

The Two-Dimensional Relationship Between Ground Reaction Force Vector and Knee Axis of Rotation Reflect Knee Loading Deficits During Squatting Post-ACLR

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ABSTRACT

PURPOSE: Individuals post-anterior cruciate ligament reconstruction (ACLR) perform reduced knee extensor moments (KEM) during squats by shifting weight to the non-surgical (NSx) limb¹ or by shifting demands from the knee to hip^{1,2}. These compensations occur without observable differences in joint angles by small adjustments in the center of pressure (COP). This makes them difficult to detect and may contribute to their persistence. Differences between limbs in COP position suggest that individuals adjust the relationship of the ground reaction force vector (GRFv) relative to the joint center to redistribute the loading demands in the surgical limb³. Recent technology allows for two-dimensional video assessment of this relationship and may provide more accessible means to identify knee loading deficits. The purpose of this study is to determine if the between-limb difference in the two-dimensional distance between the GRFv and knee joint axis of rotation and the GRF magnitude will predict a between limb difference in knee extensor moment in a squat. **METHODS:** Twenty-two individuals (age: 25.7 ± 10.3 years) 110 ± 18 days following ACLR participated. Kinematic and kinetic data were collected (3D motion capture system, force platforms) while bilateral squats were performed to self-selected depth. Joint moments were calculated using standard inverse dynamics equations. The horizontal distance from a marker placed over the lateral epicondyle of the knee and the GRFv, peak KEM and GRFv magnitude were calculated at the instance of KEM. Ratios Sx/NSx were calculated for all variables to reflect difference between limbs. Multiple linear regression assessed the influence of the horizontal distance and GRFv magnitude ratio on KEM ratio. **RESULTS:** Together, between-limb ratios of horizontal distance and GRF magnitude explained 81.4% of the variance in KEM ratio. Horizontal distance ratio explained 61% of the variance and GRF ratio an additional 21.4% of the variance of KEM ratio. **CONCLUSIONS:** Combination of GRF and the horizontal distance between the GRFv and knee axis of rotation in the sagittal plane provides good information about knee extensor loading deficits. This relationship suggests that these variables may allow for estimations of KEM deficits during a squat in individuals post-ACLR.

1. Sigward SM, Chan MSM, Lin PE, Almansouri SY, Pratt KA. Compensatory strategies that reduce knee extensor demand during a bilateral squat change from 3 to 5 months following anterior cruciate ligament reconstruction. *Journal of Orthopaedic and Sports Physical Therapy*. 2018;48(9):713-718. doi:10.2519/jospt.2018.7977

2. Salem GJ, Salinas R, Harding FV. Bilateral kinematic and kinetic analysis of the squat exercise after anterior cruciate ligament reconstruction. *Arch Phys Med Rehabil*. 2003;84(8):1211-1216. doi:10.1016/S0003-9993(03)00034-0

3. Chan MS, Sigward SM. Center of pressure predicts Intra-limb compensatory patterns that shift demands away from knee extensors during squatting. *J Biomech*. 2020;111(2020):110008. doi:10.1016/j.jbiomech.2020.110008