Comparing Three Coordinate Systems in Conventional Gait Model 2.3: Knee Moment Insights from Walking, Single-Leg Squats, and Drop Jumps

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Summary

This study evaluated the effect of coordinate system selection on knee moments using the CGM2.3 model during walking, single-leg squats, and drop jumps. Joint Coordinate System (JCS), distal, and proximal projections showed significant differences, particularly in the frontal and transverse planes under high knee flexion. JCS exhibited lower variability, demonstrating its potential for improving consistency in biomechanical assessments critical for injury prevention.

Introduction

Knee moments are key metrics in injury risk reduction [1]. However, the choice of coordinate systems, often not reported, significantly impacts their estimation and hinders cross-study comparisons [2]. This study examines how the Joint Coordinate System (JCS), distal, and proximal projections affect knee moments during walking (WALK), single-leg squats (SLS), and drop jumps (DJ) using the new Conventional Gait Model (CGM2) [3].

Methods

Twenty-four healthy adults (12 females, 12 males; mean age 28.0 ± 6.0 years) performed WALK, SLS and DJ under standardized conditions. Marker trajectories (300 Hz) and ground reaction forces (1500 Hz) were captured using a Vicon system. Trajectories and forces were processed with a Butterworth low-pass filter (15 Hz cutoff). Knee moments were calculated with the CGM2.3 model, using JCS, distal, and proximal projections with inverse kinematics. The variance between coordinate systems was quantified using RMSD, and statistical differences were analyzed using SPM ANOVA (α=0.05) [4].

Results and Discussion

Knee moments differed significantly between coordinate systems in the frontal and transverse planes. SPM ANOVA identified significant areas of difference (Figure 1), especially during high knee flexion in DJ and SLS. JCS demonstrated notably lower (Table 1) variability across participants.

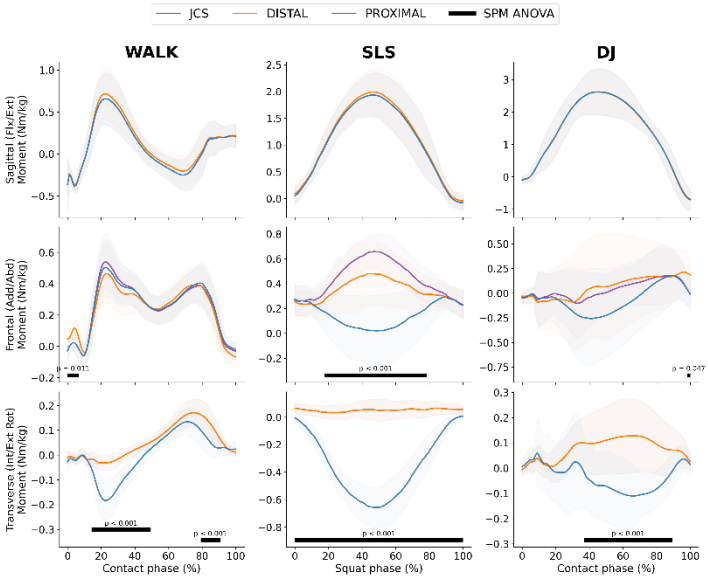

Figure 1: Knee moments for WALK, SLS, and DJ. Black bars indicate significant differences (SPM ANOVA).

Conclusions

The choice of a coordinate system affects knee moment estimations, especially in dynamic tasks involving high knee flexion. The lower variance observed with JCS underscores its value for reliable biomechanical assessments, particularly in injury prevention and rehabilitation contexts.

References

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Table 1: Knee moment variation in magnitude across planes and tasks (Nm/kg). The lowest variance is underlined.

	WALK Frontal	WALK Transversal	SLS Frontal	SLS Transversal	DJ Frontal	DJ Transversal
JCS	-0.23 - 0.88	**-0.10 - 0.24**	**0.00 - 0.94**	**-0.10 - 0.23**	**-1.18 - 0.95**	**-0.16 - 0.52**
Distal	-0.25 - 0.90	**-0.10 - 0.24**	-0.05 - 0.98	**-0.10 - 0.23**	-1.19 - 1.36	**-0.16 - 0.52**
Proximal	**-0.23 - 0.82**	-0.35 - 0.21	-0.55 - 0.57	-0.97 - 0.09	-1.53 - 1.00	-0.35 - 0.61