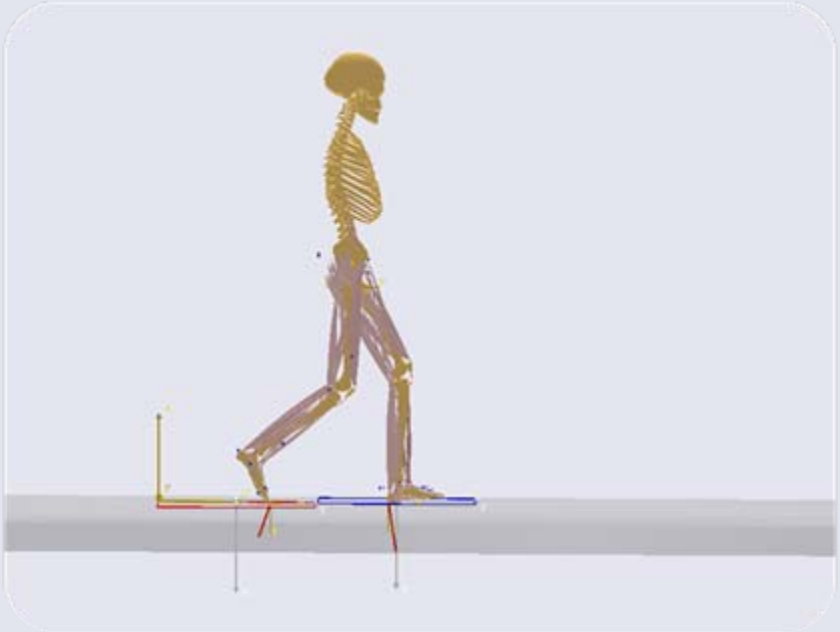
Joint Forces within the Ankle during Level Walking

Mike Arakilo



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Presenters

Mike Arakilo
(Presenter)

Søren Tørholm
(Panelist)

Casper Gerner Mikkelsen
(Webcast host)

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Q&A Panel

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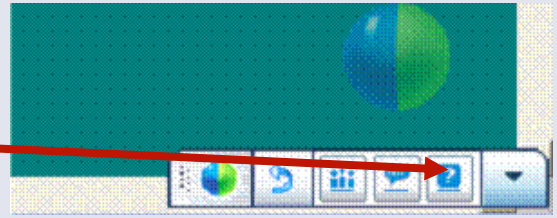

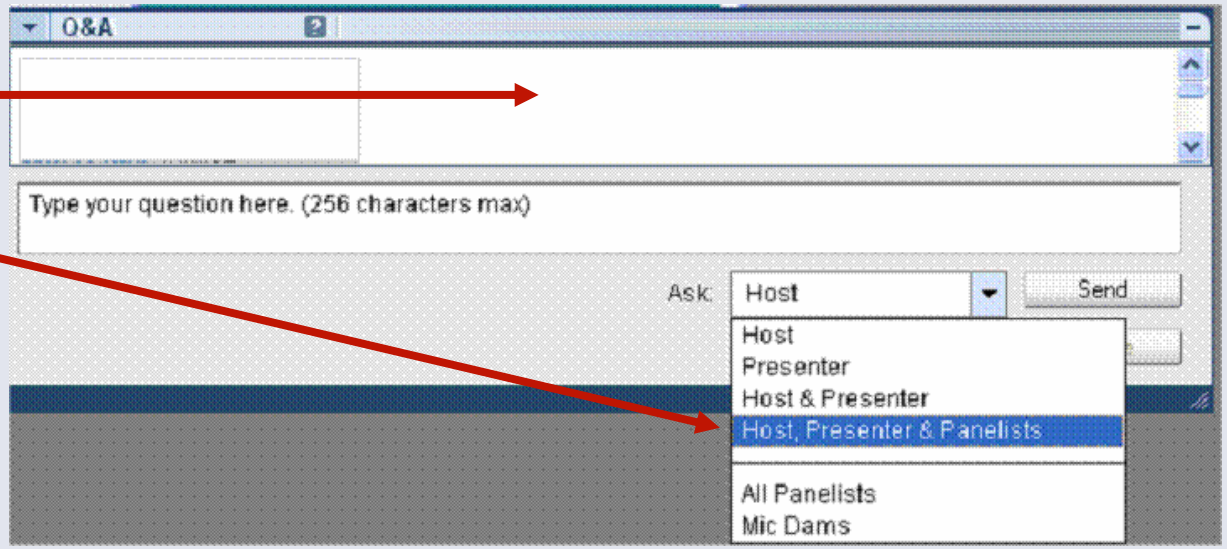

Notice the answer displays next to the question in the Q&A box. You may have to scroll up to see it.

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Purpose of the Project

" Virtual Assessment of the Latest Generation of the Total Ankle Replacement Using Motion Analysis "

Investigate the reasons for ankle joint replacement failure and possibly optimise ankle prosthesis design.

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More Perspectives

- TAR perspective is part of this work

- *Same work* can be done for other many activities …

More Activities …

Optimizing new designs related to human health *i.e. new prosthesis designs , new designs for cars, seats, …*

Reference: www.google.co.uk

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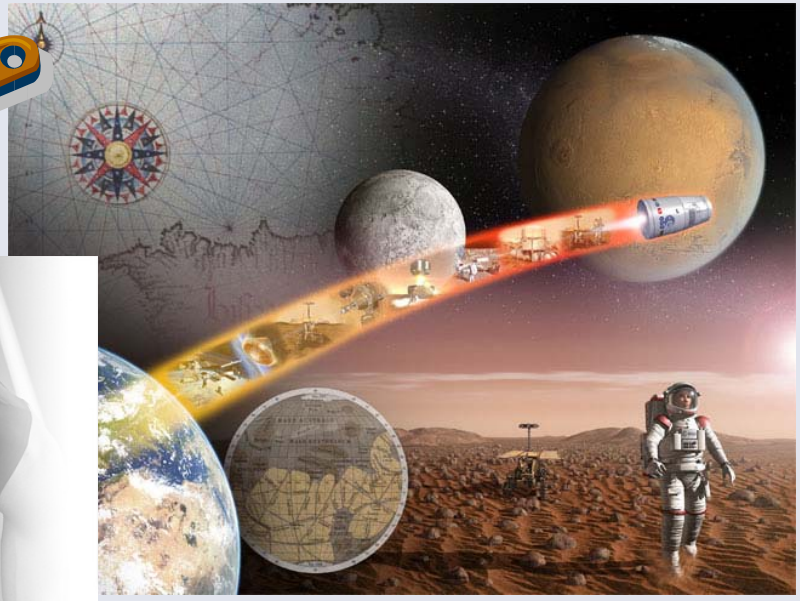
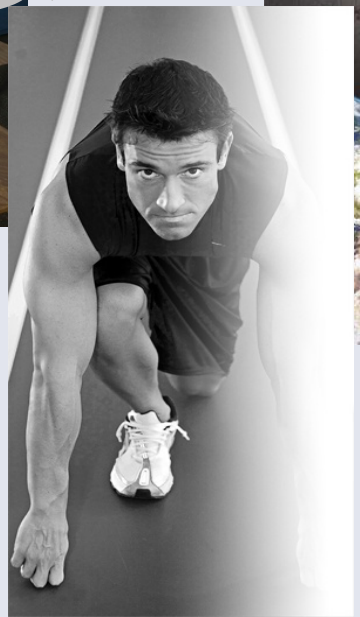
More Activities

Enhancing human conditions in various locations *i.e. muscular activities for athletes, bone loss/gain for astronauts*





Reference: www.google.co.uk

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Brief Summary of the Talk

- Total Ankle Replacement (TAR) has a lack of reliability over the long term as a result of few number of investigations compared to THR and TKR
- Few Ankle Joint Forces data is available through literature and go back to the 1970s … Compared to 2008 !
- New model design for Collecting MoCap Data and investigate the resultant musculoskeletal and ankle joint forces in AnyBody

Why TAR ?

- Treatment of ankle joint diseases, Osteoarthritis
- TAR maintains normal motion of the joint and distribution of loads on the surrounding structures

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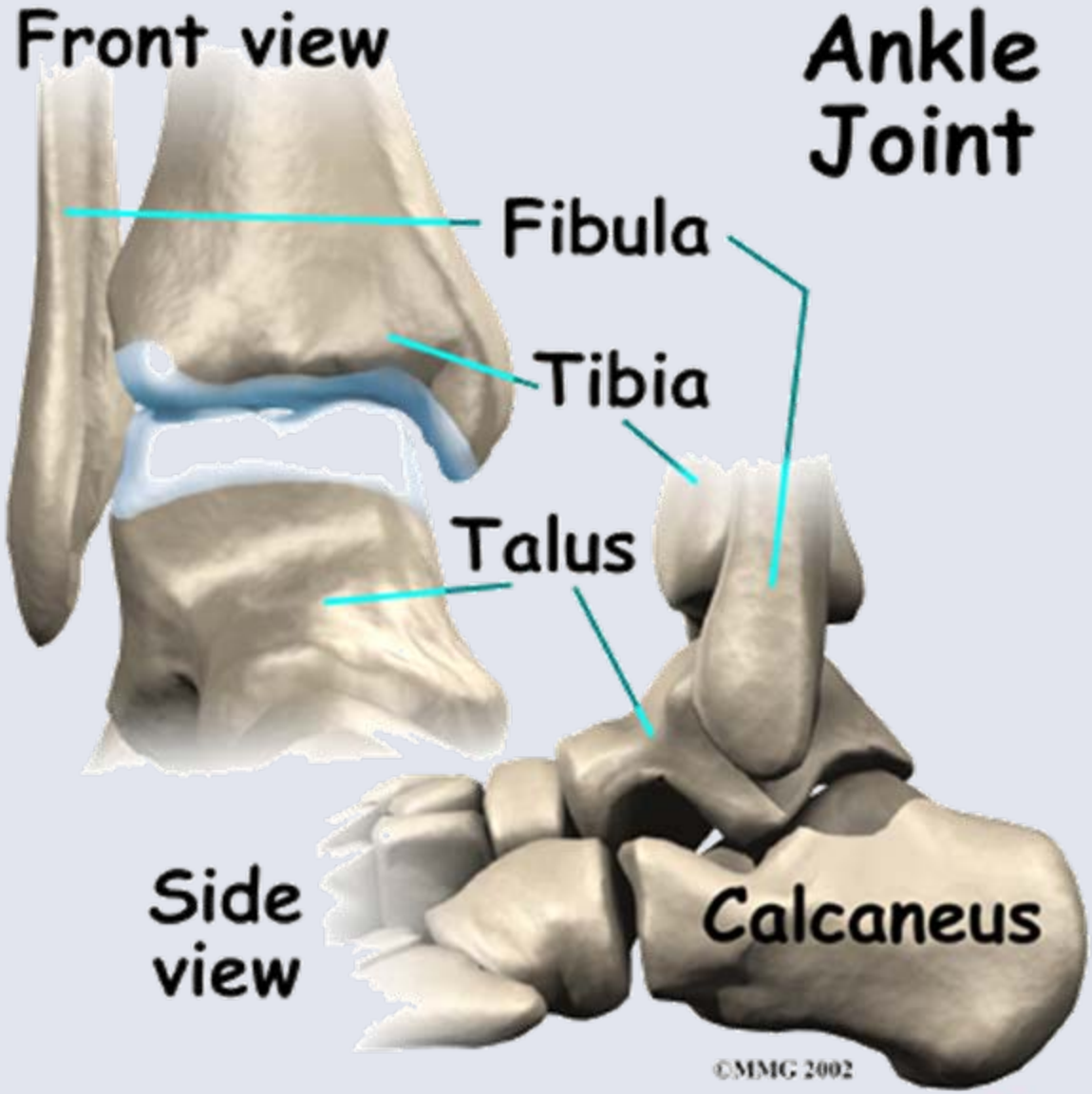

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Ankle Osteoarthritis

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Questions, it is ok to ask

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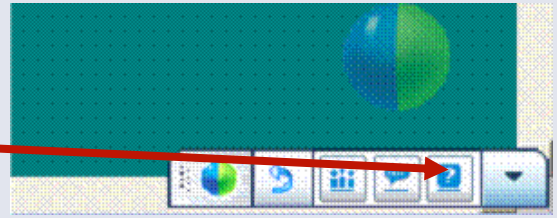

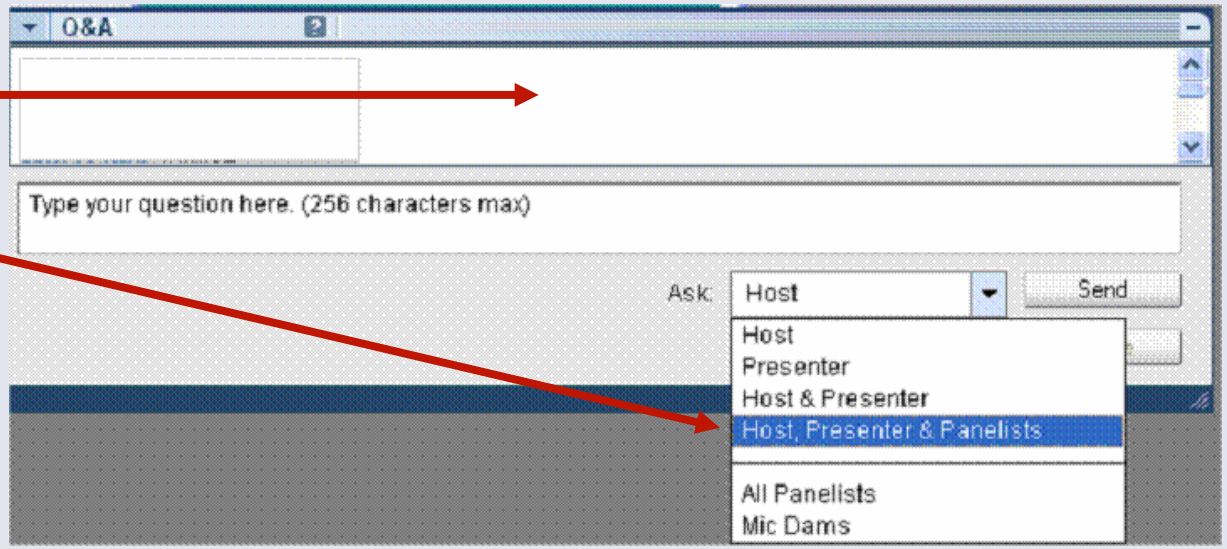

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Drawbacks of TARs

- Small size of the joint
- High resultant Moment
- High Stress, High Compressive Forces
- Disregard for anatomic component shape and physiological ankle biomechanics
- Poor reproduction of the normal mechanics of the ankle

Available Data on Ankle Joint Forces

"Forces and Motion Analysis of the Normal, Diseased and Prosthetic Ankle Joint"

Richard N Stauffer ***1977***

2D !

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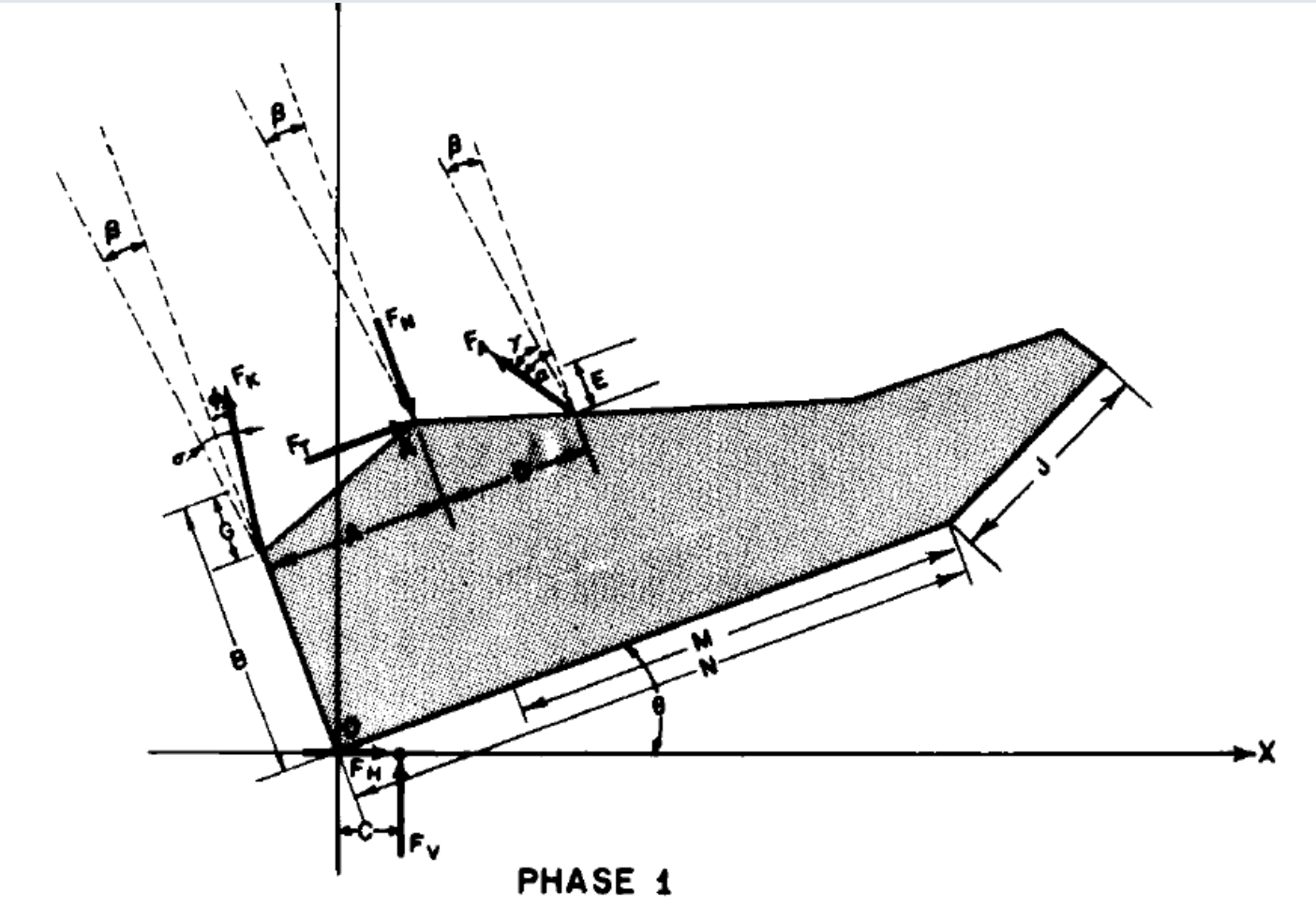
Ankle Joint Forces in Literature



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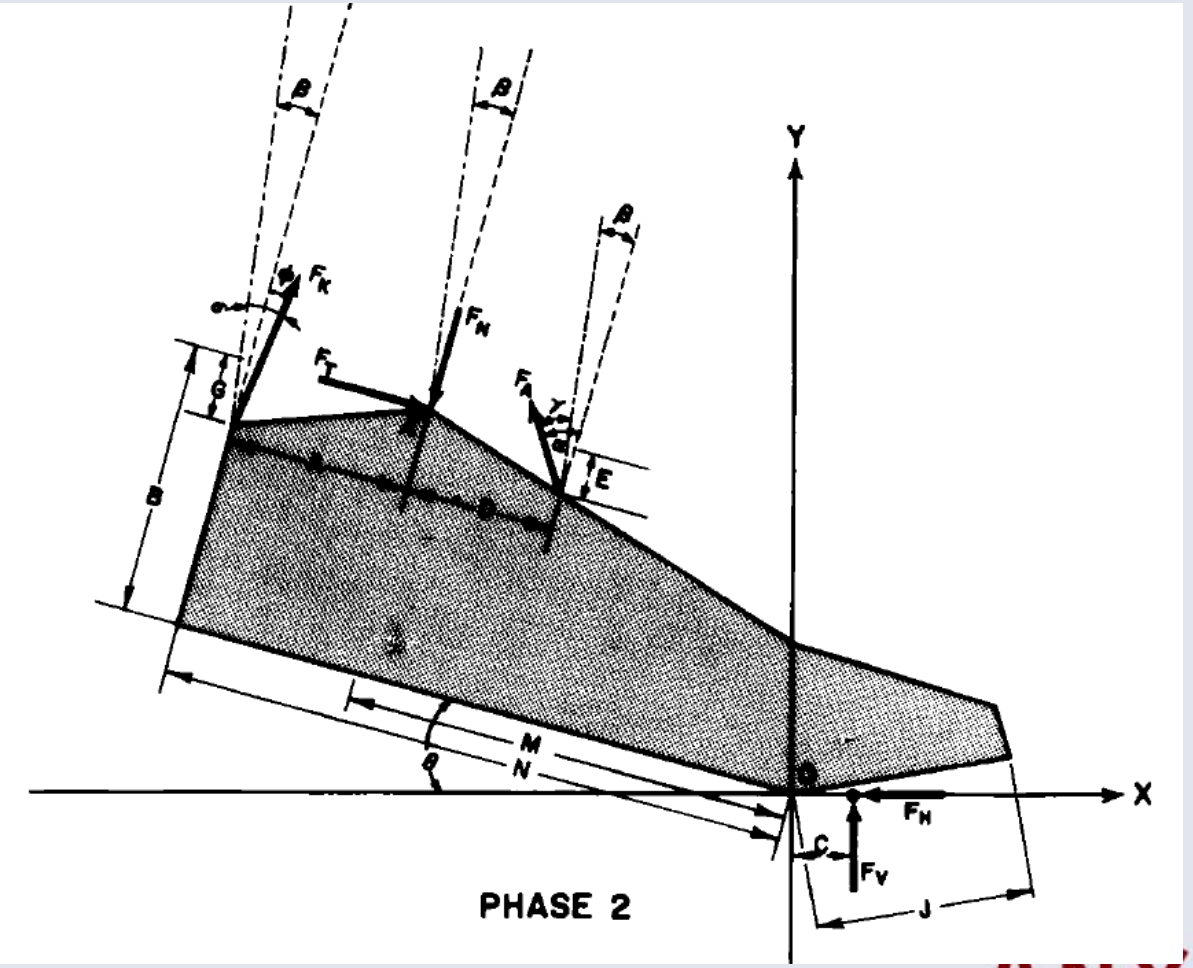
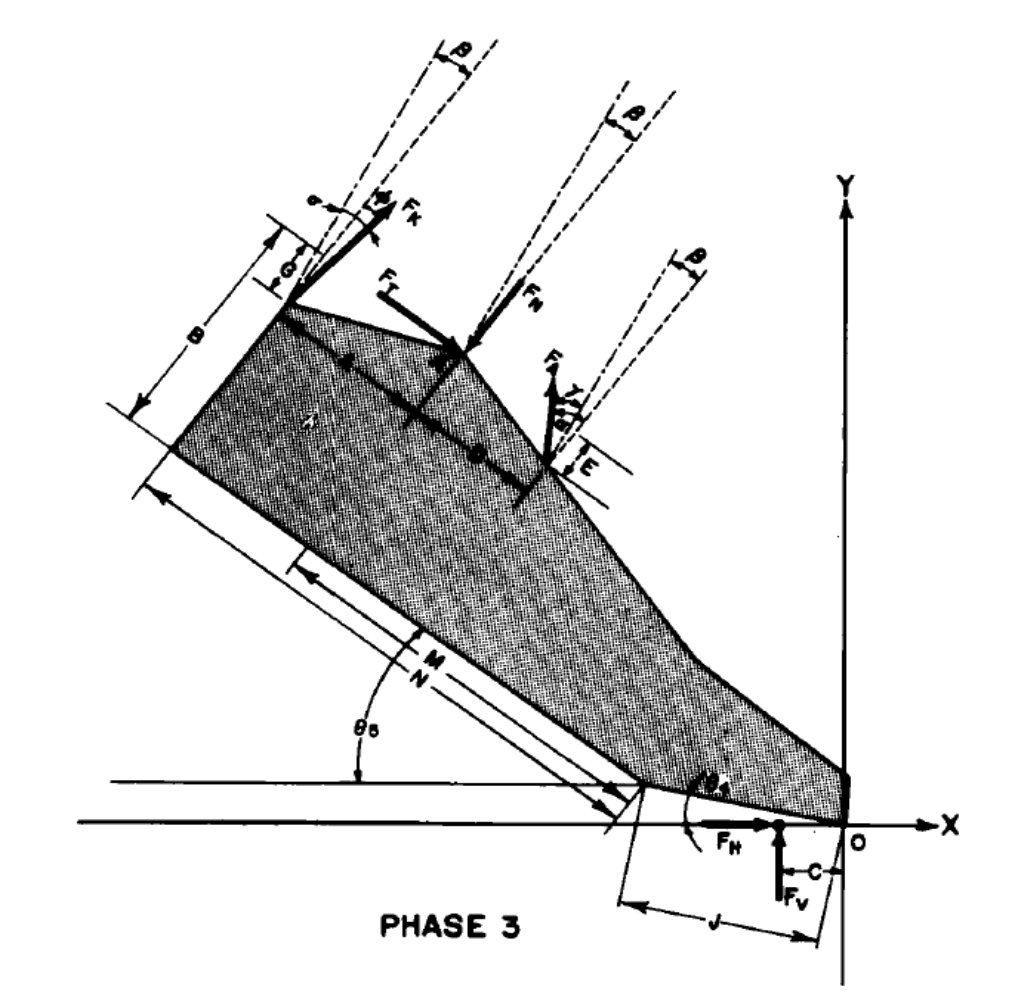
Ankle Joint Forces in Literature



Ankle Joint Forces in Literature



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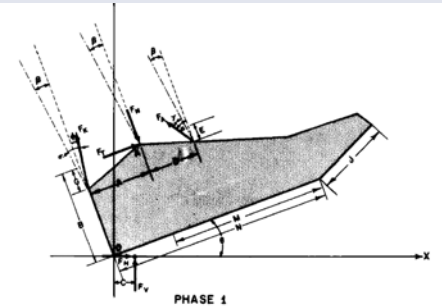
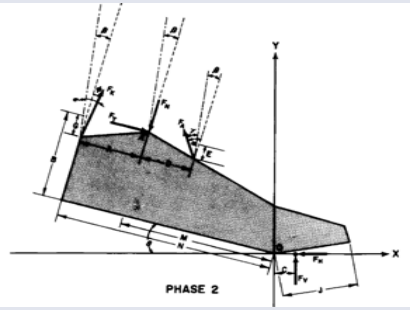
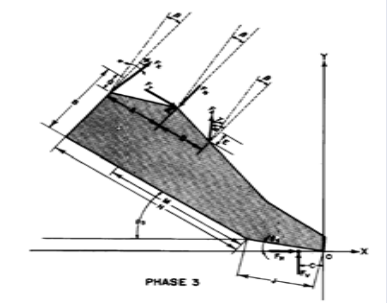
Ankle Joint Forces in Literature

Forces were calculated:

- F_A *tensile force in Anterior Tibial Tendon*
- F_K *tensile force in Achilles Tendon*
- F_N *compressive forces across Ankle Joint*
- F_T *tangential forces across Ankle Joint*







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Aim of this Study

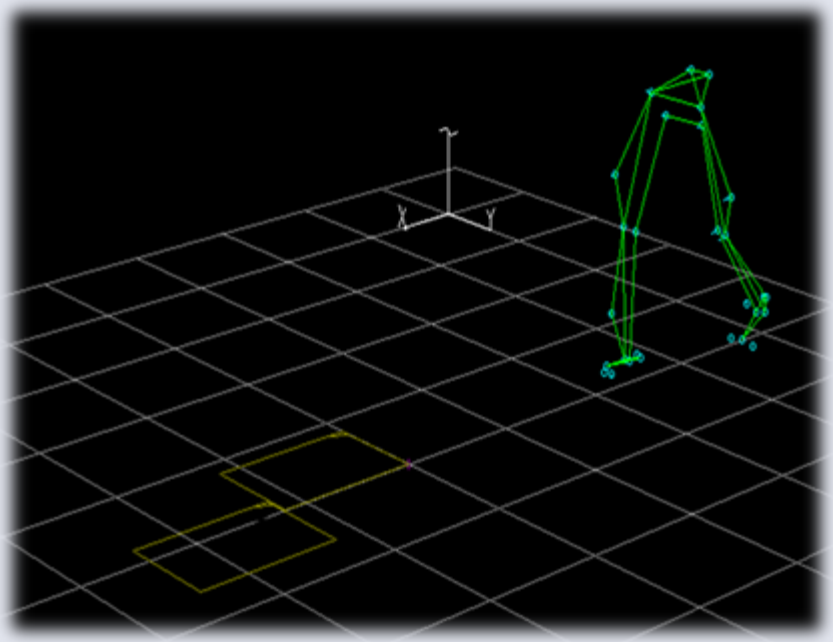
- Lack of knowledge on ankle joint internal forces
- Knowledge important because TAR not so reliable

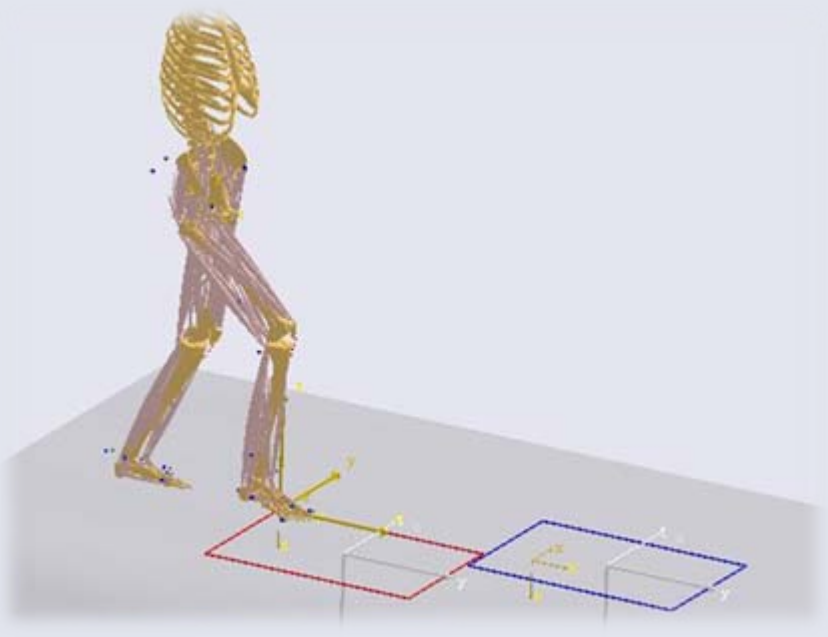
Improve Data and hence Design !

ANYBODY TECHNOLOGY

Methodology

Gait Experimental: Vicon Model Simulation: AnyBody





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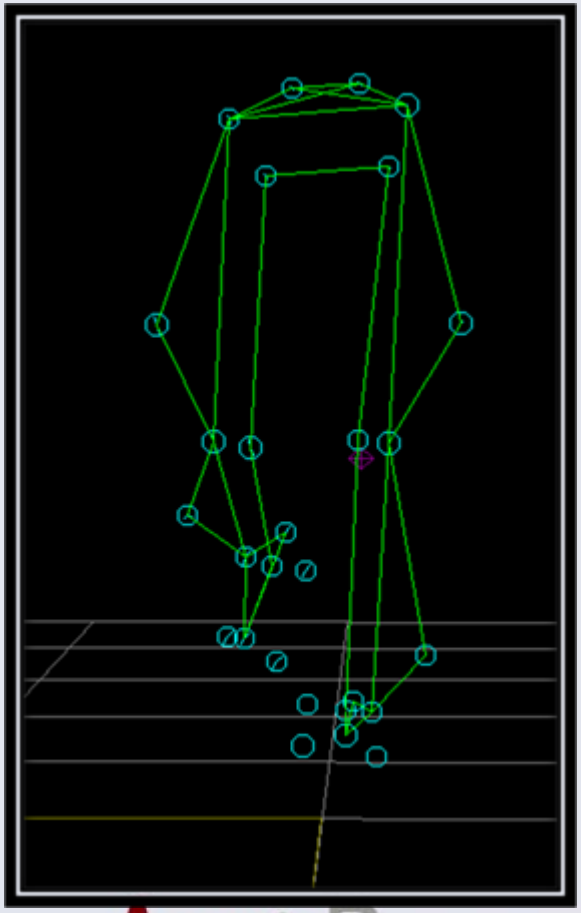
Gait Experimental

Gait Data Collection Using Vicon System

- *Custom Model definition with 22 markers (MikeArakiloGait)*
  - LASI, RASI, LPSI, RPSI
  - LTHI, RTHI, LKNEE, RKNEE
  - LTIB,RTIB
  - LANK, RANK, LMANK, RMANK
  - LHEE, RHEE, LTOE, RTOE
  - L1MEH, R1MEH, L5MEH, R5MEH



ANYBODY TECHNOLOGY

Gait Experimental

Methodology being adopted

Gait Data Collection using Vicon System®

- Vicon Cameras MxF40
  - ✓ 8 Cameras used
  - ✓ 4 Megapixel
  - ✓ Data taken at 50 Hz

Prospective Data to be taken on 120 Hz

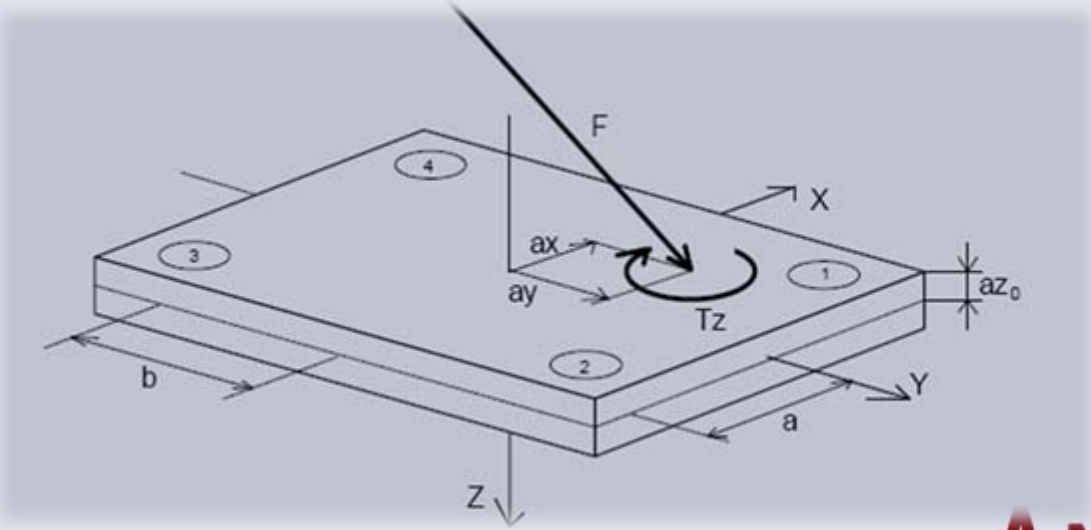
ANYBODY TECHNOLOGY

Gait Experimental

Methodology being adapted

Gait Data Collection using Vicon System

- *KISTLER FORCE PLATES*
  - 8 Channels: 4 on Z-D, 2 on X-D and 2 on Y-D
  - Analogue Data at 1000 Hz



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AnyBody Model

Methodology being adapted

Purpose of AnyBody Gait Model

- Construct a musculoskeletal body computer stimulation of the ankle joint. The model will then be employed to predict the forces transmitted through the joint and surrounding tissues.

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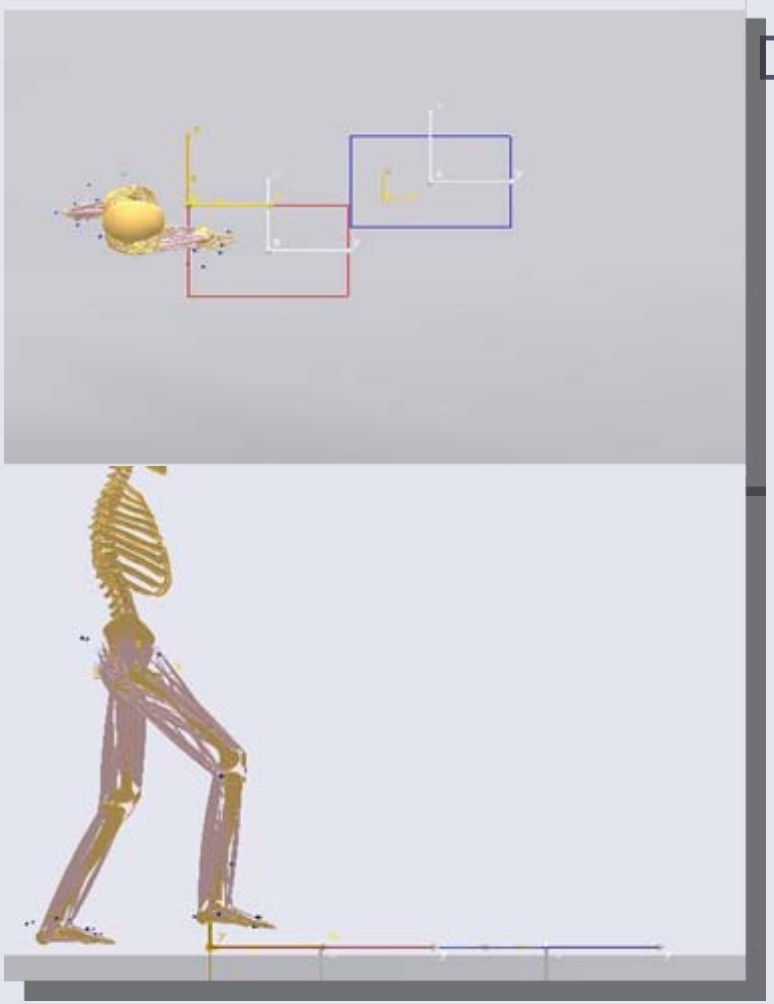
AnyBody Model



Description of Gait Model

- Anybody Musculoskeletal Model with no Muscles on the Trunk
- Anybody TLEM Model of the Leg:
  - ✓ More Sophisticated Muscles
  - ✓ More Muscles around the ankle Joint
- Ankle with 2 separate ***REVOLUTE*** joints:
  - ✓ Subtalar Joint
  - ✓ Ankle Joint

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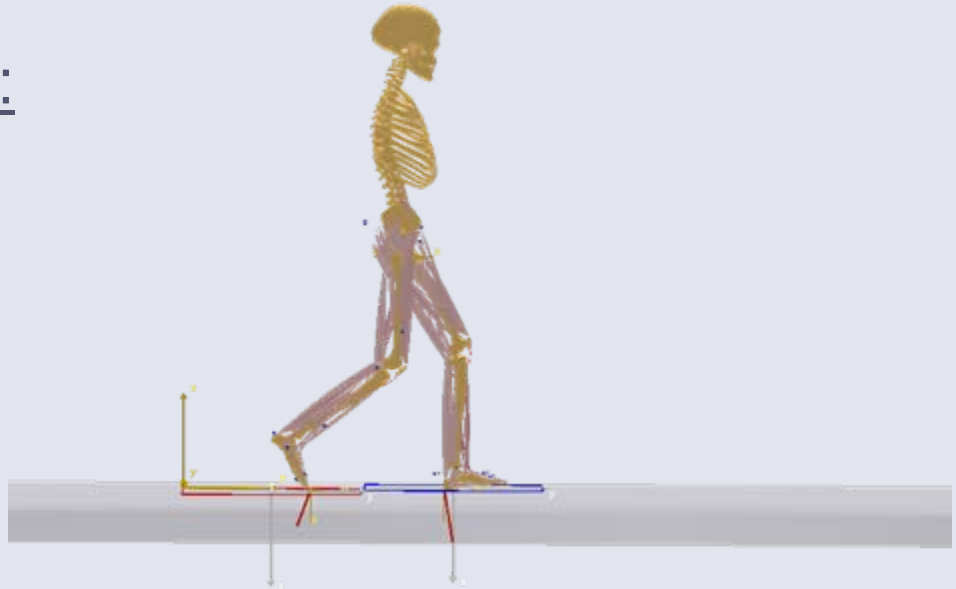
AnyBody™ Model

<u>Muscle Recruitment Solver:</u>

- *MinMax Solver*
- *Quadratic Solver*

<u>Forces Collected:</u>

- *GRF Ankle Joint*
- *Achilles Tendon*
- *Tibialis Anterior/Posterior*
- *Peroenus*



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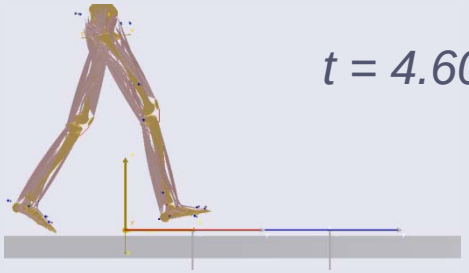
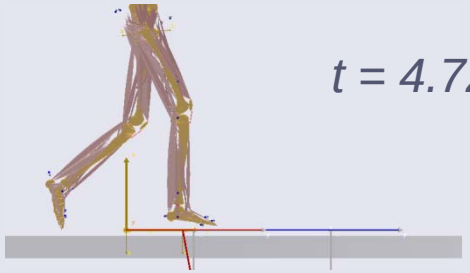
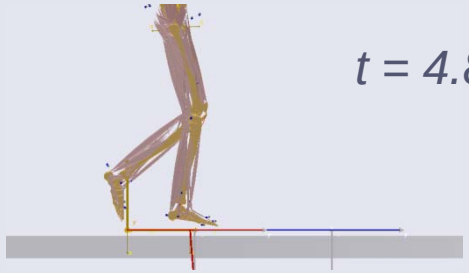
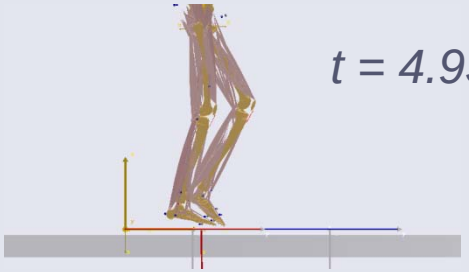
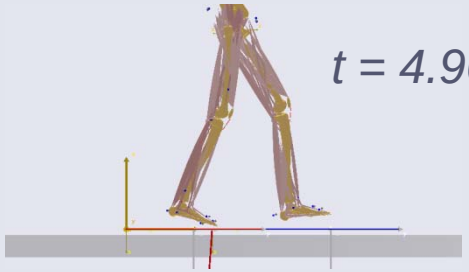
Simulation Results of the Gait

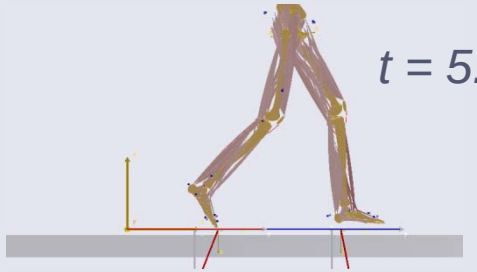


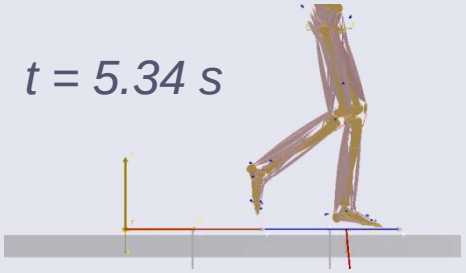


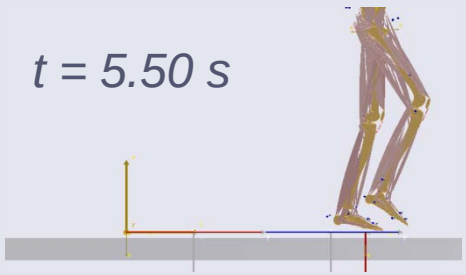












t= real time gait during walking

Animations are available through email

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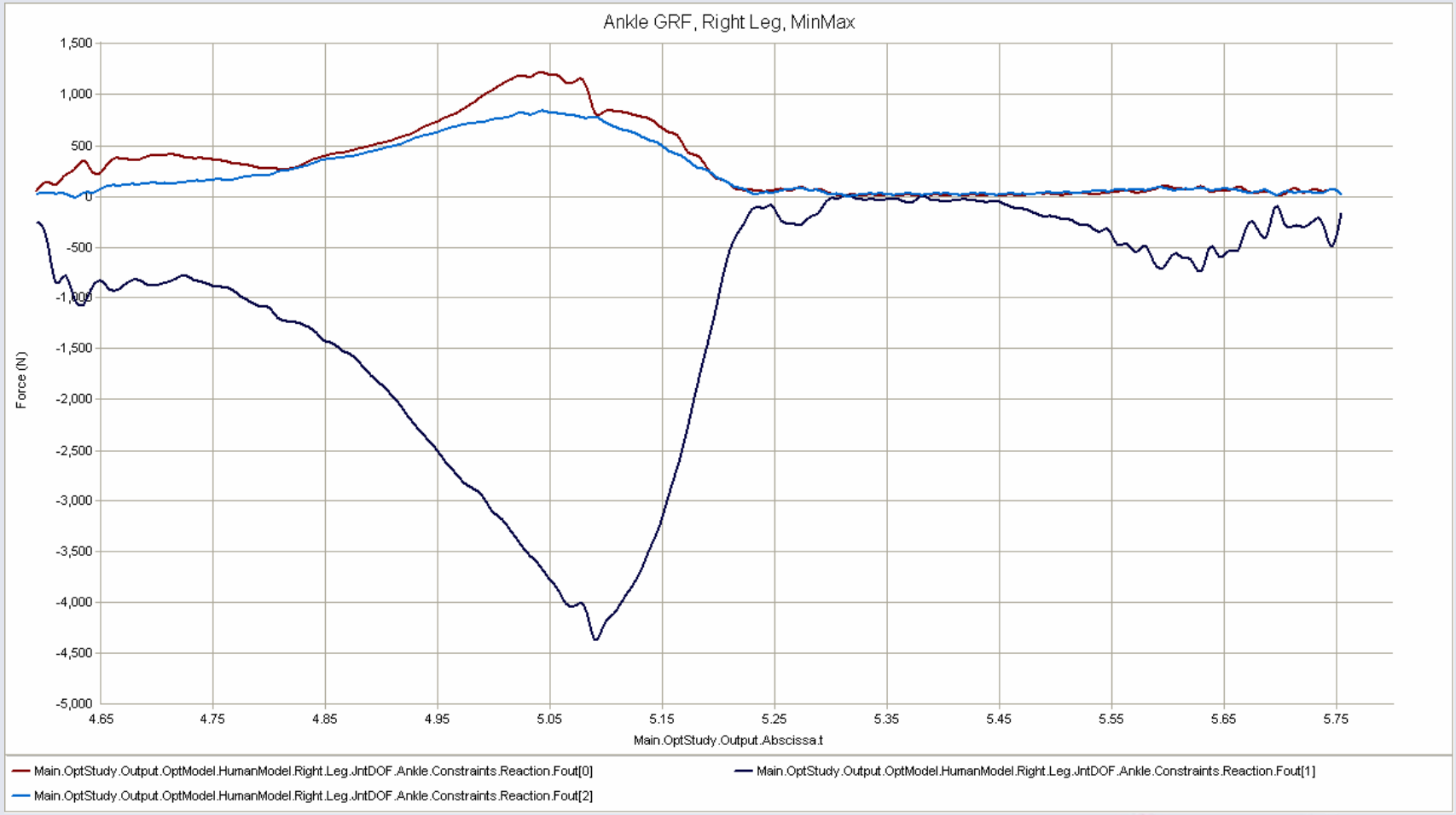
GRF Ankle Joint



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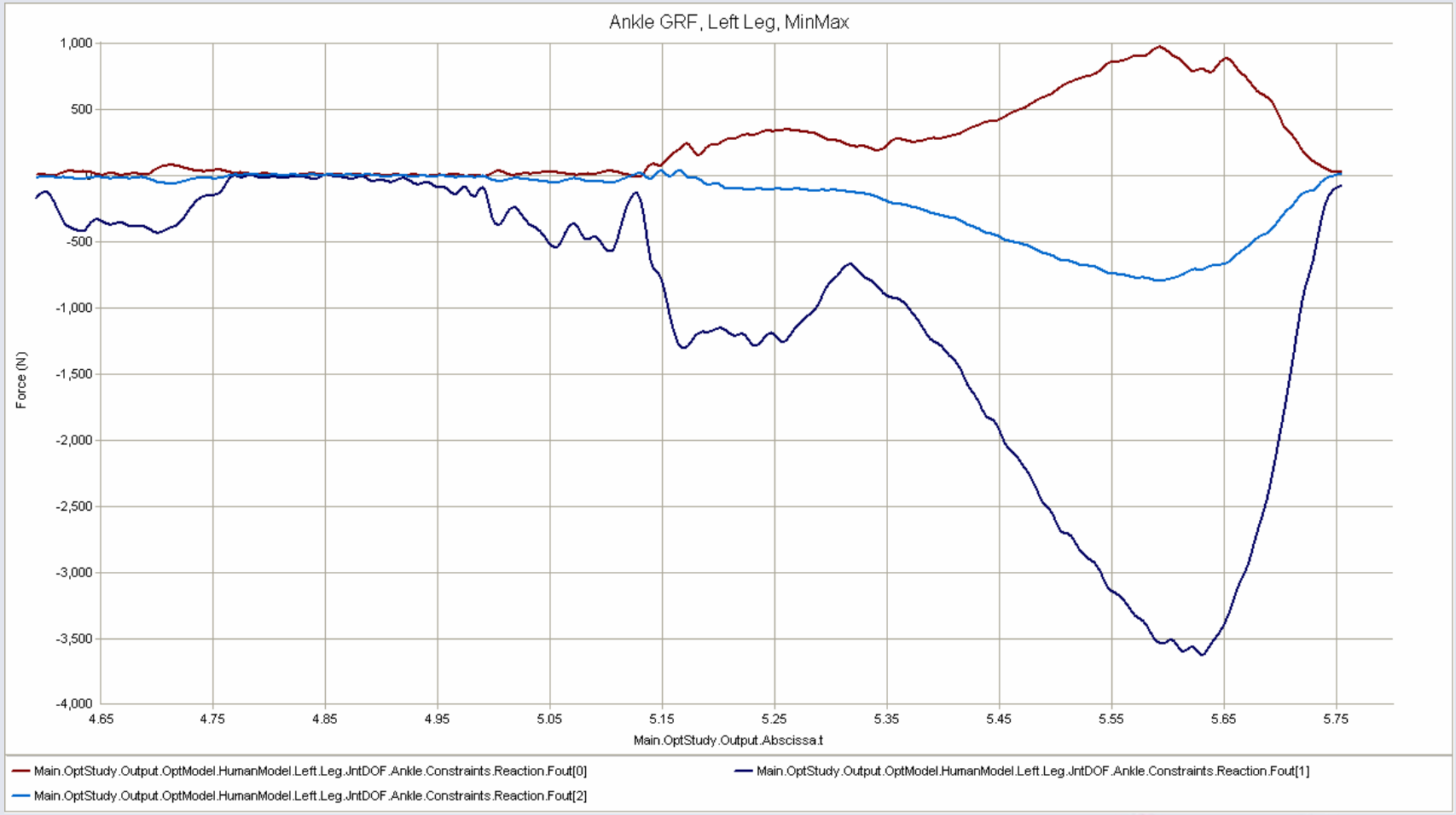
GRF Ankle Joint



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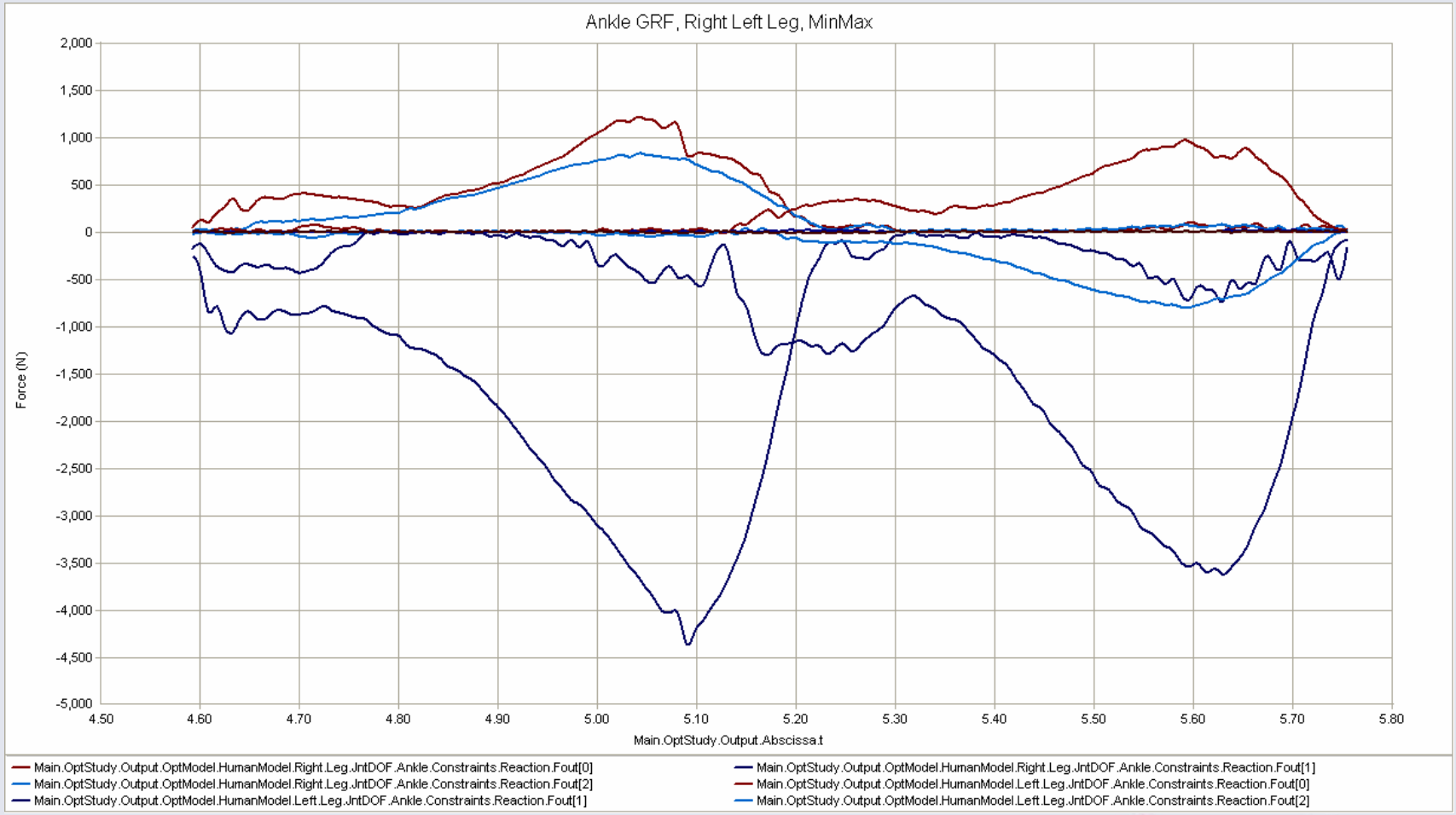
GRF Ankle Joint



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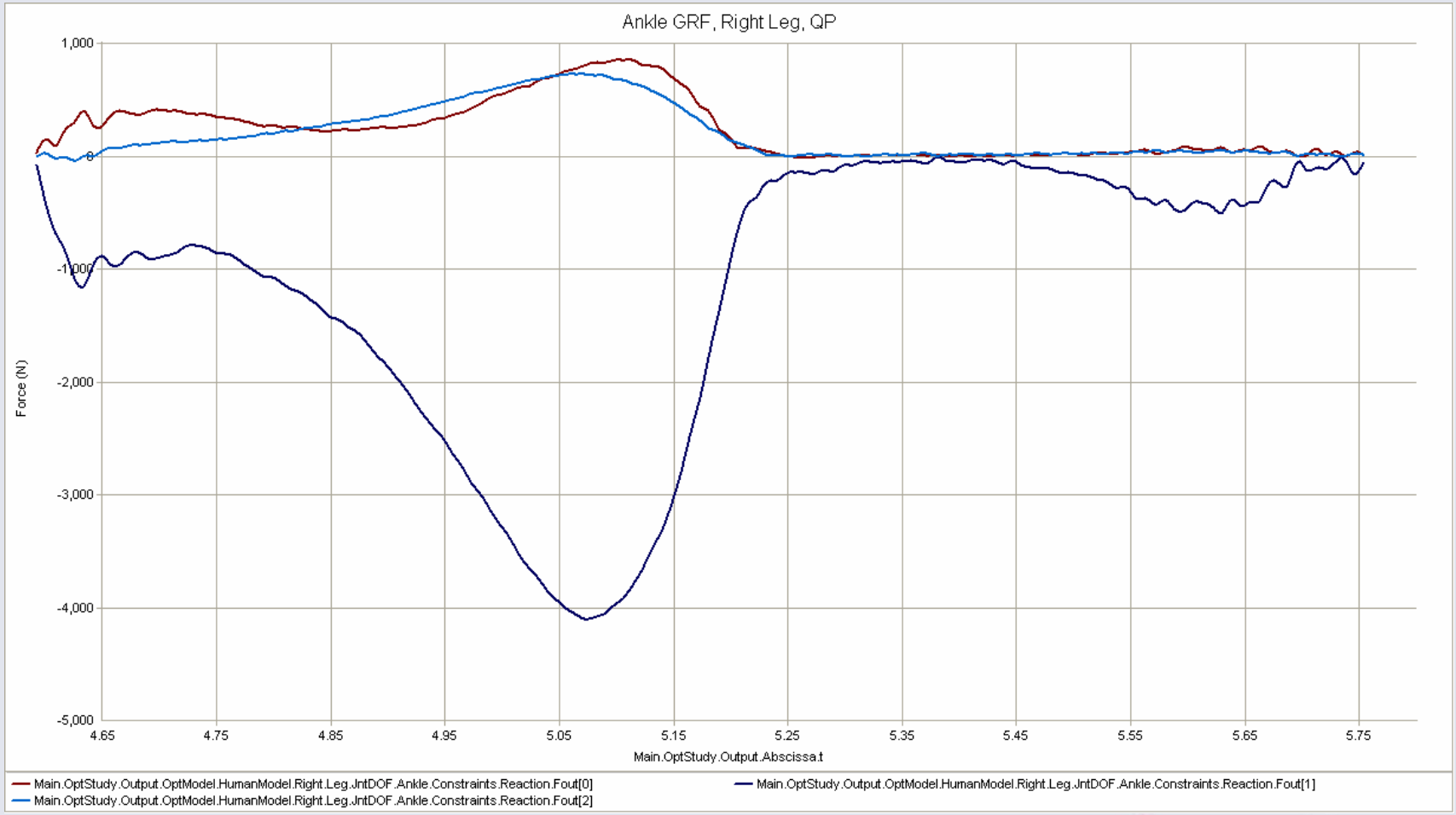
GRF Ankle Joint



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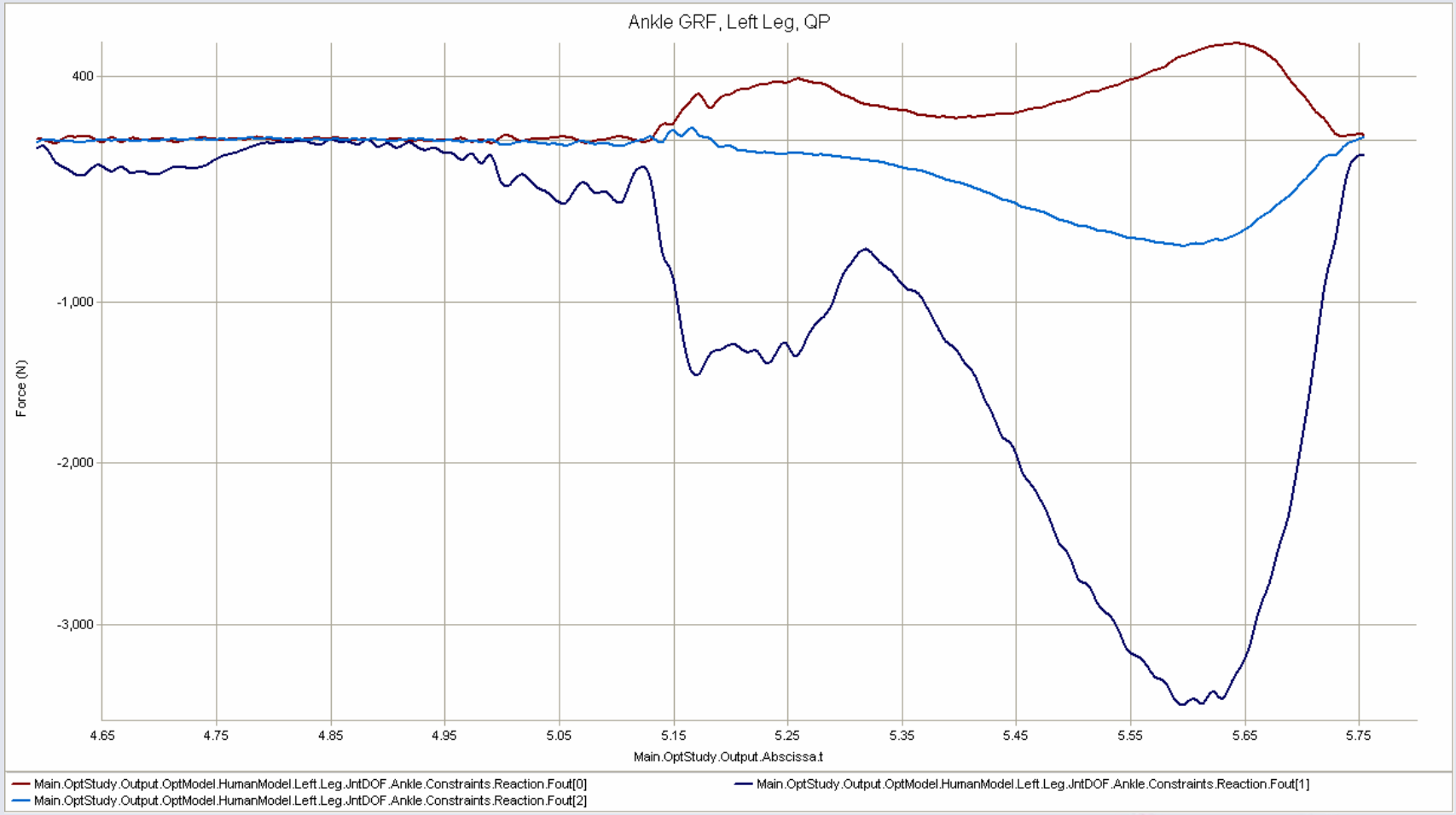
GRF Ankle Joint



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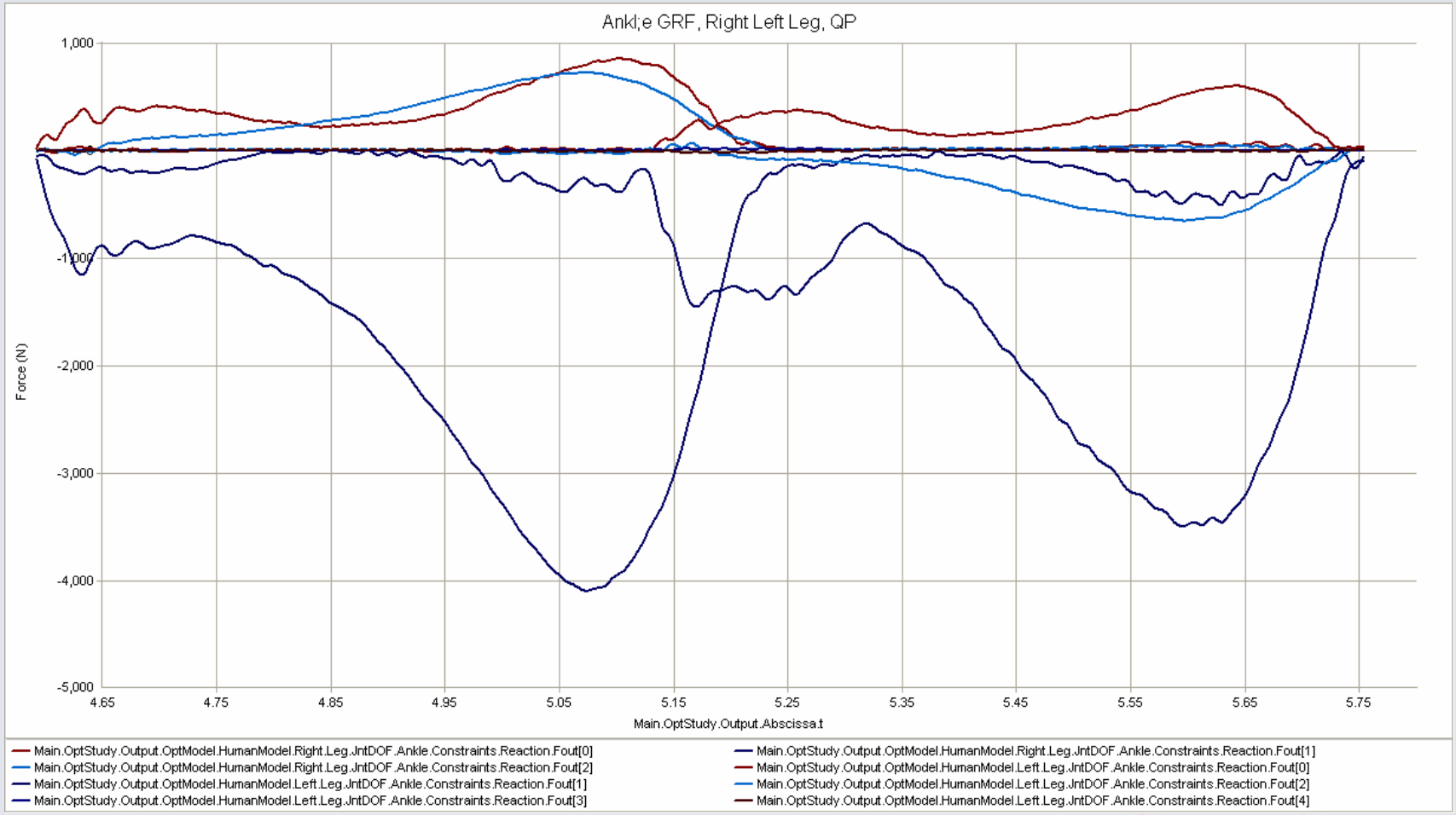
GRF Ankle Joint



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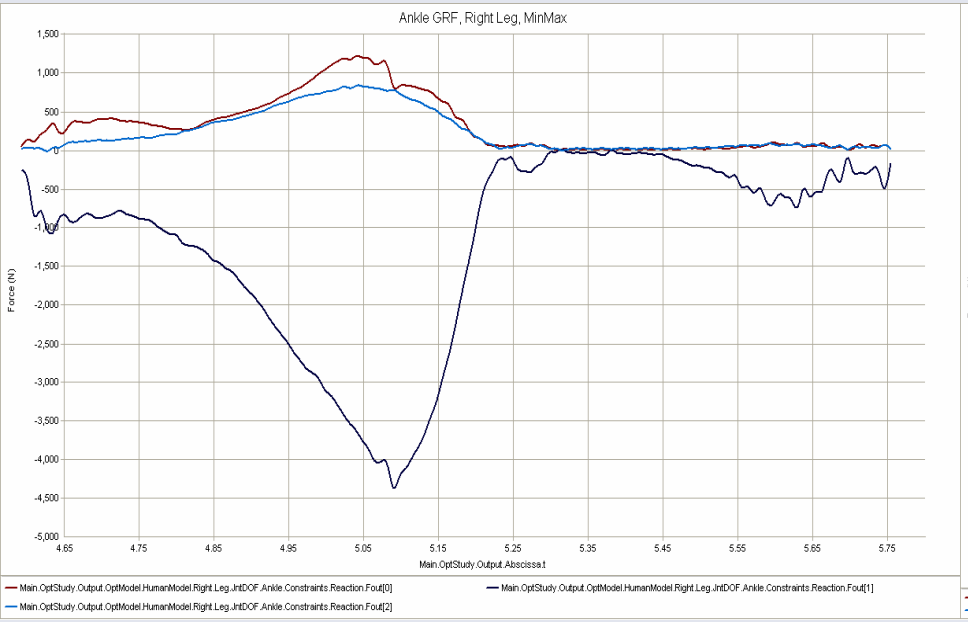
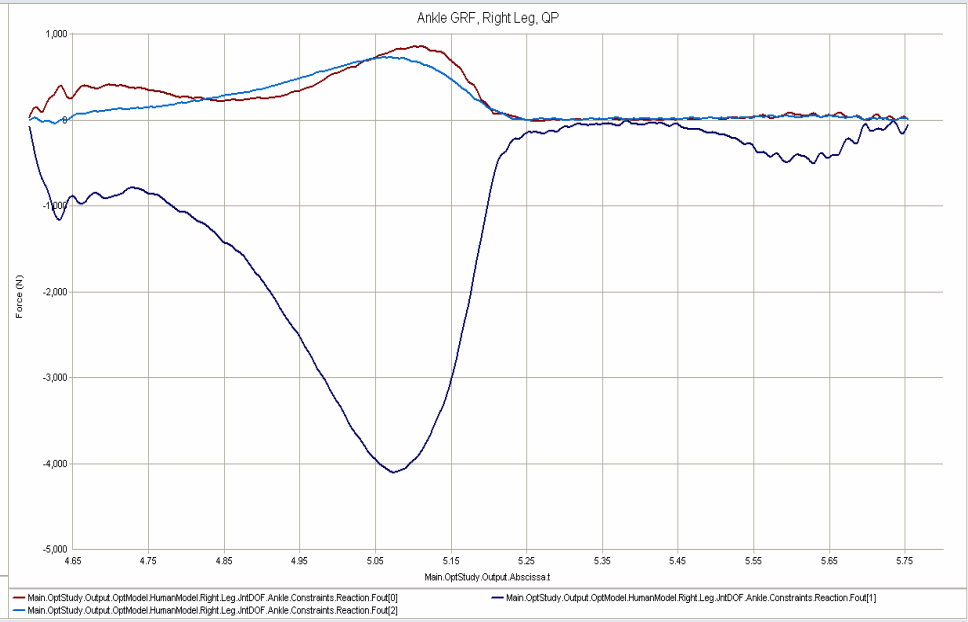
GRF Ankle Joint

MinMax Solution



Quadratic Solution



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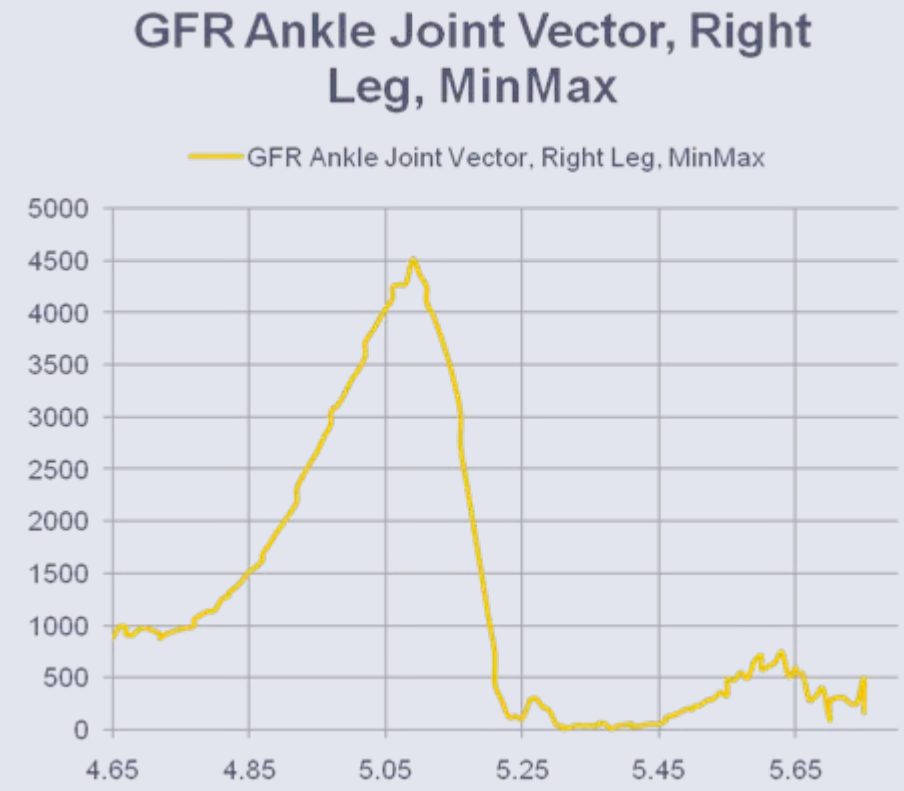
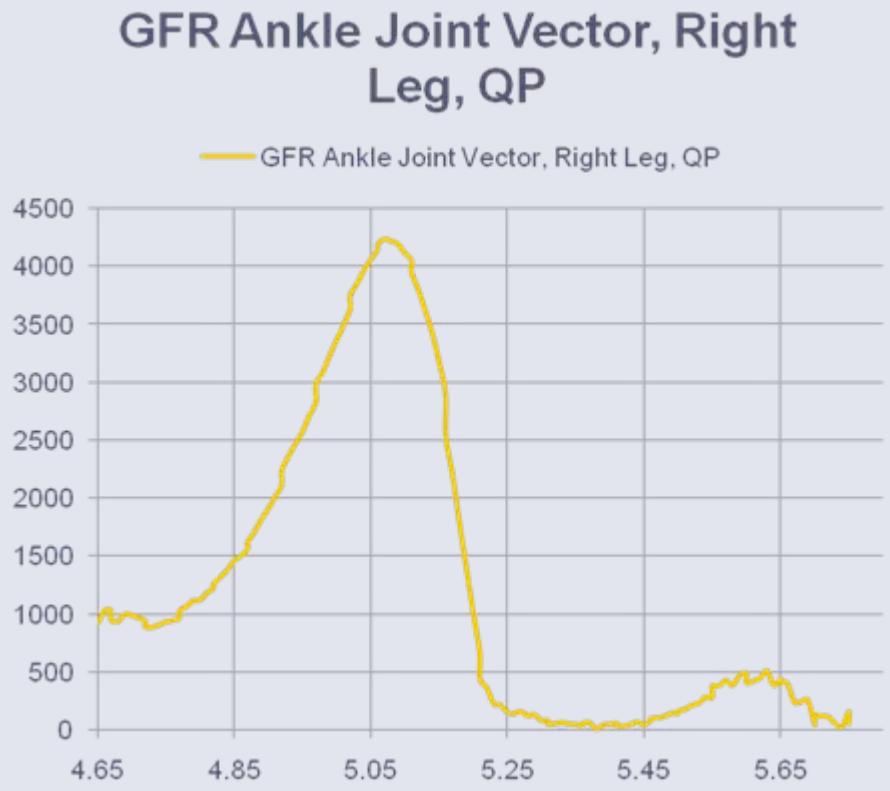
GFR Ankle Joint Vector

MinMax Solution Right



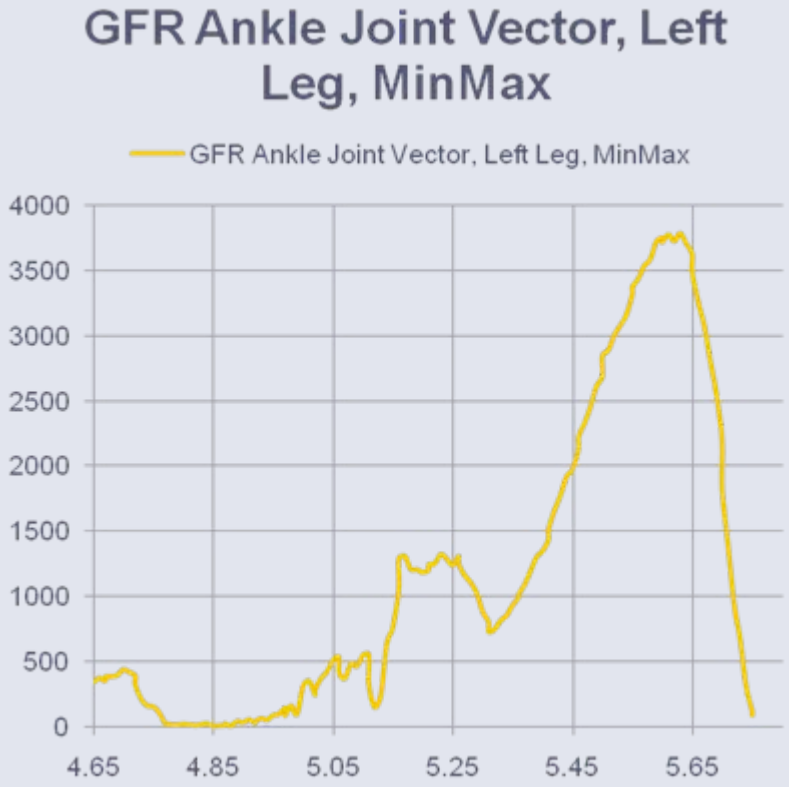
QP Solution Right



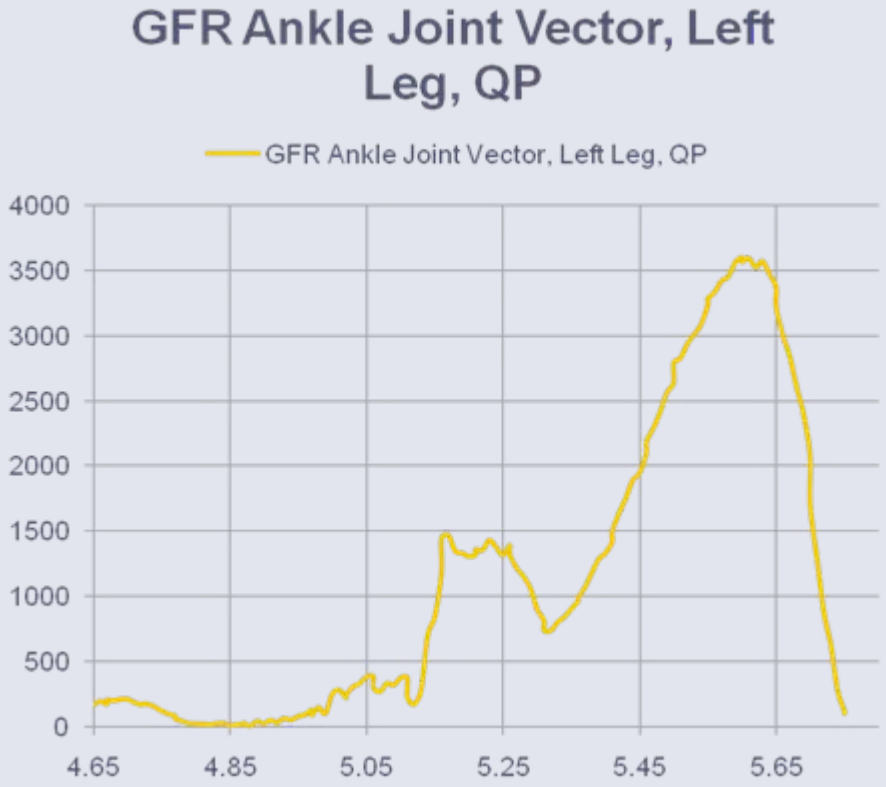
ANYBODY TECHNOLOGY

GFR Ankle Joint Vector

MinMax Solution Left



QP Solution Left



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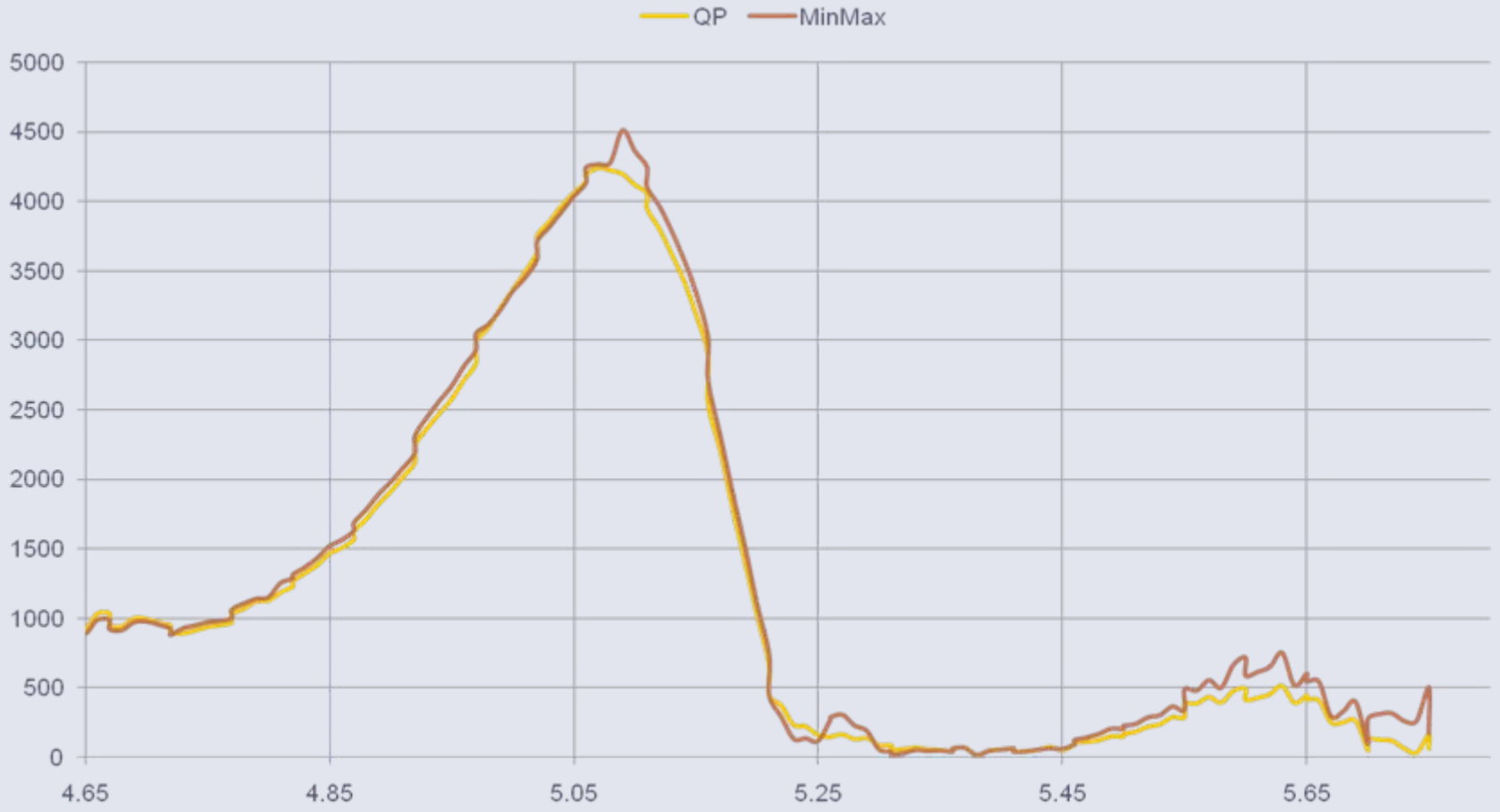
GRF Ankle Joint Vector
Comparison !



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GRF Ankle Joint Vector *Comparison !*

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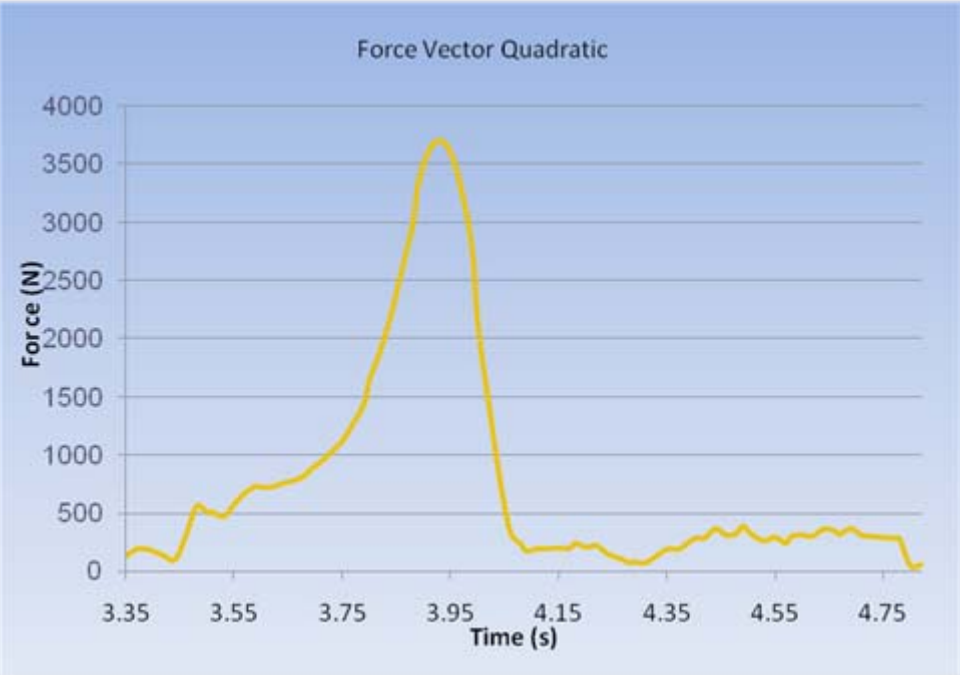
GRF Ankle Joint



- Right Ankle Total Forces Vector
  - Comparison between Quadratic and Simple Solution

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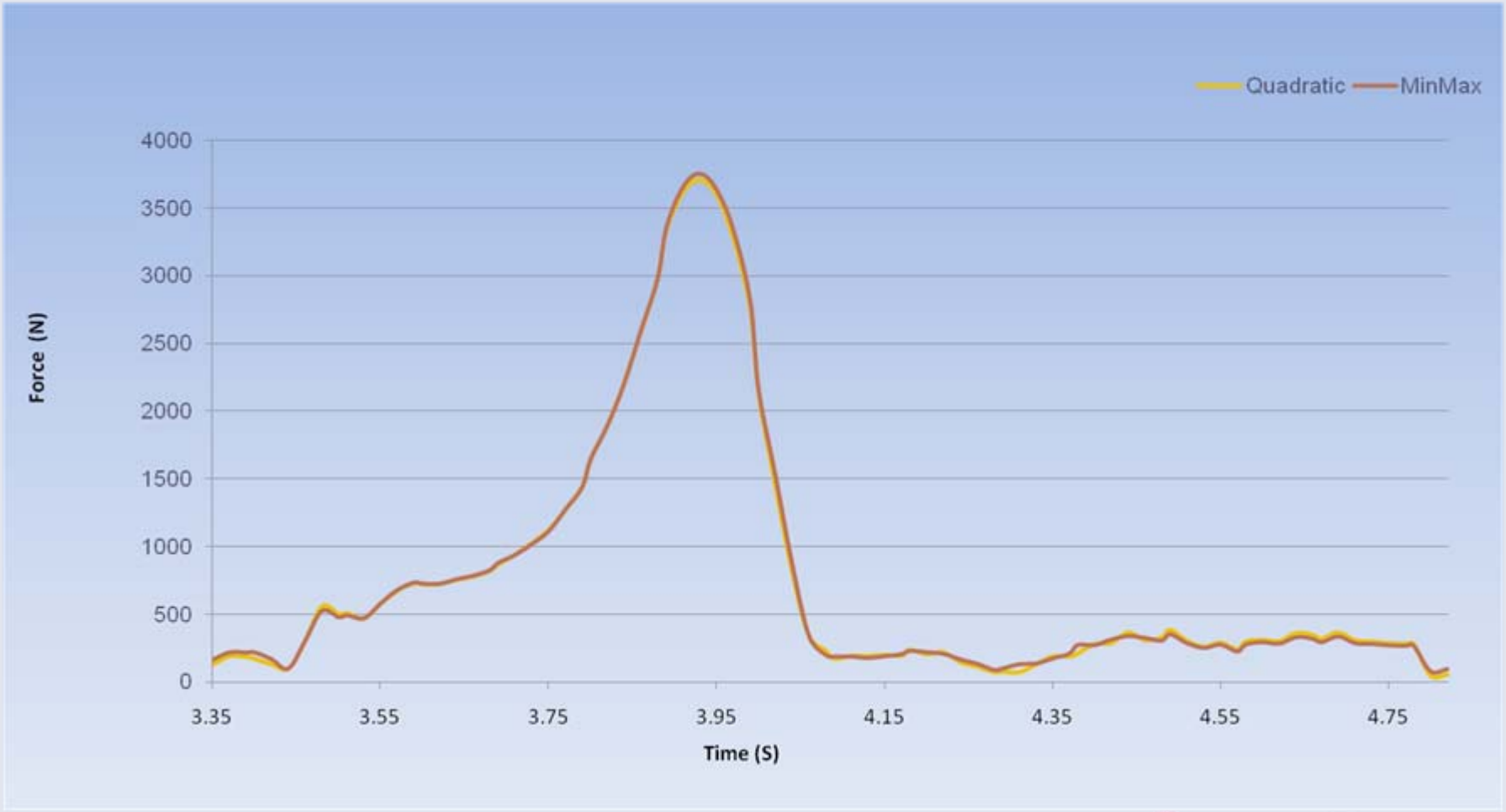
GRF Ankle Joint



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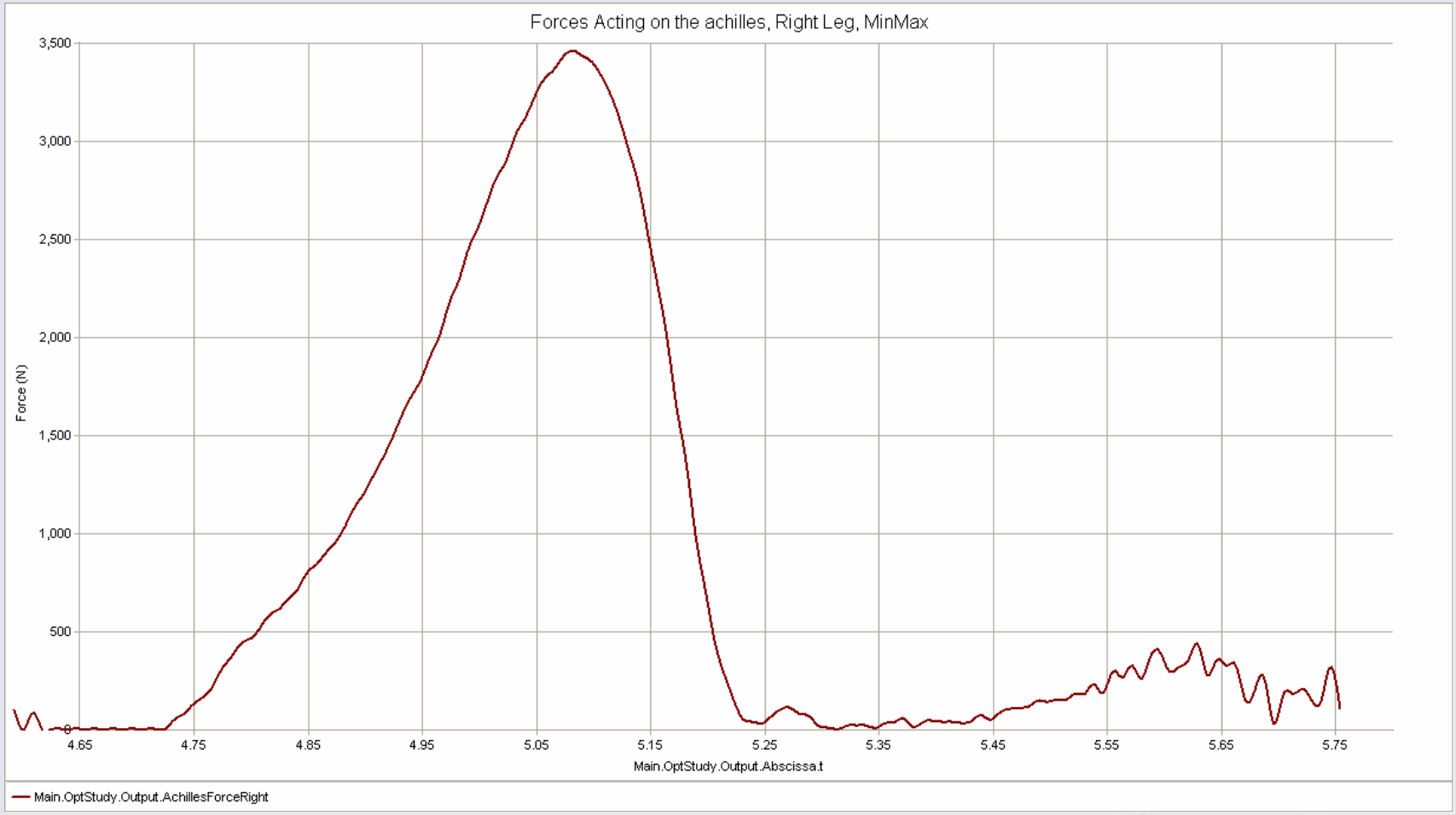
Forces Acting on the Achilles



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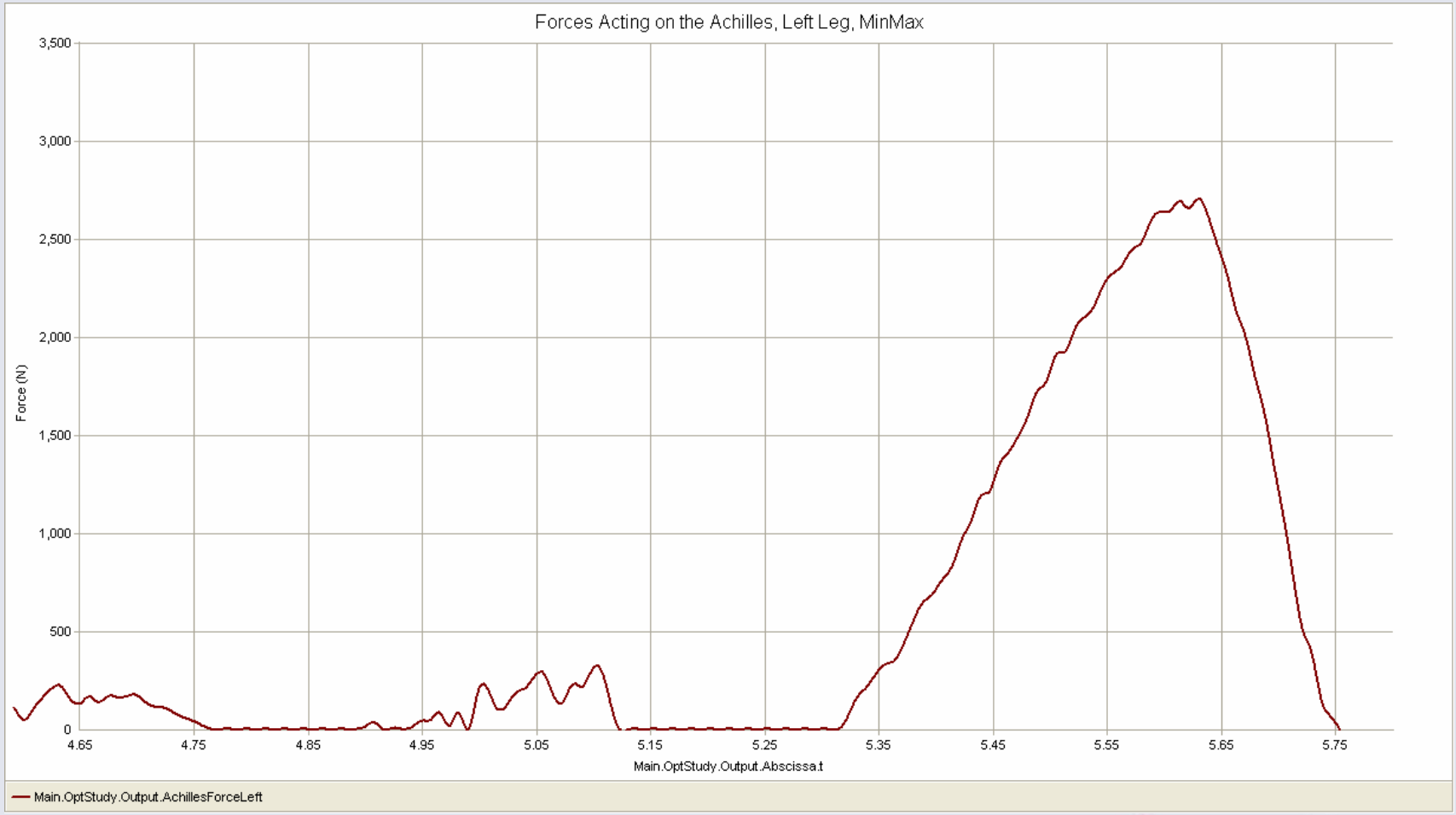
Forces Acting on the Achilles



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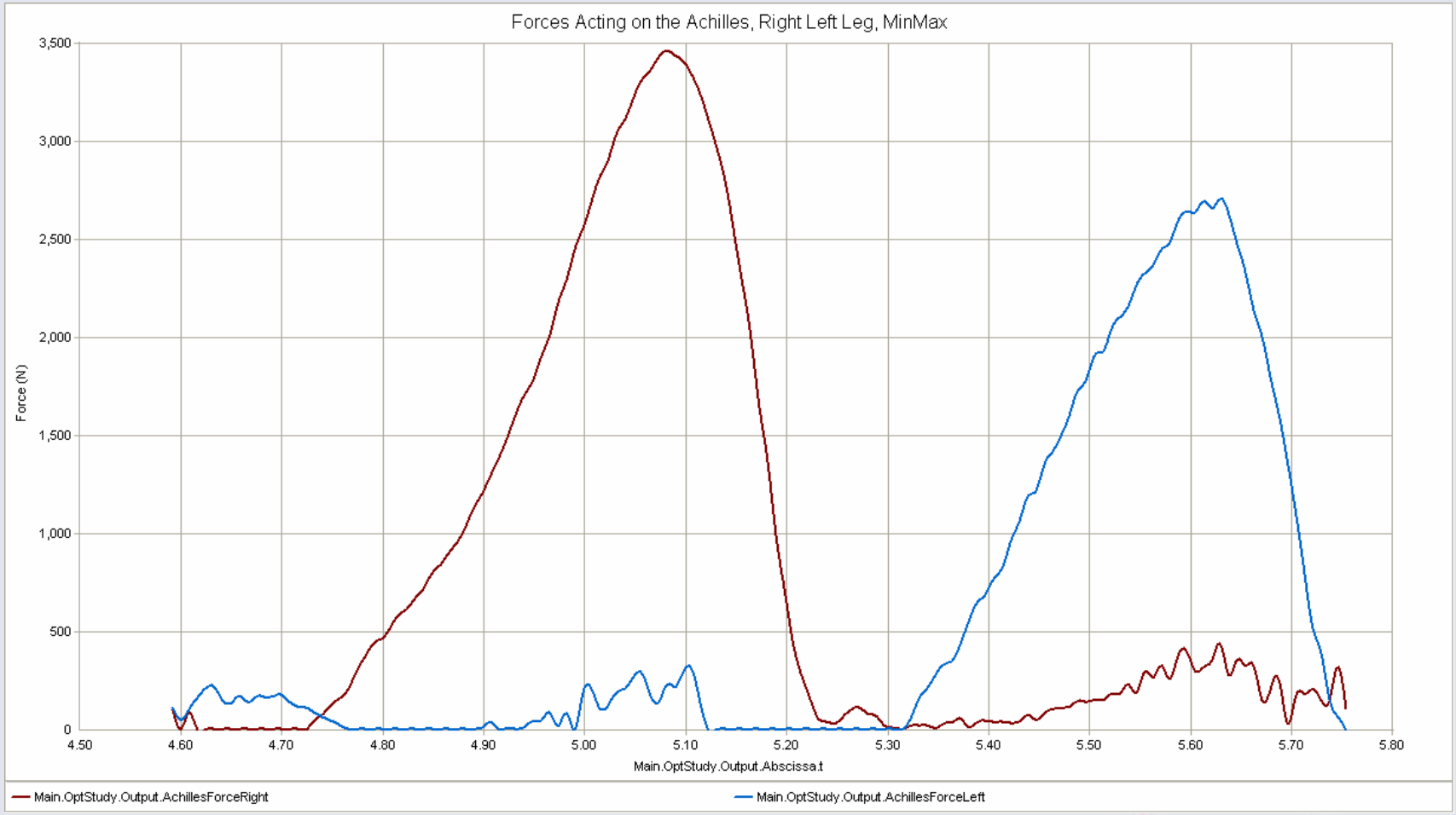
Forces Acting on the Achilles



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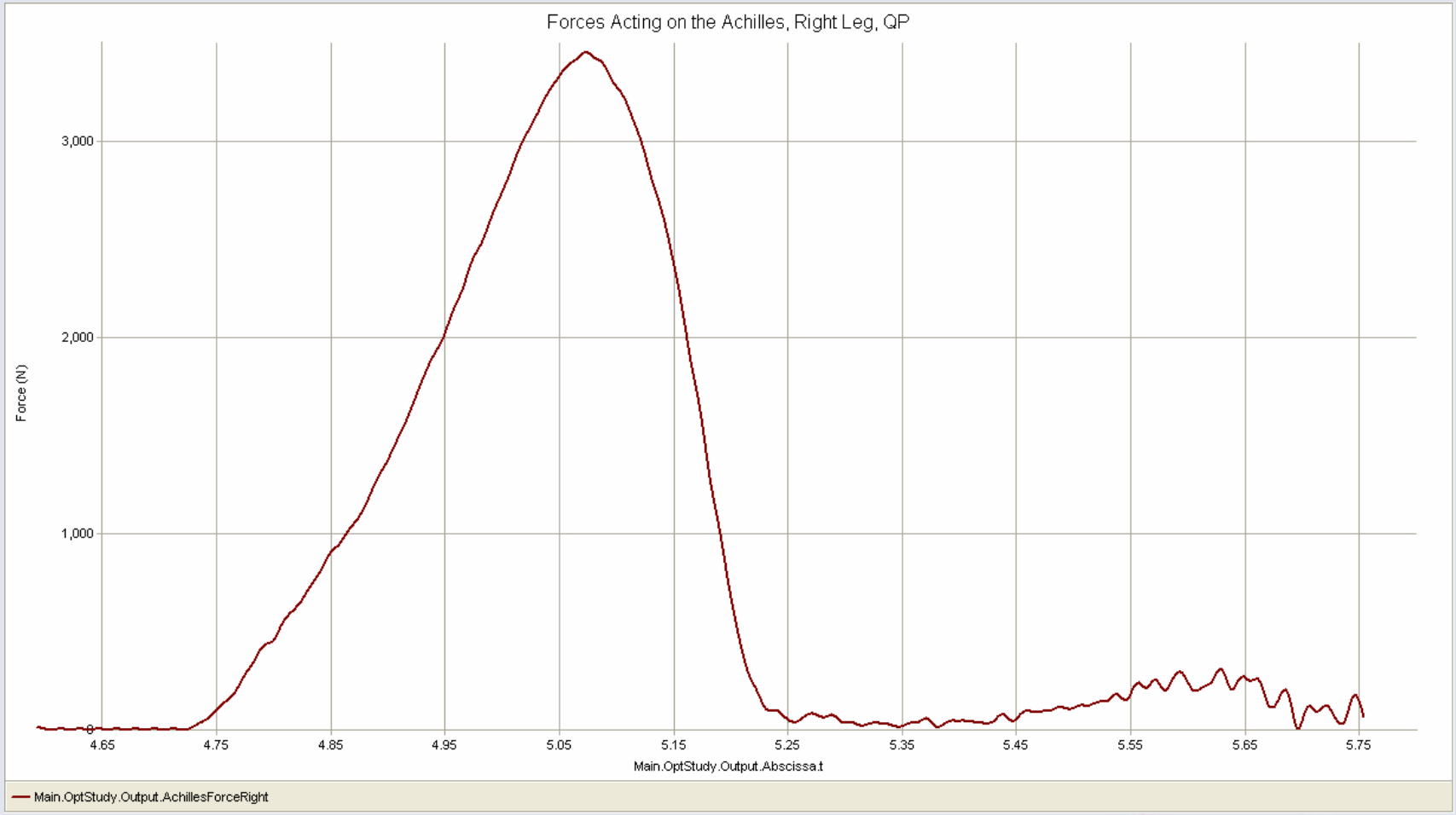
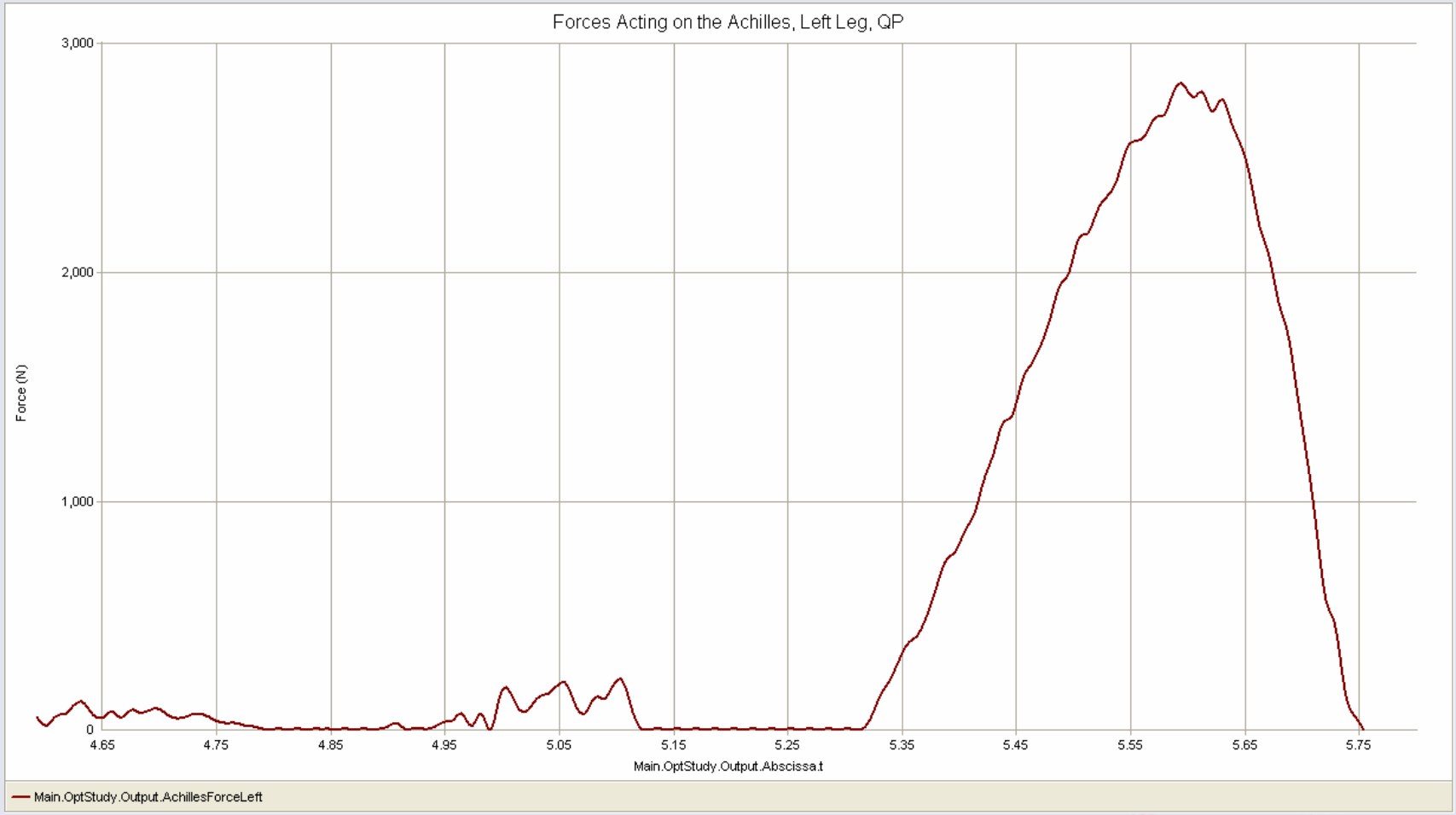
Forces Acting on the Achilles



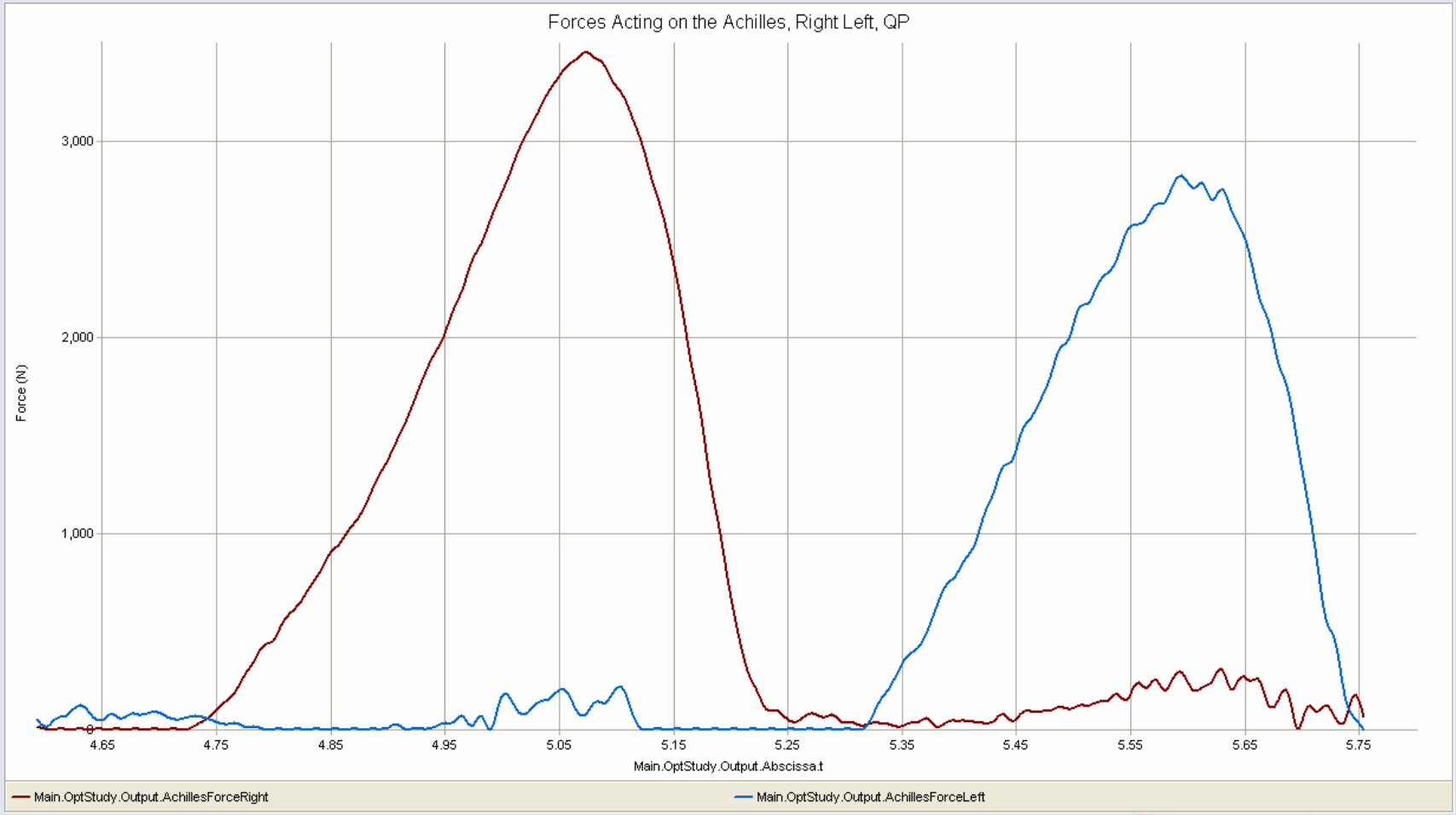
ANYBODY TECHNOLOGY

Forces Acting on the Achilles



ANYBODY TECHNOLOGY

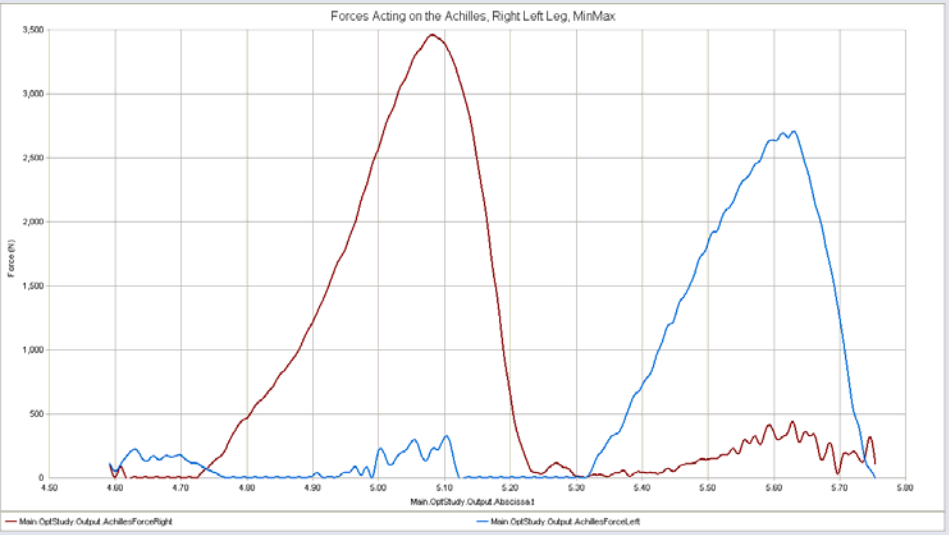
Forces Acting on the Achilles



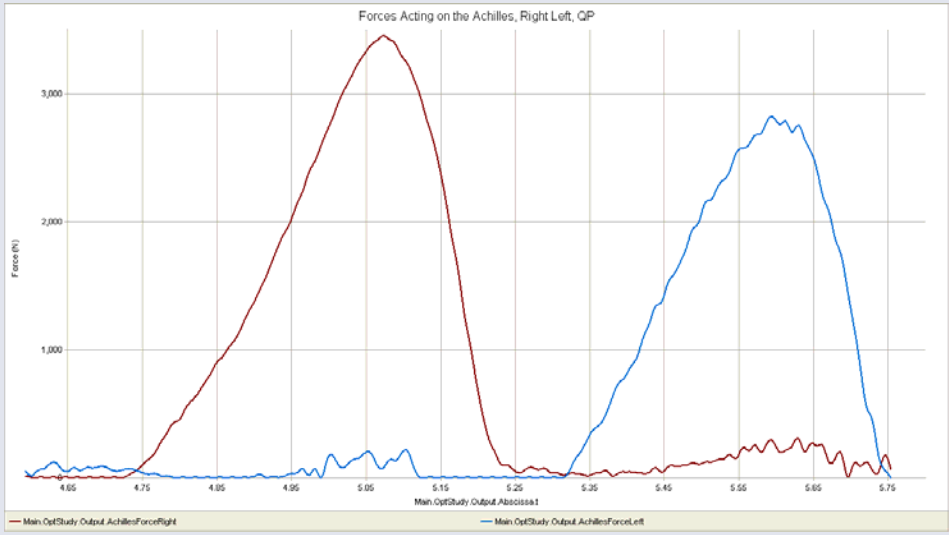
ANYBODY TECHNOLOGY

Forces Acting on the Achilles

MinMax Solution



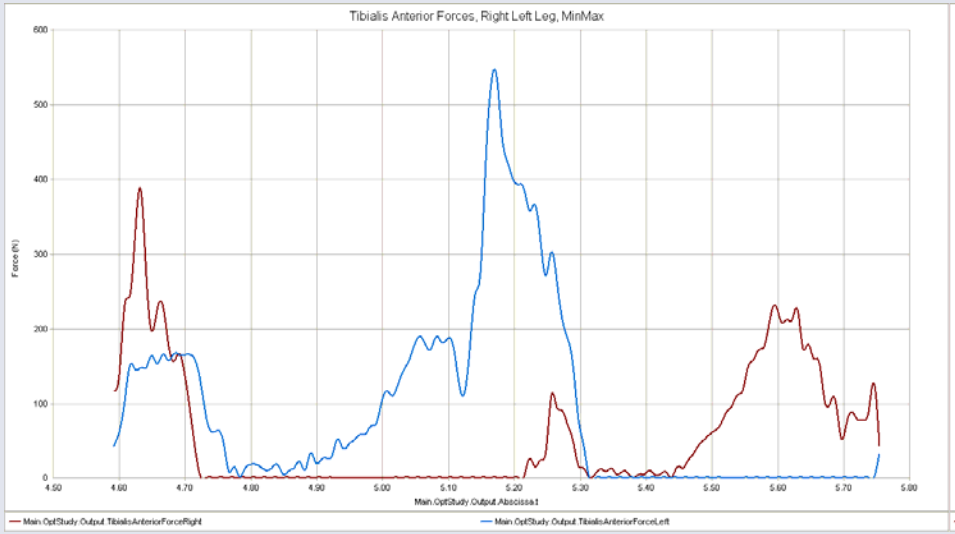
Quadratic Solution



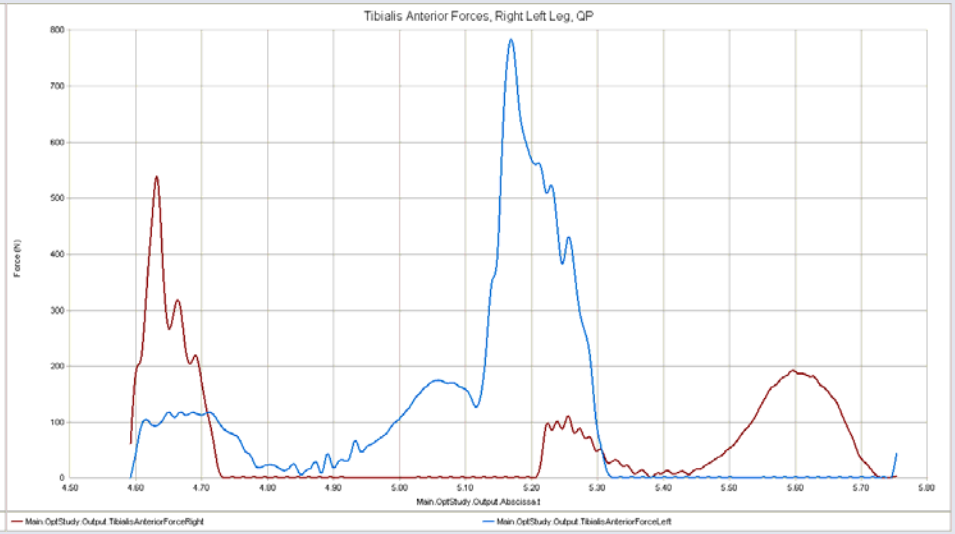
ANYBODY TECHNOLOGY

Tibialis Anterior Forces

MinMax Solution



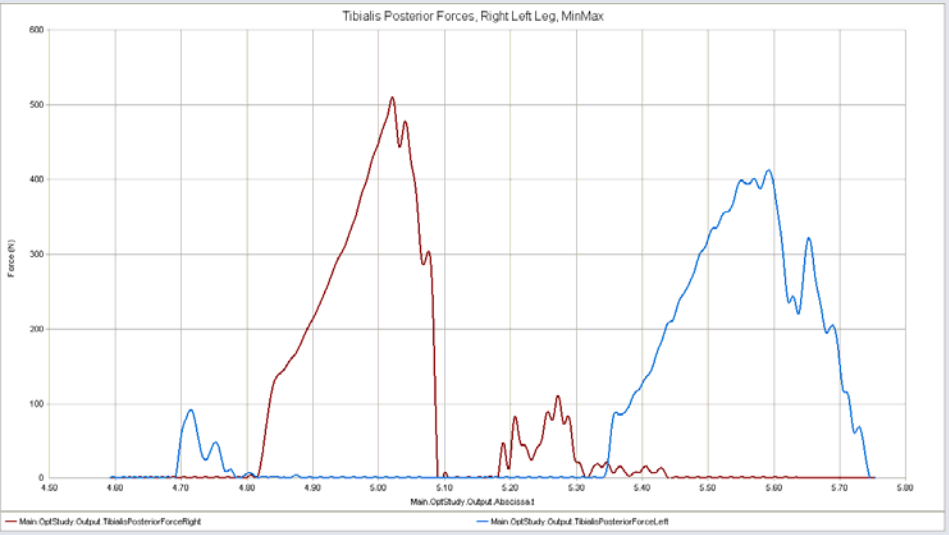
Quadratic Solution



ANYBODY TECHNOLOGY

Tibialis Posterior Forces

MinMax Solution



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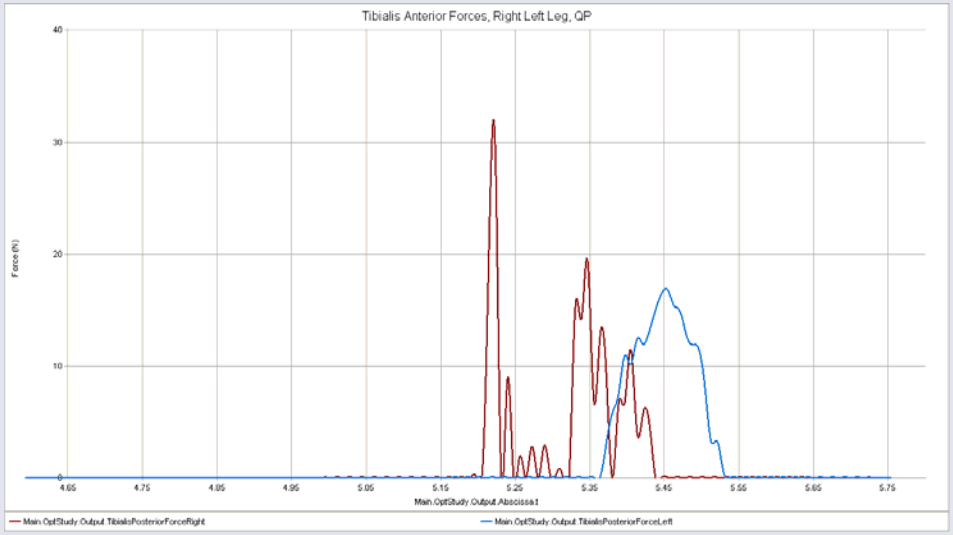
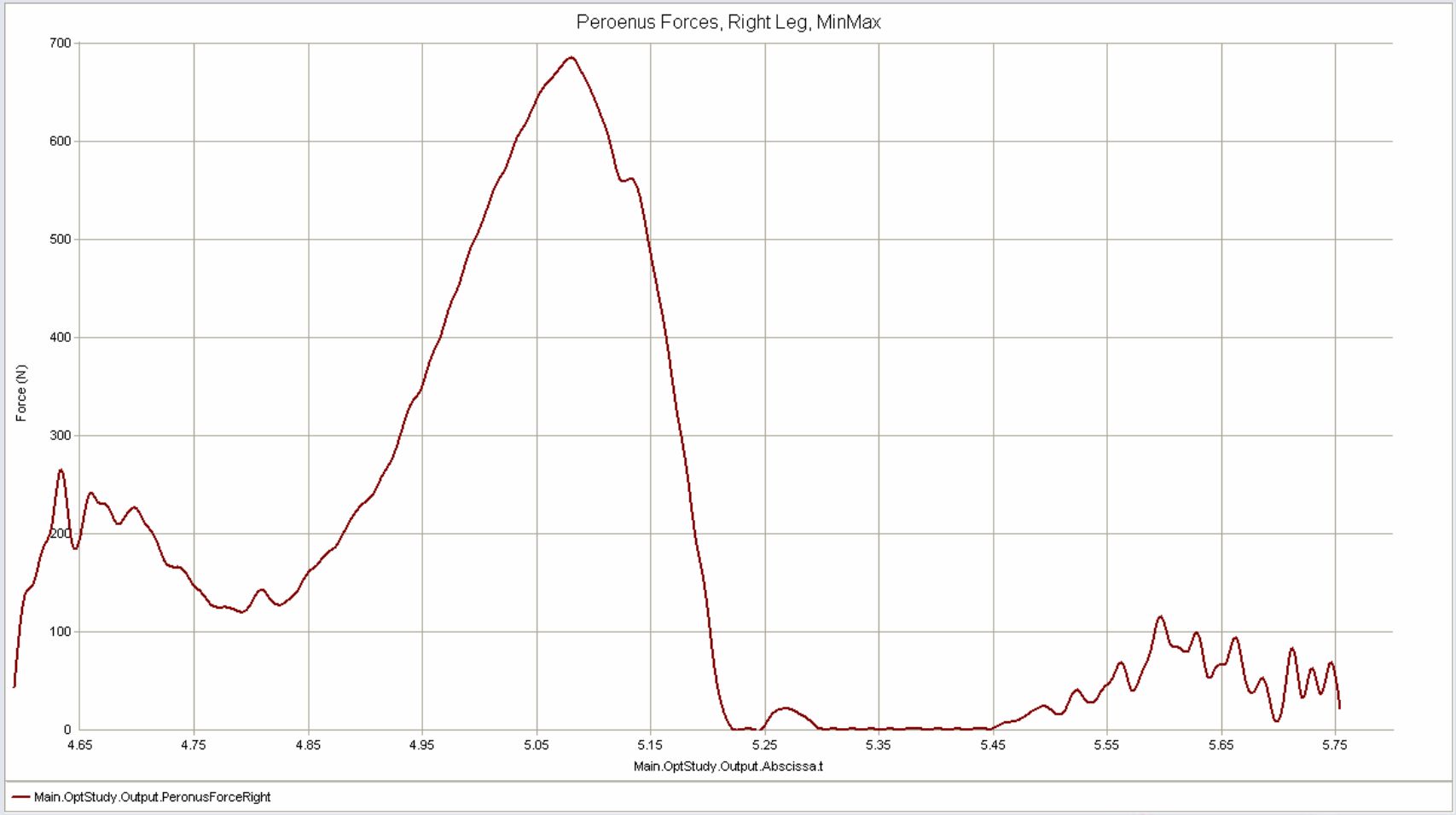
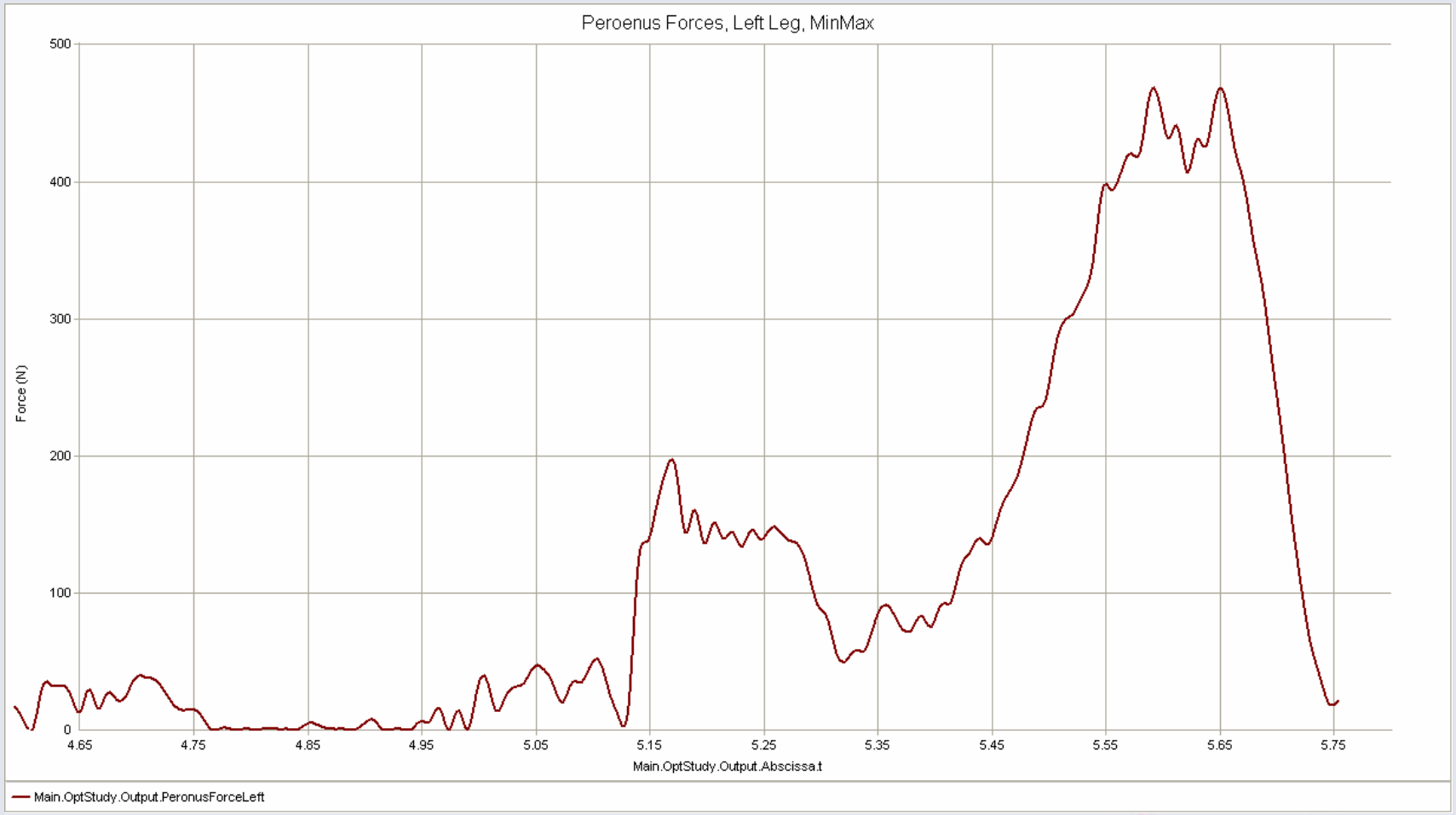


ANYBODY TECHNOLOGY

Peroenus Forces

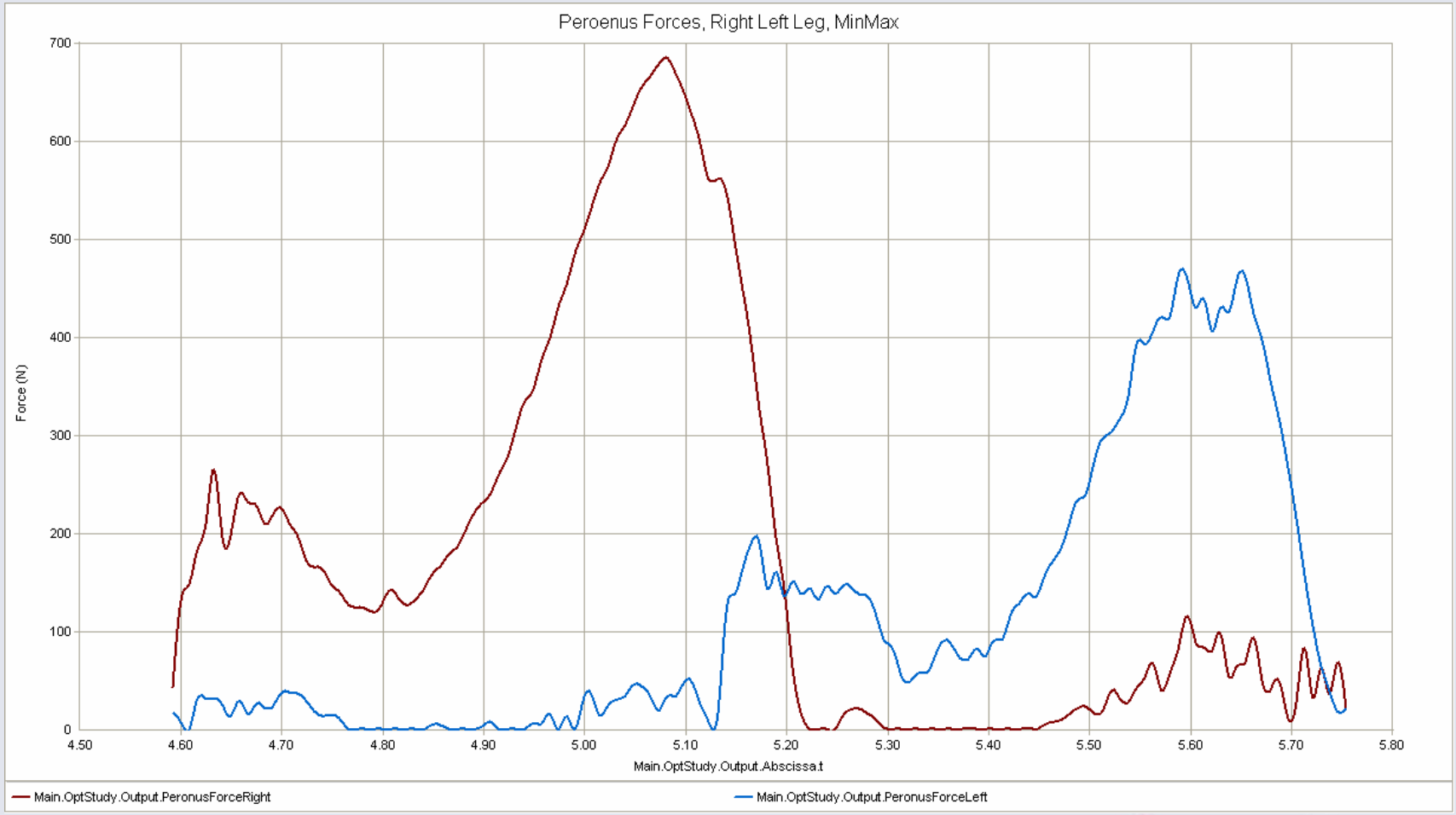


Peroenus Forces



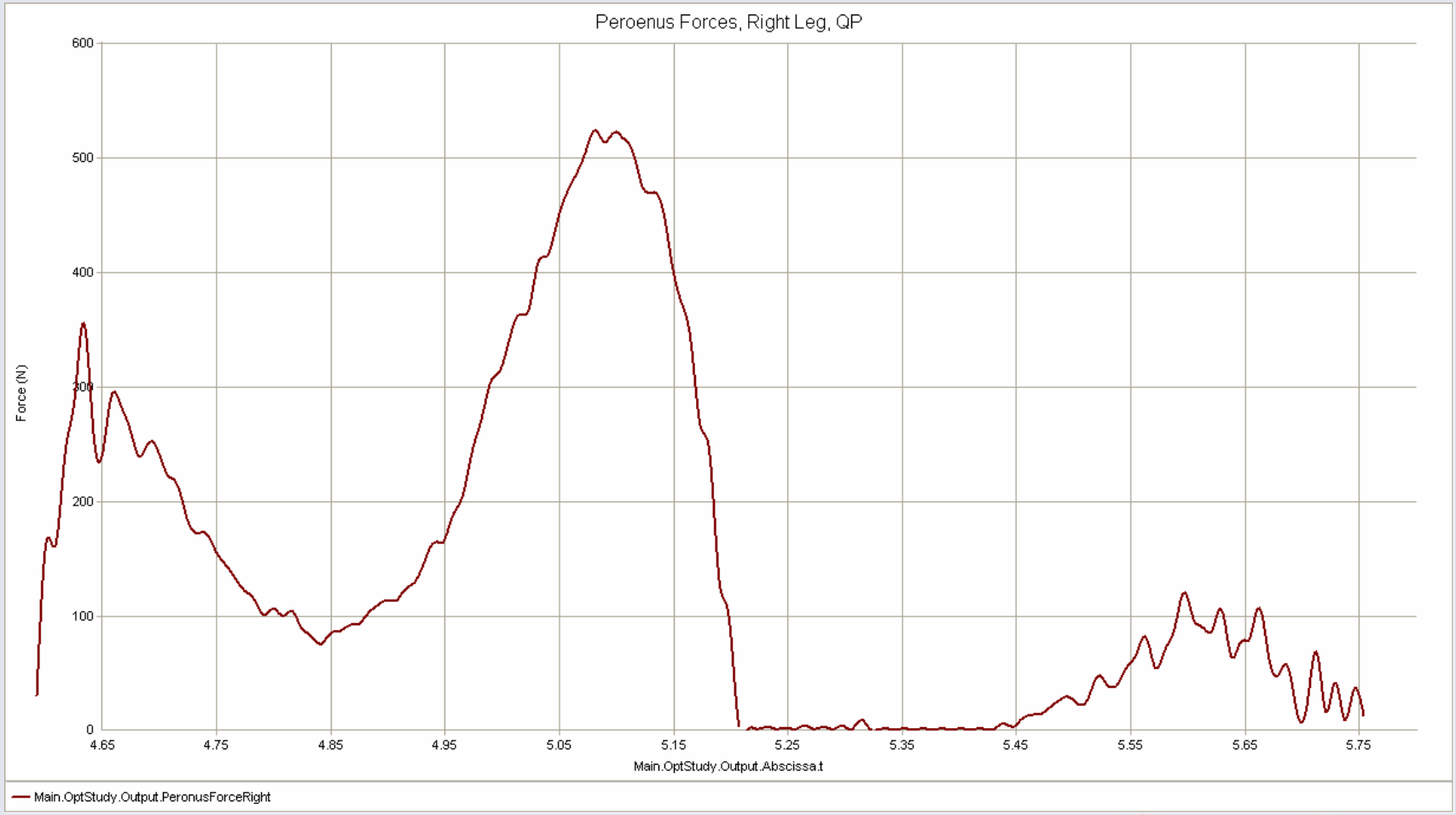
ANYBODY TECHNOLOGY

Peroenus Forces

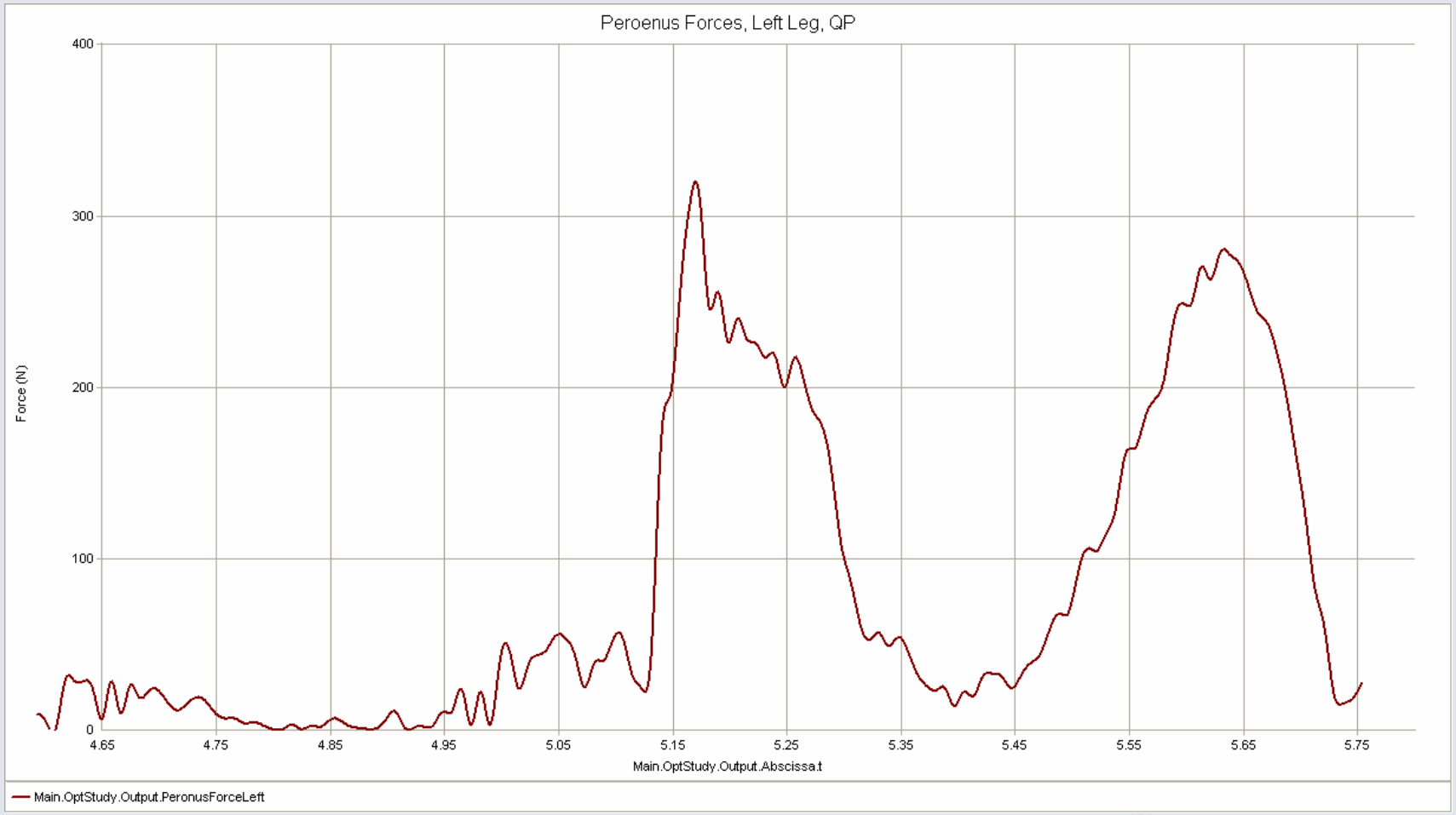


ANYBODY TECHNOLOGY

Peroenus Forces

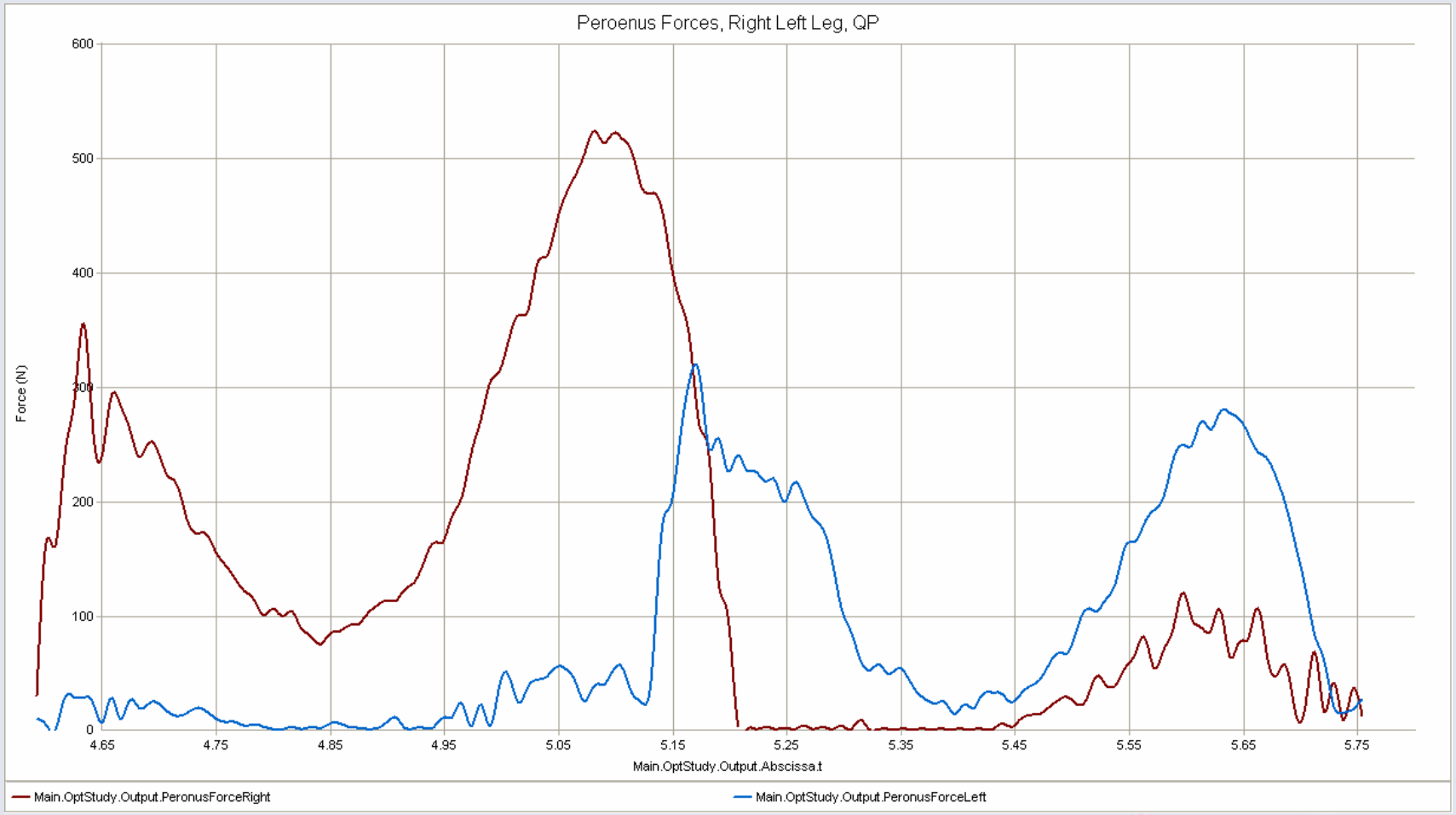


Peroenus Forces



ANYBODY TECHNOLOGY

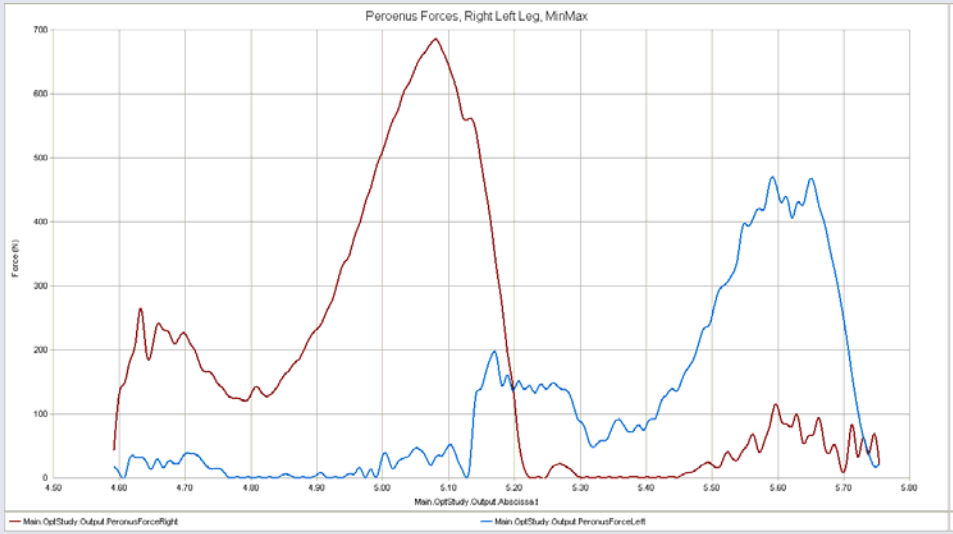
Peroenus Forces



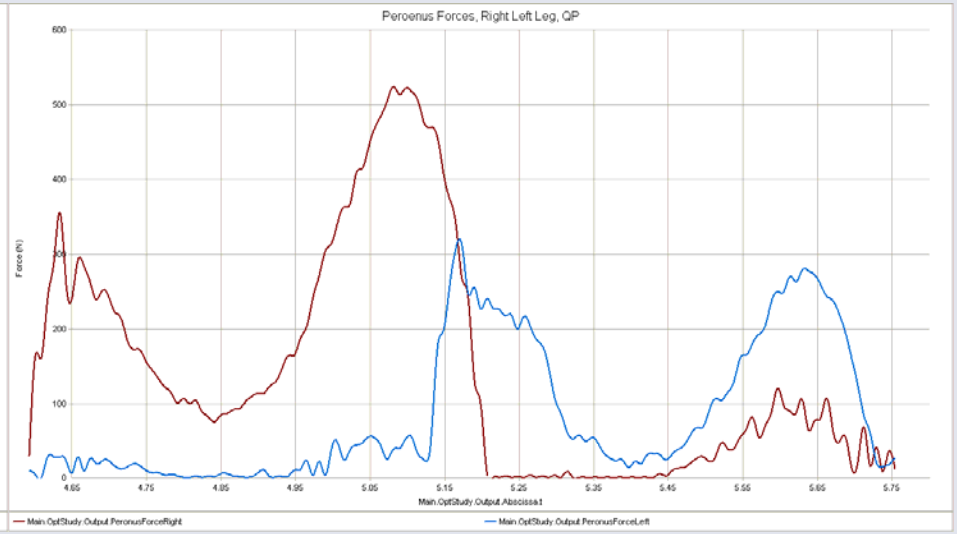
ANYBODY TECHNOLOGY

Tibialis Posterior Forces

MinMax Solution

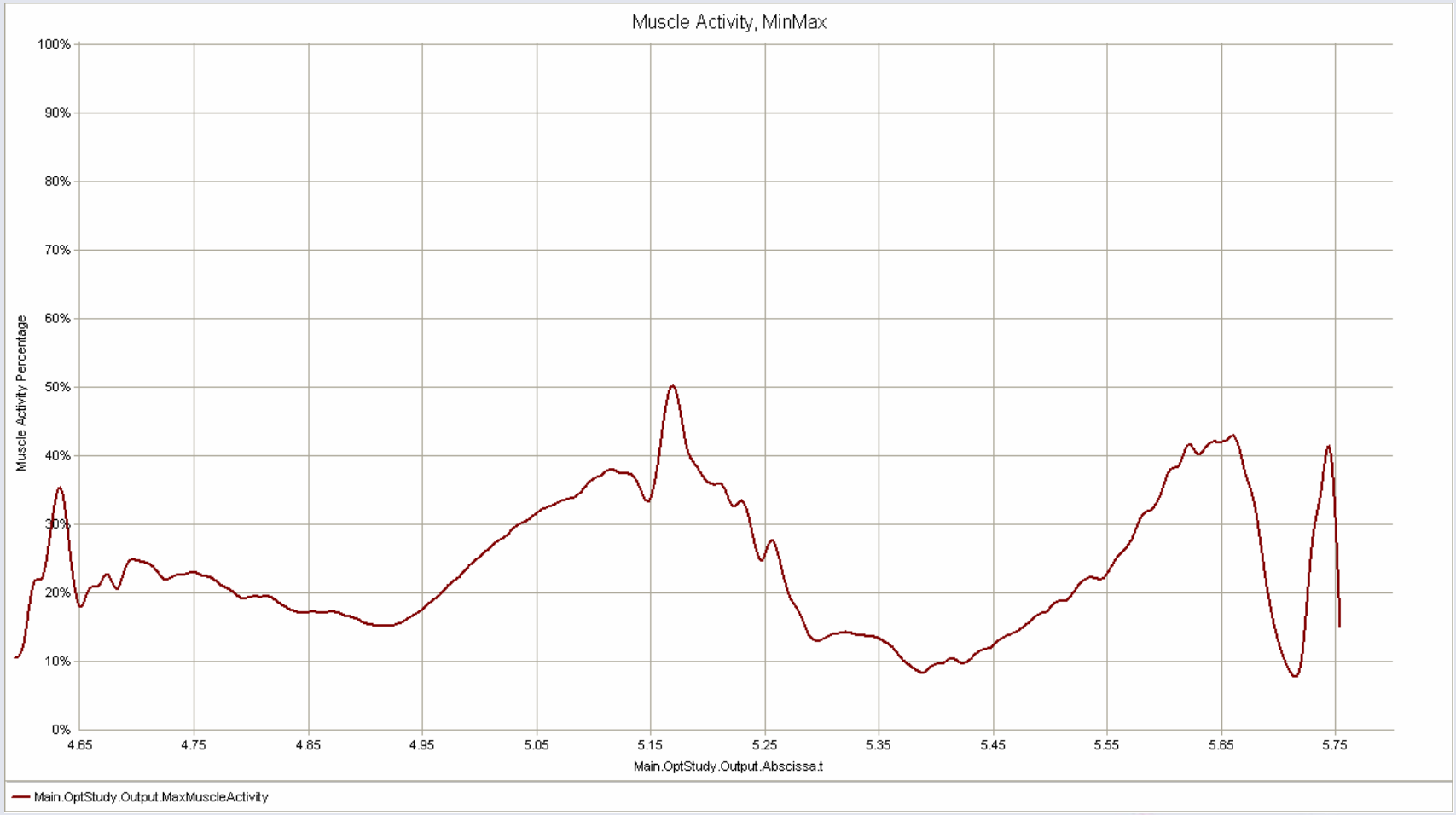


Quadratic Solution



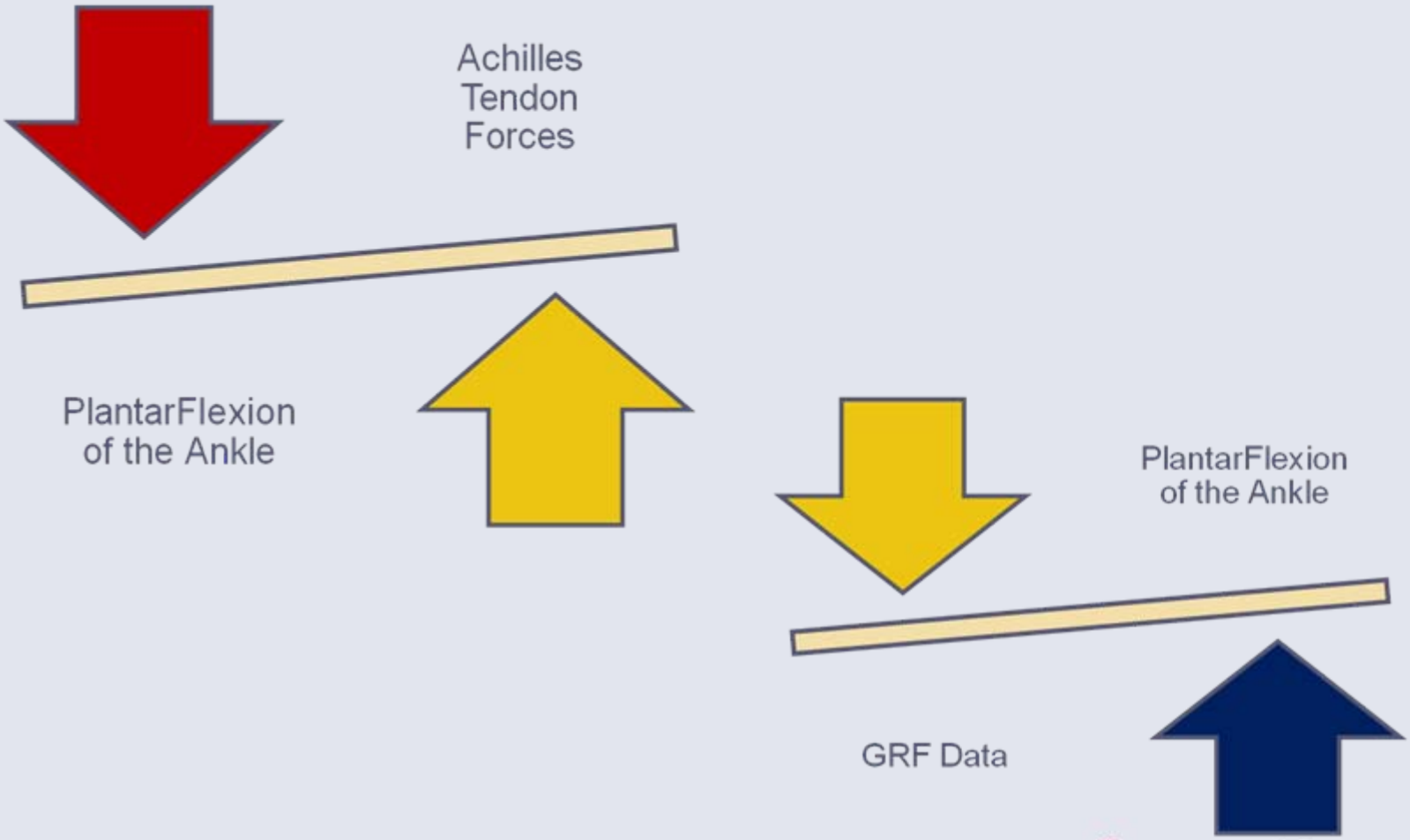
ANYBODY TECHNOLOGY

Muscle Activity



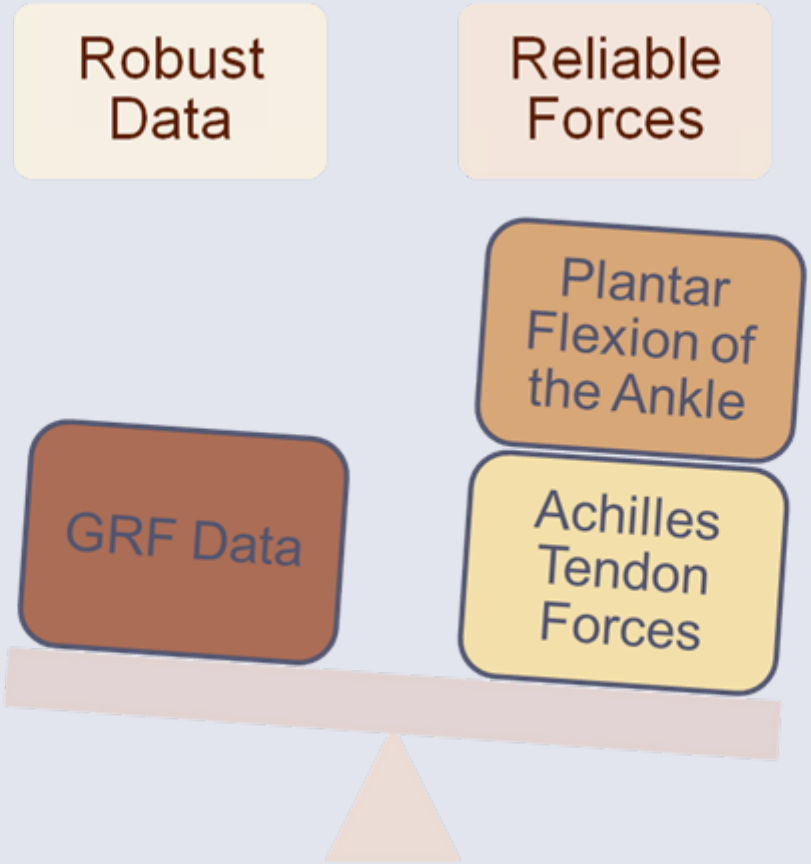
ANYBODY TECHNOLOGY

Discussion



ANYBODY TECHNOLOGY

Discussion



ANYBODY TECHNOLOGY

Discussion

- Forces Computed in the ankle **DO NOT** depend on the recruitment solver in AnyBody
- More interesting ! …
- Importance of the Muscle
- Not a problem in AnyBody : more muscles than degrees of freedom.

Summary

- Present TARs are among the joints replacement that don’t have reliable results
- Further Joint Data needed for investigation
- Data Collected in Vicon and Processed in AnyBody
- Results lie in an acceptable range
    - Therefore …

Current/Future Work

- Use an FE Model to investigate forces and on the bones and stresses on the Prosthesis *(work in progress)*
- Collect data from a defined Normal and Diseased population
- Process Data and Compare !

In Order To Achieve this Work

- We need to get TARs samples as well as TARs CAD file.
- Collaboration will be made.
- Confidential Treatment of files.
- Study will be done using those TARs and hence more logical and realistic improvements can be achieved.

In Order To Achieve this Work

- Opportunity to make a business and/or financial collaboration
- Financially and Personally difficult to rely on my family and meet the cost of living

Contact Options

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  College of Medicine, Dentistry & Nursing

  Ninewells Hospital & Medical School

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ANYBODY TECHNOLOGY

Thank You …

The next webcast hosted by AnyBody Technology will be held on January , 22nd 2009.

Title:
“Optimization of implant and prostheses design with AnyBody - boundary conditions for FE Analysis", by Alexander Nolte, CADFEM GmbH. “

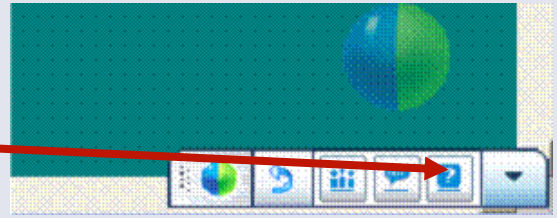
We hope to meet you there...

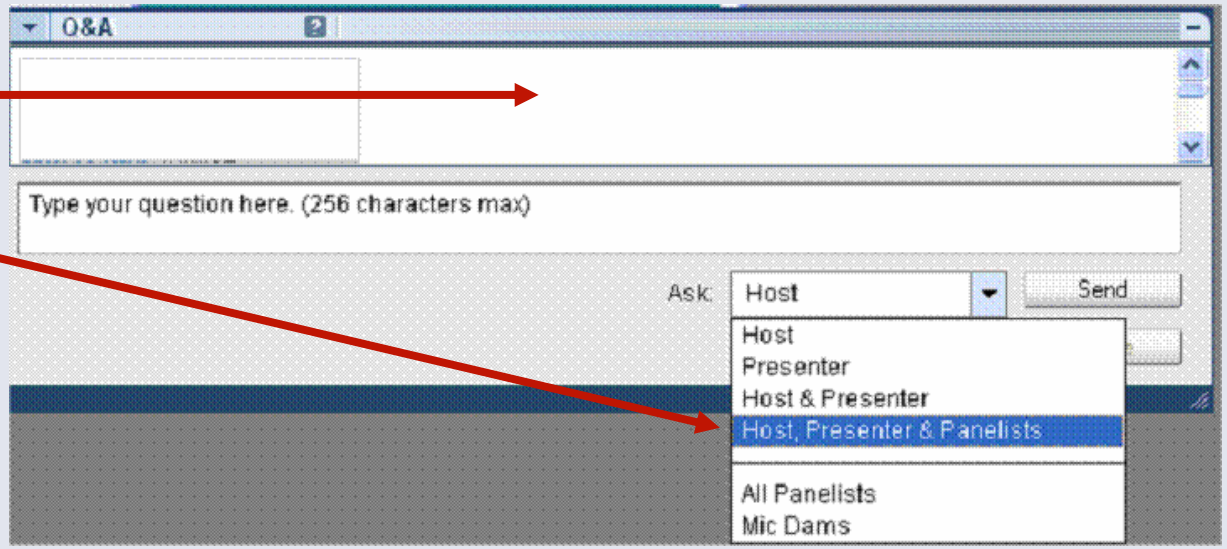
Special Thanks to :
My Supervisor : Dr Tim Drew
John Rasmussen (Aalborg University)
Arne Kiis (Anybody Technology)

ANYBODY TECHNOLOGY

Q&A Panel

- Launch the Q&A panel here.
- Type your questions in the Q&A panel.
- Send the question to ”Host, Presenter & Panelists”





Notice the answer displays next to the question in the Q&A box. You may have to scroll up to see it.

ANYBODY TECHNOLOGY