

SPORT-DEPENDENT VARIATIONS IN ARM POSITION DURING SINGLE LIMB LANDING AFFECT KNEE LOADING: IMPLICATIONS FOR ACL INJURY

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INTRODUCTION

Non-contact injuries to the anterior cruciate ligament are most frequently reported during the deceleration phase of landing after a jump or in preparation for a cutting maneuver. Video observation and patient accounts have demonstrated that the knee is

most often in a position near full extension and there is typically a valgus collapse of the knee associated with landing or deceleration (Colby 2000). Cadaver studies have shown that valgus knee moments place the ACL in greater danger near full extension (Woo 1999). Sidestep cutting maneuvers in particular can create higher valgus moments during deceleration, especially during unanticipated cutting (Besier 2001). Arm position has also been shown to affect lower limb dynamics (Ashby 2002). During single limb support, the arms are often used for balance and motion control. In sports, however, arm movement is often constrained for various reasons. Due to the role of the arms and upper body for balance and control, sport-dependent variations may cause changes in the loading of the knee that may lead to a higher risk of valgus collapse of the knee in some sports. The purpose of this study was to test this hypothesis, that sport-dependent variations in arm motion affect the potential for valgus collapse of the knee during cutting maneuvers.

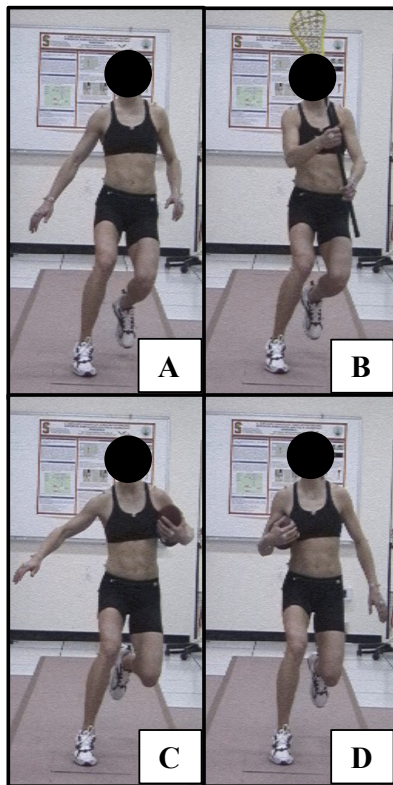


Figure 1: Examples of cutting maneuvers. (A) Normal, (B) Both arms constrained by holding a lacrosse stick, (C) Cutting side arm constrained by cradling a football, (D) Planting side arm constrained by cradling a football.

METHODS

Eleven subjects (6 females and 5 males, ages 18-29) without a history of lower limb injury and who exercise regularly were tested after providing informed consent. All subjects performed a 90-degree lateral run-to-cut maneuver on the side they felt more comfortable, first with no constraints to upper-body position and then in 3 arm-

constraining positions (Fig. 1). Lower limb kinetic data was obtained using a three-dimensional opto-electronic system and a previously described 6-marker link model of the lower extremity (Andriacchi 1997). Upper body kinematic data was obtained using a full-body marker set with 30 markers. Arm position was quantified as the distance from the wrist to the centerline of the torso. Paired Student's t-tests ($\alpha=0.05$) were used to compare the peak external knee abduction moment and arm positions between the normal maneuver and each of the 3 restricted maneuvers during deceleration.

RESULTS

The abduction moment at the knee was influenced by the arm position (Table 1). Holding a lacrosse stick caused a significant increase in the peak external knee abduction moment ($p<0.01$), and cradling a football in the plant-side arm caused an increase in the moment as well ($p<0.07$). In contrast, cradling in the cut-side arm did not cause a significant increase in the moment. The position of the plant-side arm was closer to the centerline of the body for most sport-dependent motion relative to unconstrained motion (Table 1), with the exception of cradling the football in the cut-side arm.

DISCUSSION

The results of this study indicate that sport-

dependent arm position can have a substantial influence on the types of loads that can cause non-contact ACL injury. There appears to be an interaction between torso movement and arm position. When the plant side arm cannot be used for balance, athletes may compensate by accelerating the torso laterally to maintain balance, causing an increase in the abduction moment at the knee.

Previous studies have shown that a higher knee abduction moment places the ACL in greater danger (Woo 1999), so any condition that causes higher abduction moments during deceleration and landing may put athletes at greater risk of ACL injury.

This study provides a basis for understanding the multiple factors that lead to non-contact ACL injury. In addition, these results suggest that adopting training methods that consider arm position as a risk factor could help to reduce the probability of ACL non-contact injury.

REFERENCES

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Table 1: Increase in peak external knee abduction moment, distance from body centerline to plant-side wrist, and distance from body centerline to cut-side wrist (mean \pm SD). * denotes significant difference of $p<0.05$, † denotes $p<0.07$.

	Increase in Knee Abduction Moment [%bodyweight*height]	Distance from Centerline to Plant-side Wrist [%height]	Distance from Centerline to Cut-side Wrist [%height]
Normal	--	28 \pm 3	22 \pm 6
Lacrosse	1.58 \pm 1.27 *	22 \pm 3 *	20 \pm 3
Plant-side Football	0.87 \pm 1.42 †	20 \pm 2 *	23 \pm 3
Cut-side Football	0.49 \pm 1.12	27 \pm 5	20 \pm 3