Musculoskeletal Modelling in Physical Rehabilitation

Lauren Kark (lauren.kark@unsw.edu.au)

Never Stand Still | Faculty of Engineering | Graduate School of Biomedical Engineering

Aims and Objectives

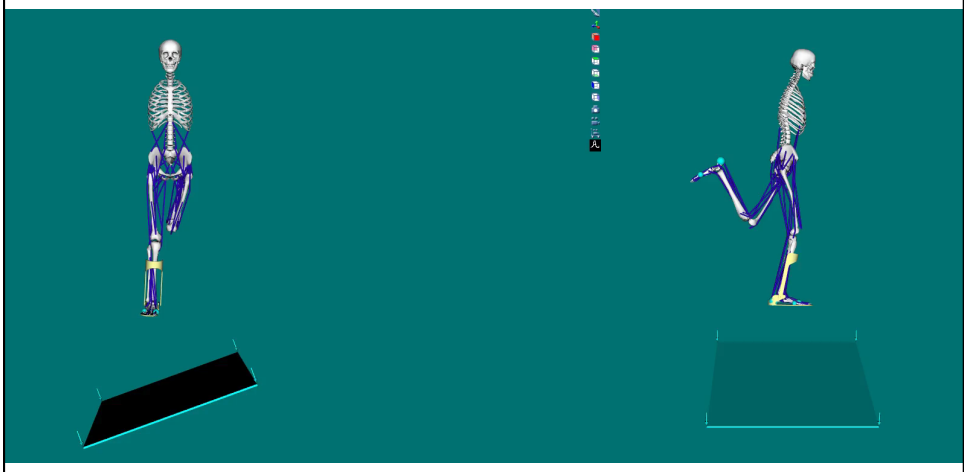
This lecture aims to:

- Introduce musculoskeletal modelling in physical rehabilitation

Following this lecture you should be able to:

- Describe the anatomy of the ankle
- Discuss the biomechanics of the ankle
- Describe the ways in which the ankle can be injured
- List current methods for preventing ankle injuries
- Develop design criteria for an optimal ankle brace
- Discuss how musculoskeletal modelling can be used to assess the efficacy of new designs of medical technology associated with human movement

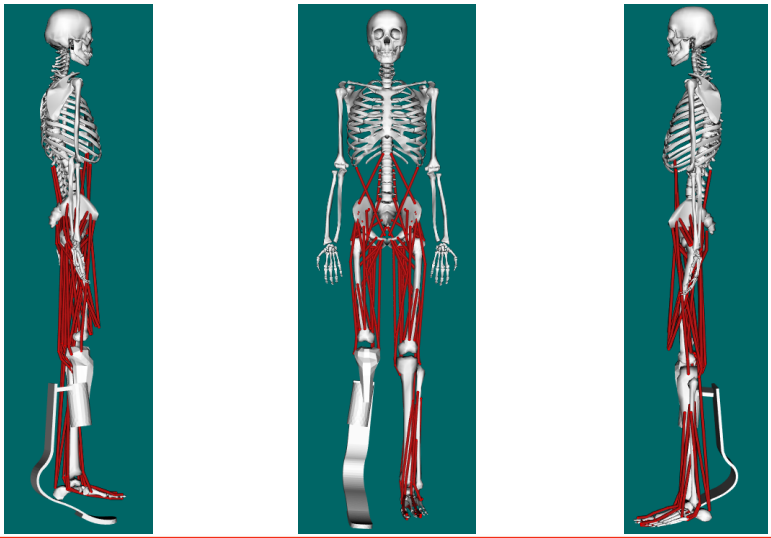
Introduction



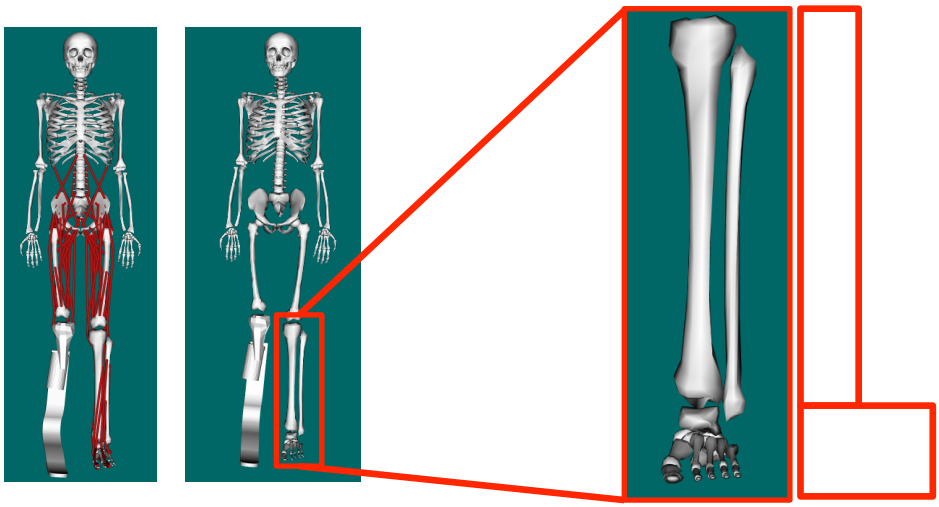
Today

1. Anatomy
2. Injuries
3. Mechanics of Injuries
4. Prevention
5. Musculoskeletal modelling

Anatomy

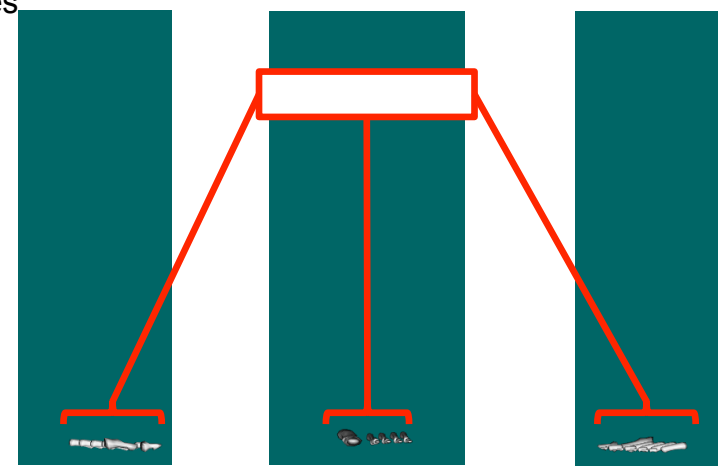


Bony Anatomy (I)



Bony Anatomy (II)

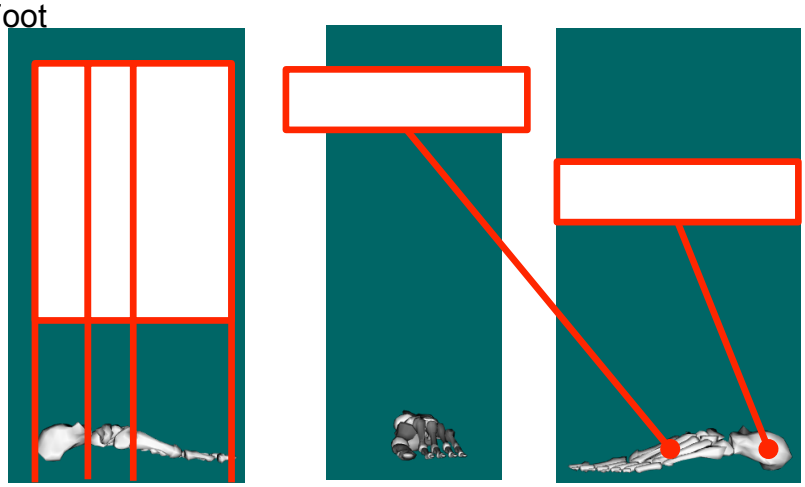
Toes



Medial View | Anterior View | Lateral View

Bony Anatomy (III)

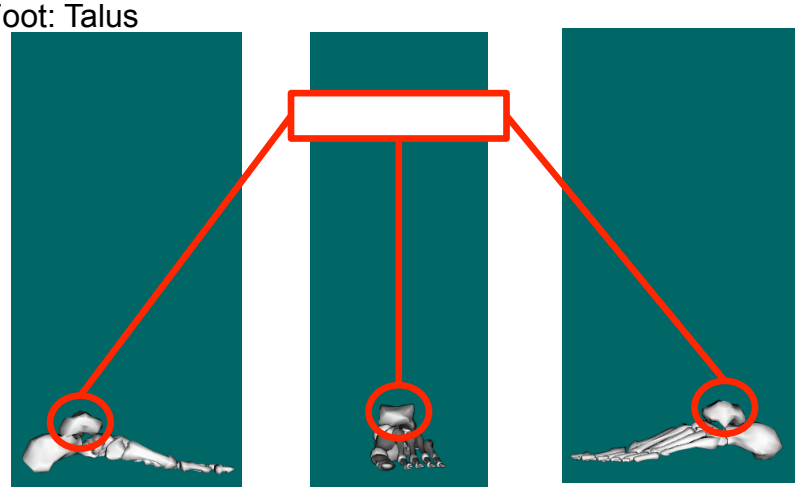
Foot



Medial View | Anterior View | Lateral View

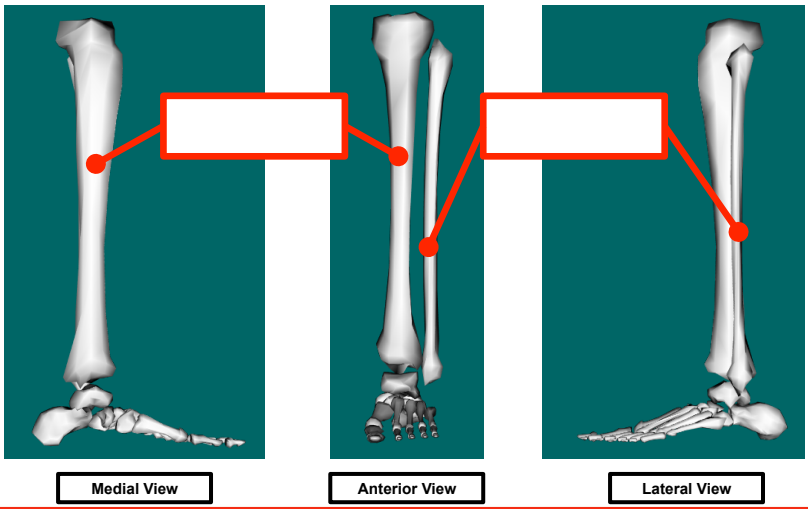
Bony Anatomy (IV)

Foot: Talus

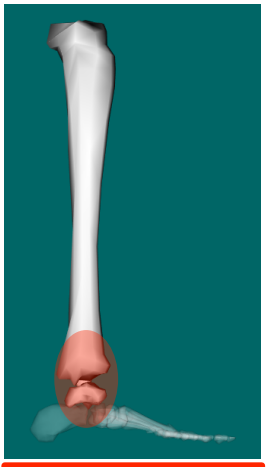


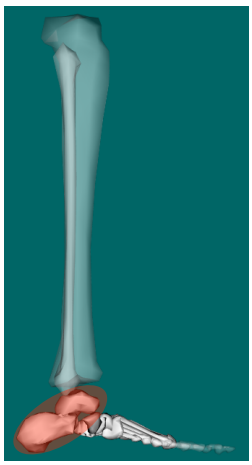
Bony Anatomy (V)

Tibia and Fibula



Joints (I)

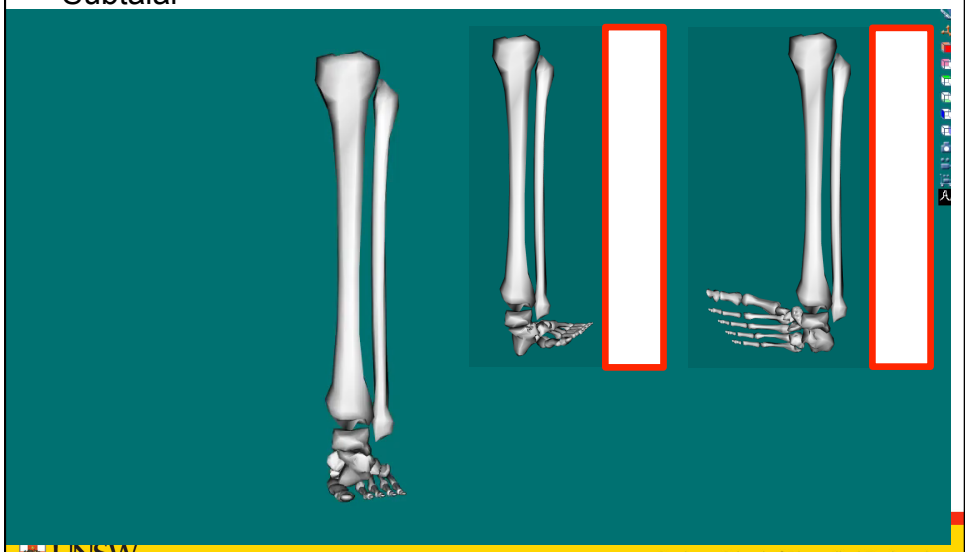




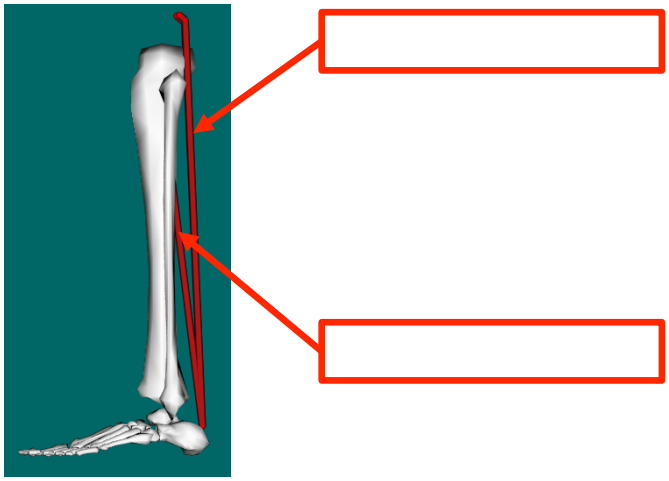
Joints (II)

True Ankle

Joints (III)
Subtalar

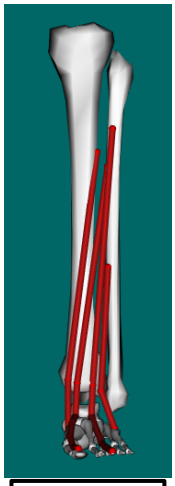


Muscles (I)
Plantarflexors

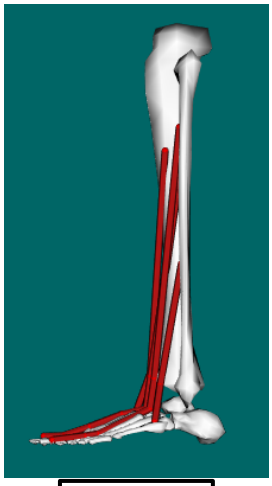


Muscles (II)

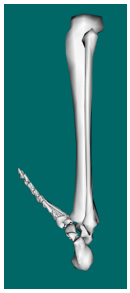
Dorsiflexors



Anterior View

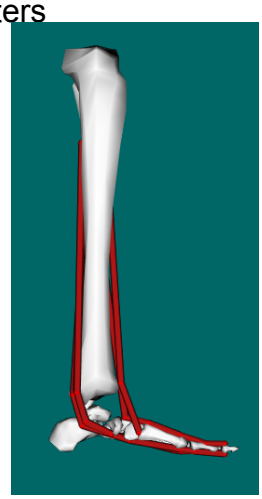


Lateral View

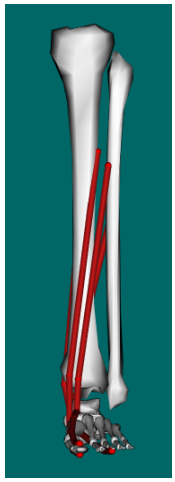


Muscles (III)

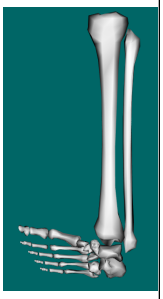
Inverters



Medial View

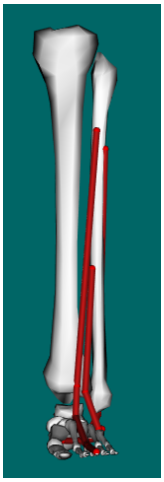


Anterior View

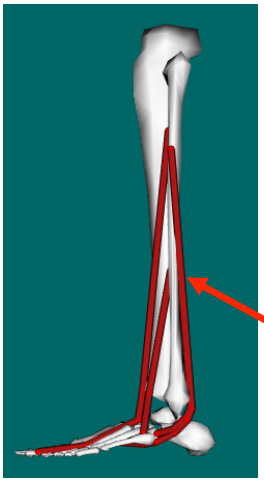


Muscles (IV)

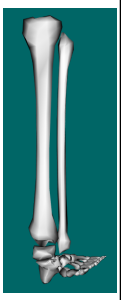
Evertors



Anterior View

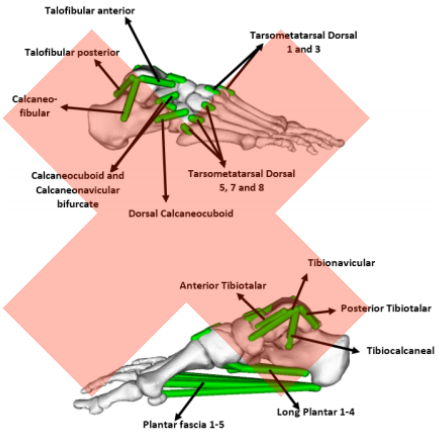


Lateral View



Ligaments (I)

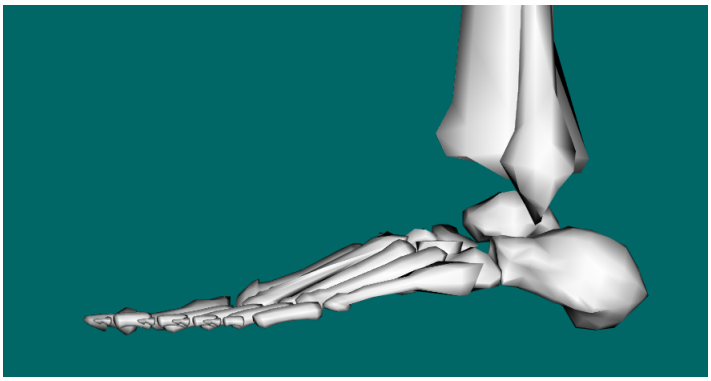
- Connect bone to bone
- Important for joint stability



https://estudogeral.sib.uc.pt/bitstream/10316/29704/1/Ana%20Carolina%20Pinto%20da%20Silveira.pdf

Ligaments (II)

Lateral



Ankle Injuries

Structure	Injury
Bone	
Ligament	
Muscle	
Tendon	

Ankle Sprains (I)

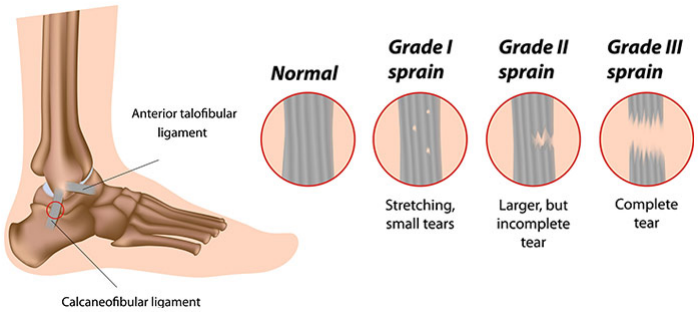
Statistics

- Account for nearly half of all sports injuries
- 25,000 people per day in US alone (9 million per year)
- > 80% of ankle sprains are a result of inversion
- 41% of ankle sprains related to basketball
- History of ankle injury makes re-injury 5 times more likely

http://anklerollguard.com/ankle-sprain-stats--info.html

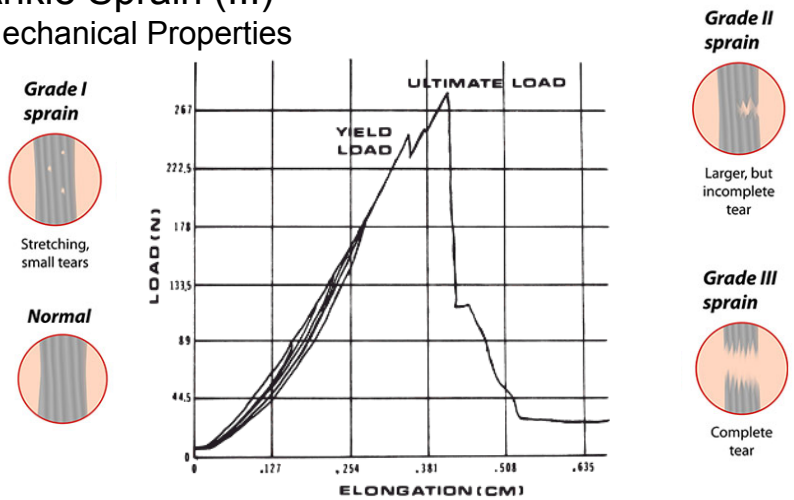
Ankle Sprains (II)

Grades



http://chicagofootcareclinic.com/footproblems/ankleproblems.html

Ankle Sprain (III)
Mechanical Properties



https://books.google.com.au/books?id=xAi7enaRlAIC&pg=PA536&lpg=PA536&dq=The+tensile+strength+of+the+anterior+talofibular+ligament.&source=bl&ots=GIXNr_gmfn&sig=bEYqGOwXAXsX8KBneBrIkQMSUHs&hl=en&sa=X&ved=0ahUKEwj68tCLjIHPAhXNNpQKHf4FAd0Q6AEIOjAE#v=onepage&q=The%20tensile%20strength%20of%20the%20anterior%20talofibular%20ligament.&f=false

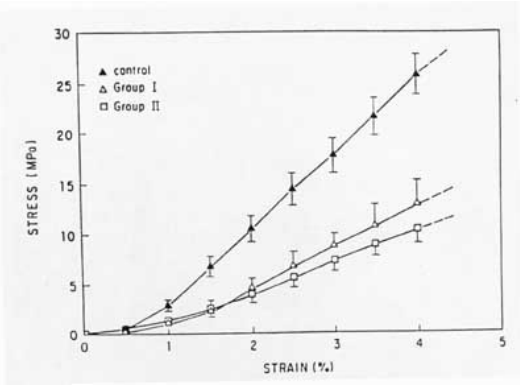
Ankle Sprains (IV)
Mechanical Properties: Stress, Strain and Young's

Ankle Sprains (V)
Mechanical Properties: Stress-Strain Diagram

Example (I)

The ATFL has an original cross-sectional area of 10mm^2 and an original length of 15mm (made up numbers!). For each of the groups shown in the stress-strain diagram on the right, calculate:

- Young's modulus
- Length at yield



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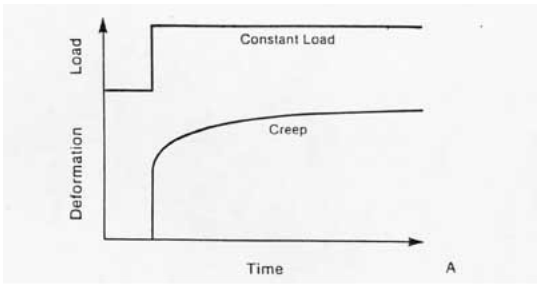
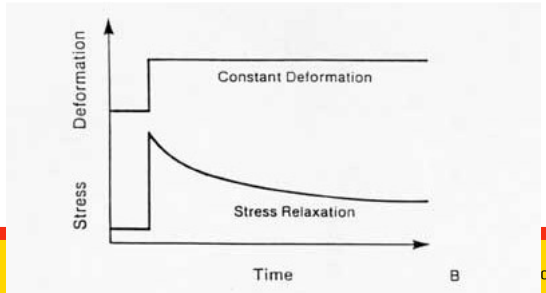
Example (II)

Viscoelasticity





Break (~10mins)

Ankle Sprains (IV)
Risk Factors

- Previous or existing ankle injury (biggest factor)
- Lack of strength and stability in the ankle
- Lack of, or extreme, flexibility in the ankle
- Poor balance
- Acceleration or deceleration (sudden change in direction)
- Increasing age

http://sma.org.au/wp-content/uploads/2011/01/719-SMA-InjuryBrochure-ankle_web.pdf

Ankle Sprains (V)
Prevention

- Balance training
- Ankle strengthening
- Flexibility
- Adequate preparation
- Taping and bracing

Taping and Braces

Taping		Braces	
Pros	Cons	Pros	Cons
Customisable	Cost	Reusable	
Less bulky	Qualified person	Cost	
Proprioception	Lost effectiveness*	Easy to apply	
		ROM restriction	
		Better prevention	

* Taping support declines by 40 – 50% within 5 – 20 minutes of activity (Paris et al., 1995)

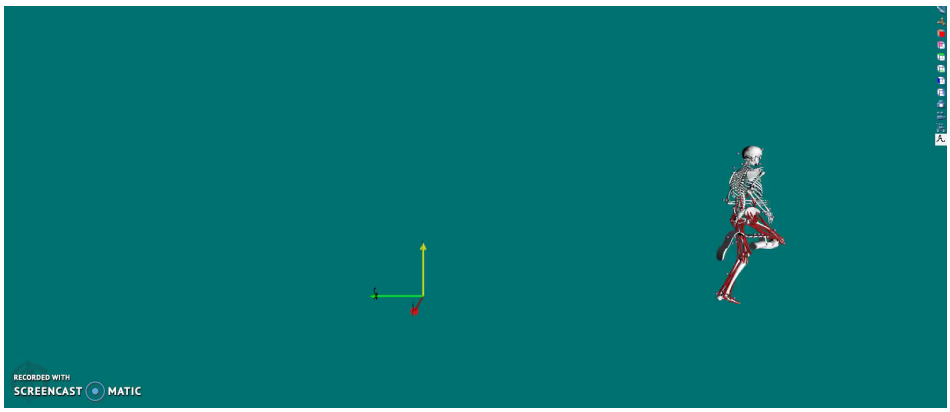
http://www.braceup.com/ankle_01.htm

Ankle Braces (I)
Types

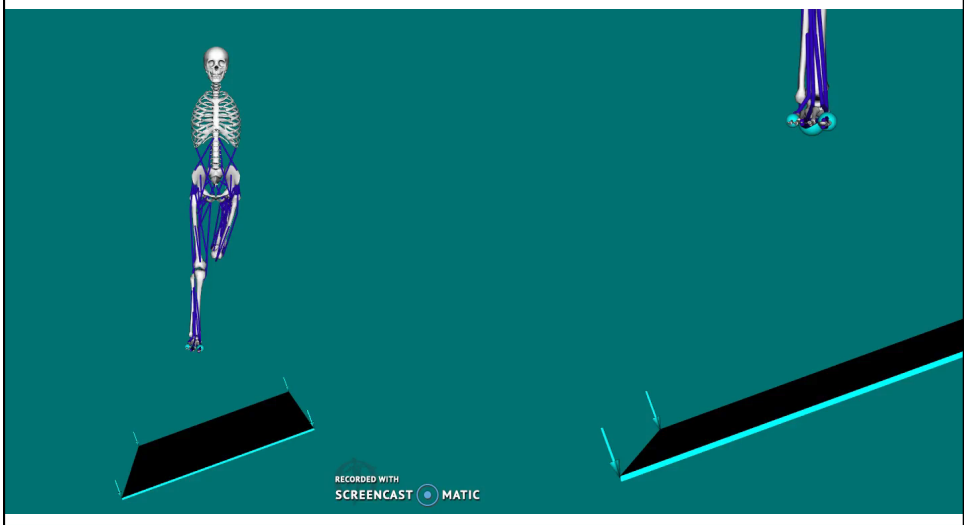
Ankle Braces (II)
Design Requirements for Hinged Braces

Go to socrative.com, join room # 872362 and share your thoughts!

Musculoskeletal Modelling (I)

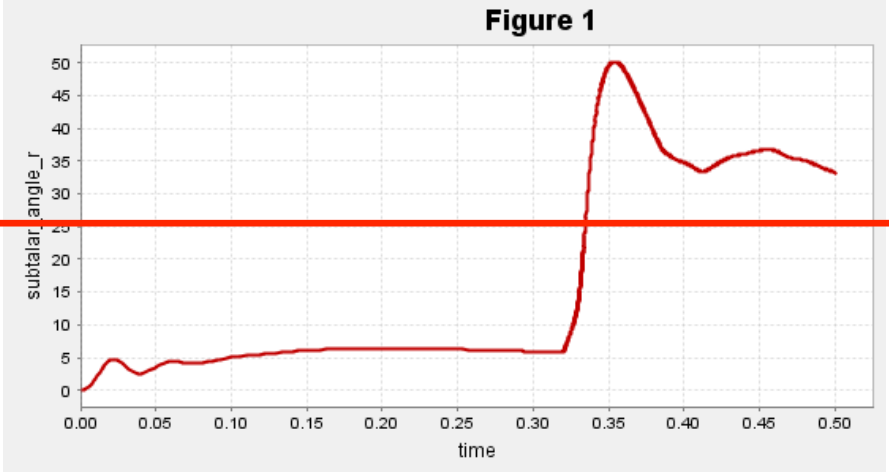


Musculoskeletal Modelling (II)



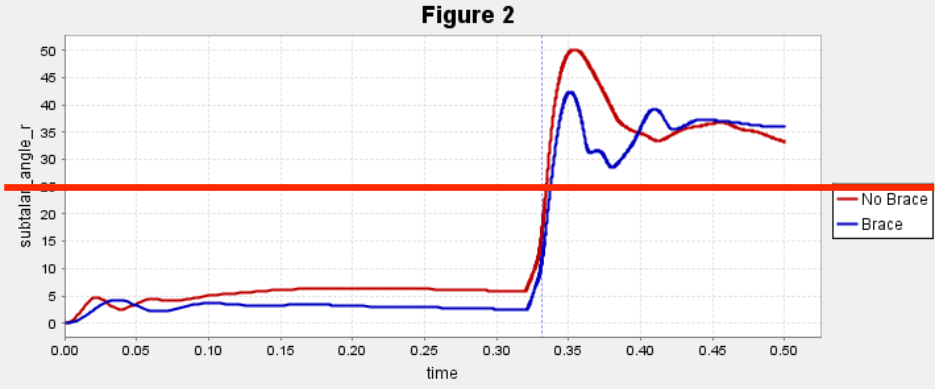
Musculoskeletal Modelling (III)

Ankle Inversion Angle



Musculoskeletal Modelling (IV)

Musculoskeletal Modelling (V)
Comparison of Inversion Angles



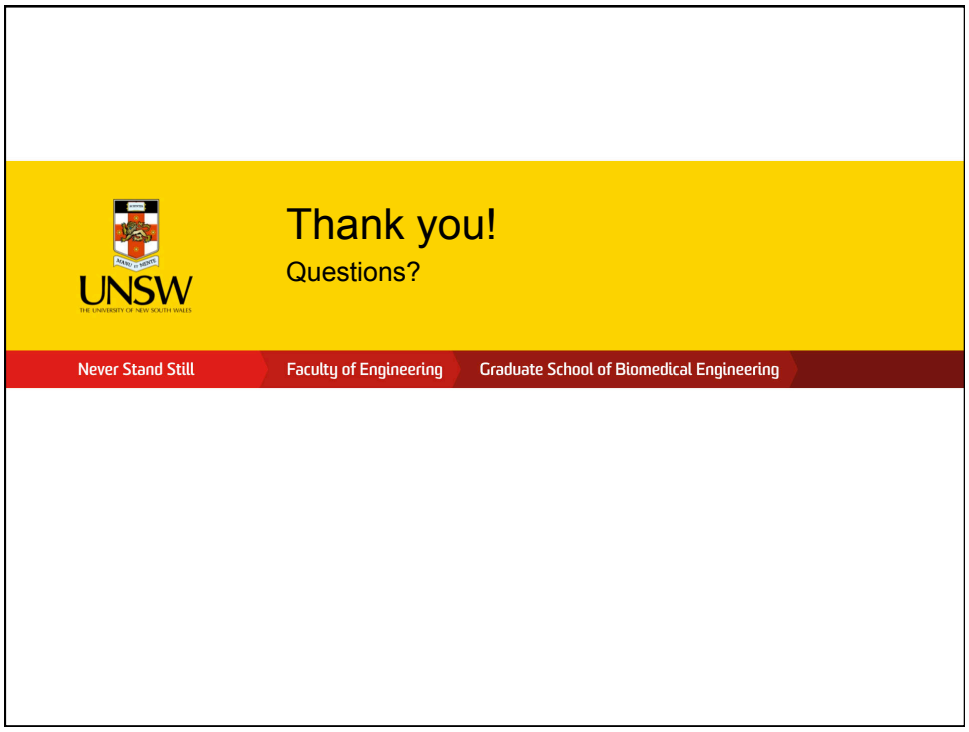
Musculoskeletal Modelling (VI)

- Your job in the tutorial next week is to design the optimal ankle brace!

- Two types of braces: passive and active (challenge)
- Minimum passive design requirements:
  - Prevent ankle injury (inversion angle<25°)
  - Minimal stiffness, for maximal comfort
- Minimum active design requirements:
  - As for passive, but also:
  - Smallest torque required for smallest motor
  - Minimal active time for maximal battery life

- Don't forget to include any other design criteria you think important.

Good luck! Have fun!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Thank you!
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