

# Comparison of Joint Mechanics of the Dominant vs. Non-Dominant Lower Limbs During Locomotion

Stephanie Molitor<sup>1,2\*</sup>, Karl Zelik<sup>1,2,3</sup>, Kirsty McDonald<sup>1,4</sup>

<sup>1</sup>Dept. of Mechanical Engineering, Vanderbilt University

Email: stephanie.molitor@vanderbilt.edu\*

## Introduction

It is common practice for biomechanical analyses of gross, bilateral motor tasks to consider the independent functional role of each lower limb. For example, when kicking a ball, the joints of the dominant limb (hip, knee, and ankle) typically move through a greater range of motion (ROM) and are cumulatively responsible for increased positive power production compared to the non-dominant limb [1]. However, the influence of limb dominance is rarely considered in walking and running research, where biomechanical symmetry between the legs is generally assumed [2]. It remains unclear whether this is a valid assumption, especially at the more distal joints. Recent work from our laboratory found that prosthetic device users who had lost their dominant limb preferred to have a toe joint added to their prosthetic foot, whereas all other participants preferred a prosthesis that lacked toe joint articulation. This suggests a potential link between limb dominance and distal joint kinematics; however, differences in foot kinematics have not been studied in relation to limb dominance in an able-bodied population. The current study therefore aims to compare dominant and non-dominant kinematics and kinetics for the hip, knee, and ankle, as well as foot kinematics (via a multi-segment model), throughout a walking and running stride. We hypothesized that dominant limb joints would move through an increased ROM compared to non-dominant limb joints.

## Methods

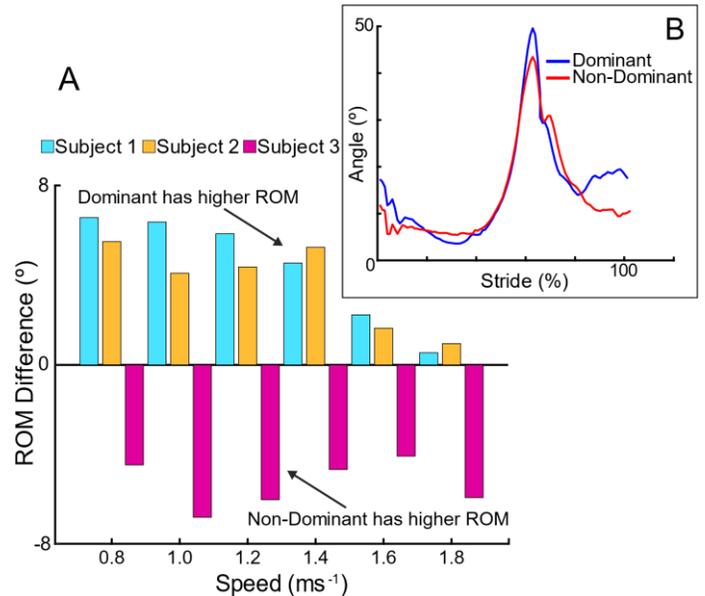
Able-bodied individuals ( $N=3$  to date, but data collection will resume shortly) completed walking and running tasks (speeds of 0.8-4.0  $\text{ms}^{-1}$ ) on a treadmill (Bertec) with motion capture (Vicon) markers placed on their lower limbs and feet [3]. After these trials, participants were asked to complete a revised Waterloo footedness questionnaire in order to determine their lower limb dominance as well as the strength of dominance.

Kinematic and kinetic data were calculated for the hip, knee, and ankle, as well as foot kinematics (Visual3D). For brevity, we present only metatarsophalangeal joint (MPJ) kinematics, but plan to share more comprehensive results at the conference. Statistical parametric mapping (SPM) analyses will also be employed on the complete dataset (target:  $N=12$ ).

## Results and Discussion

Based on the questionnaire, all three subjects exhibited weak to moderate right-limb dominance. Average differences in MPJ ROM generally fell between 4-6° (Fig. 1). Two subjects displayed a greater ROM on their dominant limb (positive values in Fig. 1), and one subject showed a greater ROM on their non-dominant limb (negative values in Fig. 1). While more testing is required to draw conclusions, we observed small but consistent differences between the dominant and non-dominant limbs of all participants. The differences between the dominant and non-dominant MPJ ROM for individual strides mirrored the average trend for each subject 90% of the time. Differences in ROM were also found between the dominant and non-dominant

limb for the ankle, knee, and hip; however, similar to the findings in [4], these differences were smaller in magnitude.



**Figure 1:** (A) MPJ ROM differences between dominant and non-dominant limbs. (B) Mean MPJ angle for Subject 1, walking at 1.0  $\text{ms}^{-1}$ .

Upon completion of data collection and analysis, we will have a more holistic view on how limb dominance may affect hip, knee, ankle, and foot biomechanics. Moreover, SPM will allow us to determine where in the gait cycle these differences are most pronounced for both walking and running.

## Significance

This study will be the first to statistically analyze continuous time-series data across the gait cycle when characterizing biomechanical differences between the dominant and non-dominant limbs during locomotion. It is expected that results will determine whether limb dominance should be considered in future gait analyses, and could inform the design or prescription of prosthetic feet.

## Acknowledgments

The authors thank Dr. Justin Wager for assistance with study design and Mr. David Ziemnicki for help with data collection.

## References

- [1] Wang, J. et al. (2019). *Adv. Mech. Eng.*, **11**: 5.
- [2] Sadeghi, H. et al. (2000). *Gait & Posture*, **12**: 34-45.
- [3] Leardini, A. et al. (2007). *Gait & Posture*, **25**: 453-62.
- [4] Forczek, W. et al. (2012). *J. Hum. Kinet.* **35**: 47-57.