Knee Joint Loading in People with a Unilateral Transtibial Amputation Across Walking Speeds

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*The data was collected at the University of Massachusetts Amherst (Amherst, MA)

Introduction

- **People with unilateral lower extremity amputation utilizing a prostheses have a higher incidence of knee osteoarthritis in their intact limb (1)**
- **Higher incidence of knee osteoarthritis could be due to greater knee loading magnitude or duration on the intact limb compared to the prosthetic limb (2)**
- **Estimated knee joint loads are potentially similar between able-bodied controls and people with recent amputation (3)**
- **People with lower extremity amputations have other objectives while walking such as energy expenditure and stability**
  - Could lead to increased knee loading and increased risk of tibial-femoral knee osteoarthritis (4)
  - People with lower extremity amputations utilizing prostheses walk slower and take more steps than able-bodied controls for the same distance
  - Could lead to greater accumulation of knee joint loads

Purpose

To compare prosthetic and intact limb tibiofemoral joint loading estimates across different speeds for people with a unilateral transtibial amputation.

- **We hypothesize that the intact limb will have greater peak and greater cumulative knee loading compared to the prosthetic limb**

Methods

	Subjects (#)	Females/Males (#)	Age (yrs)	Mass (kg)	Height (m)	Pref Walking Speed (m/s)
Sample mean	4	2/2	37.3 ± 12.3	65.6 ± 10.6	1.77 ± 0.107	1.24 ± 0.0408

Table 1: Mean ± 1 SD. Participant characteristics.

- **4 people with unilateral transtibial amputation from non-vascular causes that were either K3 or K4 ambulators (Table 1)**
- **Walked over ground at 3 speeds: preferred walking speed (PWS), and +/- 20% PWS**
  - PWS determined from three trials of participants walking 10 meters with two photogates 6 meters apart in the middle (5)
- **Motion capture data was collected at 240 Hz and force data was collected at 2400 Hz using a Qualisys Motion Capture System (Qualisys, Gothenburg, Sweden) and AMTI force plates (AMTI, Watertown, Massachusetts), respectively**
- **Tibiofemoral knee joint contact forces were estimated using an established knee model (6).**
  - V3D (C-Motion, Germantown, Maryland) used for kinetics and kinematics
  - Muscle force estimates made using net joint angles, moments, muscle moment arm, and muscle cross-sectional area
  - The gastrocnemius was not included for the prosthetic limb
- **Two (limb x speed) way ANOVA was performed to determine differences, α = 0.05**

Results

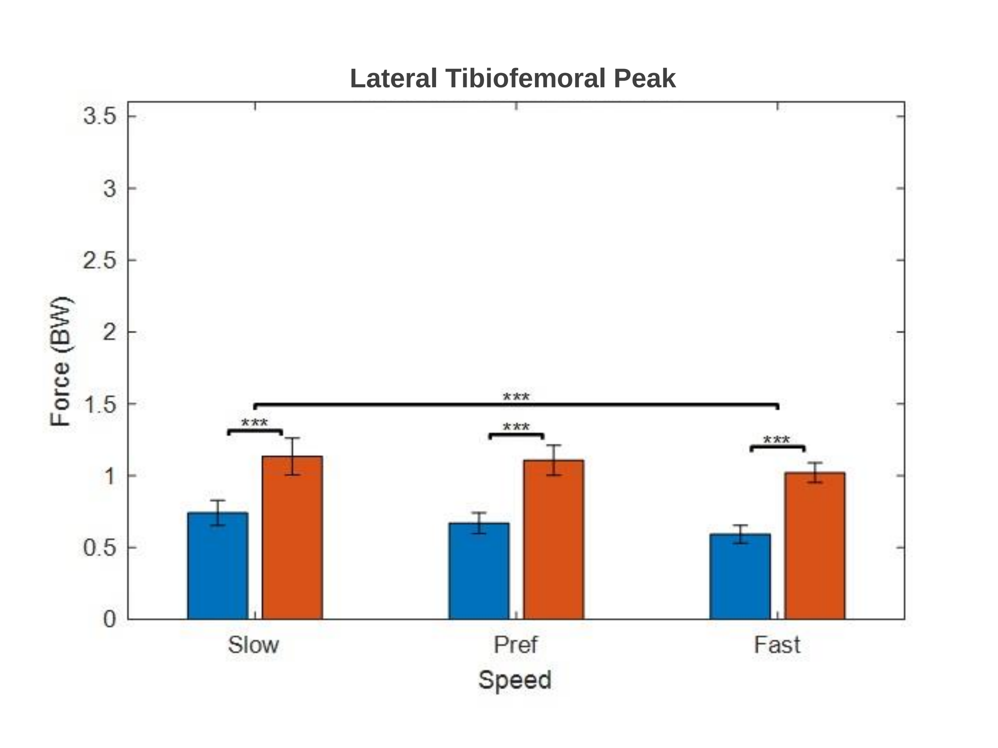


Figure 1: Mean ± 1 SD for prosthetic knee (blue) and intact knee (red). Significant Differences (p<0.001) * found between both limbs and at all speeds.**

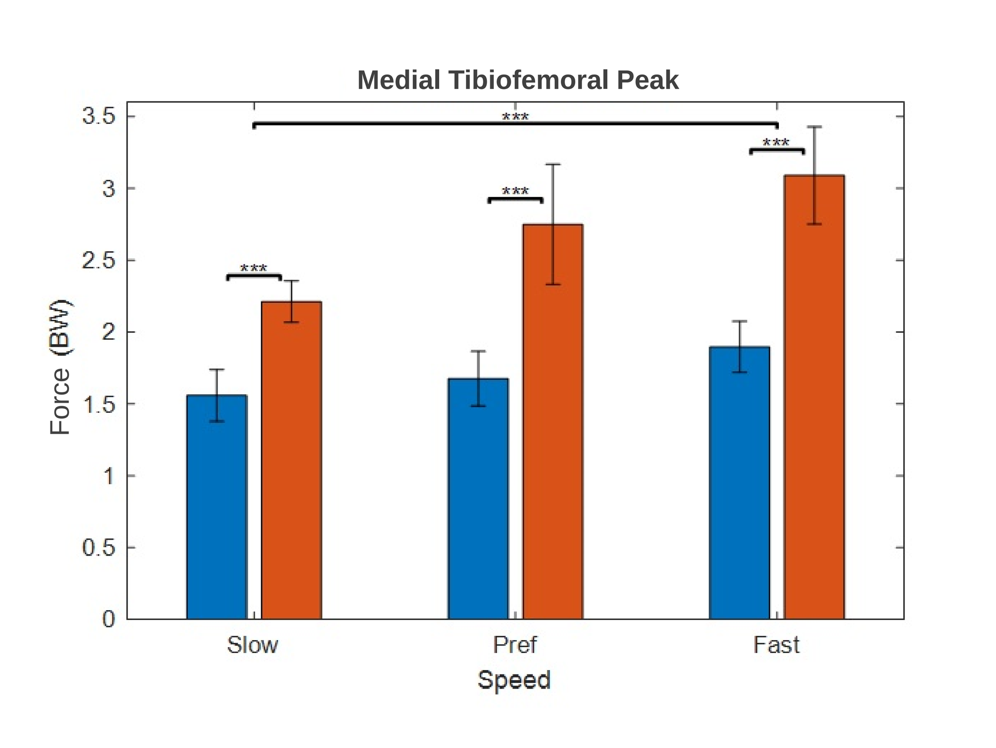


Figure 2: Mean ± 1 SD for prosthetic knee (blue) and intact knee (red). Significant Differences (p<0.001) * found between both limbs and at all speeds.**

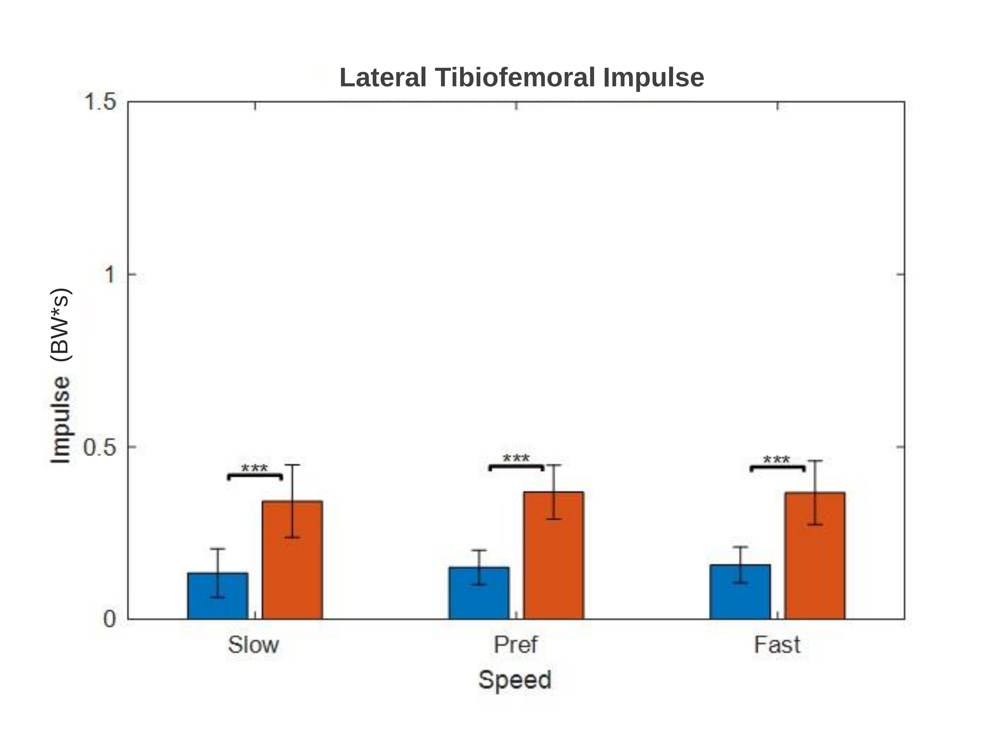


Figure 3: Mean ± 1 SD for prosthetic knee (blue) and intact knee (red). Significant Differences (p<0.001) * found between both limbs.**

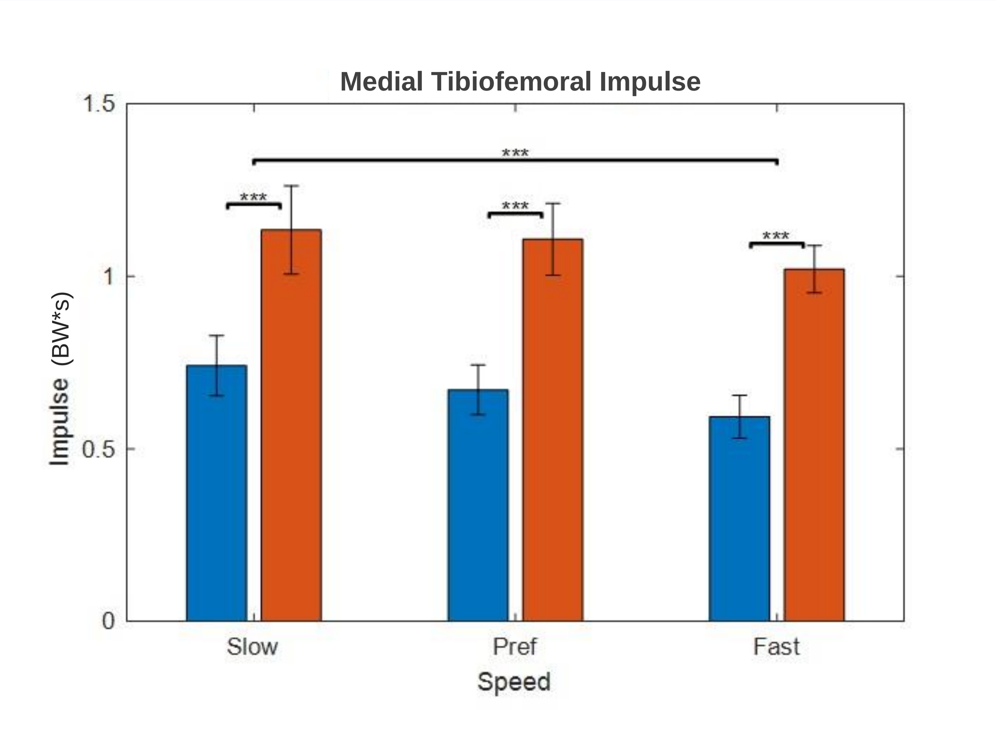


Figure 4: Mean ± 1 SD for prosthetic knee (blue) and intact knee (red). Significant Differences (p<0.001) * found between both limbs and at all speeds.**

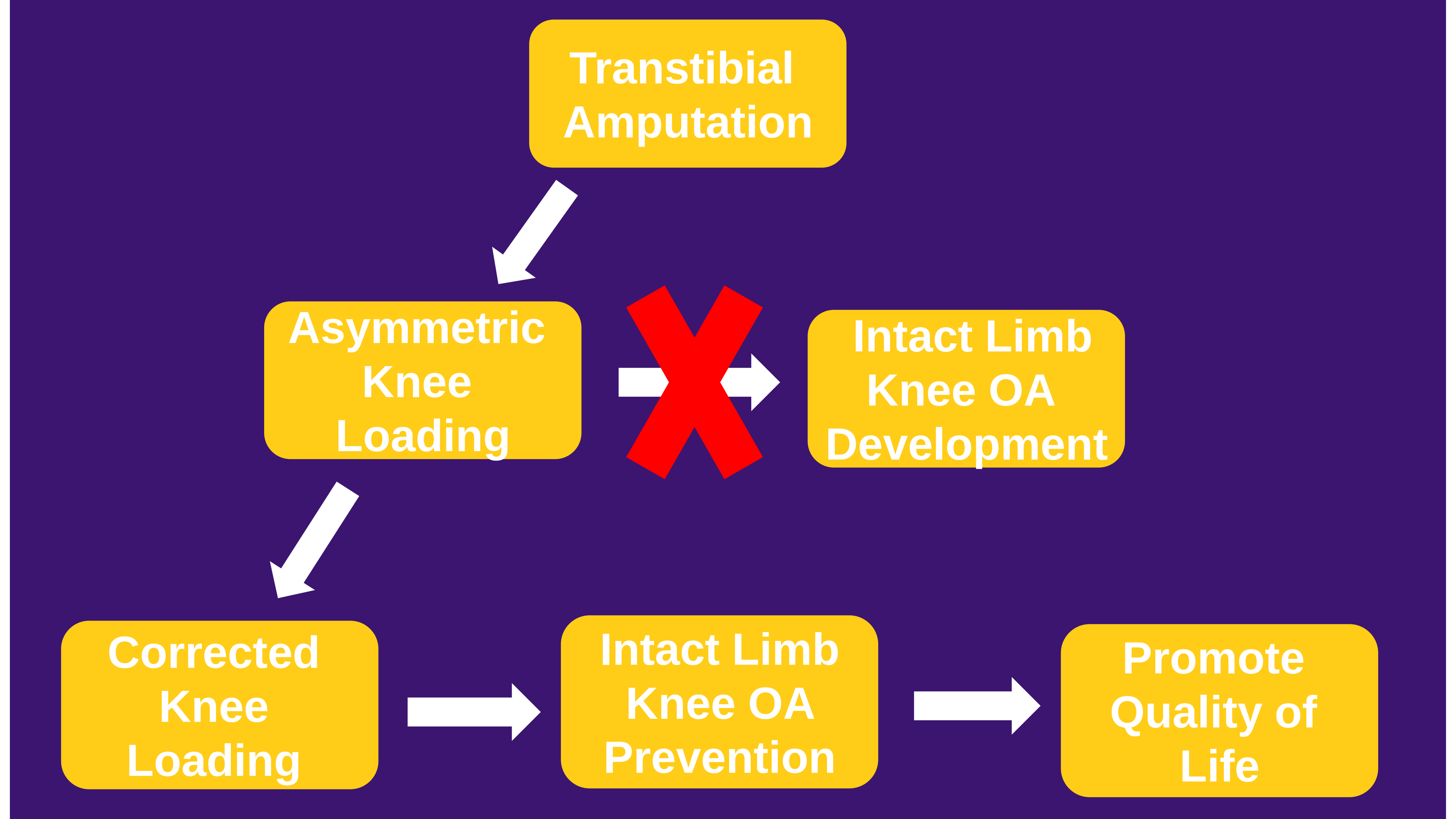
- **Our hypotheses about greater knee loading for both peak and cumulative knee loads for the intact limb compared to the prosthetic limb were supported by the data**
- **Intact limb had significantly greater peak knee loads and significantly greater knee impulses across all speeds compared to the prosthetic limb except for the lateral impulse's speed (Figures 1-4)**
  - Supported by asymmetries in walking in people with unilateral amputation utilizing prostheses (2)

Results & Discussion

- **Medial knee loading is greater than lateral knee loading at all speeds and across all limbs (Figures 1-4)**
- **Generally, increased speed leads to greater peak knee loading and lesser knee Impulse (Figures 1-4)**
  - Greater effect for the intact limb in medial tibiofemoral peaks and impulses
  - Greater tibiofemoral loads with increasing walking speeds (7)
- **Increased peak knee loads and increased knee impulse are positively associated with medial knee cartilage defects, which contribute to medial knee osteoarthritis development and severity (8)**
- **Our data shows that there are greater peak and impulse knee loads in the intact limb knee compared to the prosthetic limb**
  - Increased knee loading in the intact limb could explain the increased prevalence of knee osteoarthritis in the intact limb

Clinical Relevance

By understanding that people with transtibial amputations utilizing prostheses have increased knee osteoarthritis in the intact limb due to loading asymmetries, this asymmetry can be corrected, and joint health can be promoted. This would prevent secondary disability and maintain quality of life.



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