THE EFFECT OF LIMB PREFERENCE ON KNEE MECHANICS DURING A FATIGUED UNANTICIPATED SIDESTEPPING MANOEUVRE

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Fatigue may adversely affect knee kinetics and kinematics during the sidestepping manoeuvre. There is a lack of research examining the effect of limb preference on knee mechanics during fatigued unanticipated sidestepping. Twelve female collegiate soccer and field hockey players performed right and left unanticipated sidestepping prior to and following completion of a fatigue protocol. Magnitude based inferences were used to assess the impact of limb preference on knee mechanics during initial contact, weight acceptance, peak push-off, and final push-off of the sidestep. The preferred limb was more likely to experience increased coronal plane loading, whereas the non-preferred limb is more likely to experience increased transverse plane loading during fatigued, unanticipated sidestepping.

KEYWORDS: kinetics, kinematics, football, field hockey, females.

INTRODUCTION: The sidestepping manoeuvre is a dynamic sports task that allows the performer to change direction from standing, walking, or running. Poor mechanical execution of the sidestep manoeuvre can place the ligaments of the knee at the greatest risk of injury (Sanna & O'Connor, 2008). Given the majority of dynamic sidestepping tasks are not pre-planned during games, anticipated manoeuvres are likely not a true reflection of lower extremity mechanics.

The use of unanticipated dynamic tasks such as sidestepping is meant to mimic the nature of the task's performance in game situations (Cortes et al., 2011). Ilmane and LaRue (2008) discovered that temporal constraints (self-initiated, anticipation-coincidence, and reaction condition) have a significant effect on anticipatory postural adjustments. These anticipatory postural adjustments are centrally produced as a feed-forward mechanism to offset the mechanical effects of predicted perturbations on stability in dynamic sports tasks. During an unanticipated task an individual's ability to adjust to the environmental perturbations commonly experienced during a game or practice may be restricted, making them more susceptible to potential injury.

The majority of reported anterior cruciate ligament (ACL) injuries in team sports occur towards the end of the game, indicating that fatigue may enhance non-contact ACL injury risk (Hawkins & Fuller, 1998). Fatigue can influence the muscular mechanisms of the lower extremities, resulting in kinetic and kinematic changes when compared to non-fatigue conditions (Dierks, Davis, Hamill, 2010). In an evaluation of fatigue on single limb landing, increases in knee valgus angles were reported when landing direction was unanticipated, and may have been due to the effect of fatigue on coordination and timing. These results suggest that ACL injury risk may increase when both fatigue and decision-making conditions are present (Santamaria & Webster, 2010).

Previous research has assessed lower-limb preference related to the risk of ACL injury and athletic performance (Matava, Freehill, Grutzner, & Shannon, 2002; Negrete, Schick, & Cooper, 2007). Though significance between limbs in terms of injury risk has not been consistently observed, limb asymmetries may still pre-dispose athletes to injury (Matava et al., 2002; Negrete et al., 2007). More recently, a study comparing limb preference and ACL injury risk found that the majority of males injured their preferred limb, whereas the majority of females injured their non-preferred limb (Brophy, Silvers, Gonzales, & Mandelbaum, 2010). Research by Brown et al. (Brown, Wang, Dickin, & Weiss, 2014) identified differences between limbs during planned sidestepping in female footballers that indicated the non-preferred limb may be at an increased risk of ACL injury during weight acceptance, while the preferred limb may be at an increased risk of injury in the peak push-off phase of sidestepping. Though both soccer and field hockey don't impart a huge demand on one limb versus the other, it is still probable that a disparity will exist between limbs.

Though several studies have looked at the effect of fatigue and anticipation on knee mechanics during dynamic sports tasks, none have observed the impact of limb preference in these instances. Since unanticipated sidestepping towards the end of a game is likely accompanied by increased risk of injury, it is important to investigate how limb preference impacts knee mechanics in these instances.

The primary purpose of this study was to investigate magnitude of difference in knee mechanics due to the effect of limb preference during a fatigued unanticipated sidestep task.

METHODS: Twelve college-aged National Collegiate Athletic Association Division I female football and field hockey players volunteered for this study (mean age = 20.31±1.84years; height = 1.68±5.7m; mass = 61.99±6.45kg).

Players came to the laboratory for a single testing session. Using a modified plug-in-gait model, markers were placed on anatomical landmarks of both the upper and lower body that included 4-marker clusters on each thigh and shank. The preferred limb (PL) was defined as the leg used to kick a ball, and the opposite limb was defined as the non-preferred limb (NL) (Matava et al., 2002). All players identified their PL as the right limb. Players performed a self-selected dynamic warm-up for ten minutes, followed by three vertical jumps to determine maximum jump height. Players practiced at least three of each sidestepping task (i.e., sidestep left, sidestep right and stop) or more trials until they felt comfortable. Timing gates were set up 3 m from the centre of the force plates so that as participants ran through the timing gates, custom built computer software randomly generated an instruction (i.e., direction arrows or a stop sign) for the dynamic task for projection onto a screen in front of the player. After completing the warm-up and practice trials, players performed the Yo-Yo Intermittent Recovery Test (YYIRT) (Krustrup & Bangsbo, 2001). This protocol consisted of repeated high intensity 20 meter shuttle runs starting at 10 km/h and increasing on successive trials by 0.5 km/h with 10 seconds of recovery after each trial (20m x 2), and was repeated until the player was unable to successfully complete two 20m sprints in the allotted time. Players then ran for two minutes on a treadmill in the testing area at their estimated VO_2max speed as calculated by the YYIRT, followed by vertical jumps until they were unable to reach 80% of their maximum vertical jump height for three successive jumps. Finally, players performed the post-fatigue randomized dynamic tasks trials, without a rest period between each trial. The post-fatigue trials were considered complete once four good right and left sidesteps had been performed.

The raw marker trajectory data were reconstructed in Nexus (VICON, Oxford Metric Ltd., Oxford, UK) and processed in Visual3D (C-Motion, Germantown, MD, USA) with the use of standard segment and joint definitions. External net joint moments were calculated using standard inverse dynamics equations. Three-dimensional knee angles were calculated using a joint coordinate system approach. Knee moments were normalized to body mass and height and were displayed as Nm/kgm. The time data for all variables were normalized with respect to stance phase time (distinguished as the point from initial contact to toe-off of the stance limb, as established by the force platforms' 10N threshold readings) to allow for comparisons to be made between players. The variables were divided into several phases within stance consistent with previously determined definitions (Besier, Lloyd, Cochrane, & Ackland, 2001) and were detected using a custom Matlab (The MathWorks, Inc., Natick, MA, USA) program for initial contact, weight acceptance, peak push-off, and final push-off.

Statistical analyses included: a two-tailed, paired Student's t-test assessing the preferred versus the non-preferred limbs at a significance level of 0.05 calculated in SPSS (Version 19.0 for Windows, SPSS Inc., Chicago, IL, USA); the standard error of the measurement, 90% confidence limits, and differences between the means (the non-preferred limb minus the preferred limb) calculated using the post-only crossover Excel spreadsheets from Sportsci.org. Standardisation was used to evaluate the magnitude of the difference (i.e. the difference between the means divided by the standard deviation for the preferred limb). To evaluate the magnitude of the standardized effects threshold values of 0.0 (trivial), 0.2 (small), 0.6 (moderate), 1.2 (large), 2.0 (very large), and 4.0 (extremely large) were used to represent differences (Hopkins, Marshall, Batterham, & Hanin, 2009). The uncertainty in the estimates of effects on limb preference was extracted at 90% confidence limits and additionally as probabilities that the true effect value was either substantially positive or negative.

RESULTS and DISCUSSION: Dependent t-tests across all sidestepping trials confirmed there were no significant differences in sidestepping speed or contact time between limbs.
In comparison to the preferred limb, the non-preferred limb showed small increases in knee internal rotation moment at initial contact (ES = 0.53, -89%); small decreases in knee abduction moment at weight acceptance (ES = -0.48, -63%); small decreases in knee abduction moment (ES = -0.56, 81%) and small increases in internal rotation moment (ES = 0.55, -60%) at peak push-off; small decreases in knee abductor moment (ES = -0.57, -87%) and small increases in internal rotation moment (ES = 0.26, -15%) at final push-off. All other kinematic and kinetic differences between limbs were unclear.
The preferred limb was more likely to experience increased coronal plane loading, whereas the non-preferred limb was more likely to experience increased transverse plane loading during fatigued, unanticipated sidestepping. Both limbs had similar knee flexion angles during the stance phase, ranging from 23-49°. Given the relatively small knee flexion angles, it is likely that both coronal and transverse plane loading coupled with shallow knee flexion will place the ligaments at an increased risk of injury.
According to previous studies, the ACL experiences greater tension when knee flexion angles fall within 0° to 40° during sidestepping (Besier, Lloyd, Ackland, & Cochrane, 2001; Markolf et al., 1995). Our results suggest the ACL may have experienced high levels of tension in both the preferred and non-preferred limbs given during the initial contact of sidestepping, the average knee flexion angle was approximately 24° and increased to an average of 48° during peak push-off. It is possible the ACL was experiencing high tension across all four phases of sidestepping. In the preferred limb, knee abduction moment was greater from initial contact through peak-push-off, likely increasing the amount of tension experienced by the ACL. The combination of shallow knee flexion angles of <30° at initial contact and final push-off and greater internal rotation moments make the ACL of the non-preferred limb also likely to experience greater loading. This same trend appeared with respect to abduction moments, which would have increased the risk of injury to both the ACL and the medial collateral ligament (MCL). The MCL is primary in resisting internal rotation and abduction loads at approximately 30° of knee flexion, as experienced by both limbs in our study (Garrett & Yu, 2007). Focusing on both increasing stability in the coronal plane and transverse plane, as well as focusing on correct mechanical execution of sidestepping on both limbs under fatigued conditions may help to offset the risk of ACL injury. Training including single limb multi-planer dynamic loading may increase the ability of the knee joint to attenuate these loads during these tasks.

CONCLUSION: The purpose of this study was to investigate magnitude of differences in knee mechanics due to the effect of limb preference during a fatigued unanticipated sidestep task. The preferred limb displayed greater coronal plane loading, indicating the need for training and conditioning focused on increasing coronal plane stability, whereas the non-preferred limb displayed greater transverse plane loading, and thus potentially requires greater stability in the transverse plane.

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