Introducing directional probabilities alters the kinematics of change-of-direction maneuvers

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Summary

ACL injuries in multidirectional sports often result from neurocognitive errors in decision-making. This study examines how directional probabilities affect biomechanics during 90° change-of-direction (COD) tasks in soccer. IMU-based kinematics and completion times of COD tasks under different conditions of directional probability were analyzed. Results revealed that the motor control system adapts movement planning based on probabilities in complex COD movements, gaining advantages for high-probability events.

Introduction

ACL injuries frequently occur in multidirectional sports without direct opponent contact, often caused by neurocognitive errors that lead to injury-prone movements [1]. Biomechanical screening tests typically COD injury risk based on “unplanned” CODs with an equal left vs. right directional probability (50:50). However, this approach may not accurately reflect real-world decision-making, where players internally estimate the probability of future events (e.g., by reading the opponent or game flow) and prepare motor plans for the most likely movement direction [2]. Here, we investigated whether providing players with unequal directional probabilities (80:20) resulted in movement adaptations favoring the more likely direction (H1) and/or in more extreme movements in the unlikely event compared to an equal directional distribution (H2).

Methods

Twenty male soccer players performed 90° COD maneuvers to the left or right at maximum speed on artificial turf under three randomized conditions. In Condition 1 (100:0), participants knew the movement direction prior to the run-up. In Conditions 2 and 3, the direction cue was provided mid-run-up, with either equal directional probabilities for left vs. right (50:50) or an 80:20 probability bias favoring CODs to the right. Participants were informed of the probabilities. Each condition included 10 trials.

A timing system (BlazePod) provided start signals, directional cues, and completion times. Biomechanical data were collected using eight inertial measurement units (IMU) (Noraxon) placed on the feet, shins, thighs, pelvis, and upper back. Joint and segment angles at the initial contact (IC) of the sidestep as well as completion times were statistically analyzed using linear mixed models ($\alpha = 0.05$).

Results and Discussion

In support of H1, pelvis orientation in the transversal plane demonstrated significant adaptations in the 80% scenario, where participants oriented their pelvis more towards the new movement direction than in the 50:50 condition ($p < .001$, Figure 1) but less than in the 100% condition ($p < .001$). Completion times were significantly lower in the 80% scenario than in the 50:50 condition ($p < .001$).

In the 20% scenario, no significant kinematic differences were found compared to the 50:50 condition. Compared to the 100% condition, 20% and 50:50 scenarios exhibited higher knee ($p < .001$) and hip flexion angles ($p \leq .005$) and slower completion times ($p < .001$). While the 20% scenario did not produce more extreme movements on average (H2), individual trials showed erroneous adaptations and have to be further investigated.

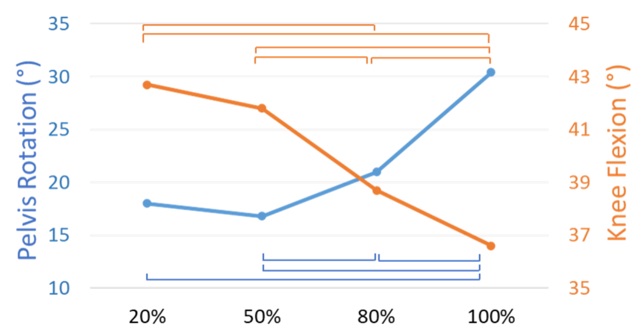

Figure 1: Angles (°) at IC for different directional probability conditions. Positive values correspond to knee flexion and pelvis rotation towards the new movement direction. Lines indicate significant post-hoc comparisons.

Conclusions

Incorporating simple probabilistic elements into COD tasks altered movement executions. These adaptations revealed that motor planning relies on directional probabilities, allowing for faster movements in high-probability scenarios, however, at a potential risk for errors in unlikely events.

Manipulating directional probabilities in biomechanical assessments of COD movements can enhance our understanding of athlete-individual movement planning and risk-taking strategies, offering insights for injury prevention and performance enhancement in unpredictable sports environments.

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References

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