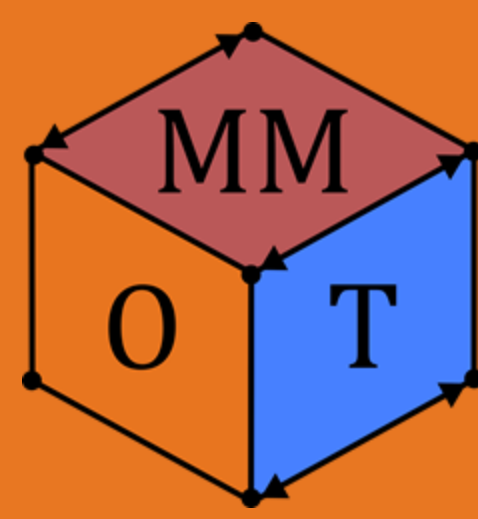




Mechanics and Modeling
of Orthopaedic Tissues
Laboratory

Comparing Torsional Gait Kinematics Between Marker-Based and Markerless Motion Capture

Kailey M. Granger¹, Allyson K. Clarke², Mark A. Seeley³, Benjamin B. Wheatley¹

¹Department of Mechanical Engineering, Bucknell University, Lewisburg PA

²Department of Mechanical Engineering, University of Washington, Seattle, WA

³Department of Orthopaedic Surgery, Geisinger, Danville PA

Bucknell
UNIVERSITY

Geisinger

Introduction

- Torsional malalignment syndrome (TMS) is a deformity where the tibia and/or femur is rotated (fig. 1) [3]
 - Causes inwards or outwards rotation of foot (fig.1)
- TMS often causes joint pain [2]
- Patient variability and bone remodeling with age makes treatment a challenge



Figure 2. Motion analysis

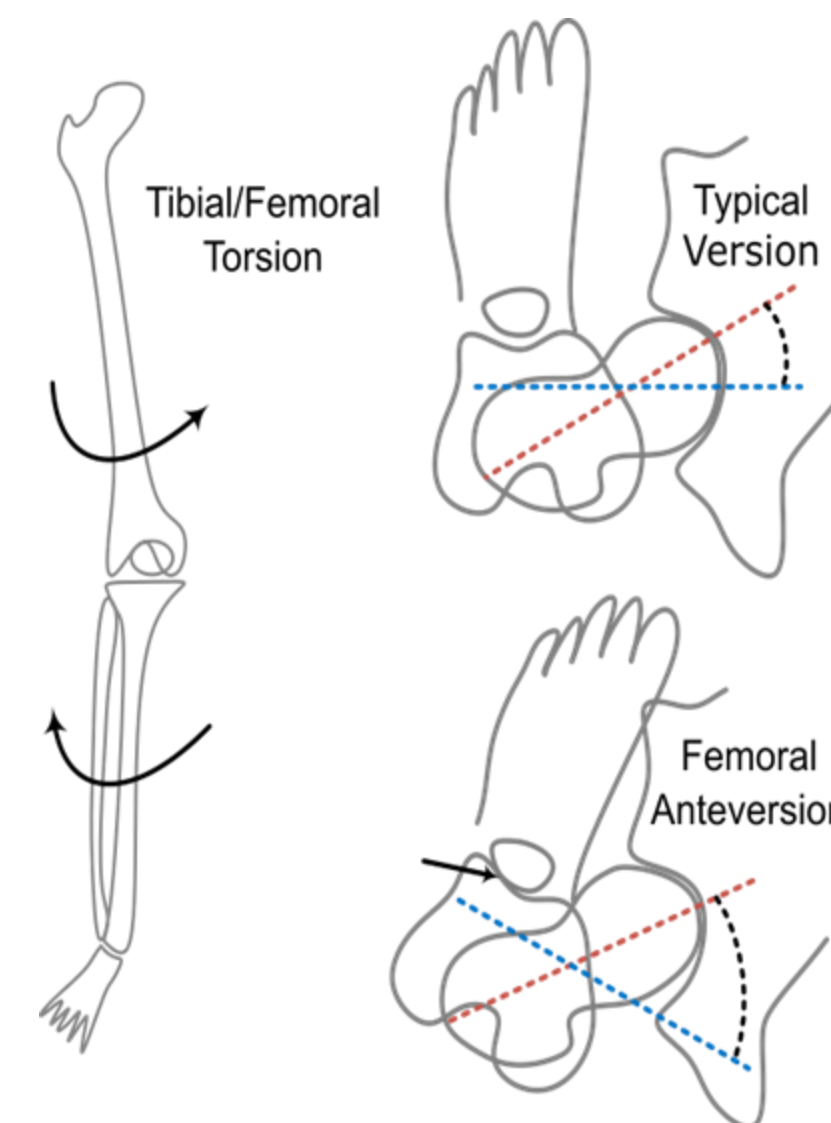


Figure 1. TMS explanation diagram

- Traditional marker-based motion analysis (for this study, VICON) can be used to estimate gait biomechanics (fig. 2)
 - Useful for treatment planning (surgery, PT, etc.)
- Marker-based motion analysis is not time or cost efficient
 - Markerless motion analysis would be easier for clinicians to use (for this study, OpenCap [1] [3])

Goal: Validate markerless motion capture (OpenCap) for toe in and toe out gait.

Methods

- Six females and five males between the ages of 18-22 were recruited for the study
- Forty-eight markers were placed on the lower and upper extremities of each subject (fig. 3)
- VICON and OpenCap were simultaneously recording and subjects were instructed to walk with three gait profiles:
 - typical gait
 - 45 degrees toe in gait
 - 45 degrees toe out gait
- All data was evaluated using OpenSim



Figure 3. Marker and EMG diagram

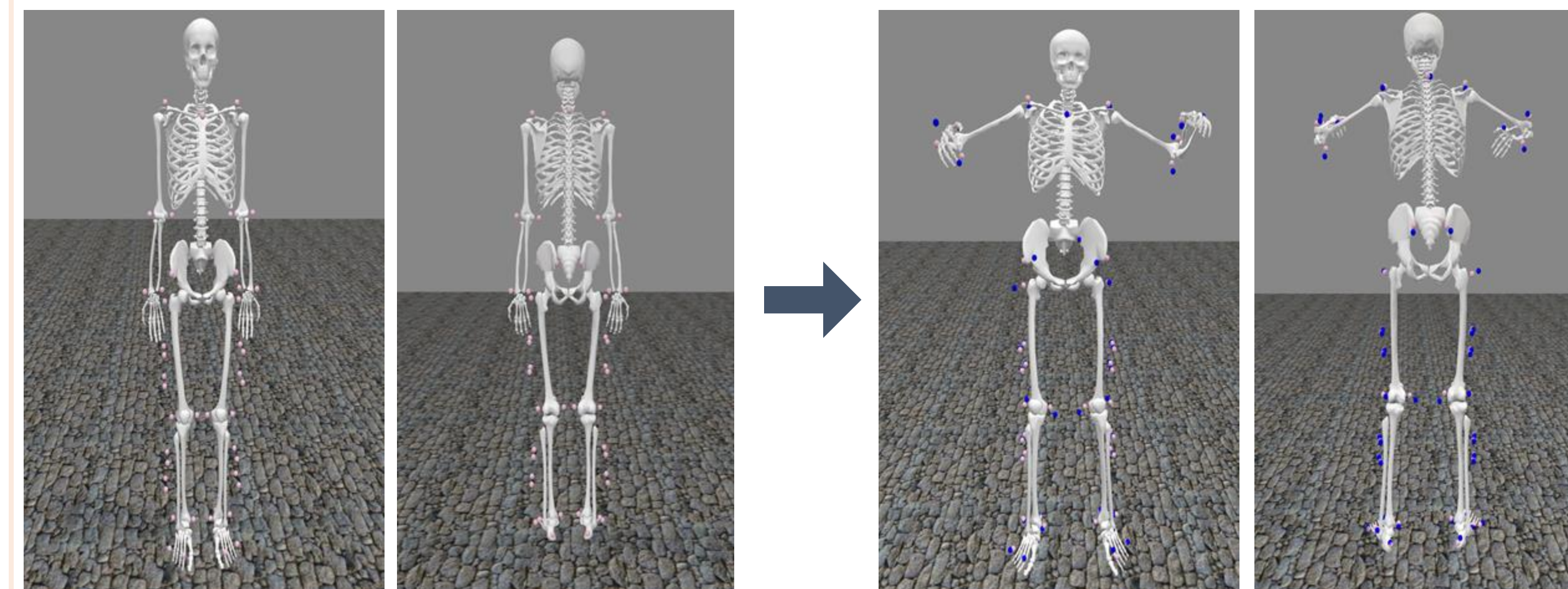


Figure 4. OpenSim scaling

- OpenSim was used to scale the model to fit each subject (fig. 4)
- The scaled model's were then used to calculate inverse kinematics for all VICON data
- OpenSim Moco was used to generate gait dynamics from OpenCap virtual marker data using a ground contact model

Results

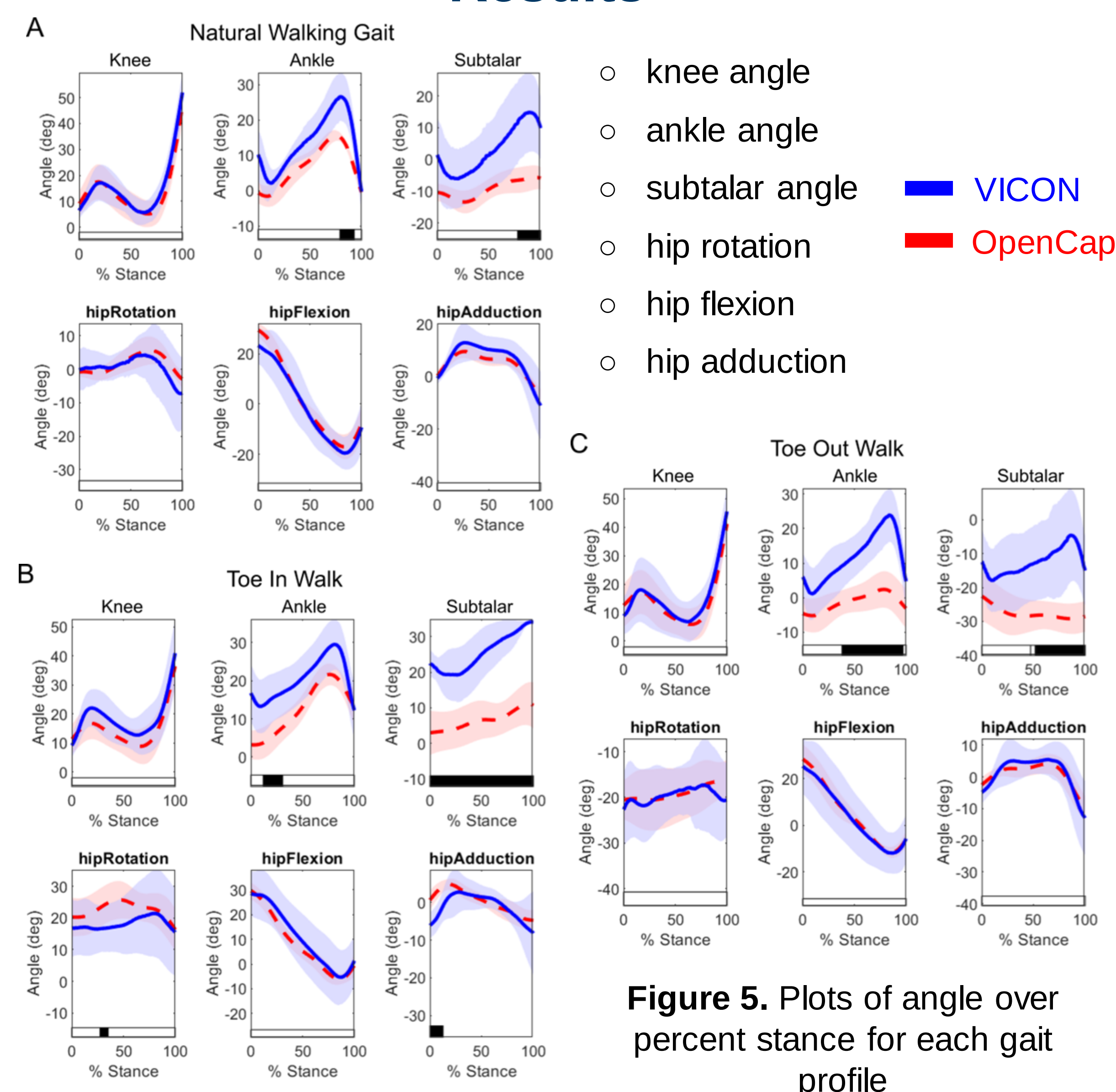


Figure 5. Plots of angle over percent stance for each gait profile

note: Plots show mean $\pm$ standard deviation. Black bars along bottom represent regions of significant difference.

- VICON and OpenCap show similar trends other than subtalar angle for all gait profiles and ankle angle for toe in and toe out gait (fig. 5)
- OpenCap captures differences in hip rotation for the 3 different gait profiles (fig. 5)
- OpenSim Moco [4] produced different ground reaction force profiles for different gait types, with statistical analysis pending (fig. 6)

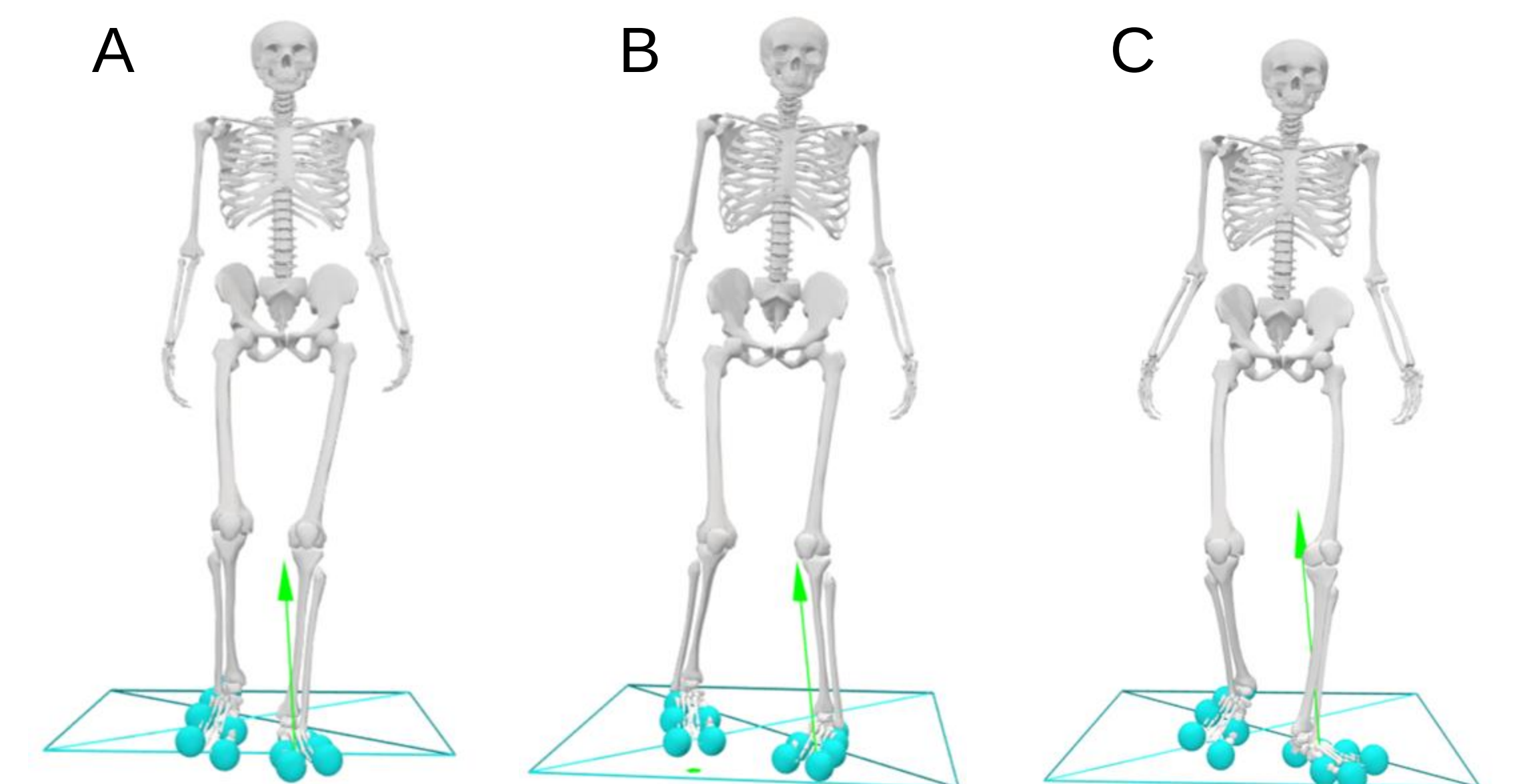


Figure 65. OpenSim Moco produced gait dynamics and ground reaction forces using a ground contact model. Simulations for A) typical gait, B) toe-in gait, and C) toe-out gait.

Discussion and Conclusions

- Marker-based (VICON) and markerless (OpenCap) motion analysis methods exhibited similar kinematics across all three gait profiles (typical, toe in, and toe out)
- This research has proven that OpenCap is a valid approach to characterizing gait kinematics for toe-in and toe-out gait
- Future work: validate gait dynamics (joint moments) and joint loads using markerless motion capture for torsional profiles
- Future work to estimate joint loads from markerless motion capture only could inform surgical or physical therapy based interventions for torsional malalignment

References

- [1] Horsak et al. (2023) *Journal of Biomechanics* 159. [2] Holbert et al. (2023) *SN Comprehensive Clinical Medicine* 5. [3] Uhlrich et al. (2023) *PLOS Comp. Bio.* [4] Dembia et al. (2020) *PLOS Comp. Bio.* 2.