Weakened Trunk Muscles Influence Knee Valgus Moments Associated with ACL Injury

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Introduction: Over 200,000 anterior cruciate ligament (ACL) injuries occur every year in the United States alone [1, 2]. These injuries often occur in sports where dynamic movements, such as jump landings, place high loads on the ACL [3, 4]. Studies have shown increased knee valgus moments, small knee flexion angles, and anterior tibia translation contributes to ACL injury during landing [5-7]. While the role of trunk muscle strength in landing biomechanics is unknown, some studies have shown altered trunk position may increase knee valgus moments [8, 9], elevating the risk for ACL injury. We used computed muscle control (CMC) to estimate baseline muscle forces for the trunk and lower-extremity during single-leg jump landing. These muscles forces were altered to investigate how weakened trunk muscles affect knee loads. We hypothesized that decreasing trunk muscle strength would increase knee valgus moments associated with ACL injury risk.

Materials and Methods: We used experimental kinematic and kinetic data collected at the University of Western Australia to study the effectiveness of balance and technique training. One athlete from this study was selected and a subject-specific simulation of single-leg jump landing (Fig. 1) was created in OpenSim [10]. A generic musculoskeletal model was scaled to the size of the subject by specifying mass properties and segment dimensions obtained from experimental data [11]. Inverse kinematics was used to derive the joint angles from the marker data obtained during jump landing. These simulated kinematic errors were minimized to be dynamically consistent with experimental ground reaction forces by using the residual reduction algorithm (peak residual forces < 1.5N). CMC was used to estimate muscle excitations, and subsequently muscle forces, during jump landing. We evaluated our hypothesis regarding trunk muscles affecting knee loads by weakening trunk muscle forces and recording the changes in knee valgus moments (Fig. 2).

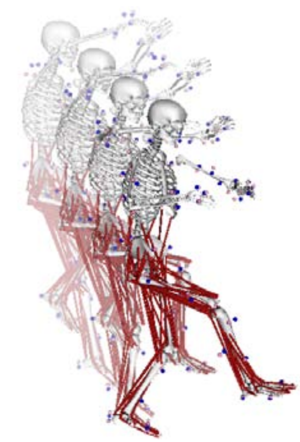

Figure 1: Series of images for a subject-specific simulation during single-leg jump landing using a musculoskeletal model with 37 degrees of freedom and 92 muscle-tendon actuators.

Results and Discussion: Knee valgus moments increased as trunk muscle strength decreased (Fig. 2). Increased knee valgus moments indicate a change in frontal plane knee motion and are an indicator for individuals at risk for ACL injury. These results show weakened trunk muscle strength may elevate this risk.

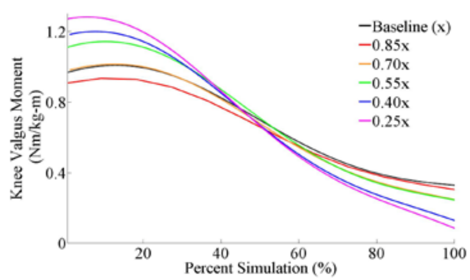

Figure 2: **Knee valgus moments (normalized by the subject's mass times height) for weakened trunk muscle forces where 'Baseline (x)' represents the moment while at initial strength, '0.85x' is the moment at 85% of initial strength, etc.**

Conclusions: Computer simulation provides the unique ability to safely investigate muscle strength during high-risk movements that would otherwise place human subjects at risk for ACL injury. Our findings indicate that trunk positioning may have a greater influence on knee loads than initially realized. Future work will analyze additional subject simulations to determine if the trends reported here truly represent the role of trunk muscle strength in single-leg jump landings.

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