Insights into Markerless vs. Marker-Based Motion Capture: Agreement in Change-of-Direction Movements

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Summary

This study investigated the agreement between markerless (ML) and marker-based (MB) motion capture systems for estimating lower limb joint kinematics during change-of-direction (COD) tasks. The Bland-Altman (BA) analysis was employed to assess agreement, providing insights into systematic and random differences across hip, knee, and ankle joints and planes of motion. Results indicated that knee flexion/extension (flex./ext.) angles exhibited the strongest agreement: bias = 0.43°, limits of agreement (LoA) = ±6.03°. In contrast, internal/external (int./ext.) rotation angles demonstrated the largest discrepancies (bias = 6.19°, LoA = ±15.78°). Movements with sharper COD angles and higher speeds were associated with greater random differences, emphasizing the challenges of multi-directional high-intensity movements for both systems. These findings have important implications for the interpretation of ML data in biomechanics research, particularly for biomechanical assessments of dynamic movements sports movements.

Introduction

ML systems offer a time-efficient alternative to labor-intensive MB systems, yet their agreement during dynamic non-linear tasks remains unclear. Previous studies have analyzed mainly linear running or walking movements and have identified the highest discrepancies in int./ext. rotation kinematics [1, 2]. This study used BA analysis to compare lower limb joint kinematics between ML and MB systems during COD movements.

Methods

Nineteen team sport athletes (6 females, 13 males; age: 23.7 ± 4.5 years, height: 178.2 ± 10.0 cm, mass: 74.7 ± 13.0 kg) participated in this study. Five movements (45°, 90°, 135°, and 180° cuts as well as straight runs) were performed at three intensities (slow, medium, and fast). Motion was captured using a ML system with eight high-speed video cameras (85 Hz) and a marker-based (MB) system with 21 infrared cameras (200 Hz, downsampled to 85 Hz). Joint angles for the hip, knee, and ankle were computed for both systems. Agreement between ML and MB systems was assessed at four discrete time points (touchdown, toe-off, positive and negative peak values) during stance using BA analysis. Bias and LoA were calculated for flex./ext., abduction/adduction, and int./ext. rotation angles across hip, knee, and ankle joints; pooled as well as separate for each movement direction and intensity. Data processing and analysis were conducted using Visual3D, MATLAB.

Results and Discussion

Knee flex./ext. angles showed the strongest agreement, with a mean bias of 0.43° and LoA of ±6.03°. In contrast, int./ext. rotation angles exhibited the largest discrepancies, with a bias of 6.19° and LoA of ±15.78°. Movements at sharper cutting angles and higher speeds resulted in wider LoA, such as ±12.32° at 180° cuts compared to ±9.09° during straight runs. Despite discrepancies, ML systems showed acceptable agreement for sagittal plane angles, aligning with previous research [3, 4], making them promising for applications in team sports where large-scale, dynamic data collection is required.

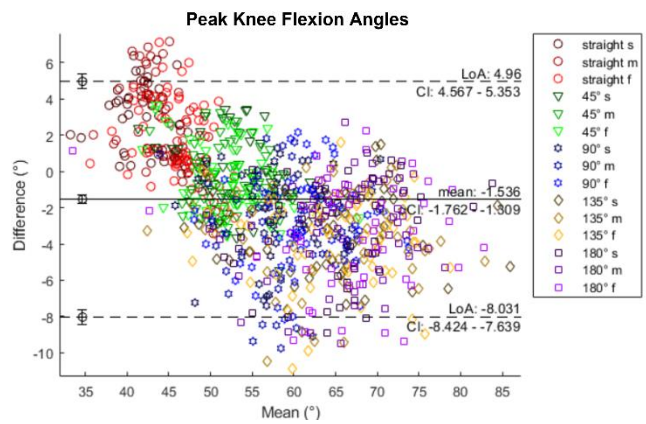

Fig 1.: BA analysis of the peak knee flexion angles pooled for all movement directions and intensities.

Conclusions

ML kinematic estimates demonstrated acceptable agreement with MB systems for sagittal plane kinematics, particularly knee flexion/extension angles, but larger discrepancies were observed for int./ext. rotation angles and during more dynamic movements. These findings highlight the potential of ML systems for biomechanical research and sports applications while emphasizing the need for caution when interpreting data in the context of existing MB estimates.

References

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