Performance-injury Conflict in Lower Extremity Biomechanics During Jumping and Cutting Movements

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Summary

Athletic movements involving rapid deceleration and direction changes are essential for sports performance but associated with anterior cruciate ligament (ACL) injury risk. This study examined relationships between performance metrics (jump height and movement time) and ACL injury risk-related biomechanics during bilateral drop jumps (DVJ), single-leg drop jumps (SDVJ), and 180° cutting maneuvers (CUT). Analysis revealed task-specific biomechanical strategies across movements, where improved performance was associated with increased ACL loading parameters, emphasizing the inherent conflict between performance enhancement and injury risk management across different movement tasks.

Introduction

Athletic movements comprising rapid deceleration, cutting, and jump-landing represent fundamental components in sports performance, yet these demanding movement patterns are also associated with ACL injury risk [1]. Although DVJ, SDVJ, and CUT are established screening protocols, the relationship between performance-enhancing mechanics and injury risk factors across these movements remains unclear [2]. This study investigated performance-injury biomechanical relationships across these three tasks, hypothesizing that optimal performance would require task-specific coordination while inevitably increasing ACL loading parameters.

Methods

Forty-five physically active adults (25 females, 20 males; age: 27.4 ± 5.8 years) performed three trials each of DVJ (30-cm height), SDVJ (15-cm height), and CUT 180° maneuvers. Three-dimensional kinematics (300 Hz) and ground reaction forces (GRF, 1500 Hz) were collected. Lower extremity biomechanics during the weight acceptance phase were analyzed, focusing on sagittal and frontal plane joint angles, peak moments, and GRF. All joint moments were normalized to body weight. Performance was quantified through jump height and cutting movement time. Correlation and stepwise multiple regression analyses ($\alpha < 0.05$) identified biomechanical predictors of performanc.

Results and Discussion

Jump height in DVJ increased with greater peak hip flexion moment. SDVJ performance was enhanced by greater peak knee flexion and hip flexion moments. For CUT 180°, those who perform faster tend to have greater lateral force and higher knee abduction moment, while increased hip flexion moment was associated with slower movement time. Interestingly, peak hip flexion moment emerged as a consistent predictor across all tasks, with distinct effects between jumping and cutting tasks.

Table 2: Stepwise Multiple Regression Analysis

Injury Risk Predictors	B (SEE)	*β*	P	VIF
VDJ Model R = 0.230				
PM Hip Flex	0.049 (0.014)	0.478	0.001	1.0
SVDJ Model R = 0.445				
PM Knee Flex	0.033 (0.008)	0.460	<0.001	1.041
PM Hip Flex	0.027 (0.008)	0.402	0.001	1.041
CUT 180° Model R = 0.723				
GRF Lateral	0.048 (0.013)	0.429	<0.001	1.108
PM Knee Abd	0.000 (0.000)	0.345	0.006	1.103
PM Hip Flex	0.000 (0.000)	-0.240	0.041	1.009

Conclusions

The biomechanical determinants of performance demonstrated task-specific profiles across movement patterns, with these performance-enhancing mechanics consistently corresponding to increased ACL loading parameters.

References

[1] Dos'Santos, T. et al. (2021). *Sports Med*, **51(9)**:1983-1998.
[2] Dai, B. et al. (2019). *J Sport Health Sci*, **8(3)**:228-234.

Table 1: Correlations with Performance Measures Across Movement Tasks

Tests	PM Knee Flex	PM Knee Abd	PM Hip Flex	PM Hip Add	Leg Stiffness	GRF Lateral	GRF Vertical
VDJ (Jump Height)	0.230	-0.087	0.447**	-0.050	0.126	NA	0.086
SVDJ (Jump Height)	0.540**	0.009	0.494**	0.099	0.347*	NA	0.356*
CUT 180° (Time)	-0.127	0.491**	-0.298*	0.176	0.190	0.555**	-0.054

Note: $\alpha < 0.05$; ** $\alpha < 0.01$; IC, Initial Contact; PM, Peak Moment; Flex, Flexion; Abd, Abduction; Add, Adduction; Df, Dorsiflexion