INTRODUCTION:
One of the most common non-contact anterior cruciate ligament (ACL) injury mechanisms is a single limb landing from a jump. It has been suggested that the knee abduction moment can predict the risk of a non-contact ACL injury among female athletes during a jump-landing task. However, complex instrumentation is required to measure this parameter. Thus, there is a need for a simple, accurate, and reproducible method for estimating knee joint kinetics to identify athletes at risk for ACL injury.

Hewett et al. recently proposed a method to predict the knee abduction moment during a jump-landing task based on independent parameters. This method was reported to account for 78% of the variance in knee abduction moment. However, this method relied on both kinetic and kinematic parameters.

The angular velocities of body segments have been shown to be a useful parameter in the study of gait. Currently, angular velocity can be easily measured in any environment using small, body-mounted gyroscopes. Thus, angular velocity could be a valuable parameter to assess the risk for ACL injury. But the relationship between angular velocity and an established ACL injury risk factor, like knee abduction moment, is currently unknown.

The objective for this study was to determine if the angular velocities of the shank and thigh segments (independently and in combination) could be used to assess ACL injury risk among healthy subjects. To this end, the inter-subject variability of the angular velocity, as well as the correlation between the angular velocity and the knee abduction moment, were evaluated during drop-land tasks.

METHODS:
26 healthy subjects (13 male, age 27.7 yrs, BMI 22.8) were evaluated in an IRB approved study with informed consent conducting a drop jump task. The subjects were asked to drop directly off of a 36 cm high box, land on both legs, and then immediately perform a maximum vertical jump. The jump was repeated three times, and data from all trials for every subject were processed. The landing directly after the drop from the box was analyzed.

Two inertial measurement units (IMUs) were used to record movement. Each IMU consisted of a 3DOF gyroscope (±900°/s) and a 3DOF accelerometer (±6g). The IMUs were connected to a light portable data logger (Physiolog®, BioAGM, CH) recording at 240 Hz. The IMUs were fixed to the right leg on the thigh and on the shank with elastic straps. Two calibration sequences were completed to express the movement. Each IMU consisted of a 3DOF gyroscope and a 3DOF accelerometer. The IMUs were connected to a light portable data logger (Physiolog®, BioAGM, CH) recording at 240 Hz. The IMUs were fixed to the right leg on the thigh and on the shank with elastic straps. Two calibration sequences were completed to express the movement.

Knee kinetic data was simultaneously collected using 47 reflective markers placed on the subject and a ten camera motion analysis system (Qualysis, Sweden) recording at 120 Hz, and two force plates (Bertec, Ohio) recording at 1200 Hz. The knee joint kinetics were calculated using the point cluster method and an inverse dynamics approach.

The correlation coefficient (r) and the p-value (p < 0.05) were used to assess the statistical significance of the correlation between the knee abduction moment and the segment angular velocities. For the thigh and shank independently and in combination (thigh–shank), the range (signed amplitude change) of the angular velocities between the initial contact and the maximum value during the landing deceleration phase were tested for correlation to the range of the knee abduction moment.

RESULTS:
The thigh and shank segment angular velocities had a small standard deviation relative to the average curve for each component of the angular velocity (Fig. 1). The correlations between the range of knee abduction moment and the range of thigh frontal velocity (p = 0.04) and the range of shank frontal velocity (p = 0.03) were significant. The correlation to the knee abduction moment improved (p = 0.01) when the relative thigh to shank frontal plane component of the angular velocity was used (Table 1).

DISCUSSION:
The results that the patterns of segment angular velocities were similar for healthy subjects during drop jump landings imply that the thigh and shank angular velocities could potentially be used to assess individual characteristics of landing mechanics at the knee. More importantly, the significant correlations between the frontal plane component of the segment angular velocities and knee abduction moment suggest that the angular velocity curves could be used to assess the risk of ACL injury. The finding that the relative thigh to shank difference in the angular velocity of the frontal plane showed the strongest relationship to knee abduction moment indicates that speed of the relative movement between the thigh and shank segments could provide additional insight into the mechanisms of ACL injury. While additional studies are needed to assess the predictive potential of the angular velocity measurement, there are many advantages to using segment angular velocity as a measure of ACL injury risk. Angular velocity can be measured directly and accurately with miniature sensors that can be used in the field. Also, it is representative of the dynamics of motion since angular velocity corresponds to the angular rate of change of the thigh and shank segments. This study provides a basis for further studies to apply segment angular velocity as an assessment of ACL injury risk.

REFERENCES:

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