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Minimizing valgus knee loading during sidestepping: implications for ACL injury risk.

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Introduction: Ruptures of the anterior cruciate ligament (ACL) are major sporting injuries [1,2,3] with the majority occurring during non-contact sidestepping [2]. To better understand what influences elevated knee loading and ACL injury risk, one must examine upper body and/or lower limb postures/kinematics during sidestepping [1,3]. In this investigation we used computed muscle control (CMC) to identify what postures/kinematics influence peak valgus knee moments during the weight acceptance (WA) phase of an unanticipated sidestepping.

Methods: Three-dimensional full-body kinematics and GRF of an athletic male (height 1.82 m; mass 67.8 kg) conducting an unanticipated sidestep manoeuvre were recorded in a laboratory setting. A scaled full body musculoskeletal model [4] was created in OpenSim. A novel optimization technique [5] with CMC was used to produced a forward dynamic simulation generally consistent with experimental kinematics (RMS errors < 3º) and dynamically consistent with experimental GRF's (peak residual forces < 2 N and moments < 1 Nm). CMC was used again to produce a second simulation that minimized varus/valgus knee moments, producing a new set of sidestepping postures/kinematics that may reduce ACL loading and therefore risk of injury. Whole body postures/kinematics and knee moments were compared before and after minimizing varus/valgus knee moments during WA.

Results and Discussion: Following valgus knee moment minimization, peak valgus and flexion knee moments were reduced by 127.8% (31.4 Nm) and 5.6% (10.7 Nm) respectively. Internal rotation knee moments increased by 23.6% (2.1 Nm). Three primary kinematic differences were observed. Arm adduction, arm flexion and ankle plantar flexion on the stance-side of the body increased by 19.5% (8.1°), 4.1% (1.8°) and 19.4% (2.9°) respectively.

Previous literature has shown that constraining an athlete's arm in adduction significantly elevates valgus knee loading during sidestepping [1]. However, our investigation showed that moving the arm into both adduction and flexion reduces valgus knee loading. This will direct the upper body CoM toward the change of direction path, which has been shown to reduce valgus knee loading [3]. Additionally, our results recommend plantar flexing of the ankle.

We are analyzing a larger sample size to see if these technique recommendations are subject specific or applicable for general athletic populations.

Conclusion: Changing an individual's arm posture and increasing their ankle plantar flexion during the WA phase of unanticipated sidestepping will decrease peak valgus knee loading and the possibility of ACL injury risk. Our results support previous findings [3] and show that CMC can be used as a technique training tool for reducing ACL injury risk in athletic populations.

References

1. Chaudhari *et al.* (2005). *Am. J. Sports Med.* **33**:824-830
2. Cochrane, *et al*. (2007). *J. Sci. Med. Sport. & Exerc.* **10**:96-104.
3. Dempsey, et al. (2007). *Med. Sci. Sport Exer.*. **39**:1765-1773

4. Hamner, *et al.* (2009). *Gait and Clinical Movement Analysis Society*. Colorado.
5. Reinbolt & Donnelly (2010). *11th International Symposium on the 3D analysis of Human Movement.* California.
6. Thelen & Anderson (2006). *J. Biomech*., **39**:1107-1115.

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