QUANTIFICATION OF FOOT KINEMATICS WITHIN TENNIS FOOTWEAR USING MOVEMENT COUPLING

APPLIED MEASUREMENTS X LACOSTE

Sydney Kobak, Jack Oldridge & Siributr Wanichpongpan

BACKGROUND

- Footwear plays a crucial role in reducing injury and enhancing motor performance via limiting foot-shoe movement [1][2]

- Key tennis shoe features which affect foot movement are
  - Tread and outsole structure [3]
  - Ability of shoe to “lockdown” foot during play

INVERSION AND EVERSION

Figure 1: Image of inversion and eversion on human feet

- Ankle sprains account for 20–25% of tennis injuries [4]
- In tennis, 85% of sprains result from excessive inversion [4]
- Understanding inversion and eversion of the foot during movement is *key* to limiting injuries

SO HOW IS IN SHOE FOOT MOVEMENT CURRENTLY MEASURED?

INDUSTRY STANDARDS FOR MEASURING FOOT KINEMATICS

- Marker-based optical motion capture is the gold standard for measuring foot kinematics [5]
- Traditional methods require cutting shoe “windows” to access markers, negativity impacting structure/performance [6] [7]
- *Less invasive methods are needed to preserve natural movement and footwear integrity*

Figures 2a & 2b: (Left to right) Picture of shoe from [8] and [9] study respectively

MOVEMENT **COUPLING**

- One potential alternative method of measurement is… movement coupling

Def: the coordinated motion that occurs between different body parts or joints where the movement of one part is linked and influenced by the movement of another [10]

- Applied in studies of walking/running and footwear-limb interaction [11]
- Not yet studied with a view to use as a proxy measurement

OBJECTIVES & RESEARCH QUESTION

- Assess a *non-invasive* method for measuring foot kinematics
- Evaluate *tibia-foot movement coupling* as an alternative to traditional motion capture for tracking inversion and eversion

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Is movement coupling relating the **tibia rotation relative to ankle joint angle** an accurate method of measuring foot inversion and eversion?

OUR RESEARCH STUDY

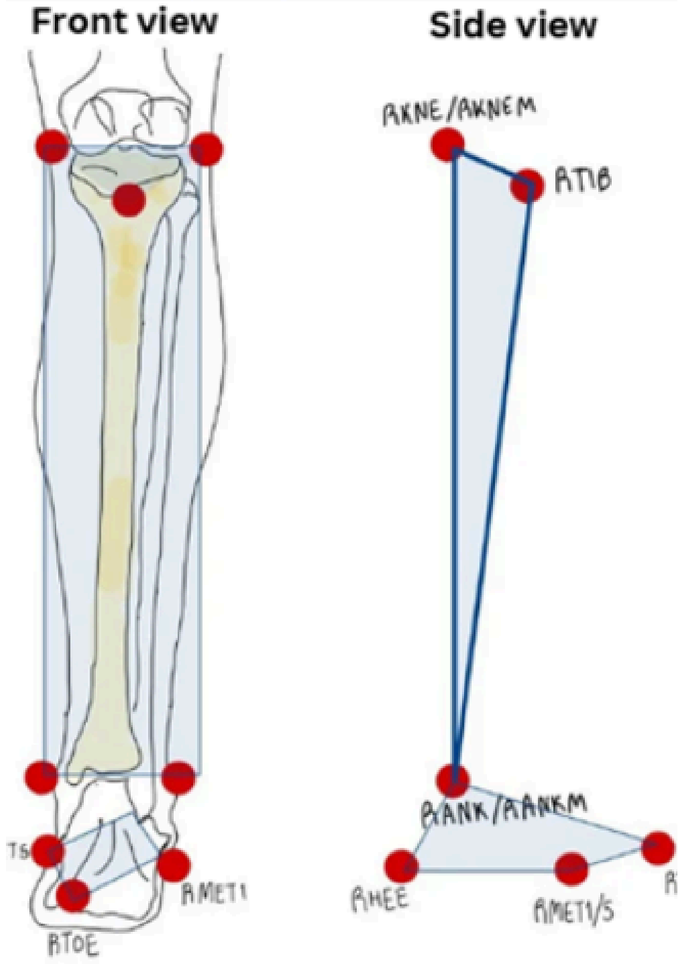


Figure 3: Shank and foot diagram with reflective markers on anatomical landmarks

METHODOLOGY

Participants

- Two participants: One male (26) and female (23)

Motion Capture Setup

- 24-camera Qualisys 3D motion capture system
- Sampling frequency: 200 Hz
- Reflective markers placed on foot, ankle, and shank
- Modified Plug-in-Gait and Freiburg marker set used

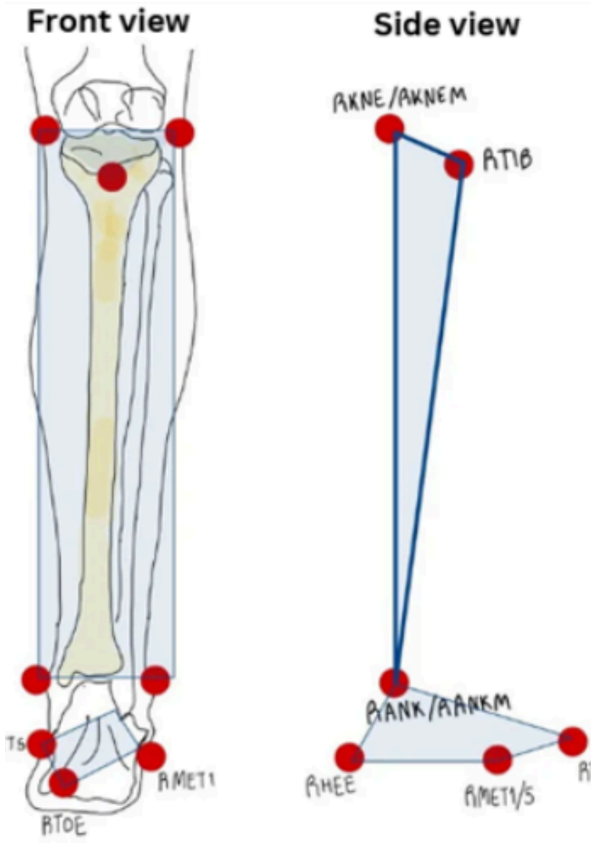
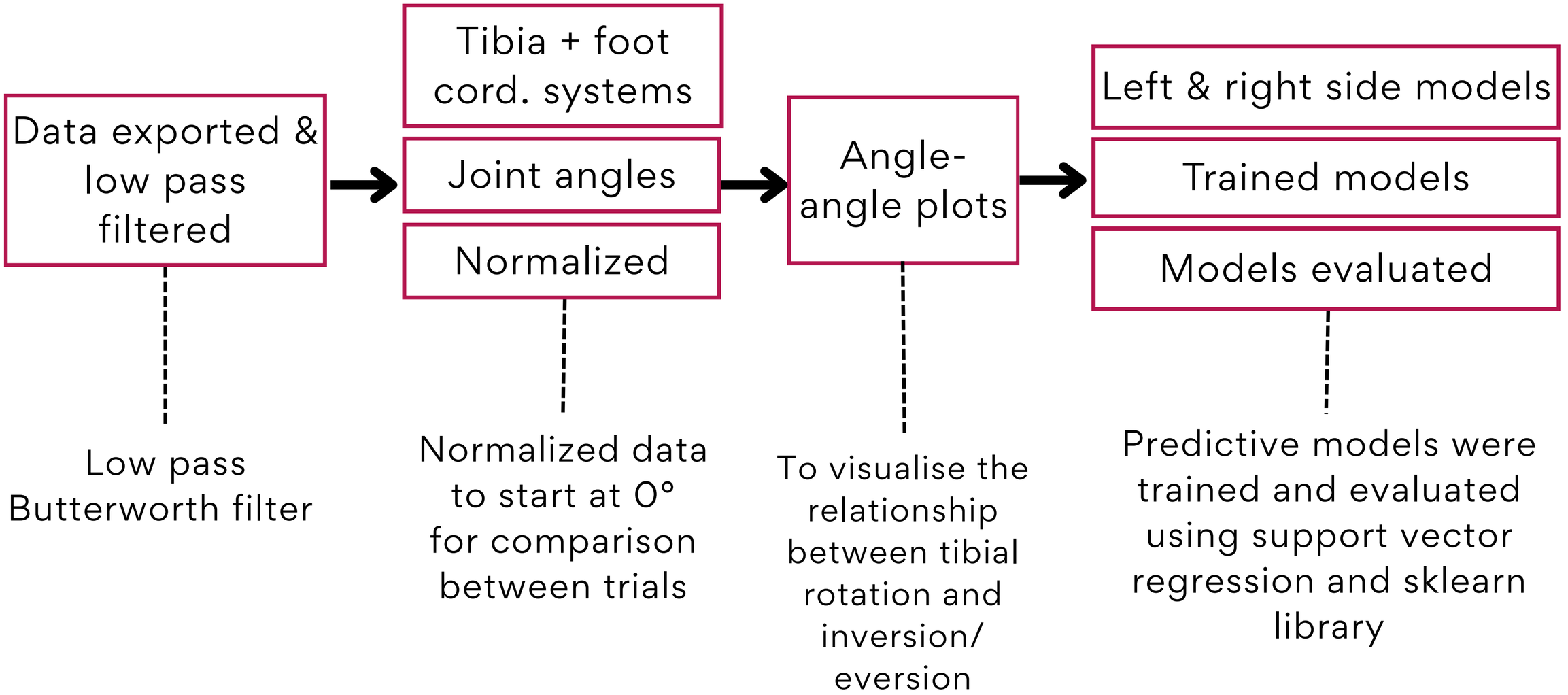


Figure 3 . Shank and foot diagram with reflective markers on anatomical landmarks

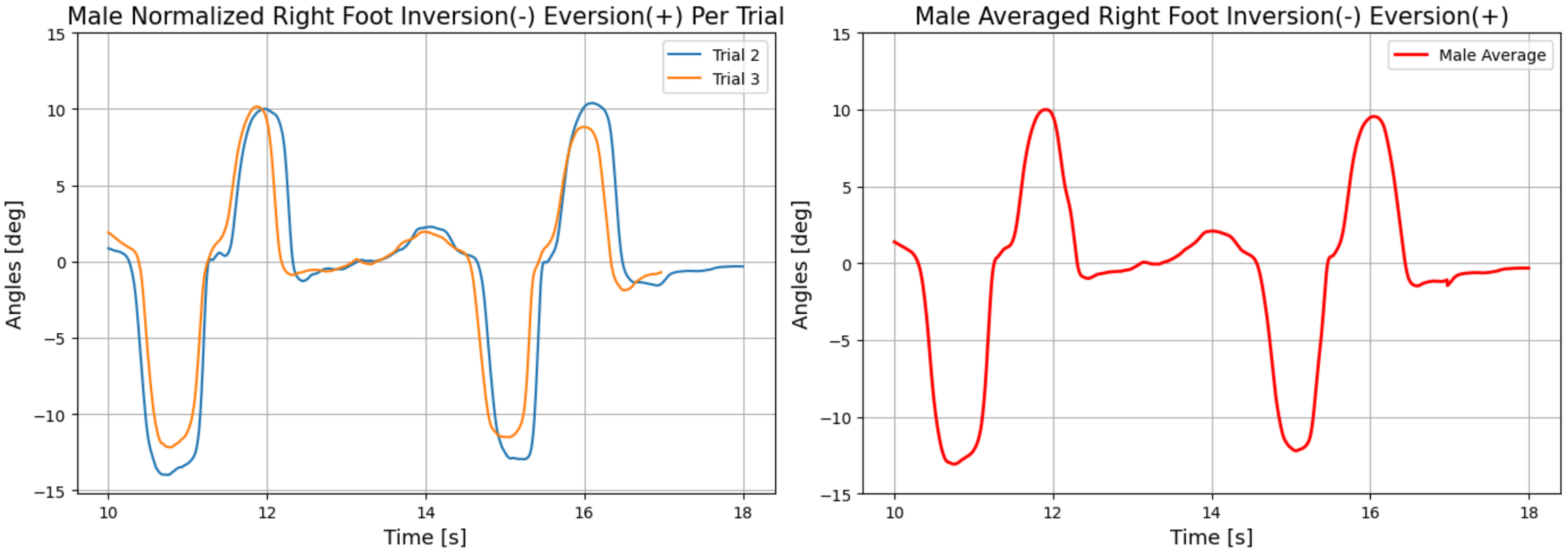
Video 1. Video of male and female participant performing one test trial

Each participant completed three trials, during which they performed three repetitions per foot of the following sequence: *static* → *eversion* → *static* → *inversion*, while barefoot

DATA ANALYSIS

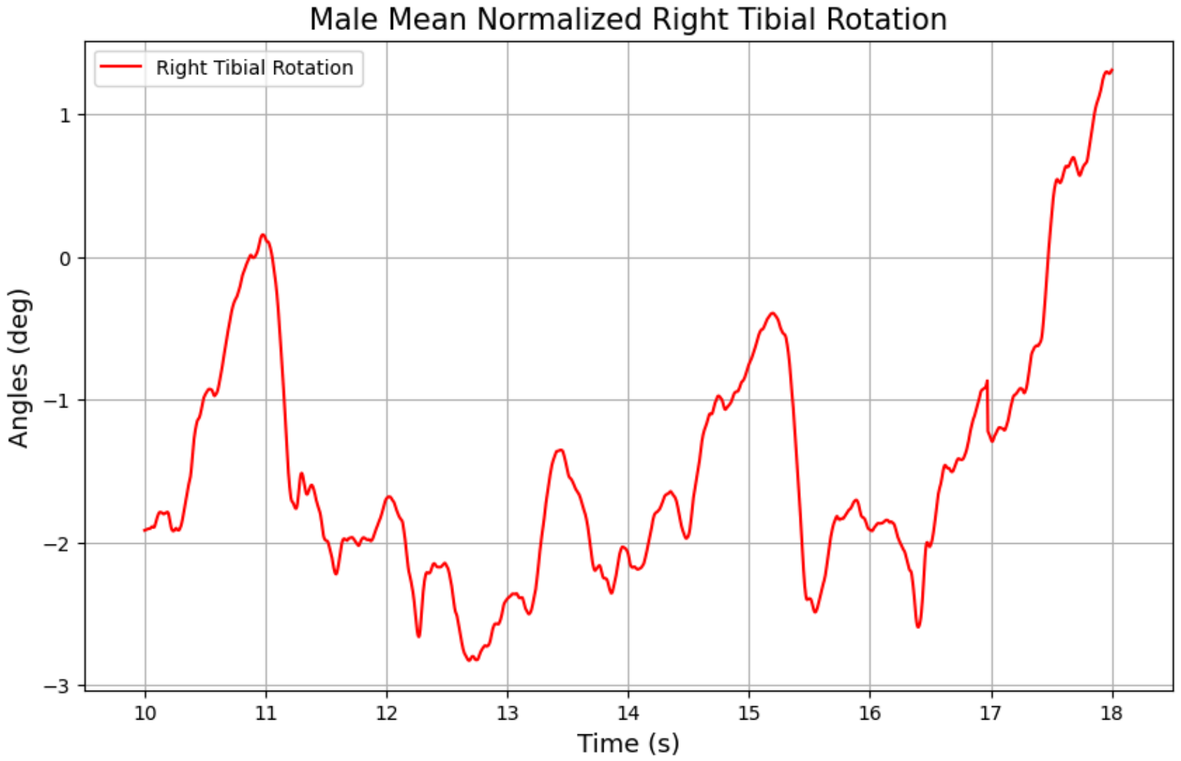


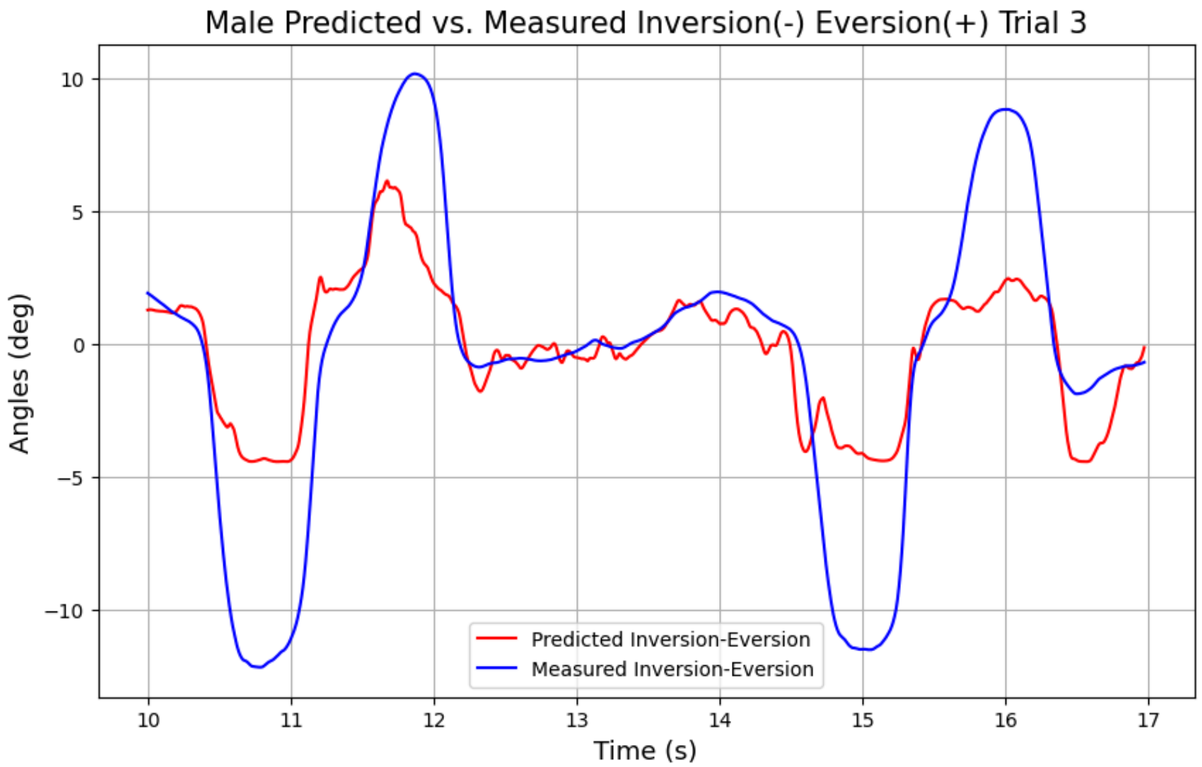
RESULTS: MALE PARTICIPANT



Figures 5a & 5b: (Left to right) Normalized male right foot inversion and eversion per each trial and average of all trials

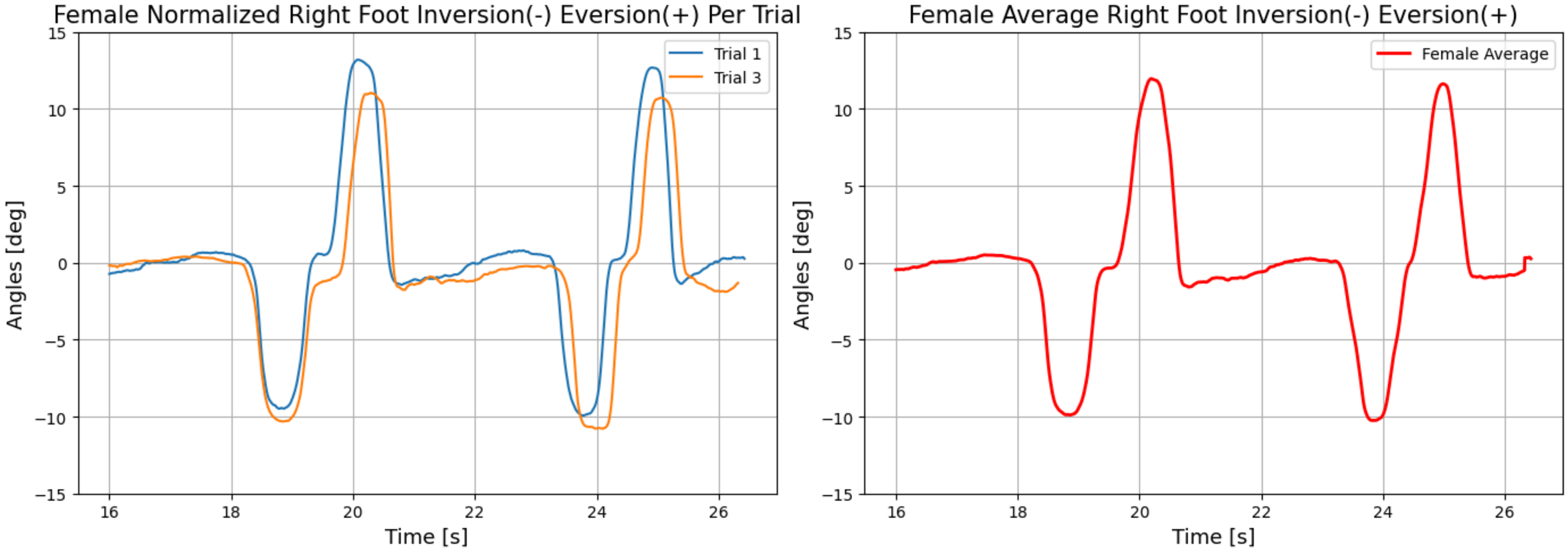
RESULTS: MALE PARTICIPANT





Figures 6a & 6b: (Left to right) Normalized mean right tibial rotation and predictive model of inversion and eversion based on tibial rotation data. RMSE ~ 0.4

RESULTS: FEMALE PARTICIPANT



Figures 7a & 7b: (Left to right) Normalized female right foot inversion and eversion per each trial and average of all trials

RESULTS: FEMALE PARTICIPANT

Predicted vs. Real Inversion-Eversion Over Time Female Participant for Trial 3

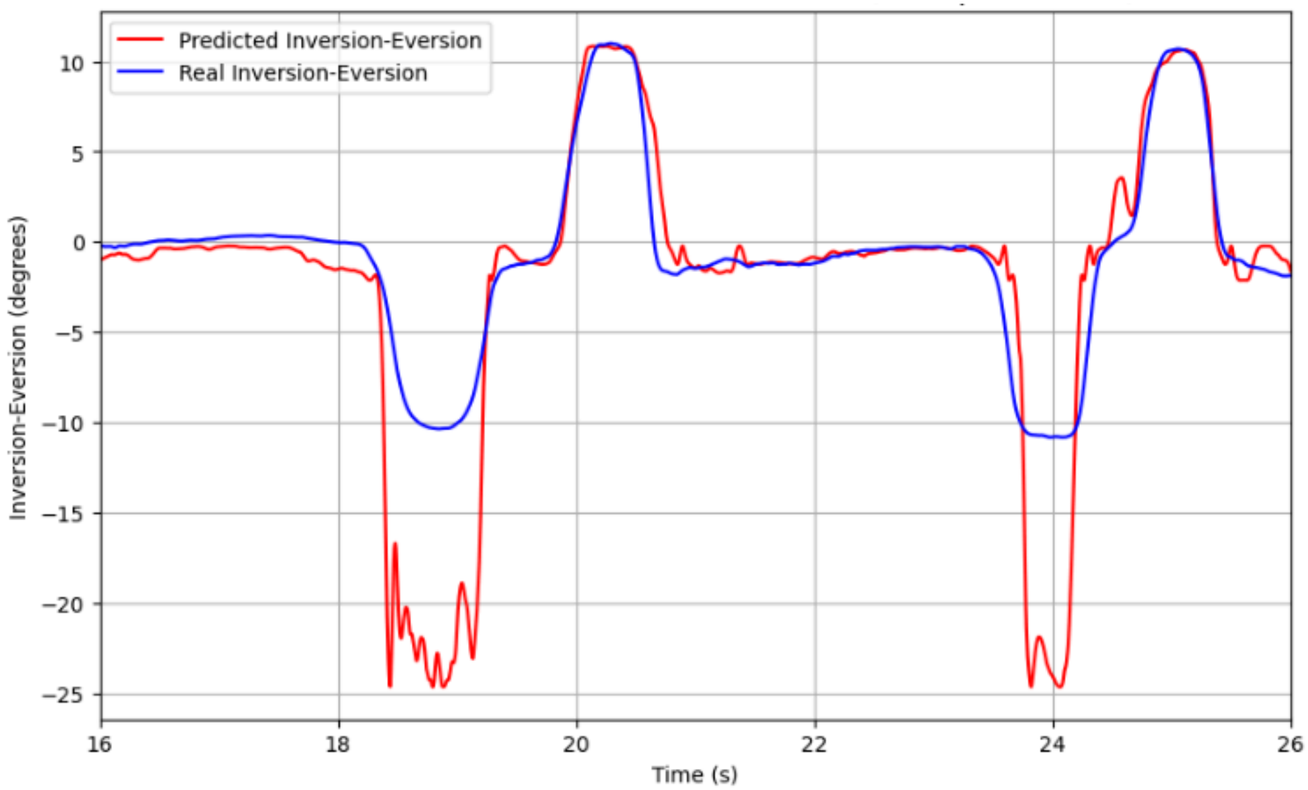


Figure 8: Predictive model of inversion and eversion based on tibial rotation data (red) compared to the real inversion and eversion data (blue)

DISCUSSION

- Predictive model shows appropriate shape and some accurate values

- Only simple movement completed, data often difficult to interpret and the model is not robust when tested against measured data for multiple trials

- Future research should explore more complex barefoot movements and compare them with shod conditions to better evaluate this approach

CONCLUSION

- Our findings suggest that using the tibial and ankle movement coupling is not a reliable method for accurately measuring foot inversion and eversion
- We recommend against its use for assessing foot kinematics in this context at this time

THANK YOU

WHAT ARE YOUR QUESTIONS?

“DONT RUN B4 YOU CAN WALK” - BEN HELLER

REFRENCES

- [1] Malisoux, L., & Theisen, D. (2020). Can the “appropriate” footwear prevent injury in leisure-time running? Evidence versus Beliefs. Journal of Athletic Training, 55(12). https://doi.org/10.4085/1062-6050-523-19
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- [10] Stacoff, A., Nigg, B. M., Reinschmidt, C., van den Bogert, A. J., Lundberg, A., Stüssi, E., & Denoth, J. (2000). Movement Coupling at the Ankle During the Stance Phase of Running. Foot & Ankle International, 21(3), 232–239. https://doi.orNeedham, R.
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Figures 2a & 2b: (Left to right) Picture of shoe from [8] and [9] study respectively

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  - Not yet studied in tennis-specific movements

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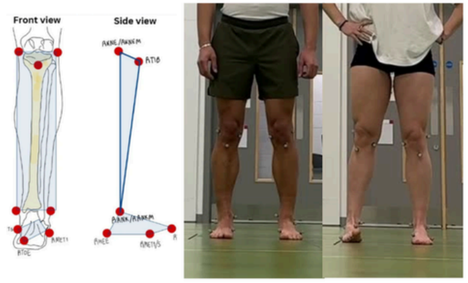

Figure 3 and Videos 4a & 4b: (Left to right) Shank and foot diagram with reflective markers on anatomical landmarks, video of male and female participant performing test

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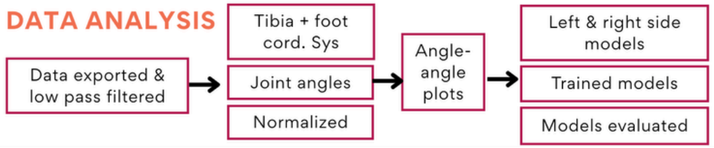
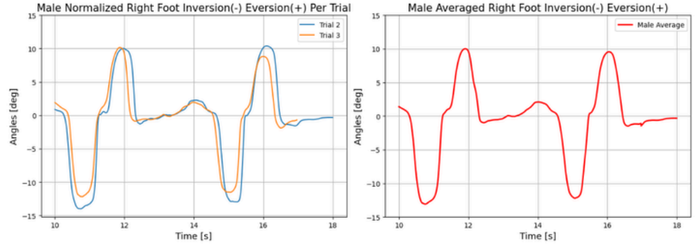


RESULTS



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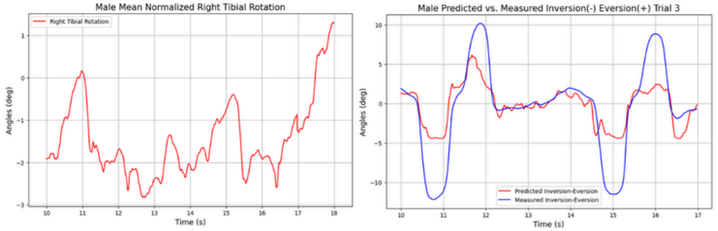

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CONCLUSIONS

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