Knee Joint Moments of Transtibial Amputees While Cycling

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INTRODUCTION

Main Goal

- Improve Quality of Life for Amputees
  - Rehabilitation
  - Exercise
    - Amputees less active than nonamputees [Bussmann, 2008]
  - Recreation

Cycling

- Currently used in Physical Therapy
  - Soft tissue injuries [Hunt 2004]
  - Spinal cord injuries [Sinclair 1996, Scremin, 1999, Gerrits 2001]
  - Cerebral palsy [Williams 2007]
  - Chronic heart failure [Jonsdottir 2006]
- Popular for general exercise and recreation

Amputee Cycling

- Popular among amputees
  - Recreational
  - Competative
- Possible for most amputation levels
- Little research
  - 1 leg cycling [Chin 2001, Chin 2002]
  - Effect of Prosthesis is unknown

[http://www.mtb-amputee.com]

Cycling Research

- Performance Enhancement
- Injury Prevention
- Enhanced Physical Rehabilitation

Cycling Research

- Various subject populations
  - Elite athlete
  - Rehabilitation population
- Various aspects
  - Conditioning
  - Muscle coordination – EMG
  - Biomechanics – Force/Moment/Power
  - Equipment setup

Cycling Research

- Biomechanics
  - Reaction force normal to the pedal [Gregor 1985]
  - Moment about the ankle, knee, and hip [Gregor 1985]
  - Limb asymmetry [Daly 1976, Hunt 2004]
  - Effect of saddle height and foot position [Ericson 1986]

Purpose

- Determine moment about the knee in persons with a trans-tibial amputation while cycling with a prosthesis.
- Baseline data

[www.ronwilliams.com]

Goals

- Baseline values of common measurements
- Understand how changes effect baseline
- Relate previous research to amputee populations

[http://picasaweb.google.com/stopmines/CyclingAgainstLandminesAVLoContreLesMines]

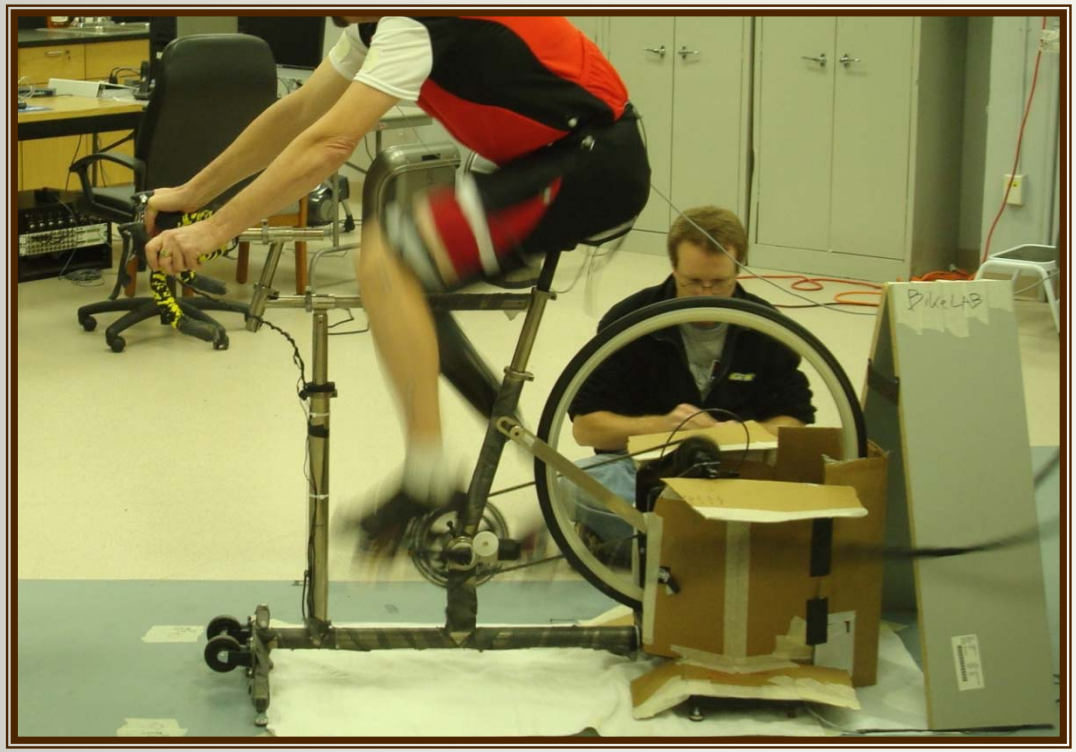
METHODS

Methods

- 3 subjects
  - 2 with unilateral transibial amputation
    - Experienced prosthetic user
    - Use current prosthesis and suspension
  - 1 intact
  - >6 months of cycling experience

Methods

- Vicon motion capture system
- Instrumented pedals
- Adjustable bicycle
- Standardized prosthetic foot

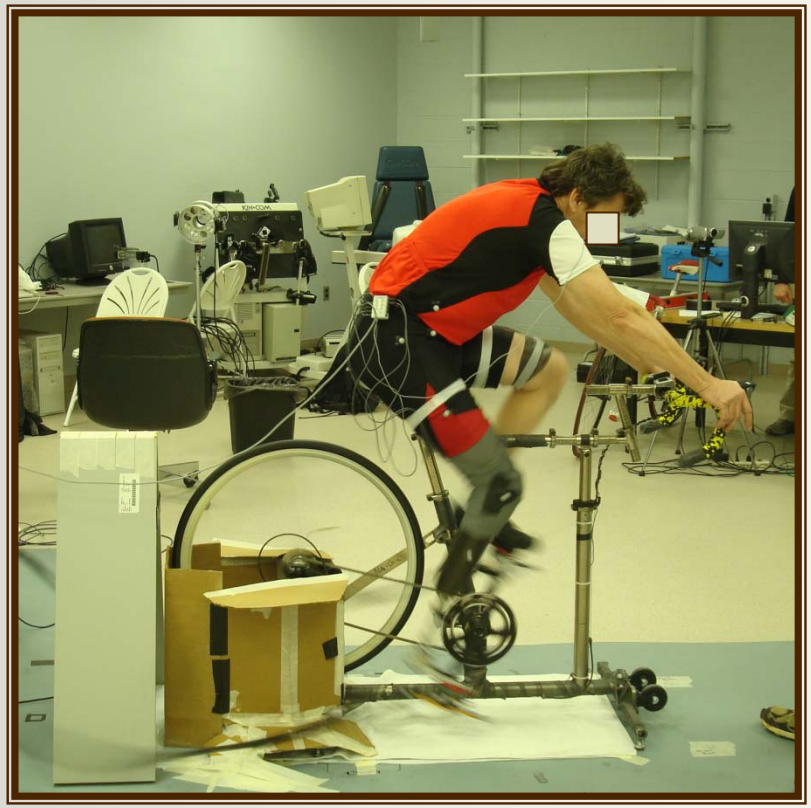


Methods

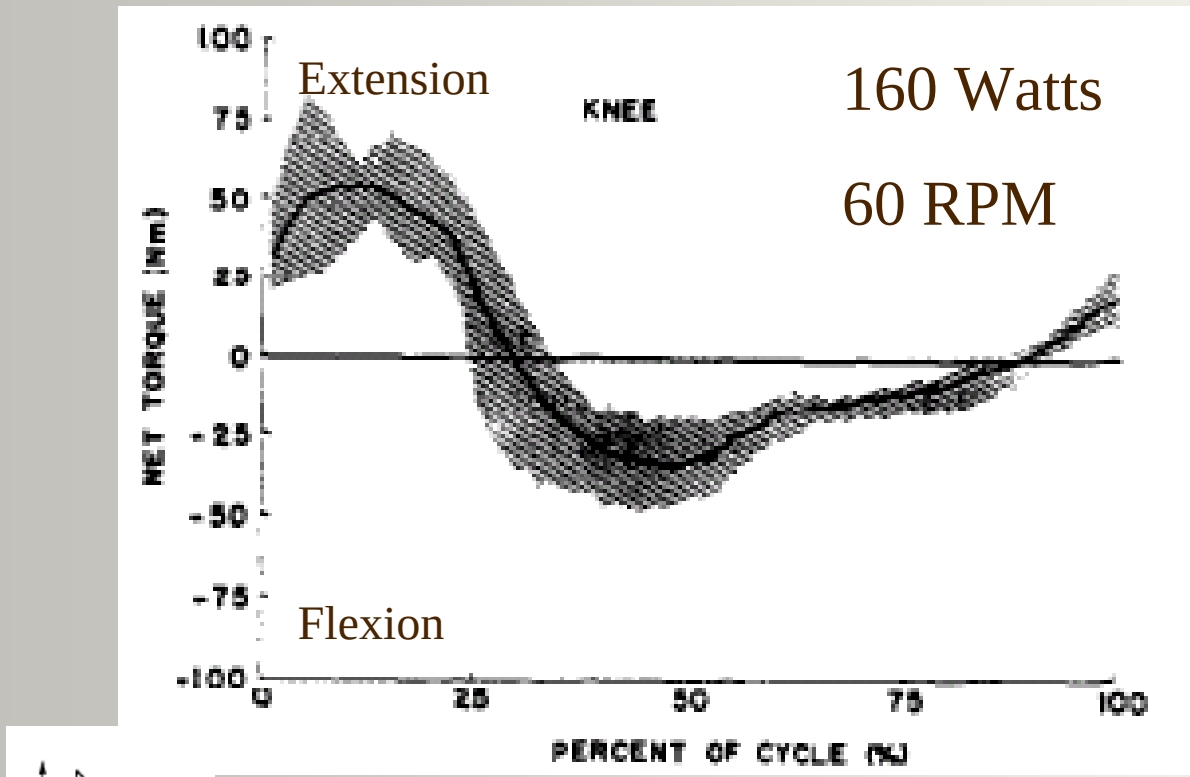
- 6 Cycling conditions
  - 3 loads
    - Self selected “Easy”
    - Self selected “Hard”
    - 100 W
  - 2 pedaling velocities
    - 60 rpm
    - 90 rpm

Methods

- Knee moment calculation [Prilutsky 2000]
  - Inverse dynamics
  - Program used previously
- Prosthesis characteristics
  - Inertial characteristics

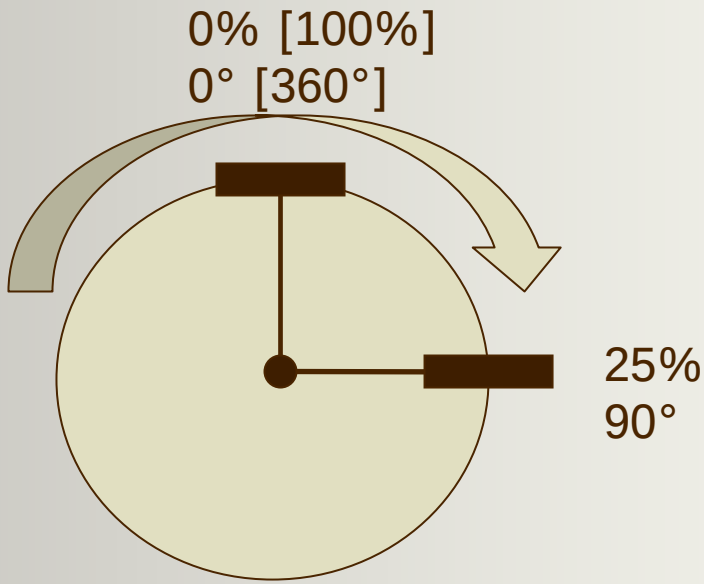


Expected Data



[Gregor 1985]

Expected Data



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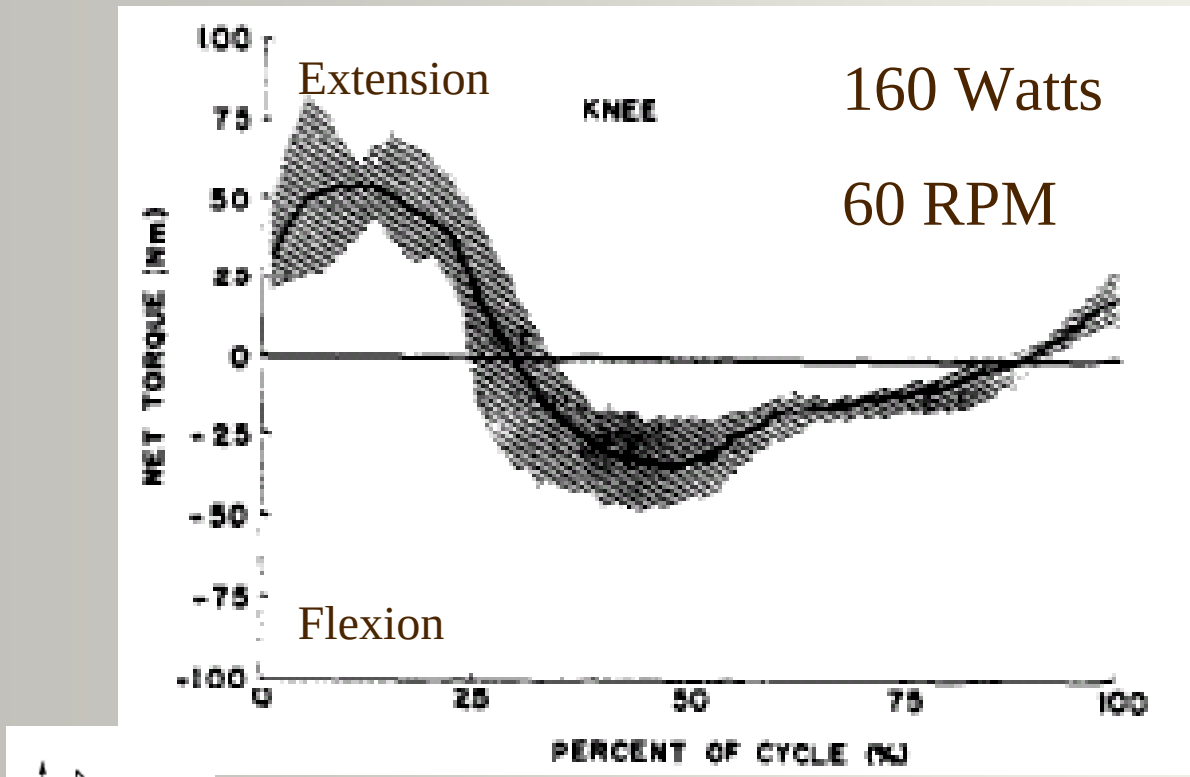
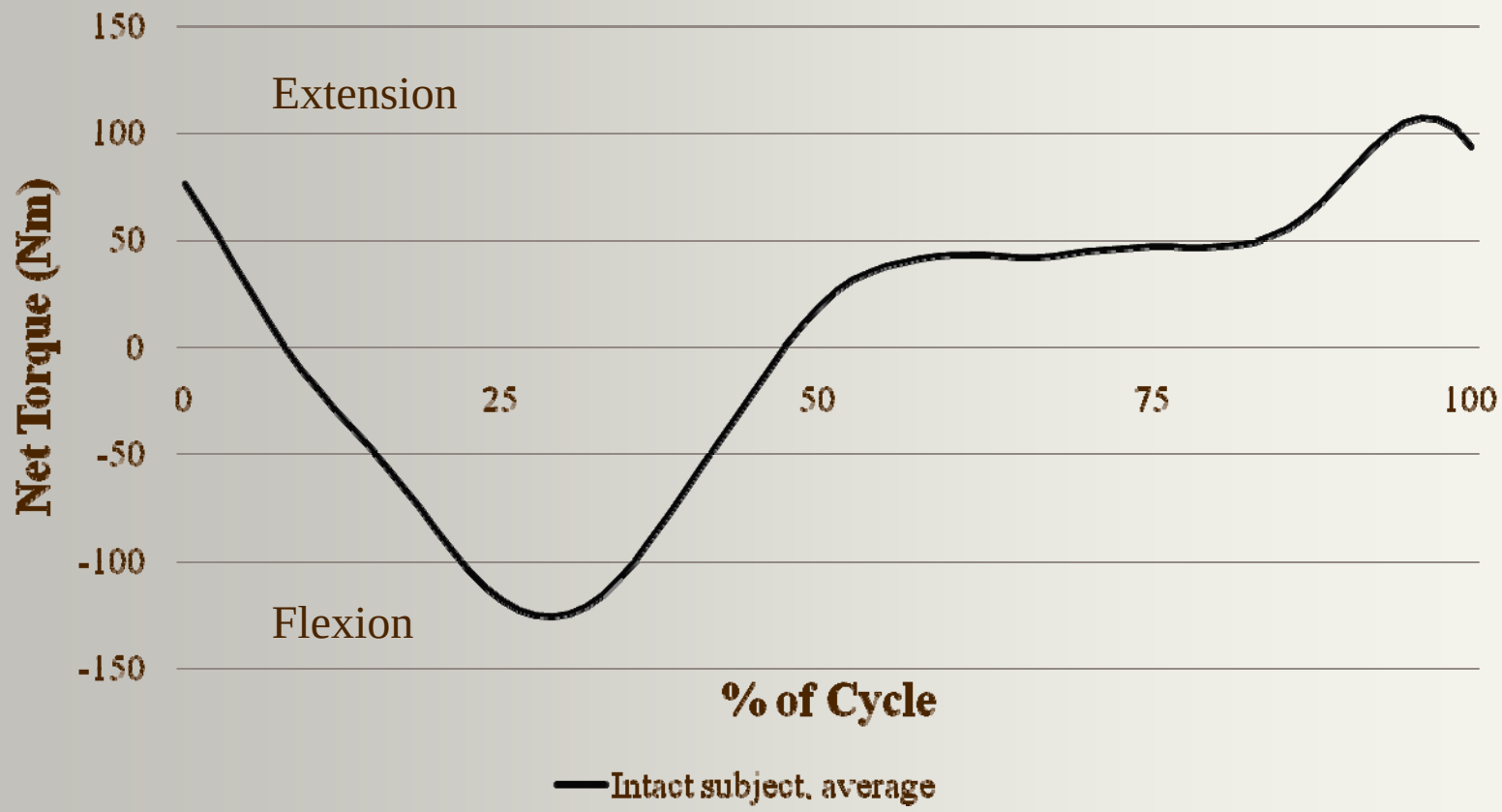


[Gregor 1985]

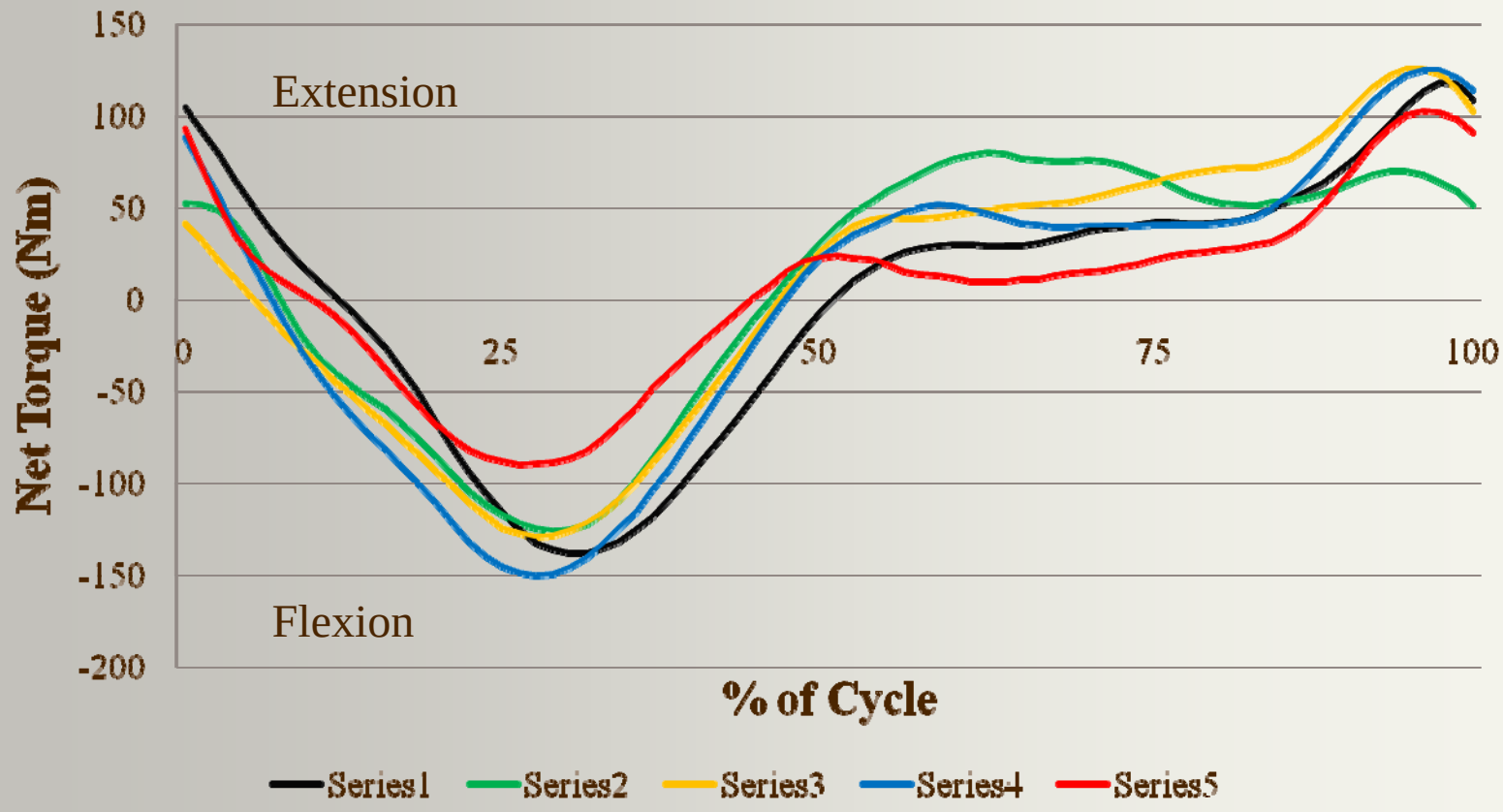
RESULTS

Intact Subject, Hard, 90 rpm



Self selected ‘Hard’ = 209 Watts

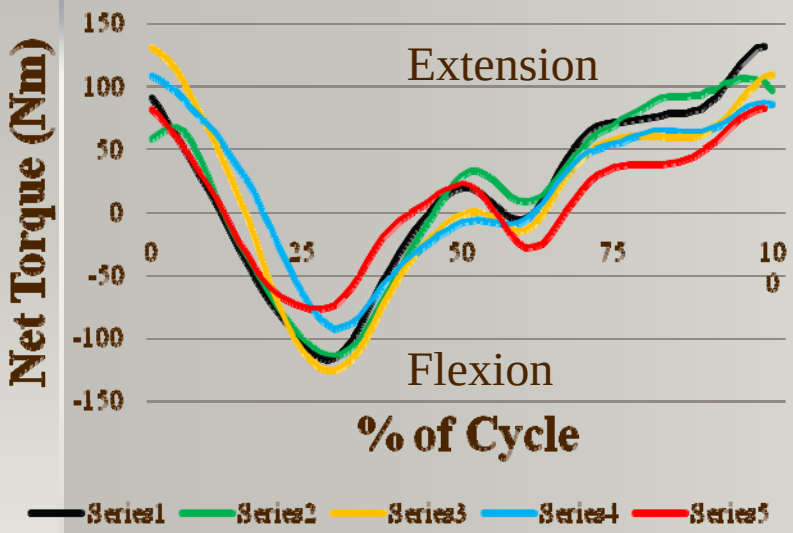
Intact Subject, Hard, 90 rpm



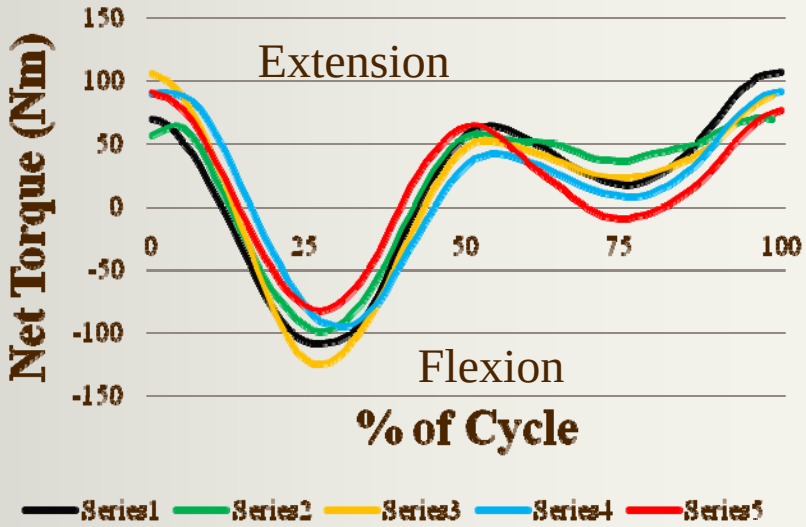
Self selected ‘Hard’ = 209 Watts

Amputee Subject, Hard, 90 rpm

Intact leg

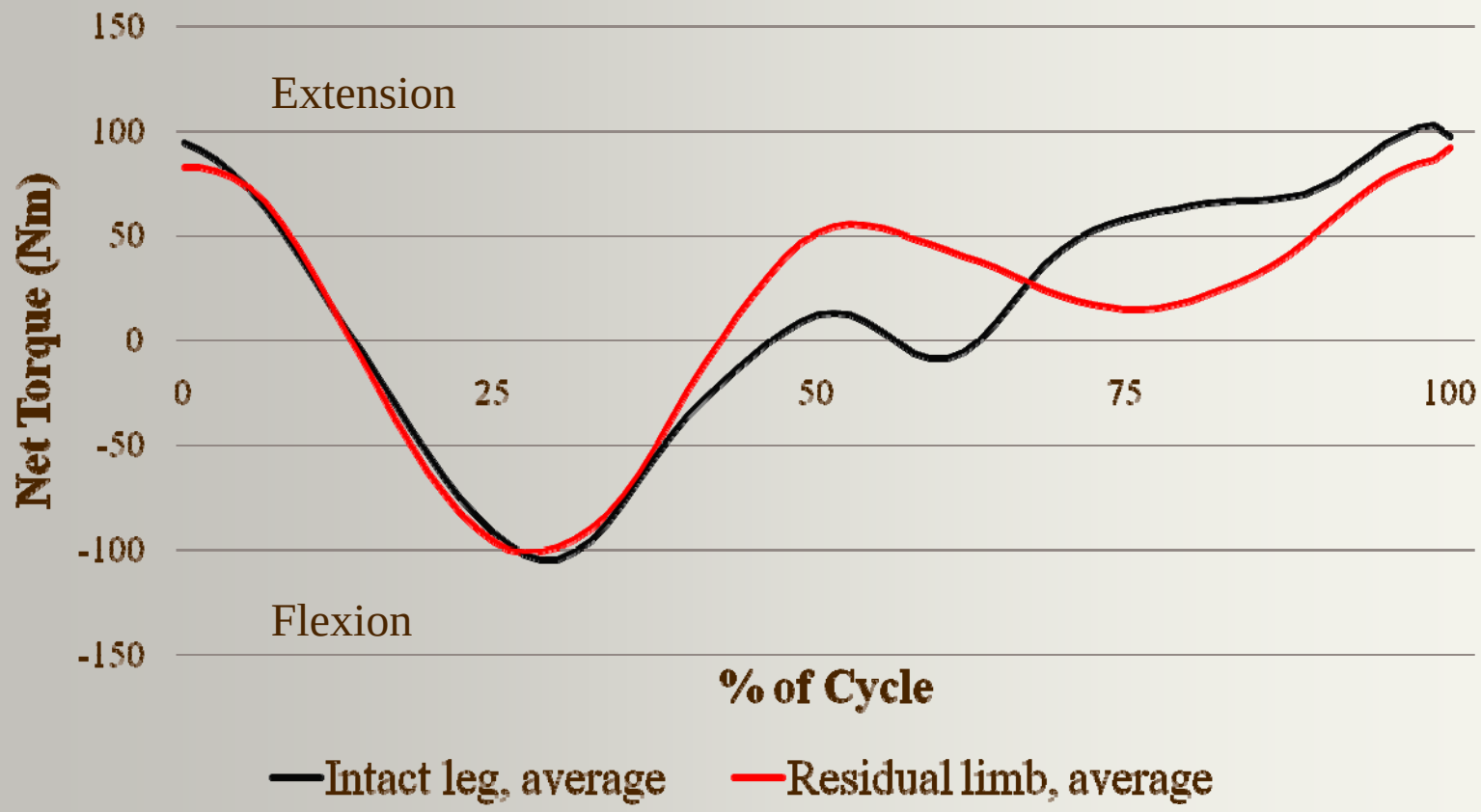


Residual limb



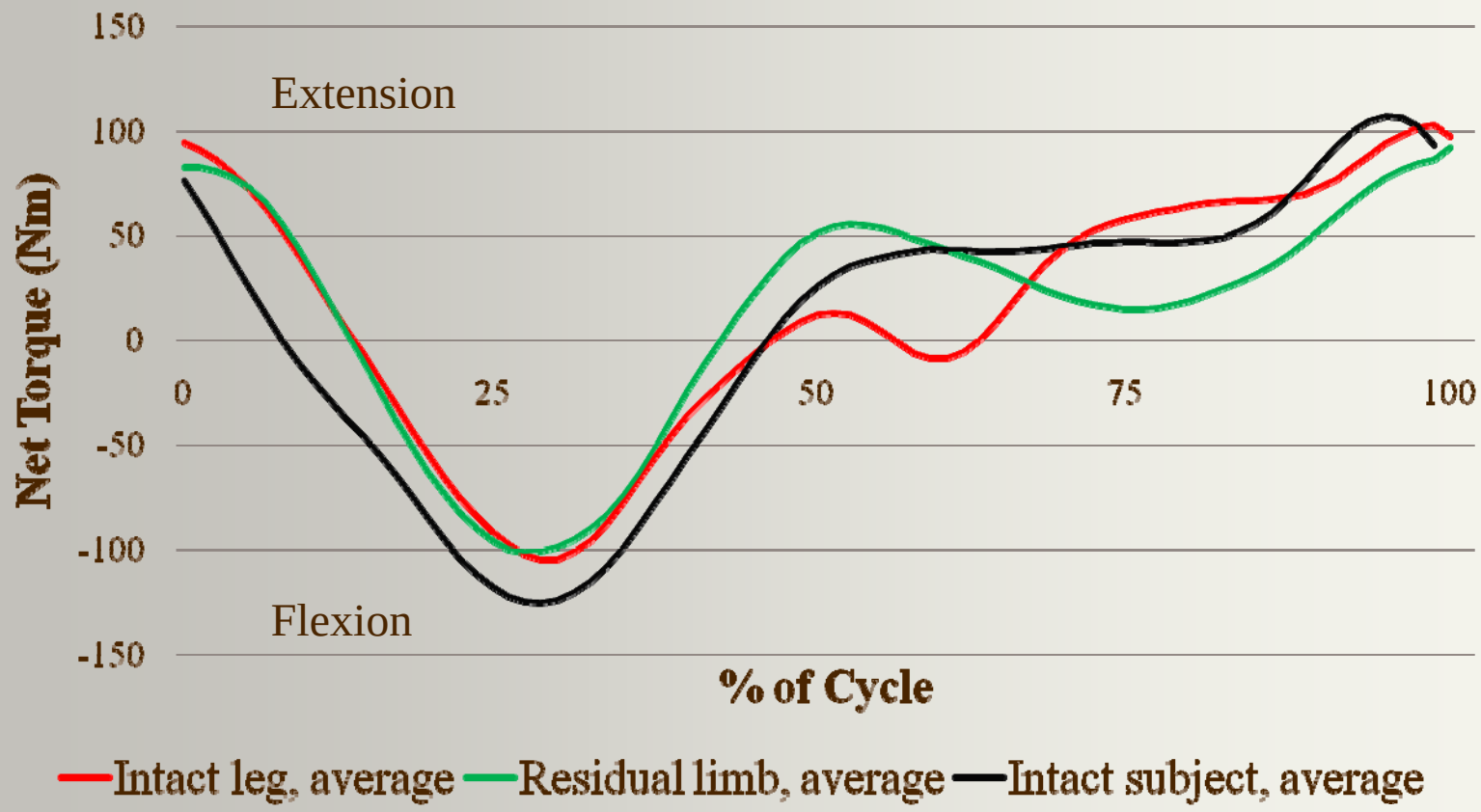
Self selected ‘Hard’ = 209 Watts

Amputee Subject, Hard, 90 rpm



Self selected ‘Hard’ = 209 Watts

Hard, 90 rpm, 2 subjects



Self selected ‘Hard’ = 209 Watts

Future Application

- Understanding effect of the prosthesis
  - Improve amputee cycling
    - Safer
    - More effective
- May impact rehabilitation programs
- May impact configuration
  - Prosthesis
  - Bike

Limitations

- Few subjects
- Experienced cyclists
- Characteristics of residual limb
  - Scan limb in future research

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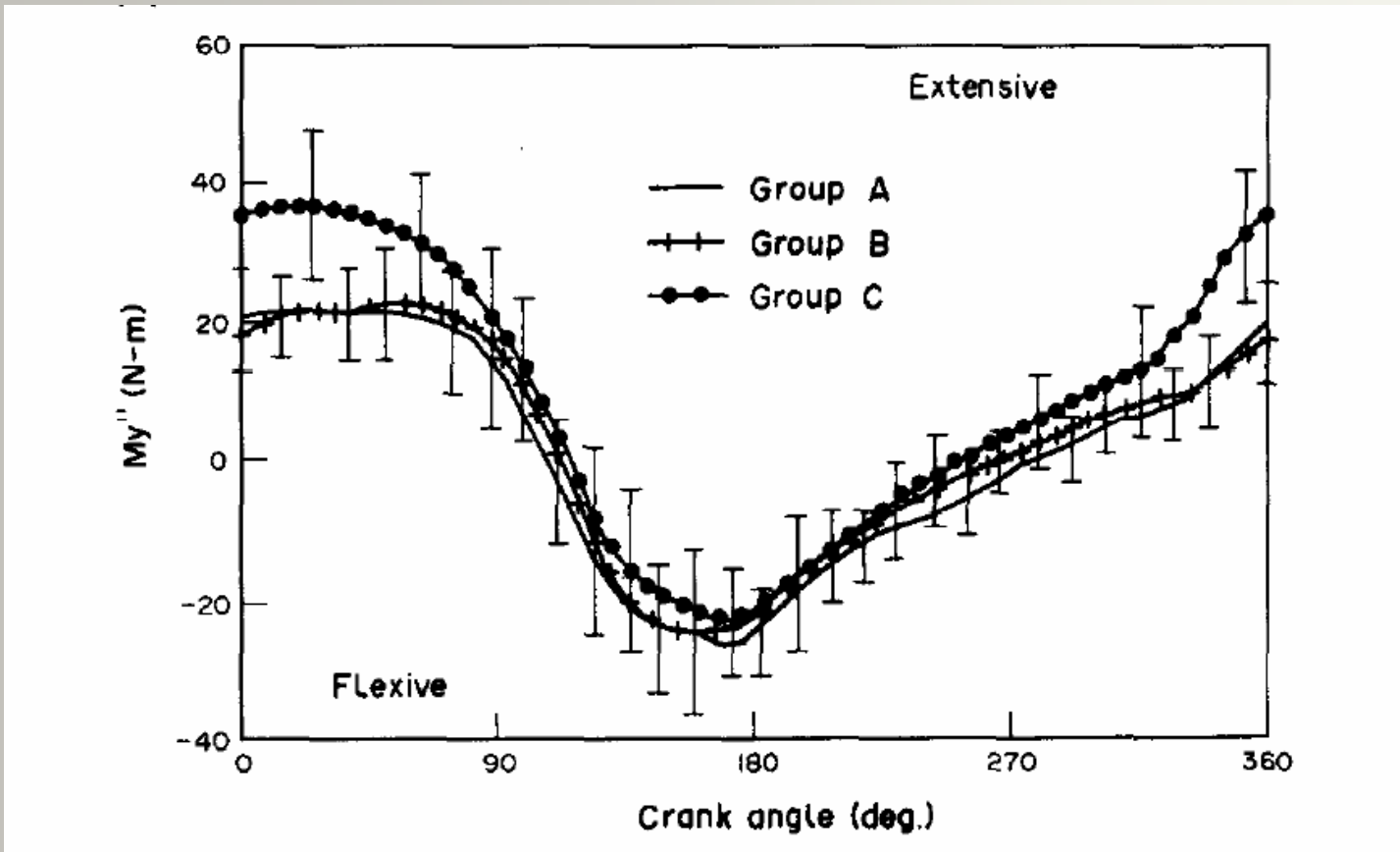
Questions?

Amputee Anthropometrics

- Prosthesis
  - Moment of Inertia [Street 2007]
    - Pendulum method
  - Center of Mass
- Theoretical “intact” body weight
- Residual limb
  - Theoretical mass
  - Interial characteristics
  - Assumed elliptical parabaloid

Expected Data



225 Watts, 90 RPM [Ruby 1992]

Overview

- Introduction
- Purpose
- Methods
- Results

Main Goal

- Modality
  - Walking
  - Running
  - Swimming
  - Bicycling

Others – level walking, stairs, etc.

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- Andriacchi TP, Andersson
- Other
  - Look into knee/muscle/cardio strength training/injuries in amputees
  - Look at http://www.kneeguru.co.uk/insights/doku.php/rehab/cycling01
- Ruby P, Hull ML, Hawkins D. Three-dimensional knee joint loading during seated cycling. *J Biomechanics* 1992;25(1):41-53.