

KINEMATICS COMPARISON OF OPENCAP AND IMU WITH MARKER-BASED MOTION CAPTURE IN TREADMILL RUNNING: A PILOT STUDY



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INTRODUCTION

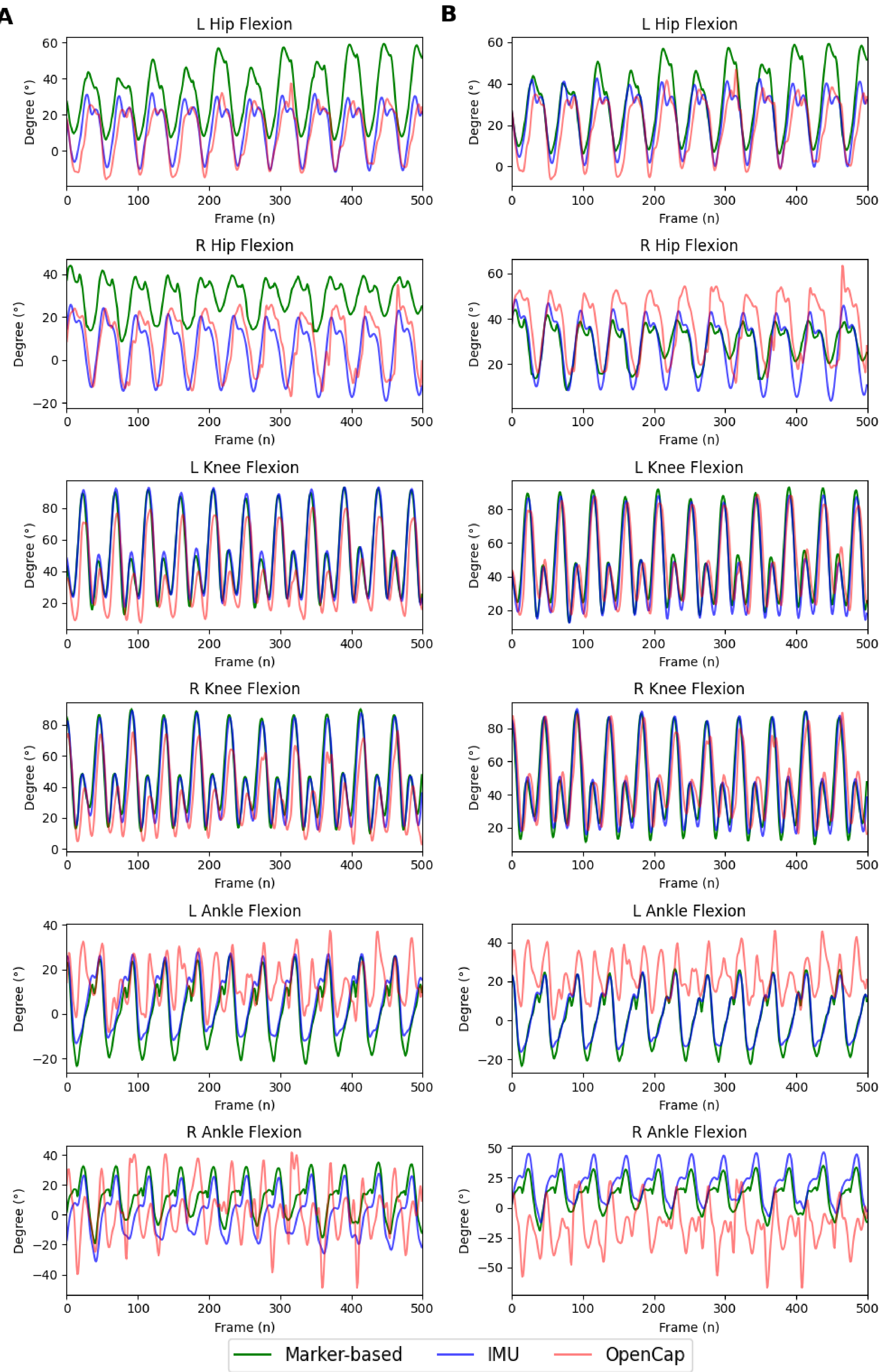
- OpenCap utilizes pose-estimation algorithms and muscle-driven simulations to estimate 3D movement kinematics and kinetics through a web-based platform (Uhlrich et al., 2023).
- Initial validation shows that its accuracy is comparable to other markerless systems and inertial measurement units (IMUs) for walking, squatting, and other movements.
- **Research gap** → unclear whether OpenCap retains the accuracy in faster dynamic motions like running.
- **Aim** → assess the accuracy of OpenCap in analyzing treadmill running kinematics.

METHODS

- Treadmill speed: 2.22 m/s for 1 minute
- **Equipment:**
  - IMU → Noraxon (100 Hz)
  - Markerless → OpenCap, 2 devices (60 Hz)
  - 3D mocap → lower limb marker set (200 Hz)
- **Data processing:**
  - Time synchronization → Peak knee angle at the start
  - Offset correction → Aligning values at time synchronization with 3D mocap
  - Low pass filtered + downsampled to 60 Hz



RESULTS



	MAE (°)		RMSE (°)	
	Before	After	Before	After
<b>IMUs</b>				
<i>Left</i>				
Hip flexion	19.3	9.1	20.7	11.5
Knee flexion	3.2	4.4	3.9	5.3
Ankle flexion	4.3	2.4	5.1	3.1
<i>Right</i>				
Hip flexion	24.3	6.1	25.4	7.8
Knee flexion	5.4	5.1	6.9	6.3
Ankle flexion	10.9	8.1	11.6	8.9
Overall	11.2	5.9	12.3	7.2
<b>OpenCap</b>				
<i>Left</i>				
Hip flexion	21.1	13.6	23.6	16.0
Knee flexion	14.0	12.0	17.3	14.3
Ankle flexion	14.8	20.1	17.6	23.9
<i>Right</i>				
Hip flexion	20.4	11.3	22.9	13.5
Knee flexion	15.7	13.4	19.0	16.0
Ankle flexion	18.0	29.1	21.6	33.7
Overall	17.3	16.6	20.3	19.6

Table 1: Comparison of MAE and RMSE values between IMUs and OpenCap with a marker-based mocap system. Bold values in red indicate a lower error comparing IMU and OpenCap.

CONCLUSION

- Both systems demonstrate challenges in analyzing running kinematics.
- Findings suggest it would benefit from further refinement and optimization to match the marker-based mocap system for running analysis.
- **Future research direction:**
  - Utilize >2 devices for running when using OpenCap
  - Record at 120 Hz

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References:  
Uhlrich, S. D., Falisse, A., Kidziński, Ł., Muccini, J., Ko, M., Chaudhari, A. S., Hicks, J. L., & Delp, S. L. (2023). OpenCap: Human movement dynamics from smartphone videos. *PLoS Computational Biology*, 19(10), e1011462. <https://doi.org/10.1371/journal.pcbi.1011462>

Figure 1: The kinematic waveforms of lower-limb kinematics in the first 500 frames comparing marker-based mocap, IMU, and OpenCap (A) before offset, and (B) after offset correction.