

A Comparison of Ground Reaction Forces During Treadmill and Overground Walking in Transfemoral Amputees

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Introduction

Why This is Important

- As of 2005, 1.6 million people were living with limb loss, with this number projected to double by the year 2050¹.
- Treadmill and overground walking are used to quantitatively characterize gait in individuals with lower limb amputation.

What is Known

- In healthy adults, peak vertical ground reaction force (GRF) is greater during overground walking than during treadmill walking².
- Patients with transfemoral amputation have greater vertical and anterior/posterior GRF in their sound limb compared to their prosthetic limb³.

What is Unknown

- Are GRF data collected during treadmill walking representative of GRF data collected during overground walking in individuals with transfemoral amputation?

Aim

- Aim: Compare overground and treadmill GRF in subjects with transfemoral amputation

Hypotheses

- Peak GRF and impulse are greater on the sound side during overground and treadmill walking.
- Peak GRF and impulse are greater during overground compared to treadmill walking.

Methods

Subjects

- 11 Individuals with transfemoral amputation (age 24 to 63 years; weight 59 to 130 kg, height 1.6 to 1.9 m).

Data Collection

- 10 overground and 2 to 10 treadmill walking trials were collected for each participant.
- Overground: Participants walked across a 7 m lab walkway, taking 1 to 3 steps on an instrumented treadmill (Bertec Corp.) at the midpoint each trial (Figure 1A).
- Treadmill: Walking speed was set to match overground speed. 9 to 12 steps were recorded per trial (Figure 1B).
- GRF collected at 1000 Hz for all trials.

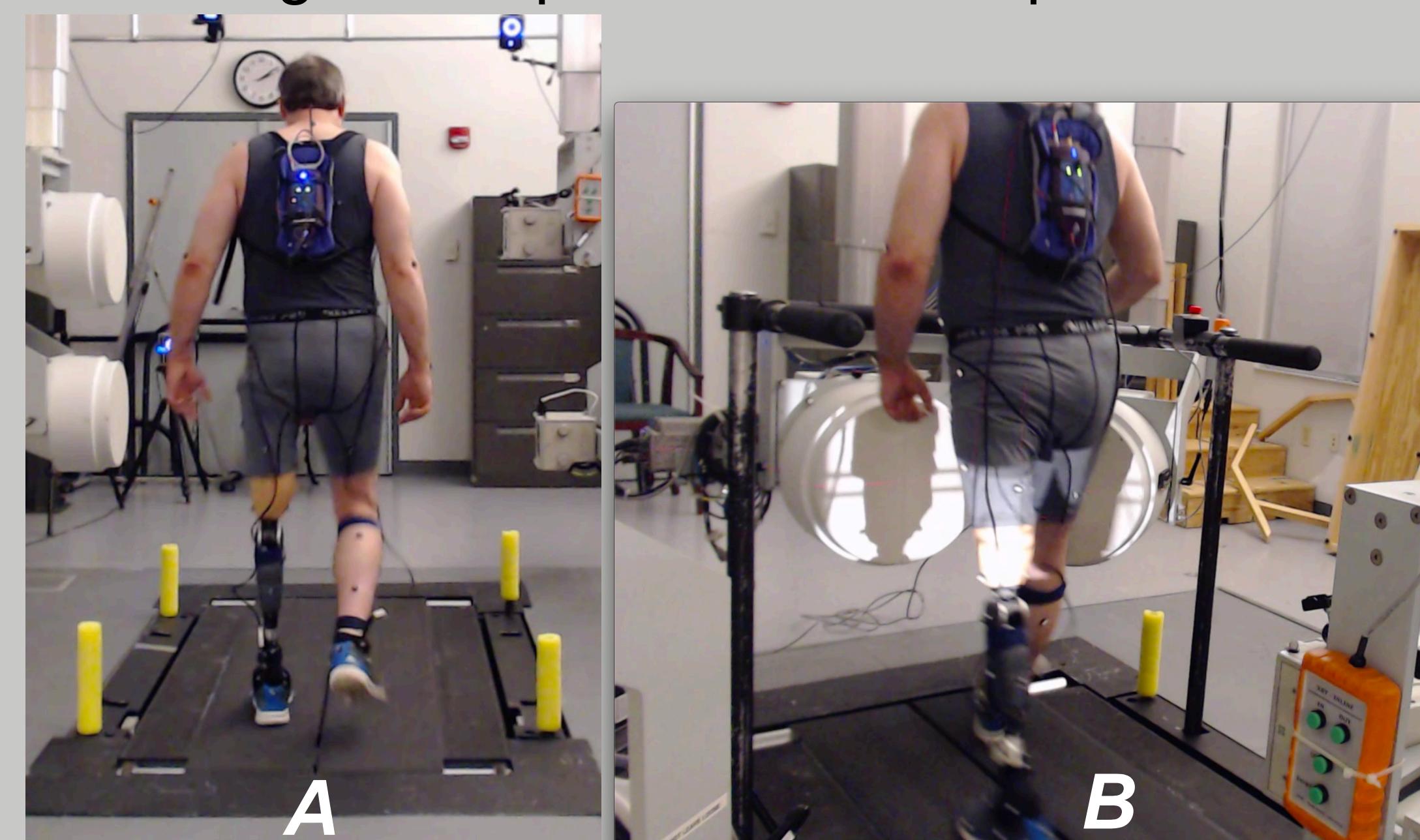


Figure 1: Data collection during (A) overground walking and (B) treadmill walking.

Data Processing

- GRF data was filtered using a 4th order Butterworth filter with a 20Hz cutoff frequency.
- GRF data were normalized to body weight (%BW).
- Heel strike and toe off were identified using a threshold of 50N vertical GRF.
- A validated volumetric model-based tracking technique⁴ was used to match the subject-specific bone models to the biplane radiographs with a precision of 1.2° and 0.5 mm (Figure 1).
- GRF variables were averaged over all trials for each subject.

Data Analysis

- Outcome variables were AP, ML and vertical GRF peaks and impulses (area under the curve).
- A paired t-test was performed to compare prosthetic and sound limb outcomes as well as walking surface for each GRF parameter.
- Significance was set at $p < 0.05$.

Results

- Sound side vertical (Figure 2) and anterior-posterior (Figure 3) GRF was greater than prosthetic side GRF during overground and treadmill walking.
- GRF parameters were greater during overground compared to treadmill walking (Figures 2 and 3).

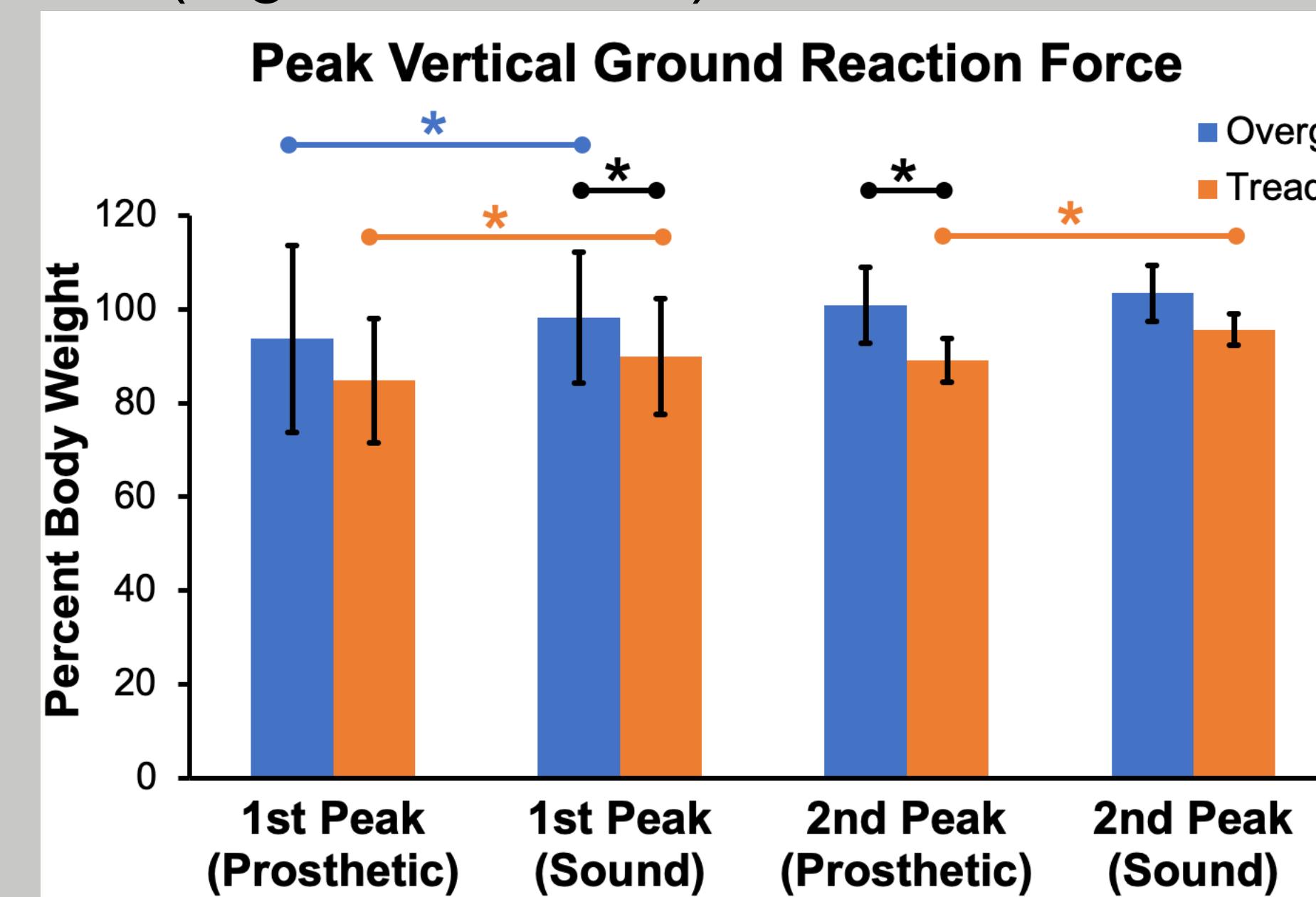


Figure 2: Peak vertical GRF in prosthetic and sound limbs. * indicates significant difference between overground and treadmill walking. * and * indicate significance difference between limbs.

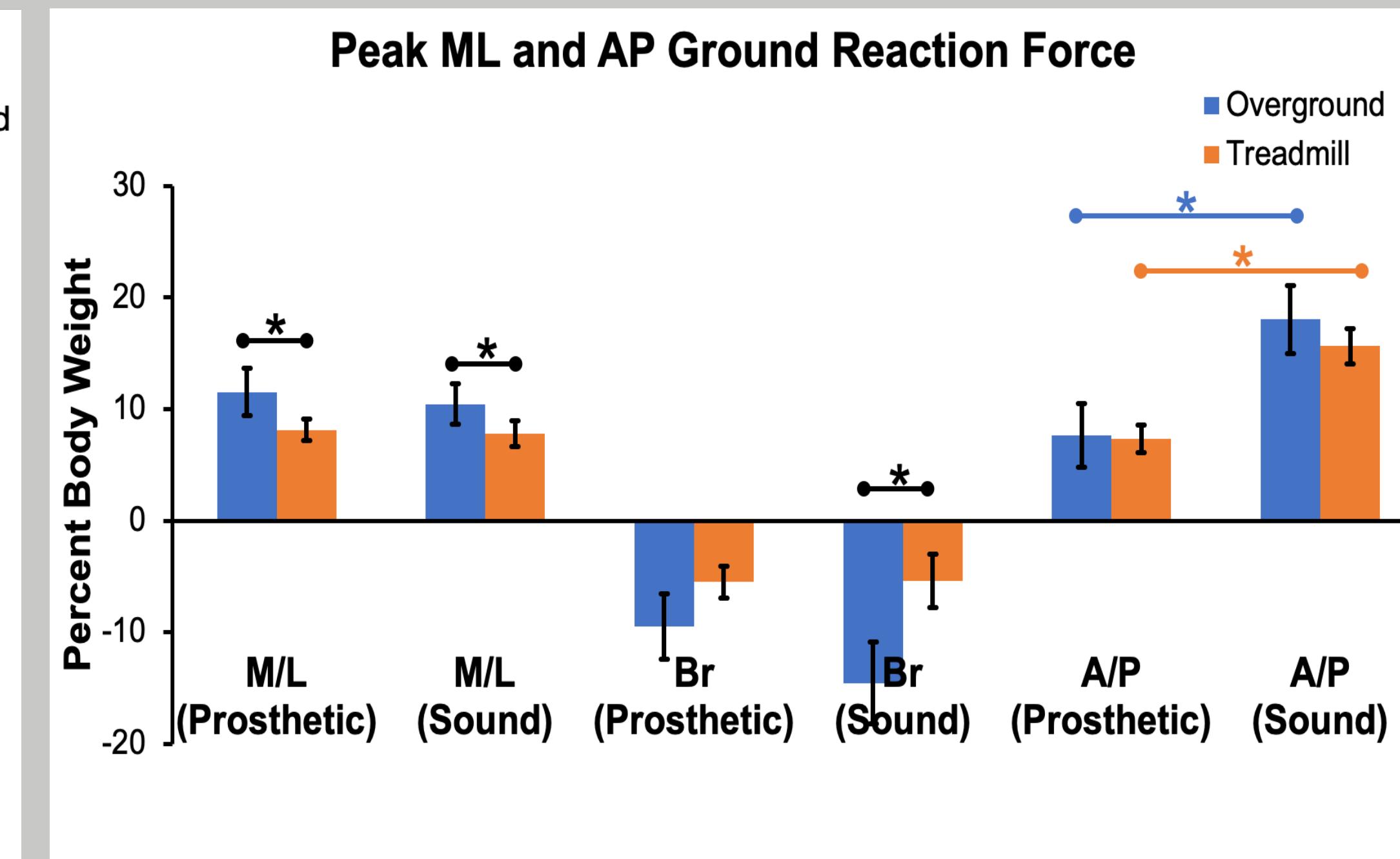


Figure 3: Peak medial-lateral (ML), breaking (Br), and anterior-posterior (AP) GRF in prosthetic and sound limbs. * indicates significant difference between overground and treadmill walking. * and * indicate significance difference between limbs.

- Sound side vertical (Figure 4) and anterior-posterior (Figure 5) impulse was greater than prosthetic side.
- ML impulse was greater during overground walking, while AP impulse was greater during treadmill walking (Figures 4 and 5).

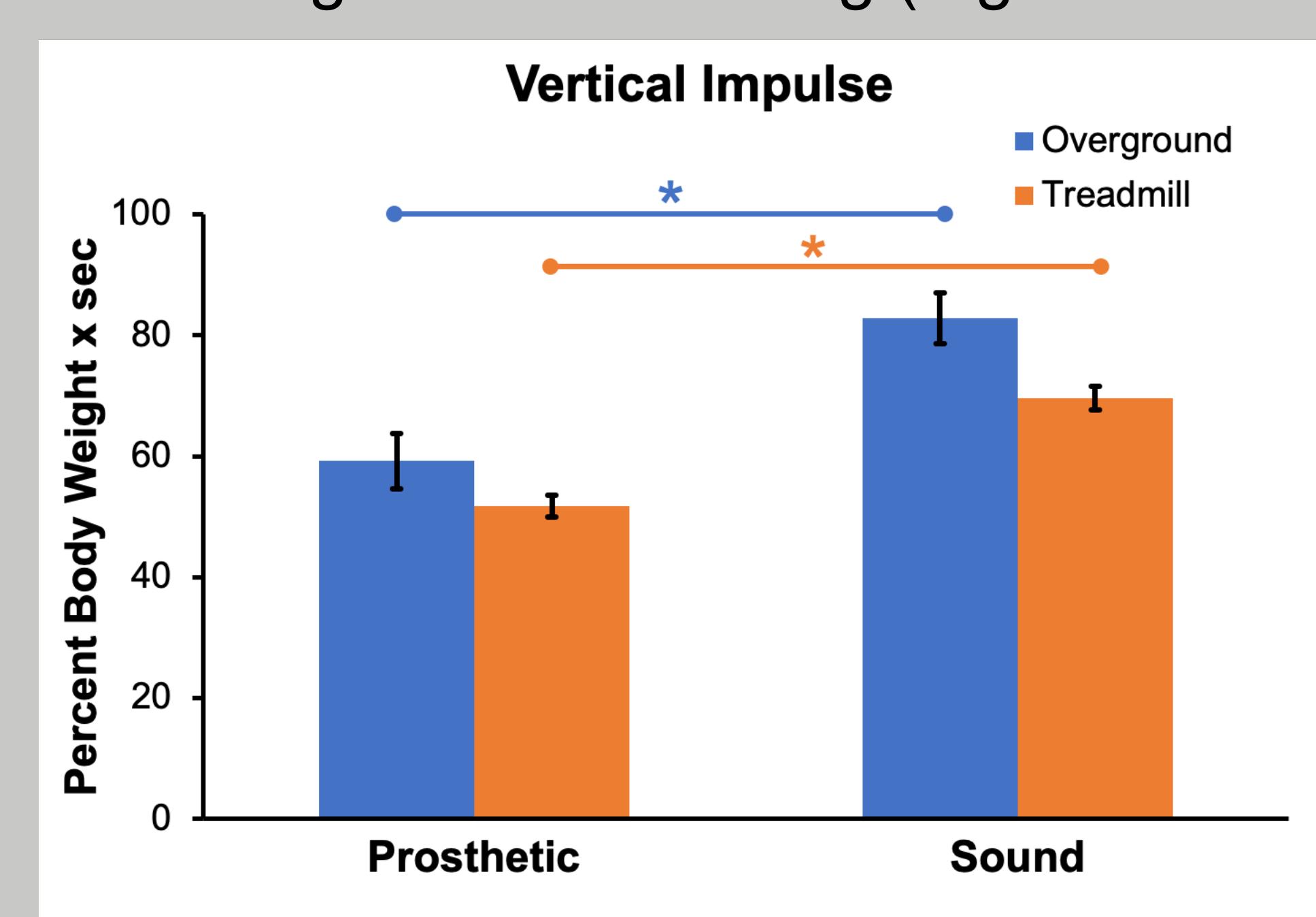


Figure 4: Vertical impulse in prosthetic and sound limbs. * and * indicate significance difference between limbs.

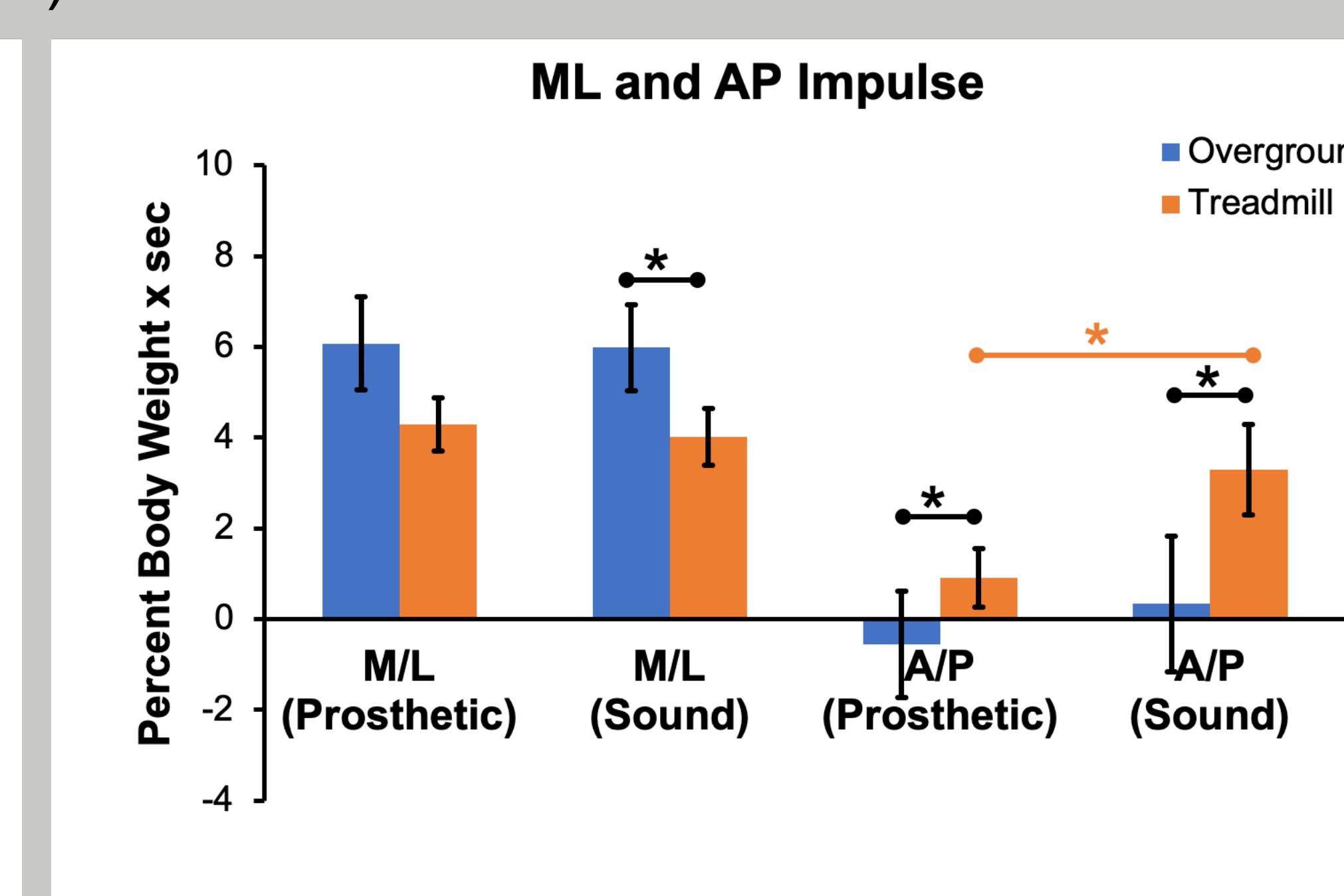


Figure 5: Medial-lateral (ML) and anterior-posterior (AP) impulse in prosthetic and sound limbs. * indicates significant difference between overground and treadmill walking. * and * indicate significance difference between limbs.

Discussion

- Our first hypothesis was supported: **GRF and vertical impulse is greater on the sound side.**
 - This confirms that individuals who have an amputation load their sound limb more during overground and treadmill gait.
- Our second hypothesis was supported: **GRF and impulse is greater during overground walking.**

Clinical Significance

- Given the differences in GRF between overground and treadmill gait, clinicians should be wary of evaluating kinetics, socket fit, and alignment during treadmill walking.
- Researchers need to be aware of limitations associated with testing persons with an amputation during treadmill walking.

References and Acknowledgements

- Ziegler-Graham, et al., PM&R, 2008.
- White, et al., MSSE, 1998.
- Gailey et al., JRRD, 2008.