Kinematic Effects of Sloped Surfaces on Shank Angle for Persons with Drop Foot

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Introduction

- Drop Foot: passive equinus or excessive ankle plantarflexion in swing phase (Perry)

- Orthotic Treatment
  - Traditional: Ankle Foot Orthosis (AFO)
  - Alternative: Functional Electrical Stimulation (FES) of peroneal nerve

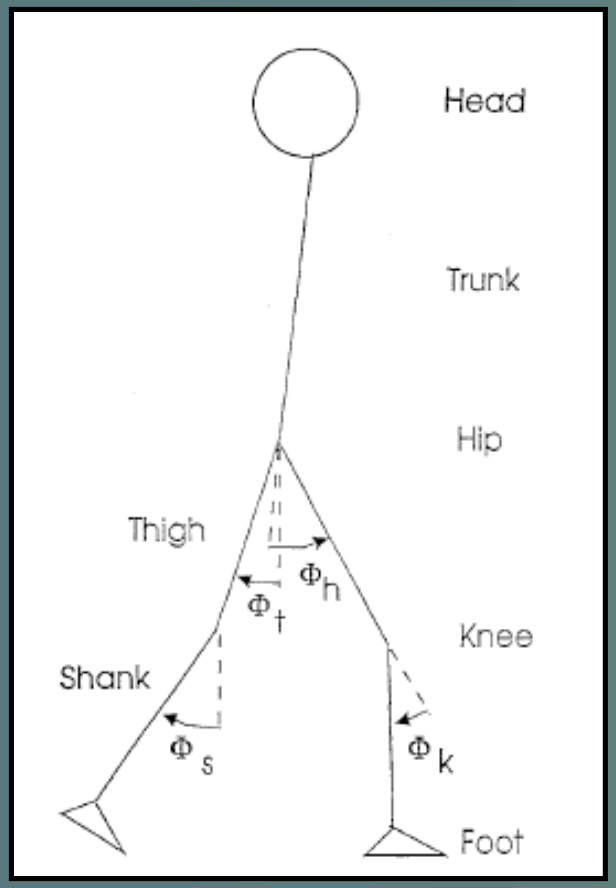
http://www.alimed.com

Functional Electrical Stimulation (FES)

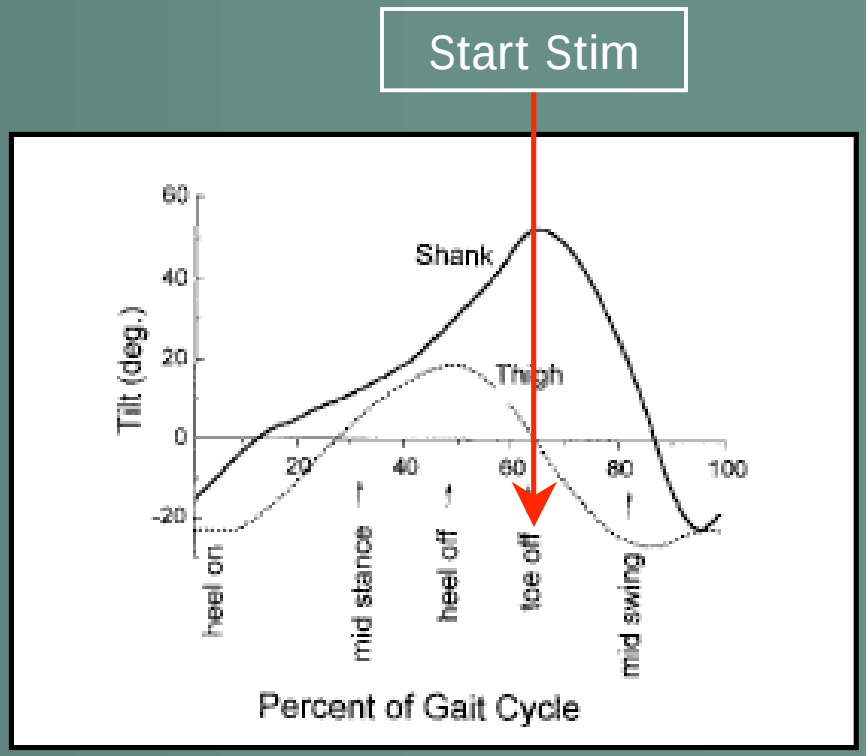
- Peroneal Nerve Stimulators (PNS)
  - First described in 1961 by Liberson
  - Must control timing of stimulation → want stimulation at toe off
- Types of PNS Regulators
  - Heel sensor (Liberson 1961)
  - EMG sensors (Lyons 2002)
  - "Natural" sensor – sural nerve (Haugland 1995)
  - Tilt sensor (Dai et al, 1996)

http://www.walkaide.com

Tilt Sensor



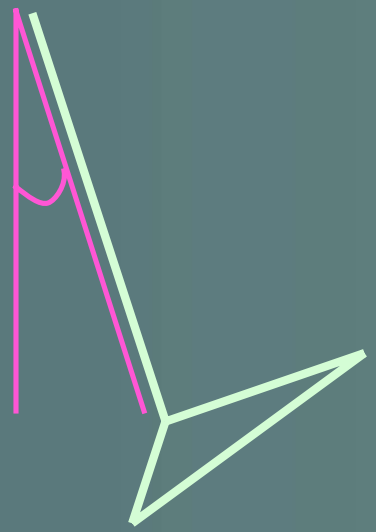
Dai et al, 1996



Dai et al, 1996

Shank Angle & Phases of Gait

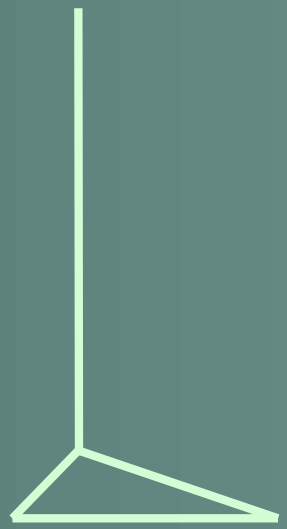
$f_s(-)$



Heel Strike

(Initial Contact)

$f_s=0$



Mid-Stance

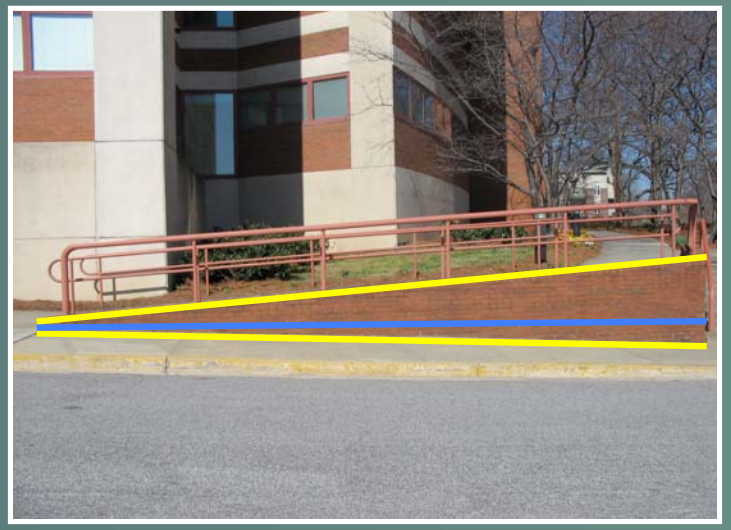
$f_s(+)$

Toe-off

(Pre-swing)

Purpose

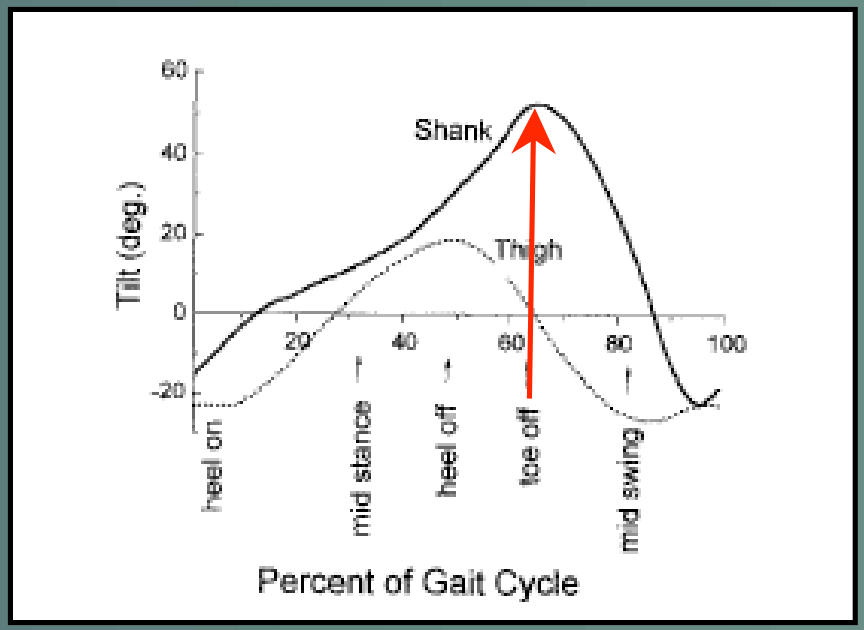
- Describe differences in shank angle when walking on inclined/declined surfaces compared to a flat surface



- Determine if tilt sensor FES control is reliable on inclined/declined surfaces.

Hypothesis

- Shank angle at toe off will be significantly different on inclined/declined surfaces compared to a flat surface.



Dai et al, 1996

Methods: Subjects

- Inclusion criteria:
  - Unilateral drop foot
  - Own and use a Walk Aide
  - Over 18 years of age
- n=7
  - Gender: 3 Female , 4 male
  - Average Age: 59.04 yrs (STD=11.42)
  - Dx: 4 Multiple Sclerosis, 2 CVA, 1 TBI
  - Time using Walk Aide: 2 mos to 2 yrs

Methods: Protocol

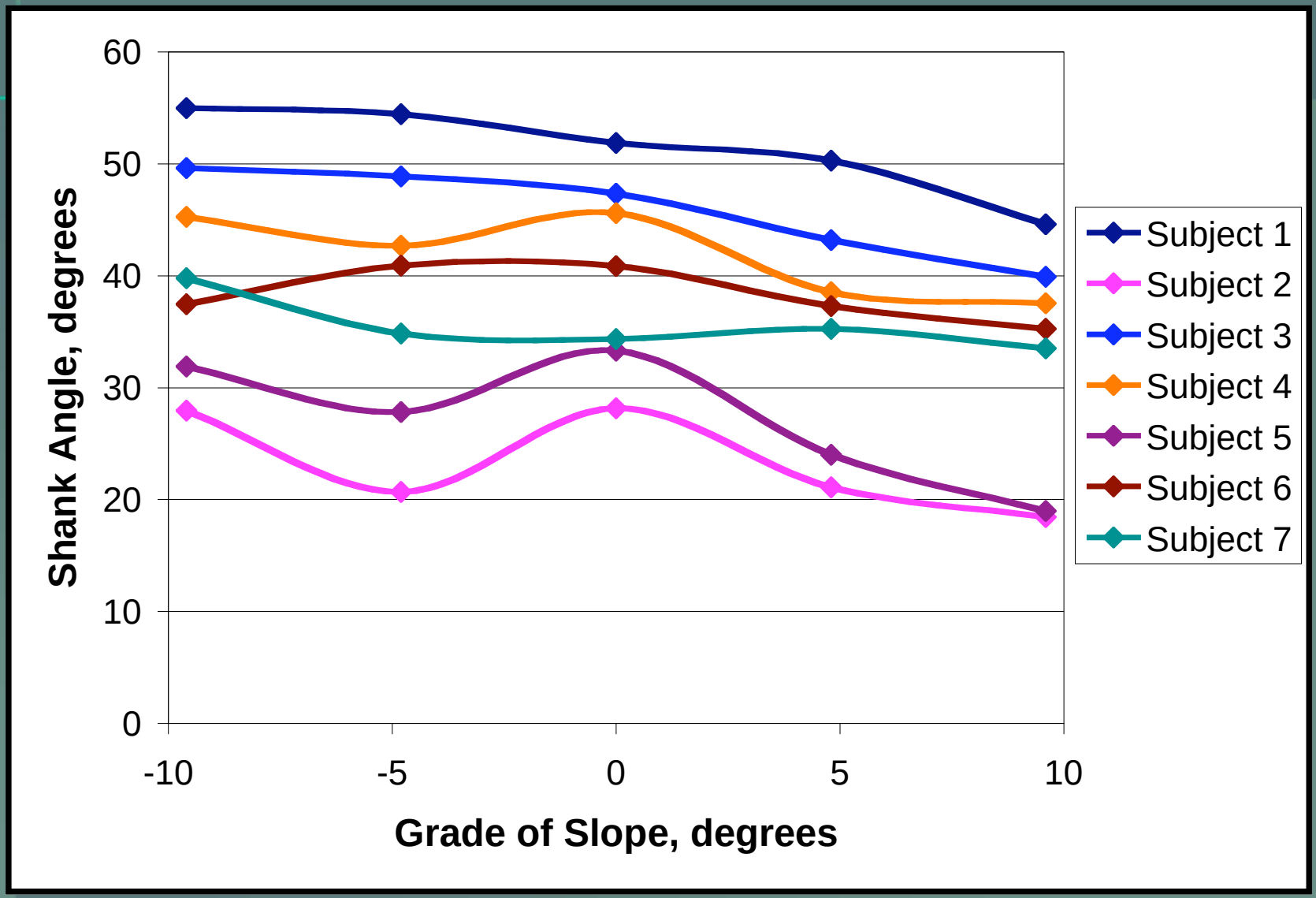
- Vicon motion analysis system
- Standard Lower Extremity marker set
- Walk Aide setup “as is”
- Walking speed self-selected

Methods: Equipment

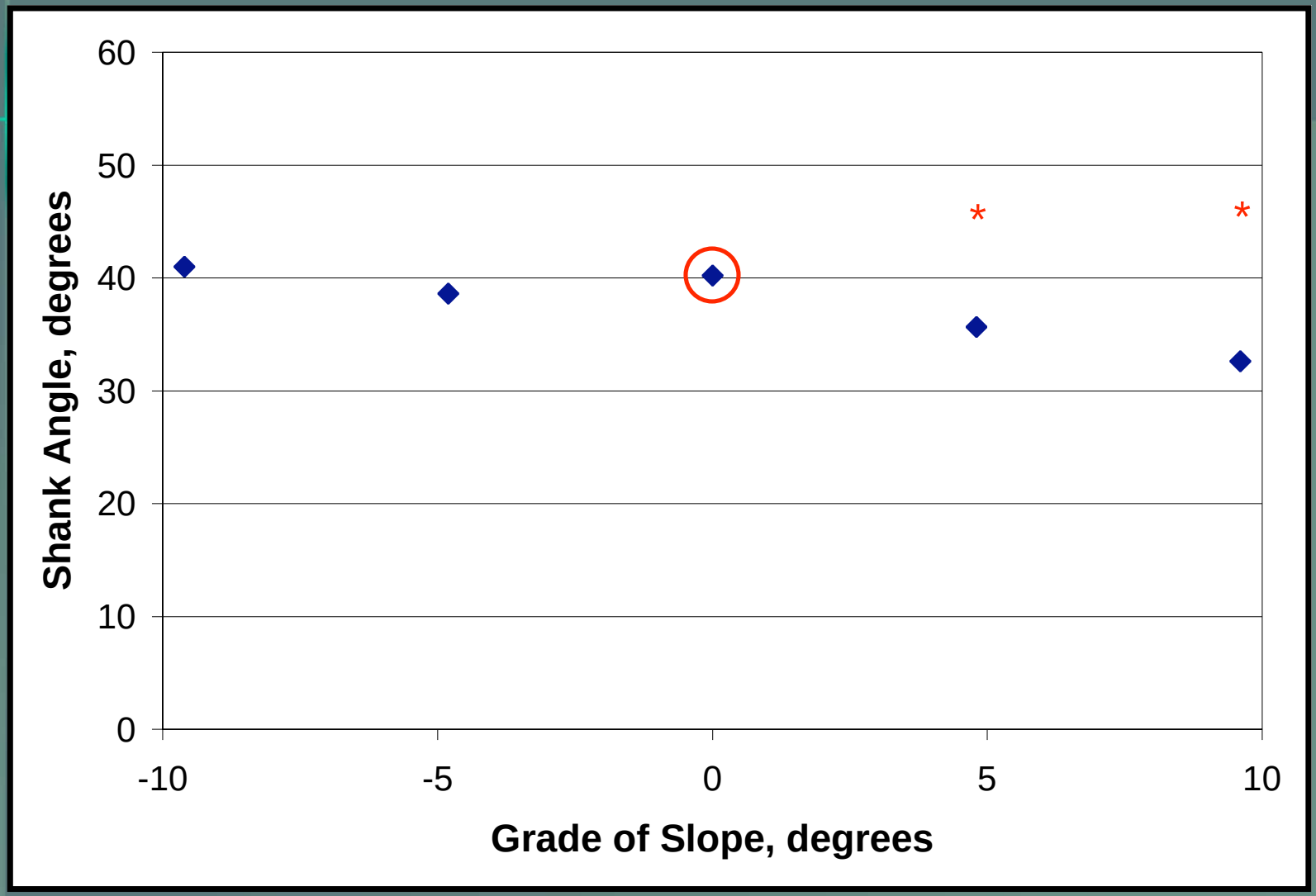
- Flat surface
- Two stationary ramps
  - Wood
  - Modular Design
  - 8’ Length
  - 4.8^{o} and 9.6^{o}

Results

Shank Angle at Toe Off



Shank Angle at Toe Off



* indicates significant difference from 0 degree condition ($p<0.05$)

Conclusion

- ✓ Hypothesis
  - Shank angle at toe off IS significantly different (lower) on inclined surfaces compared to a flat surface.
- ✗ Hypothesis
  - Shank angle at toe off IS NOT significantly different on declined surfaces compared to a flat surface.

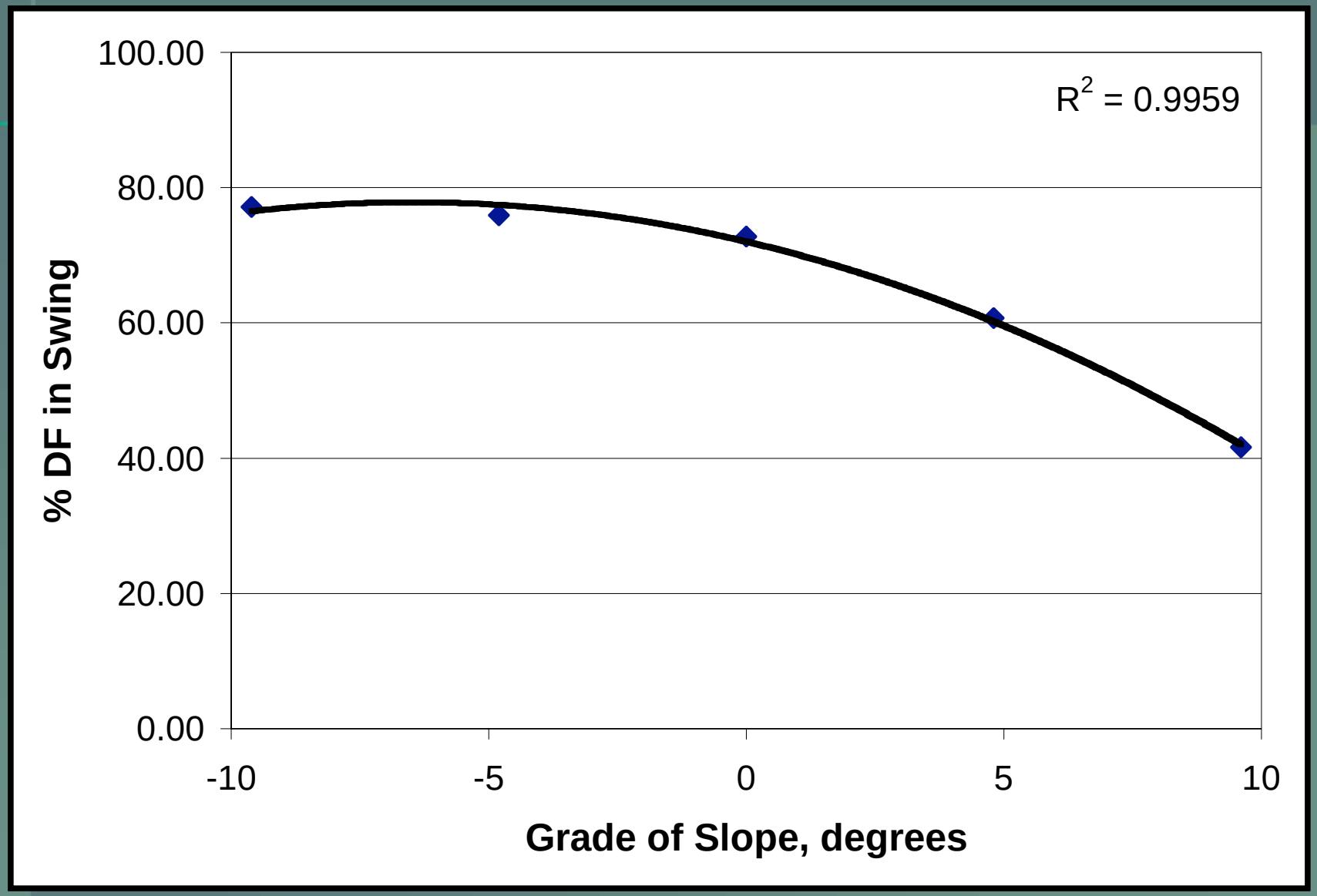
Discussion: Shank Angle

- Key Finding: Shank angle at toe off is significantly reduced for both inclined surfaces compared to a flat surface.

- Clinical Application: Does this affect stimulation?

  YES

% Dorsiflexion in Swing



Limitations and Future Research

- Limitations
  - Short ramps → limited strides observed
  - Did not directly monitor performance of Walk Aide
- Future Research
  - Monitor operation of the FES device on different sloped surfaces.
  - If stimulation is reduced on sloped surfaces, determine if this is detrimental to patients.
  - Smart sensors? → Cikajlo et al, 2008

References

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Questions?

http://www.vimeo.com/

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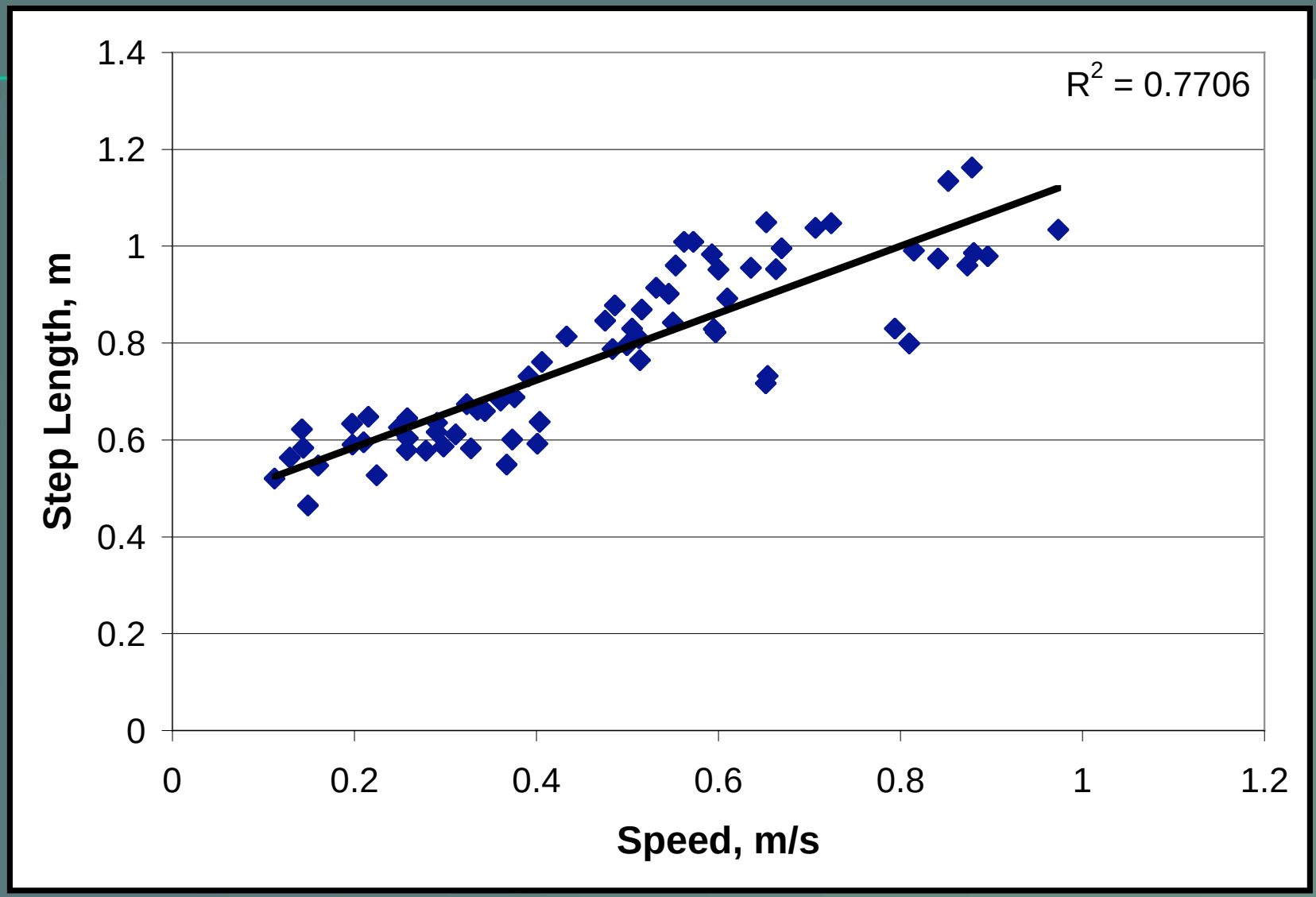
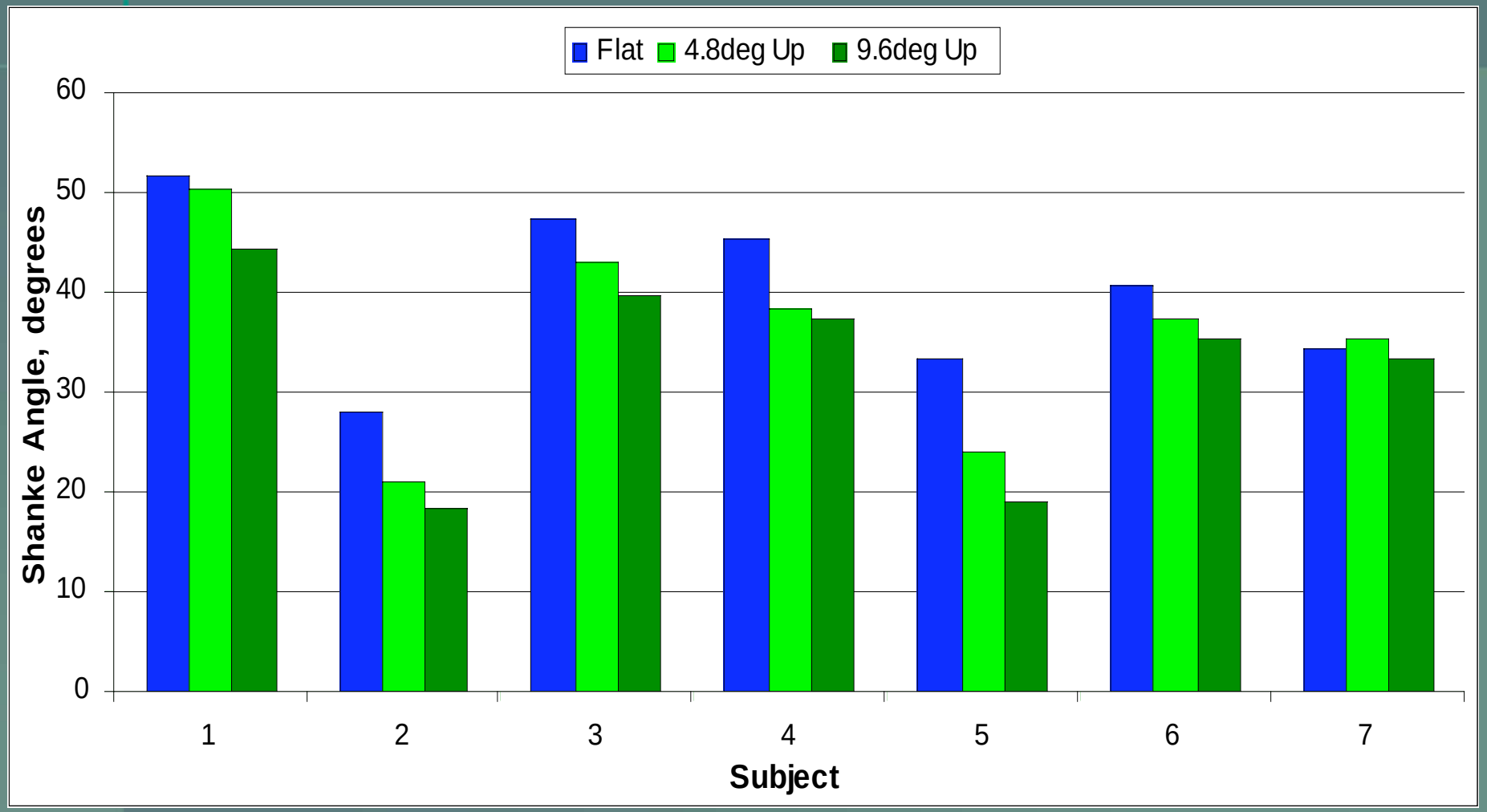
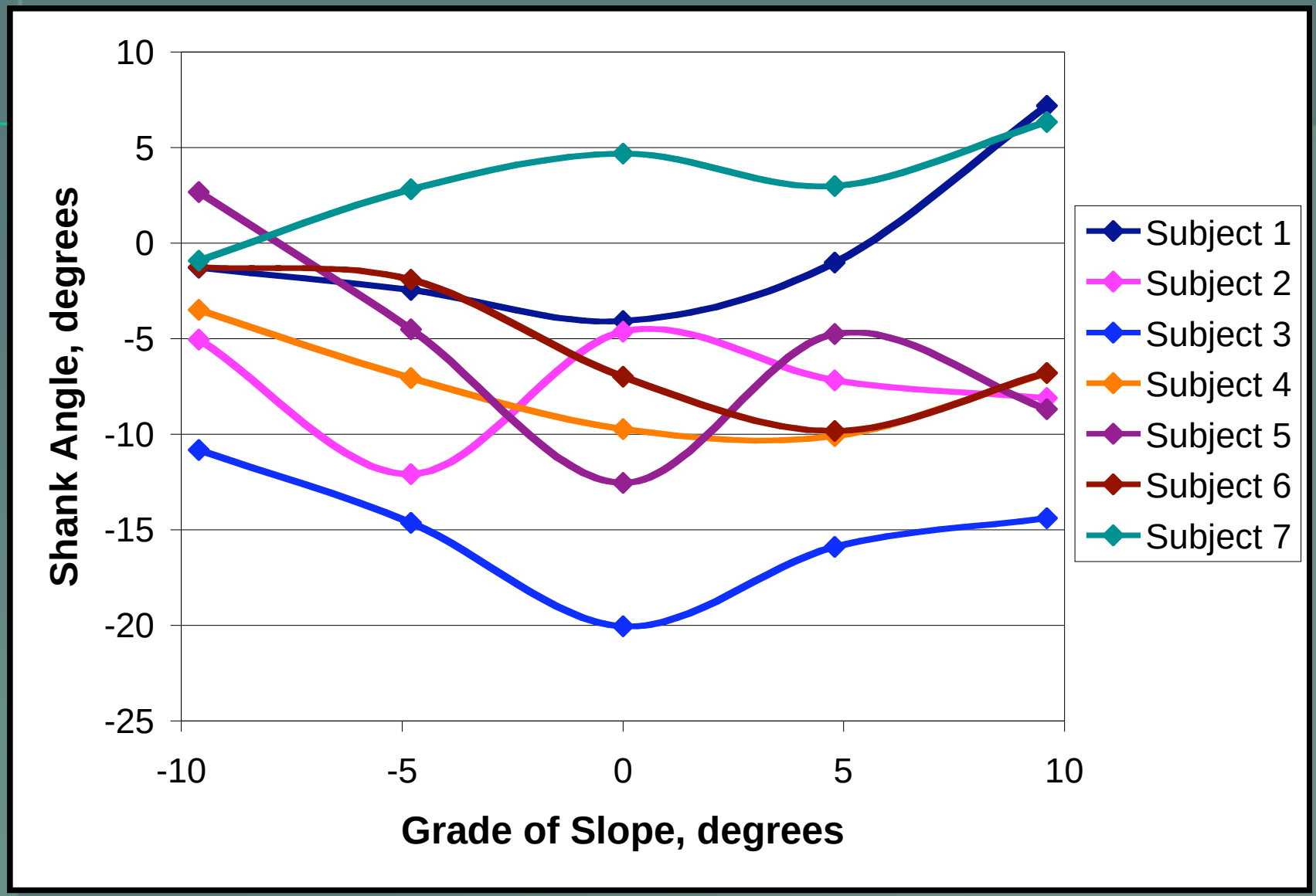
Step Length vs Speed



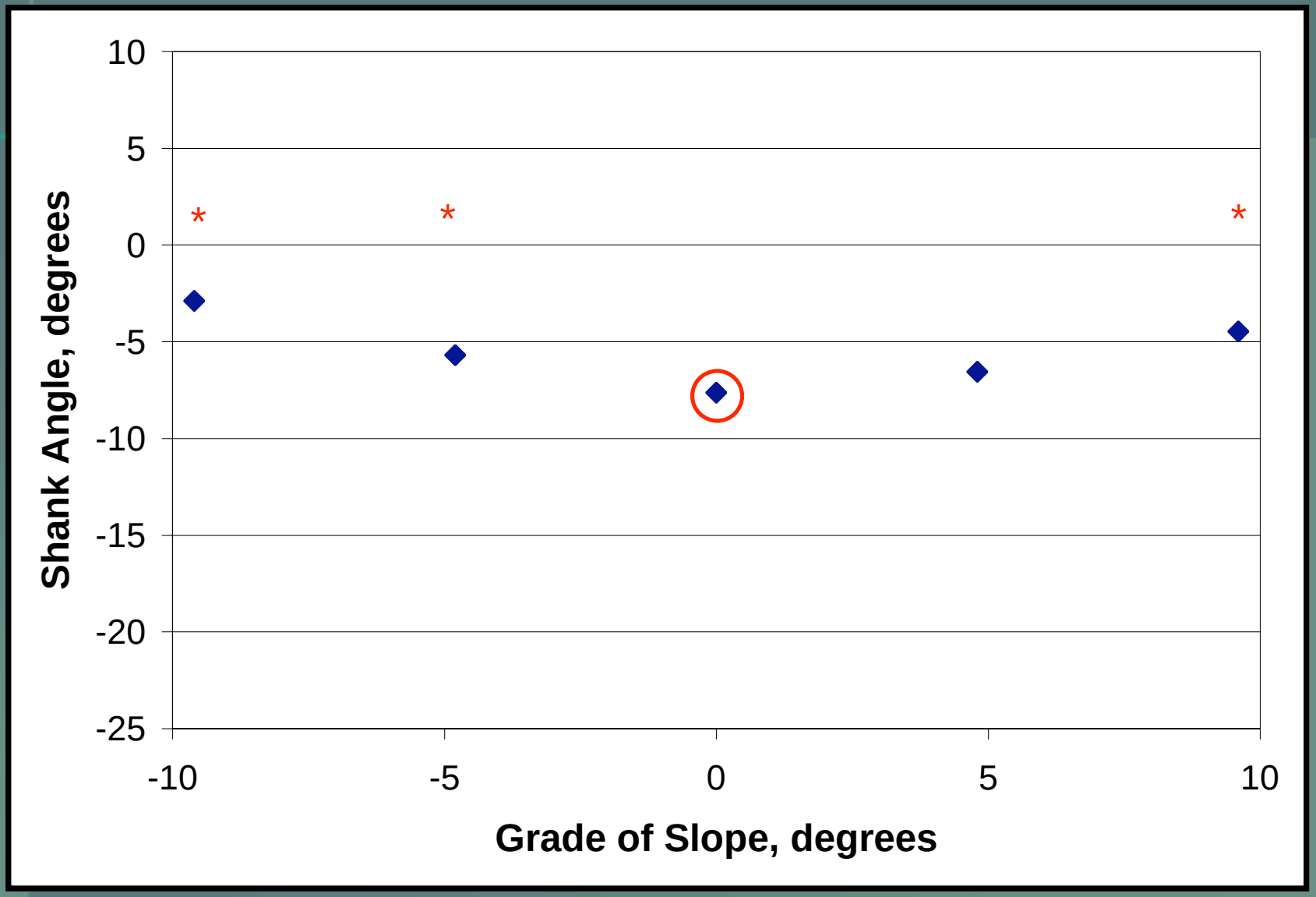
Shank Angle at Toe Off



Shank Angle at Heel Strike



Shank Angle at Heel Strike



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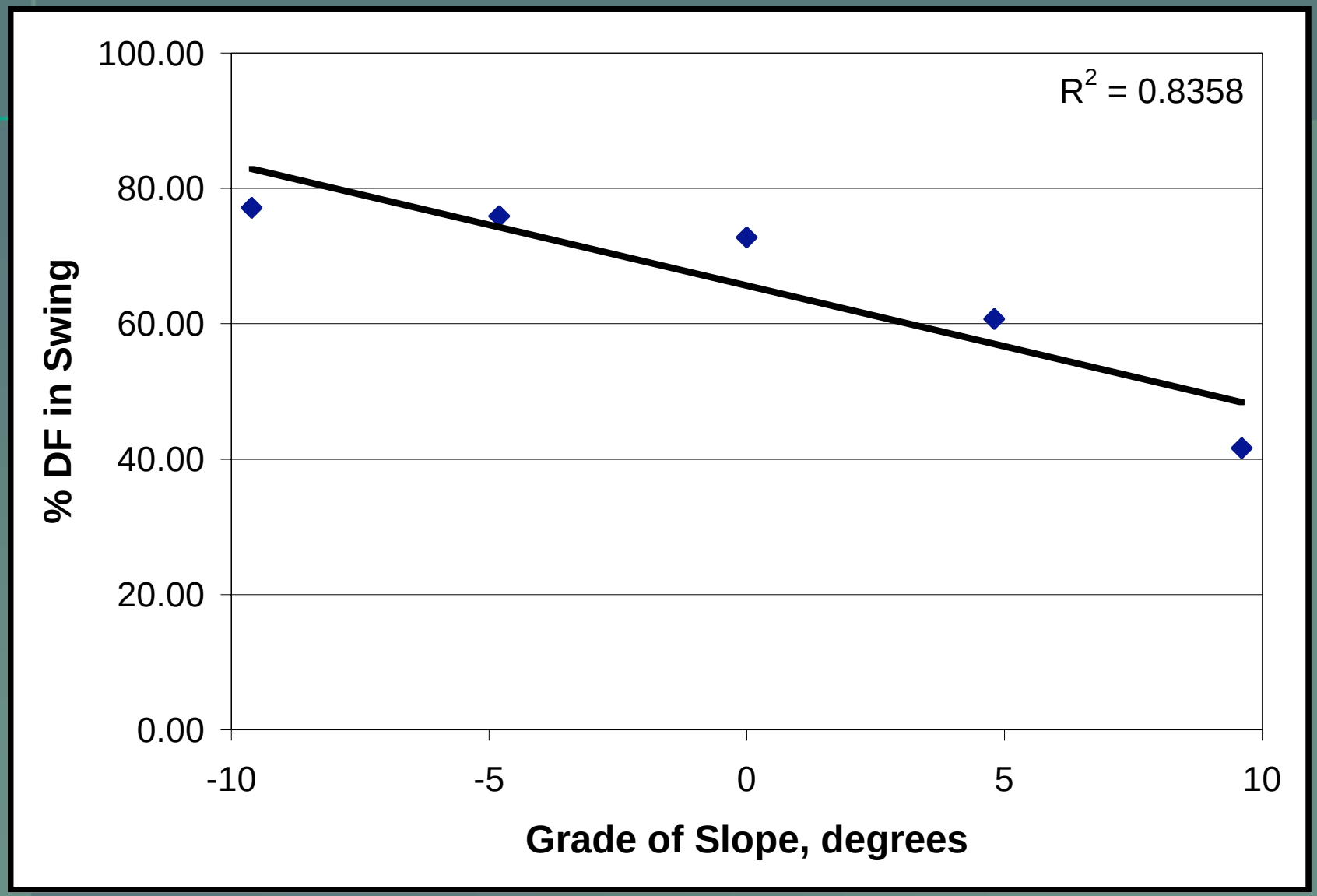
% Dorsiflexion in Swing



Outline

- Introduction/Background
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- Hypothesis
- Methods
- Results
- Discussion