*Margaret Coad*
*Tony DiBlasi*
*Laura Hallock*
*Chris Merian*

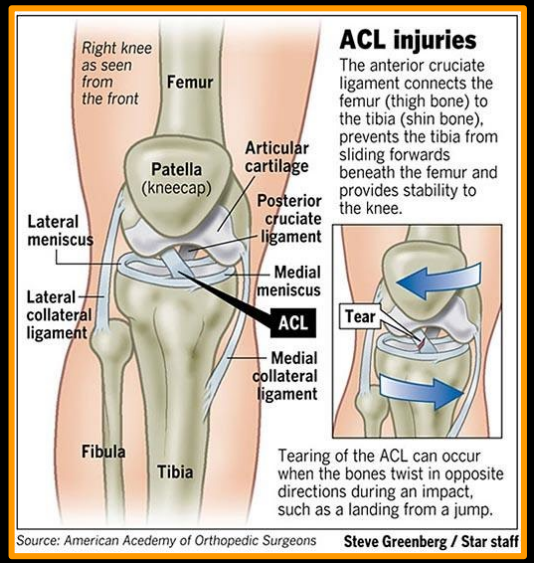
*MAS.600*
*Spring 2015*

# LONG FALL BOOTS

A proof of concept for reducing joint torques during landing.

# Introduction

# Motivation




Humans are bad at landing, and being better would be useful.

# Our Approach

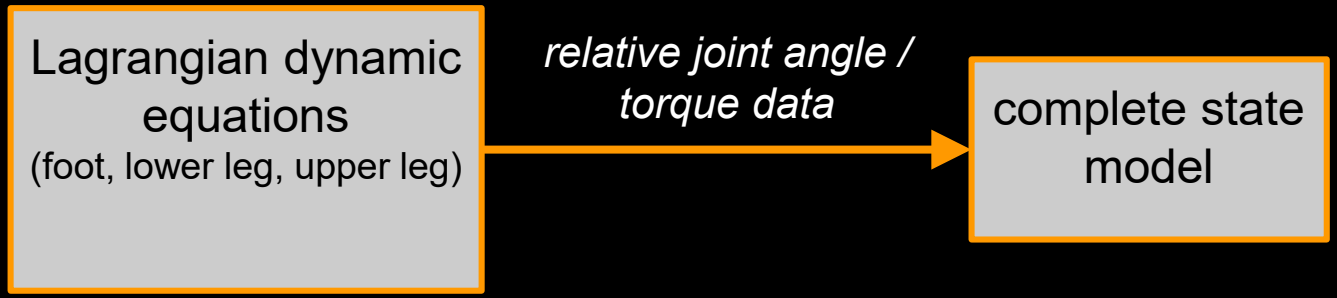
- Passive system
- Focus on ankle
  - most energy absorption
- Damper (not spring)

# Hypothesis

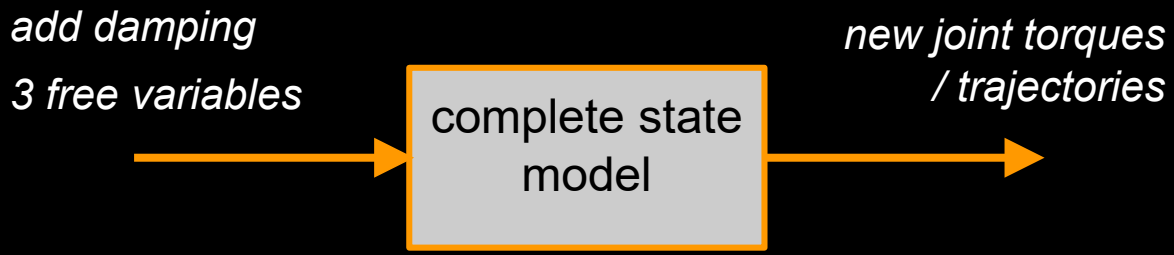
Adding a damper in parallel with the ankle will **decrease the torque** that the ankle joint needs to provide, making landing **safer** for that joint.

# Computational Model

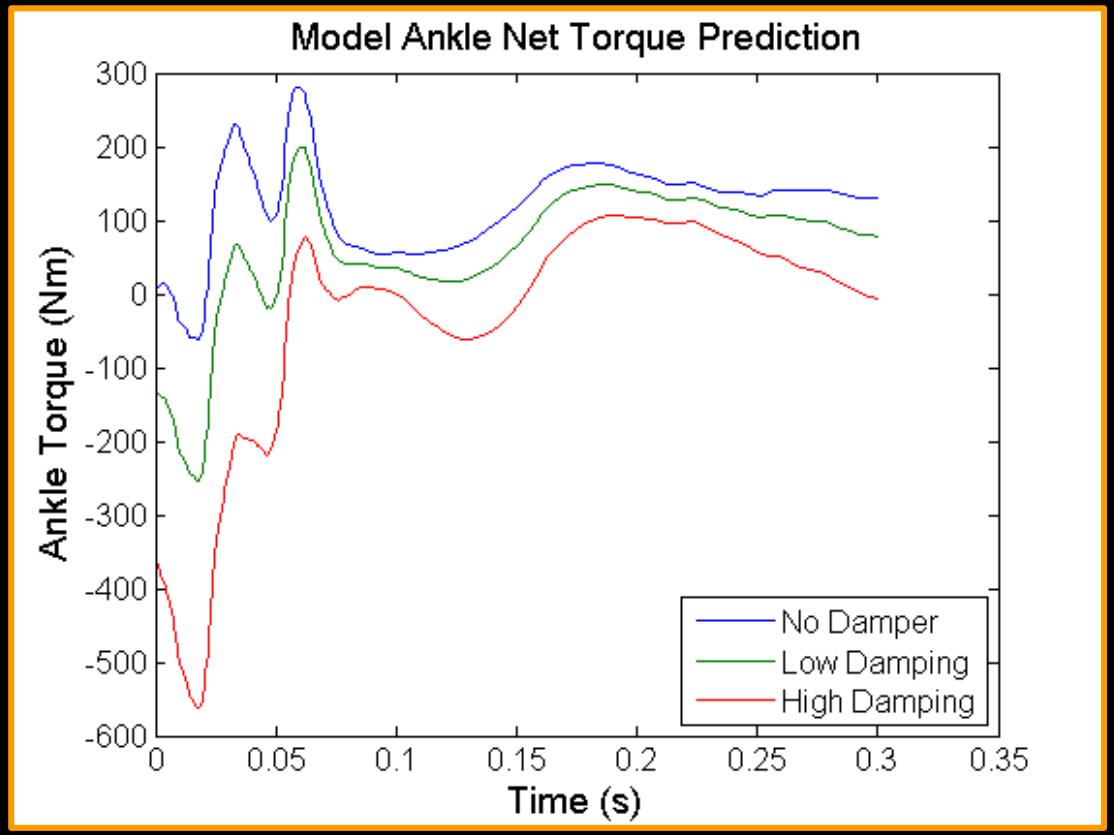
**Teach model with data**



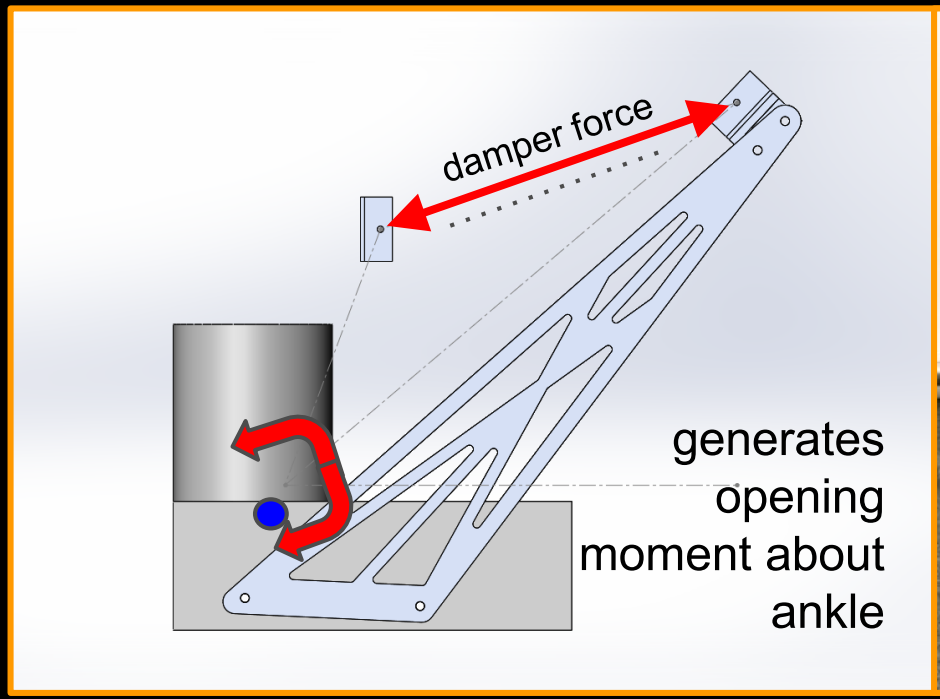

**Use model with perturbations**



# Computational Model

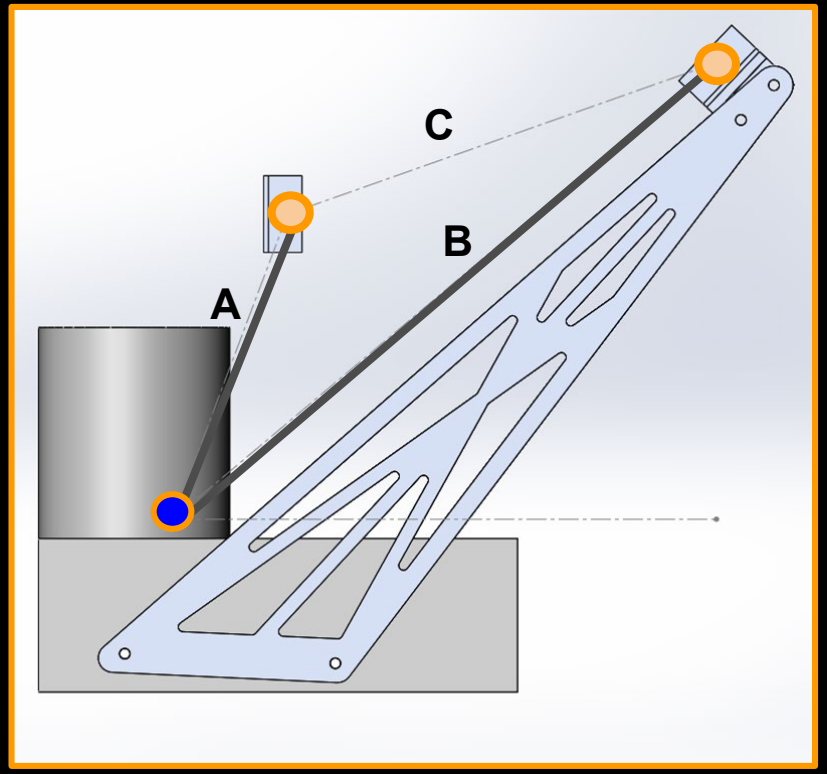


# Device Design




# Device Design

- Pivot locations affect
  - torque magnitude
  - force angle
- Constrained by
  - damper geometry (C)
  - torque required (100-200 Nm)



# Device Fabrication

- Mechanical
  - bracket mounted to shin guard
  - side plates bolted through sole of military boot
  - all parts very simple to machine

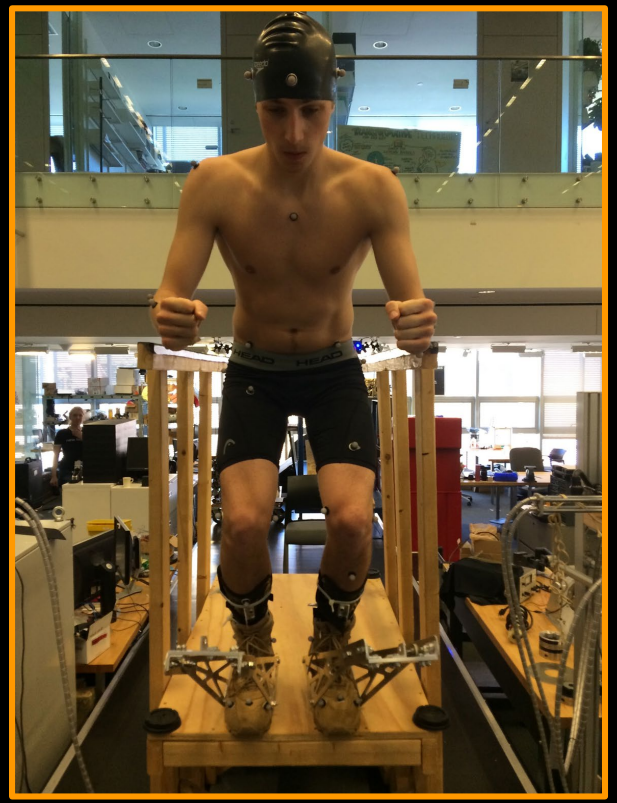

- McMaster 9899K91
  - max 270 lbf
  - 14.5” to 24.5” length
  - **adjustable damping**

# Experimental Design

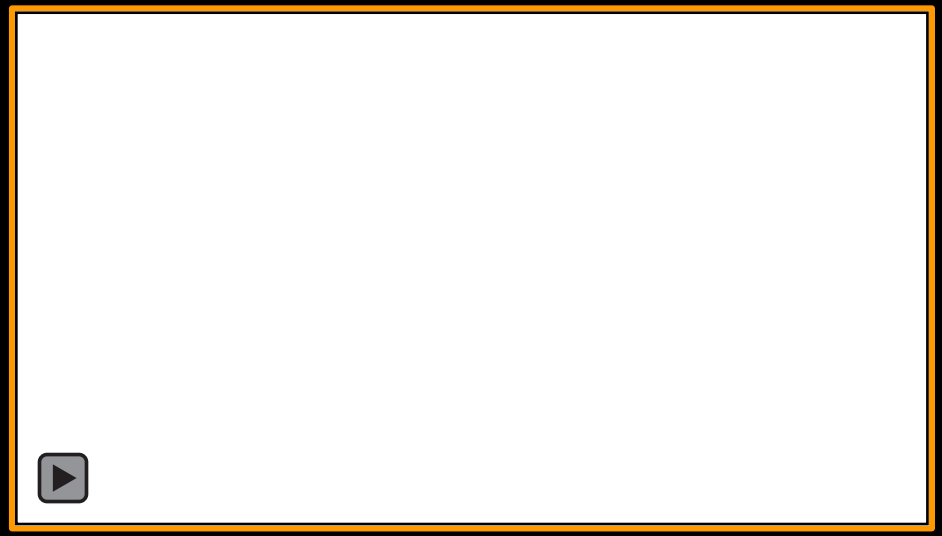
- **Objective**: quantify device's ability to mitigate injury
- **Metrics**:
  - peak ankle torque
  - *(peak GRF)*
  - *(time to peak GRF)*
  - *(peak knee torque)*

# Experimental Procedures

- 30 total jump trials
  - 10 no damper
  - 10 low damping
  - 10 high damping
- 15 trials used in analysis (most complete mo-cap data)

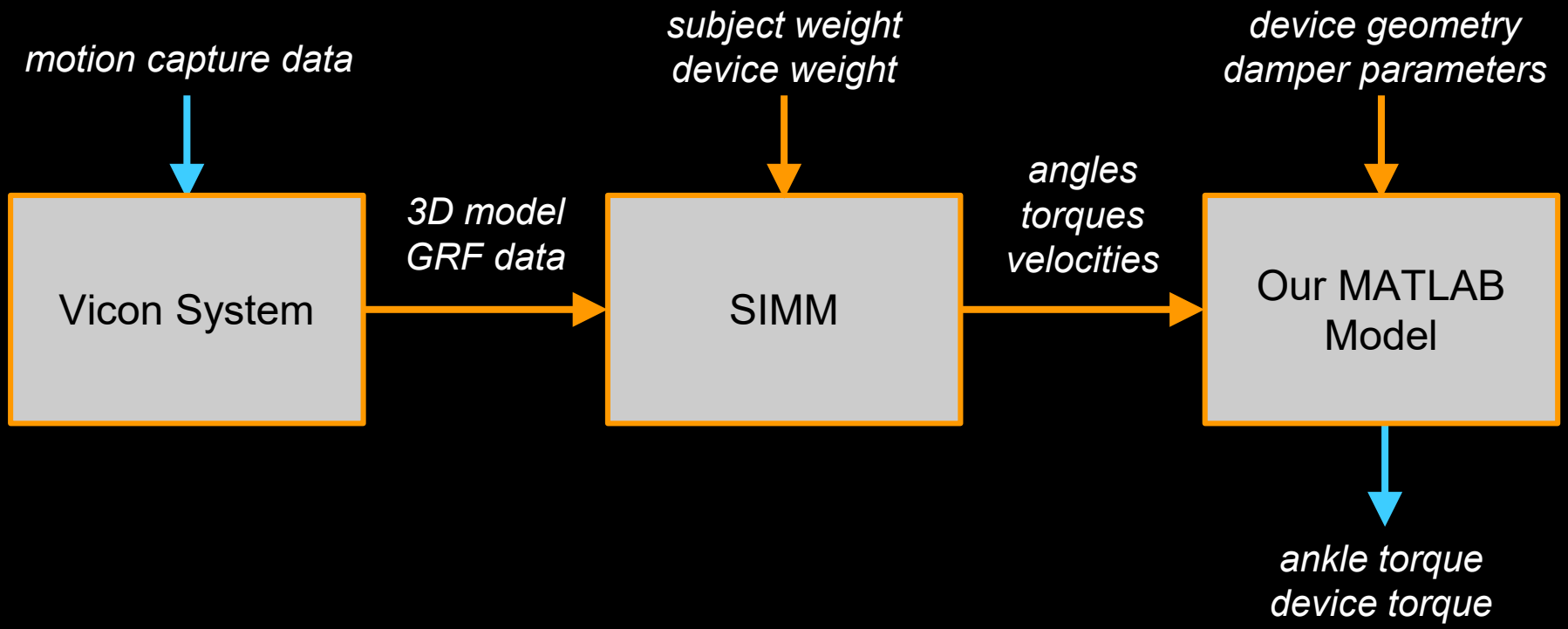


# Experimental Procedures



- two-foot jump off 2'4" platform
- one full subject dataset, some data from second subject
  - 160-170 lb, ~ 6'2"

# Data Analysis



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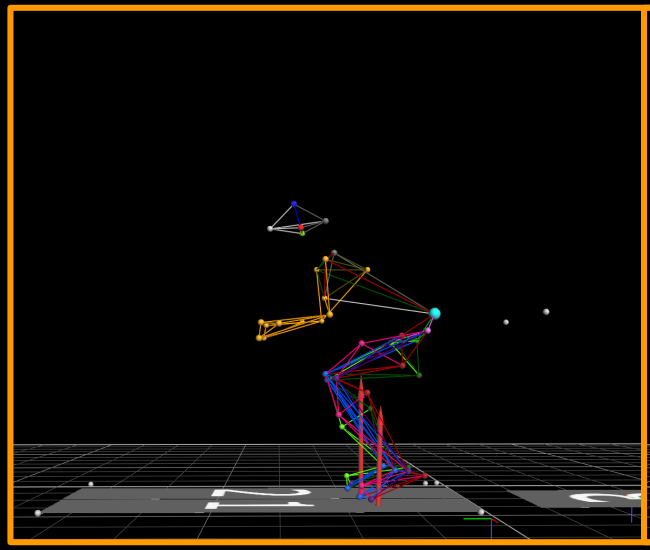
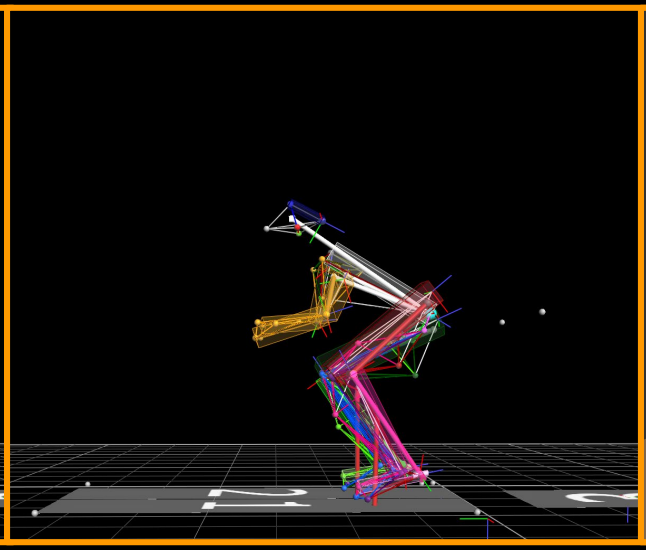
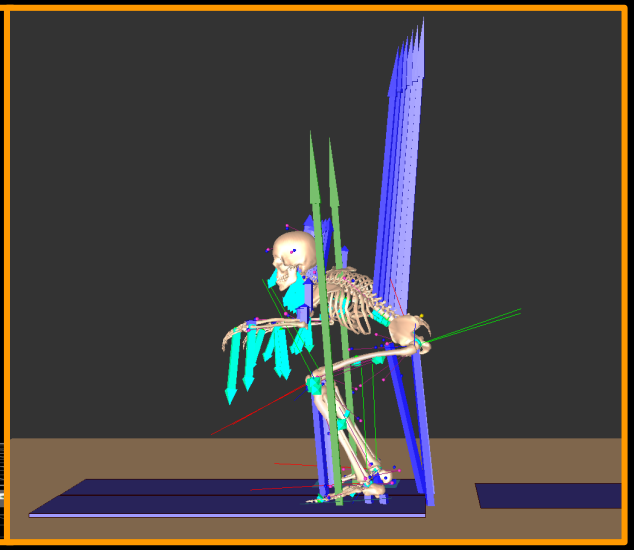


skeleton
(*Vicon*)

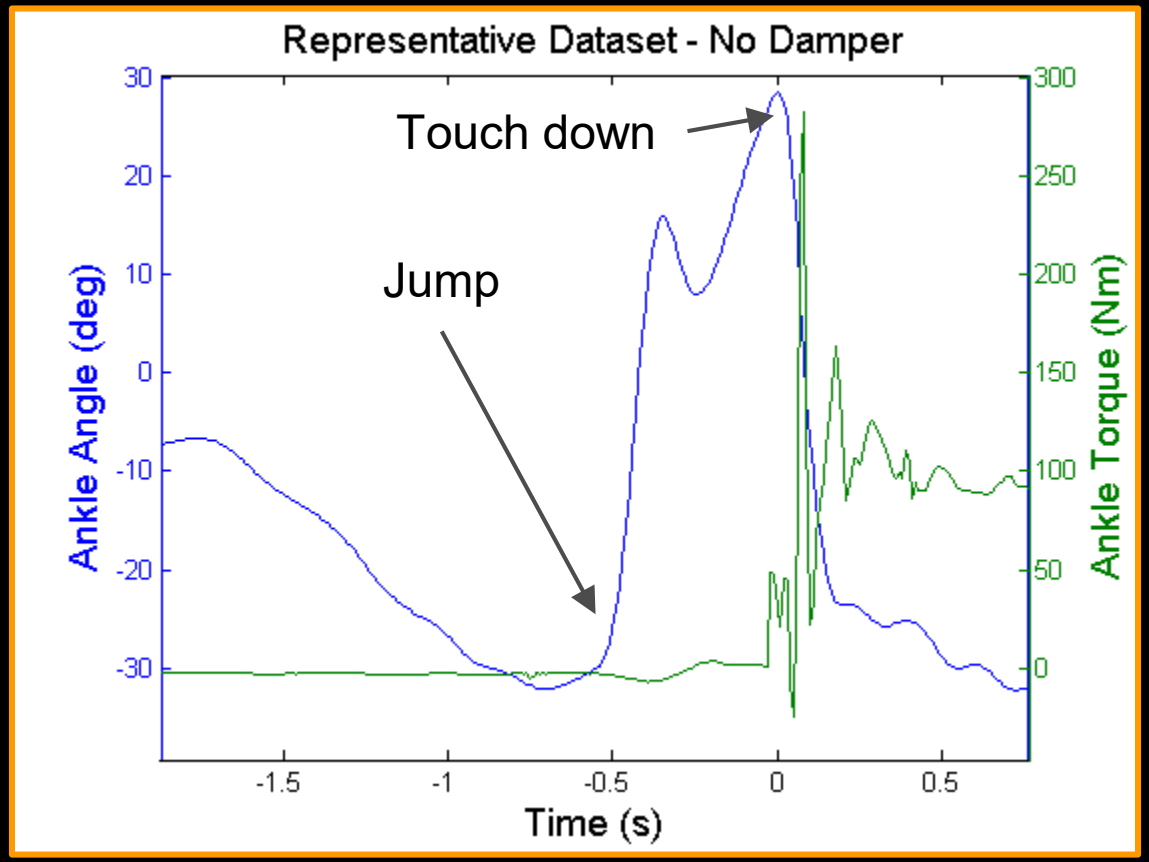


solid model
(*Vicon*)



torque/angles/velocities
(*SIMM*)

# Quantitative Results



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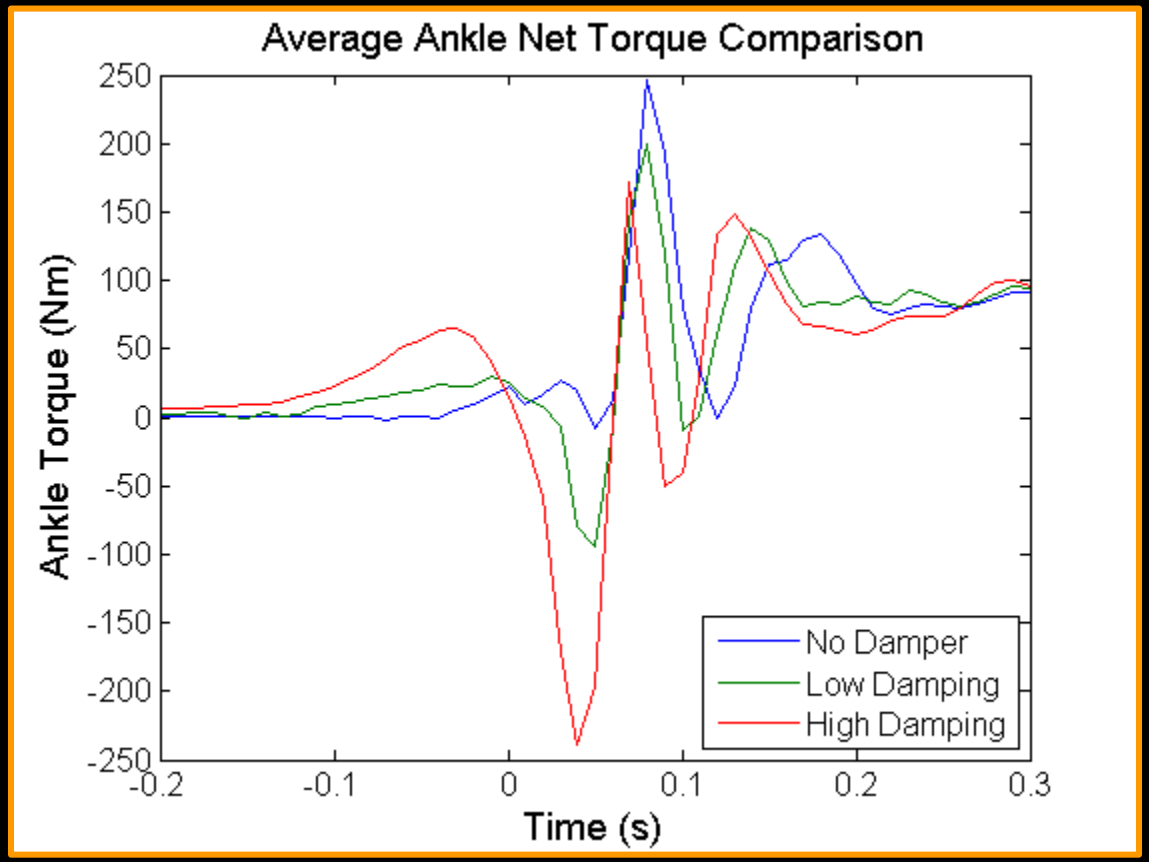

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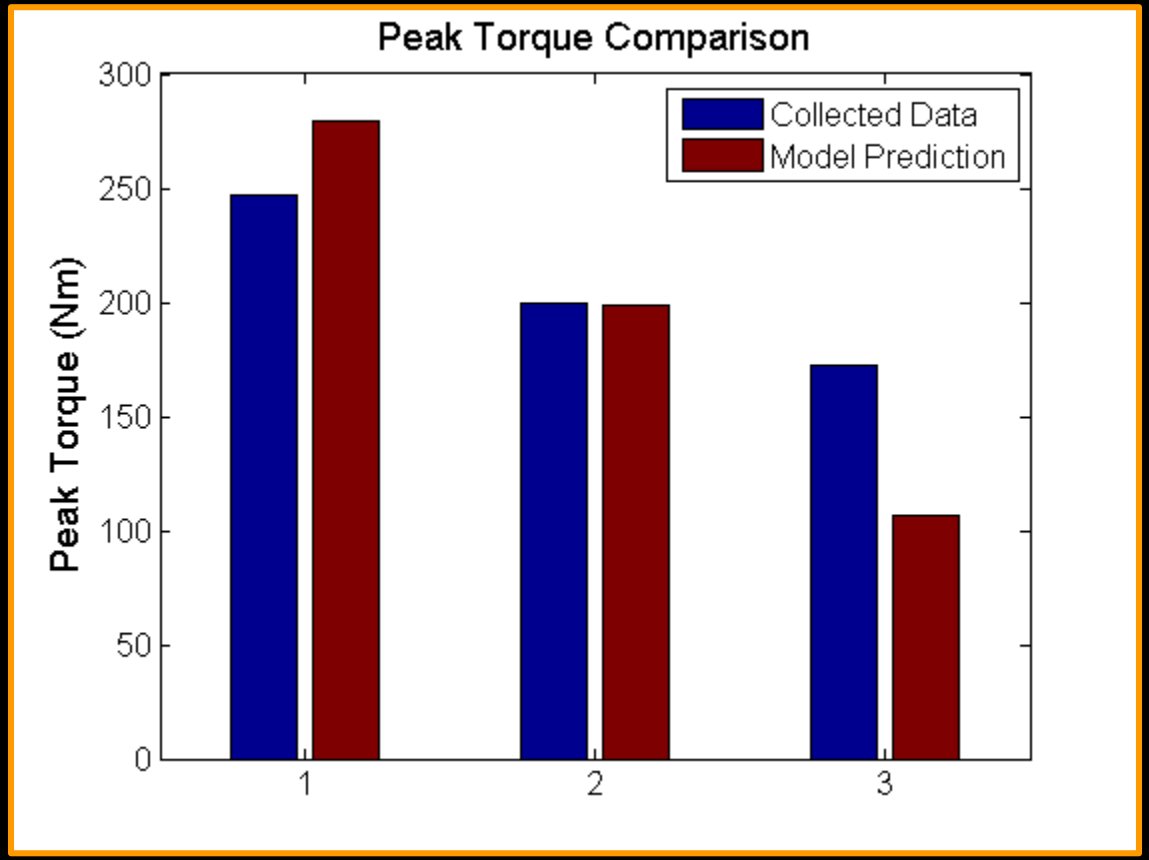

# Subject Feedback

- Subject 1
  - liked higher damping
  - learned how to land with device
  - shins got red
- Subject 2
  - ‘getting kicked in the shin’

# Future Work

- This week:
  - complete data analysis (GRF, knee torque, etc.)
- Beyond:
  - test from multiple heights
  - measure rather than model damper forces
  - expand exoskeleton to other joints

# Special Thanks

## Mentors

Luke Mooney, Michael Eilenberg, Tyler Clites

## Test Subjects

Brady Knight and Kyle Archer