dot product between the sagittal plane projection vectors gives Equation 3.

\[
\Theta_{xy} = \cos^{-1}\left(\frac{\sqrt{L_5^2 - L_{3Z}^2 - L_{5Z}^2} - L_3}{\sqrt{L_5^2 - L_{3Z}^2 - L_{5Z}^2}} + L_3, L_5 \right) \quad \text{Eq 3}
\]

• Knee flexion angle (KFA) was defined as the supplemental angle to \( \Theta_{xy} \) and was made negative by convention
• KFA calculated using joint center pixel coordinates from frontal plane video at initial contact and peak flexion
• Frontal plane joint center coordinates from 3D motion analysis used to calculate continuous KFA across contact phase
• Correlation between actual and calculated ROM from video
• Paired, two-tailed t tests at 10% intervals from calculated vs actual (3D) knee flexion angle

RESULTS

• Figure 1 shows actual (blue) and calculated (red) continuous knee flexion during the contact phase of a DVJ
• Significant differences between the two were noted at low flexion angles, but not at high flexion
• Calculations from frontal plane video accounted for approximately 90% of the actual sagittal plane ROM, as shown in Figure 2

DISCUSSION

• Method accounts for most of sagittal plane knee ROM, however lacks ability to take transverse plane motions into account
• Use of this method is currently specific to DVJ and should not be interpreted as universally applicable

CONCLUSIONS

• Further validation is required, however for this specific screening test, the methodology appears to be accurate
• The extent to which the error affects a screeners’s ability to determine risk of high knee abduction moment is not yet clear