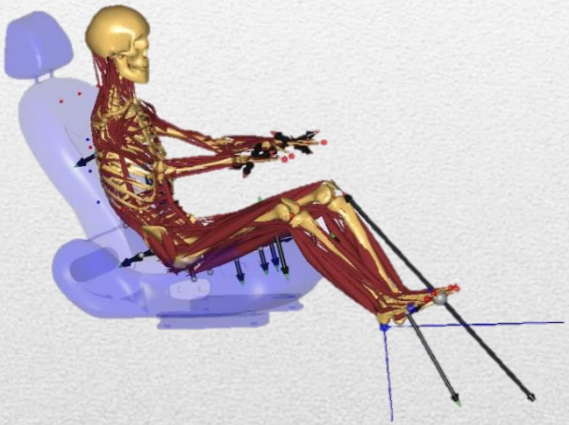
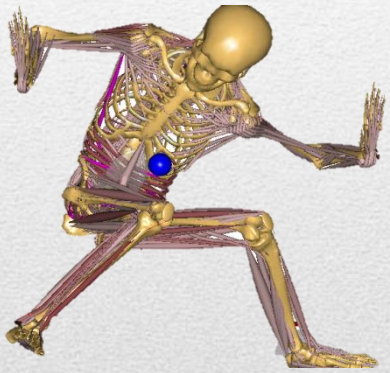
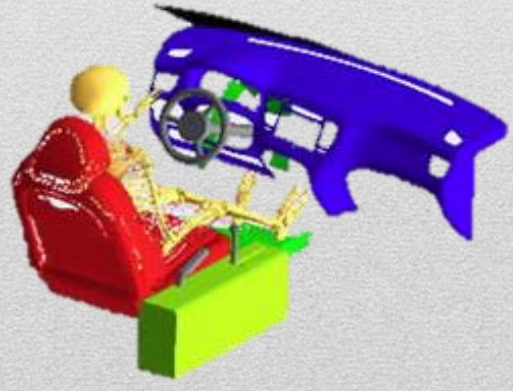
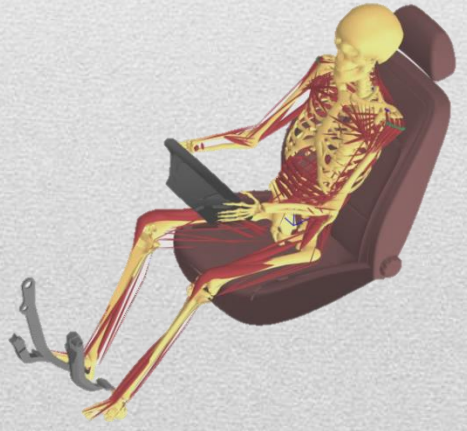
Musculoskeletal Simulation in an Automotive Environment

The web cast will start in a few minutes….





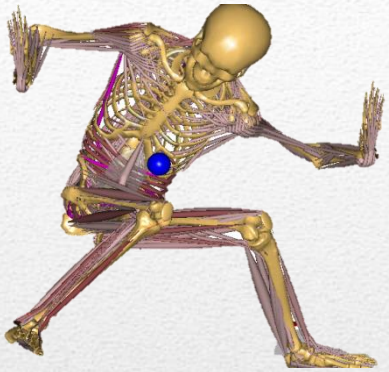




Amir Al-Munajjed

AnyBody Technology

ANYBODY TECHNOLOGY



Outline:

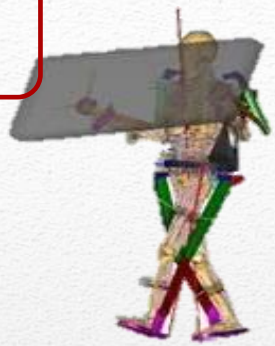
- Who & what is AnyBody?
- Automotive application
  - Package design
  - Ingress/egress
  - Seat development/comfort
  - others
- Questions & answers

Moonki Jung
(Panelist)

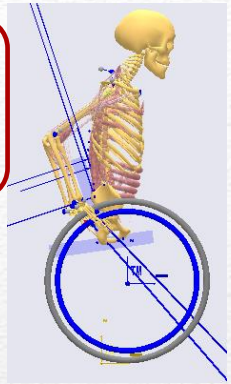
Amir Al-Munajjed
(Presenter)

ANYBODY TECHNOLOGY

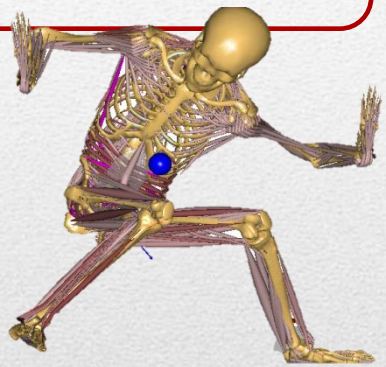
Work Environment/
Assistive devices



Product
Design
Optimization



Ergonomic Analysis
and Documentation

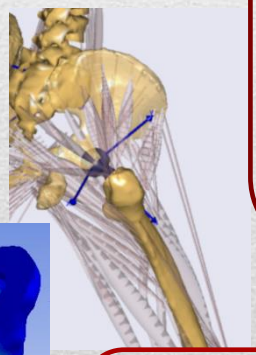


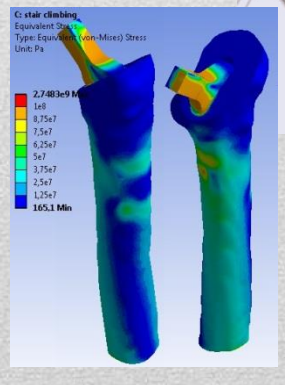
Who is AnyBody?

AnyBody Technology

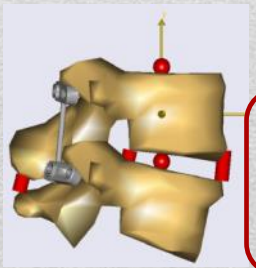
(Aalborg, DK; Boston, US)

- *AnyBody Modeling System*
- *Licenses, Training, Support*
- *Consulting*





Physiological Load
Cases for Finite
Element Analysis



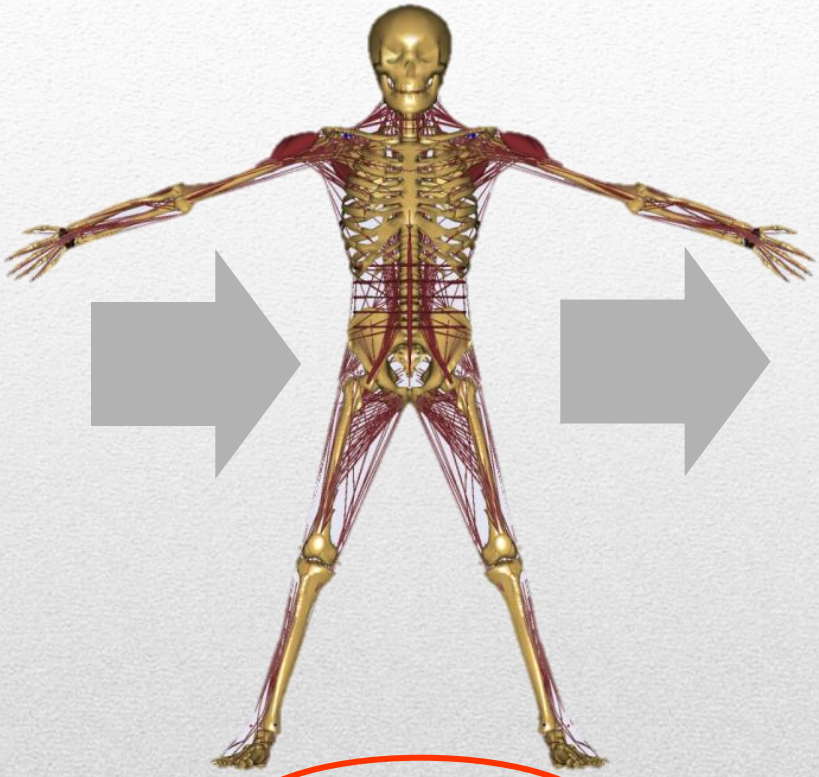
Surgical Planning, -
Evaluation & -Failure
Analysis

ANYBODY
TECHNOLOGY

Musculoskeletal Simulation

Input

Activity/
Motion



Output

Muscles:
forces, activity, power
Joints:
forces, moments,
...

Body Model

Bones

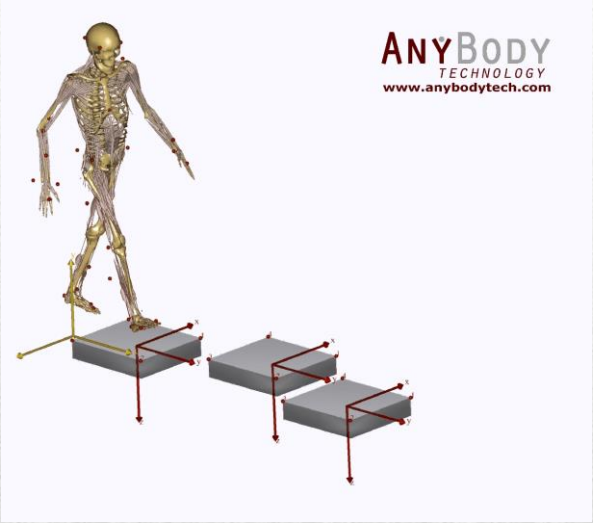
Joints

Muscles

Ligaments

Inverse Dynamic Analysis

Input:

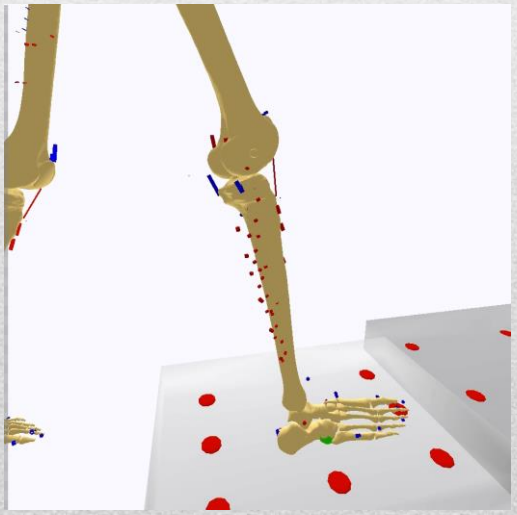


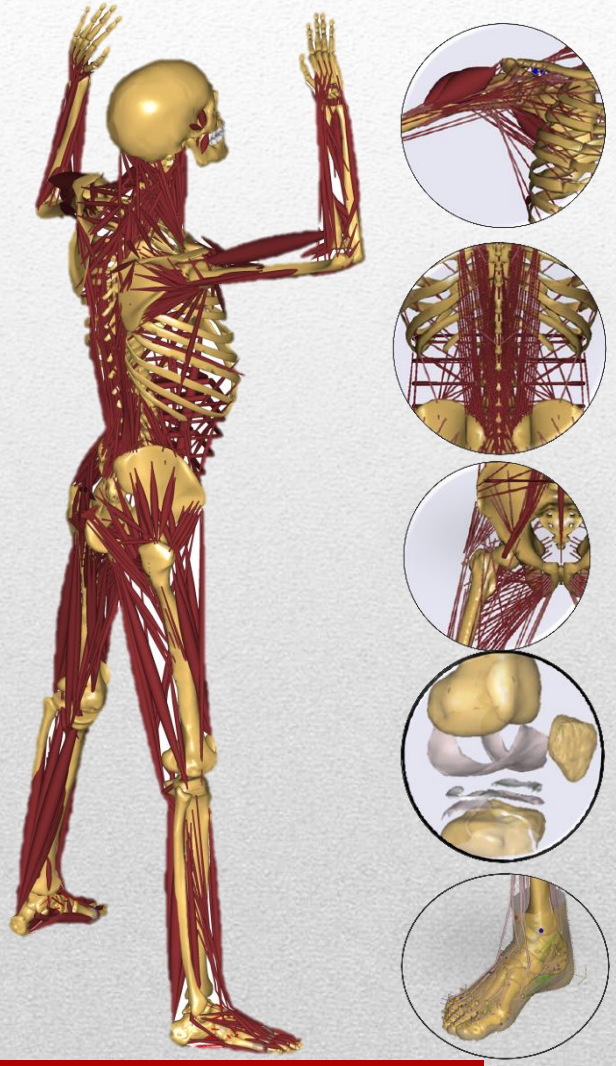
Motion & ext Forces:

- Motion Capture (Vicon, Qualisys, ...)
- Joint Angle Input

Output:

- Muscle Forces (activations)
- Joint Reaction Forces





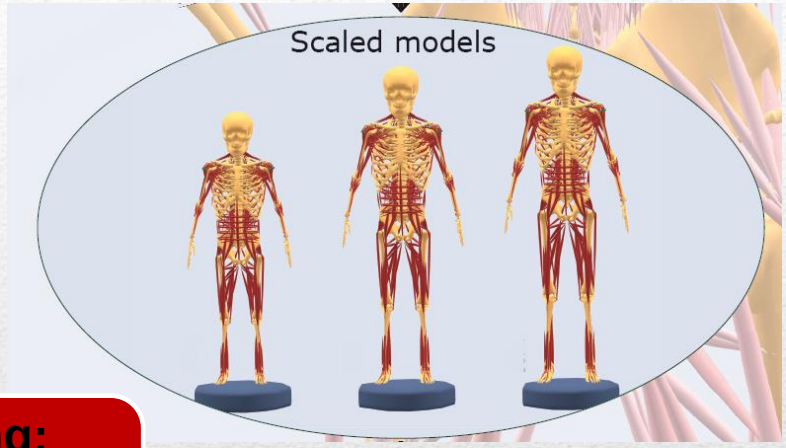
Subject - Specific Modeling

Standard avg. European Male

Anthropometric Scaling

Kinematic Scaling: Dynamic or Static

Morphing: Subject Specific Bone Geometry



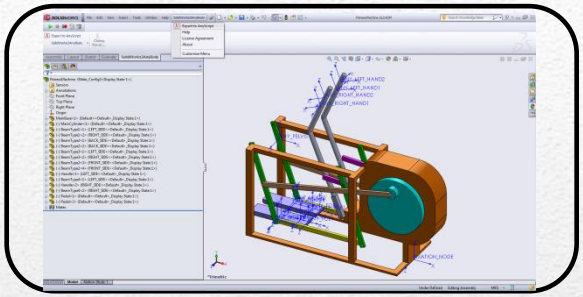
Rasmussen et al. 2005

Nakashima et al. 2010

Possibility to scale:

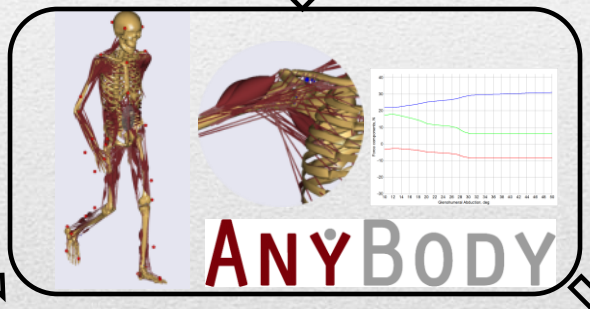
- Standard subjects, like 50%, 5% or 95% or in between
- Individual subjects: from real experiments
- Population groups: elderly, pregnant, obease...

Advanced Work flow



CAD environment model
(SolidWorks2AnyBody)

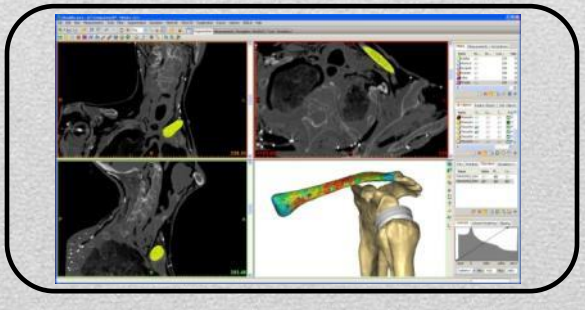
Applications: Activities of daily living



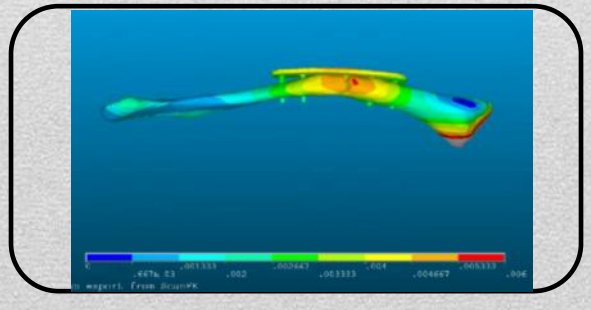
Processing workflows:

- Scripting e.g. Python, Matlab.
- Optimization software

Subject information

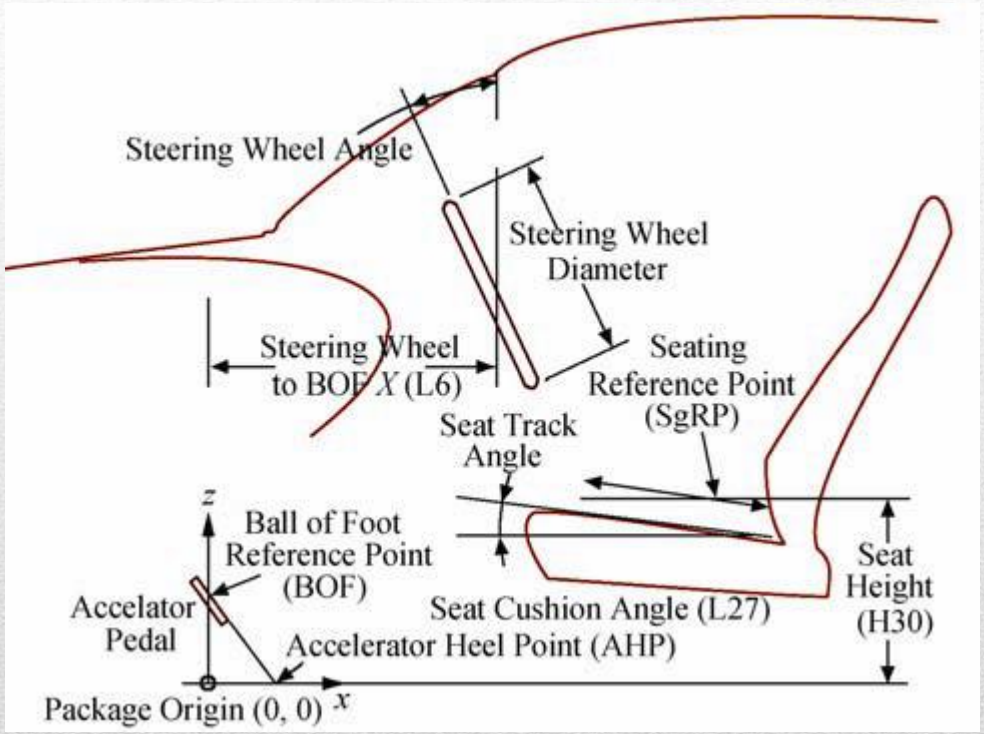


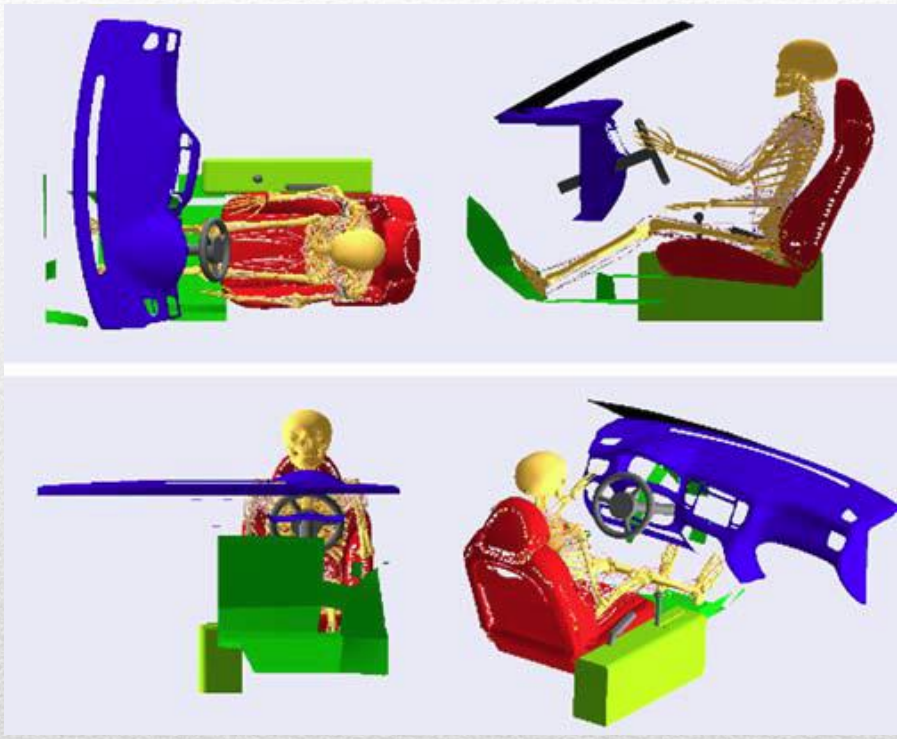
FE-model



- **Automotive Application**
  - **Package design**
  - ***Ingress/egress***
  - ***Seat comfort***
  - ***others***

Package Design & Optimization

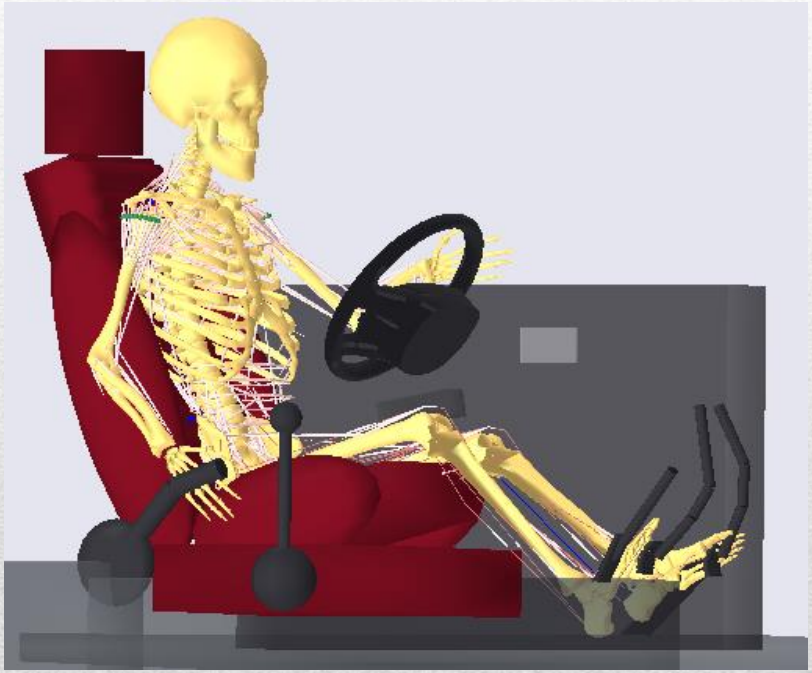




Typical parameters that can be optimized and analyzed using the AnyBody modeling System

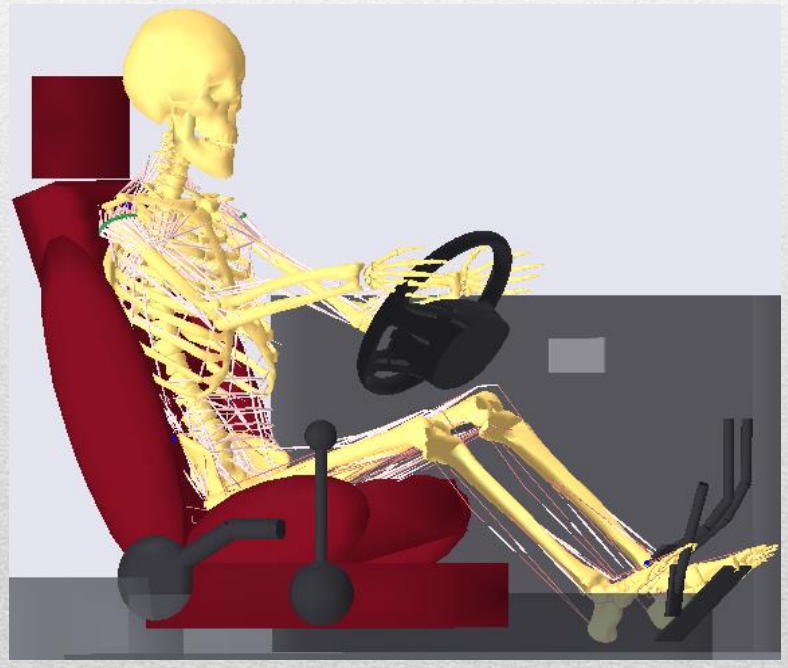
Jung et al., 2009, J. Computer Science Tech.

Ford: Best position of handbreak and pedals for lowest muscle activation

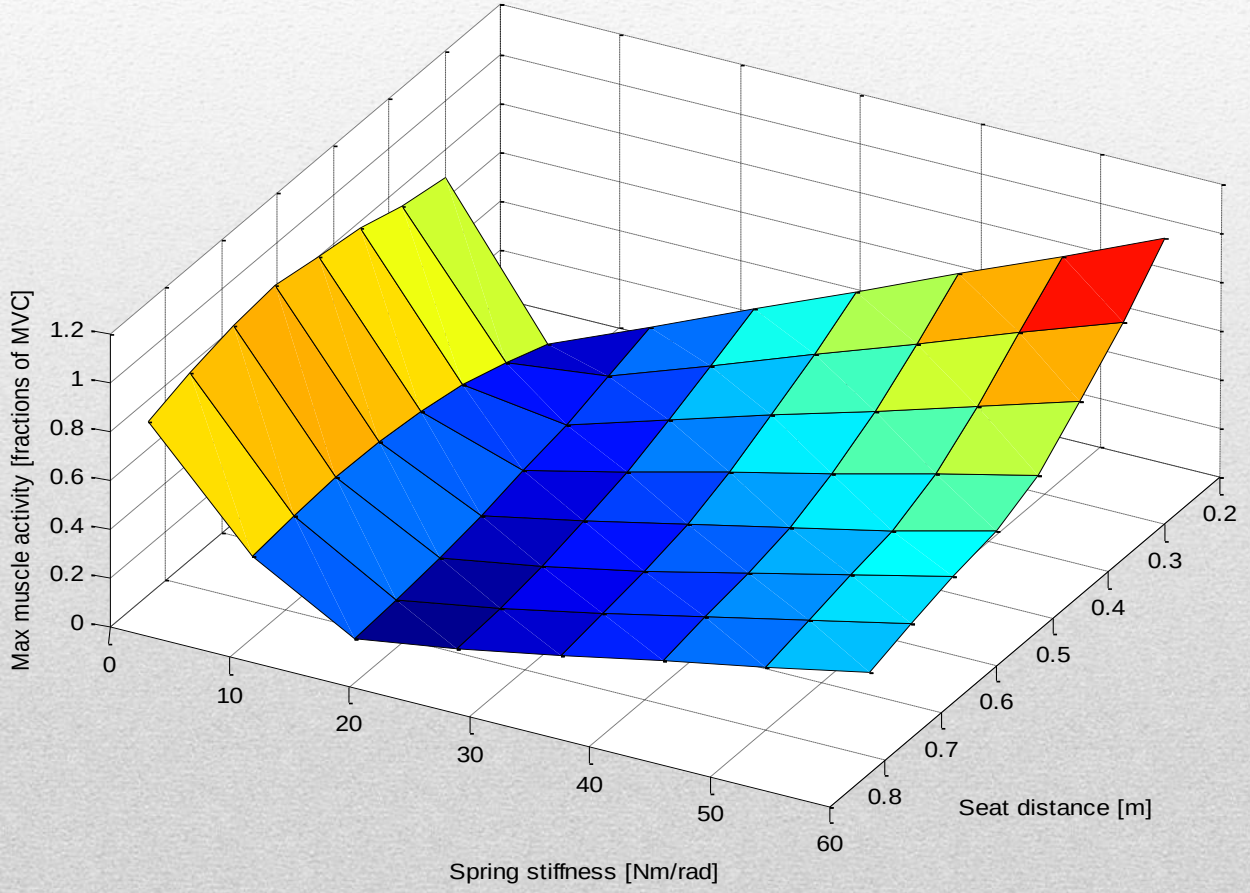


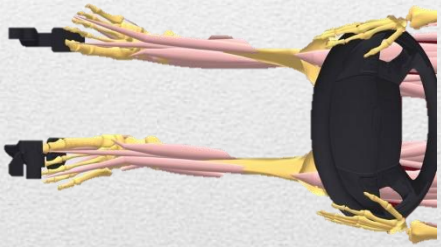
Handbrake: fast movement, high muscle activation

Acceleration: long term, low muscle activation



Clutch pedal optimization



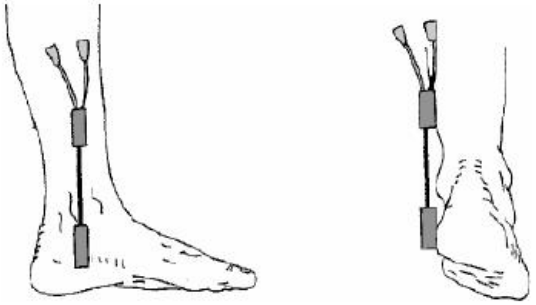


Validation Study: Braking

Validation Study: Braking

- Ford test vehicle, tunable force characteristic for brake pedal. Partially obstructed view.

- Motion analysis:
  Qualisys for the upper body and the left leg;
  Goniometers at the right leg;
  Potentiometer for right heel
- External Loads:
  contact switch to identify heel position;
  pressure mapping to estimate seat support;
  force transducer at the brake pedal
- EMG measurements of right leg muscles



Research & Advanced Engineering

ONE FORD
ONE TEAM • ONE PLAN • ONE GOAL

Rausch & Siebertz (2009), ANSYS Conf. & 27. CADFEM User's Meeting, Leipzig, Germany

Validation Study: Braking - foot

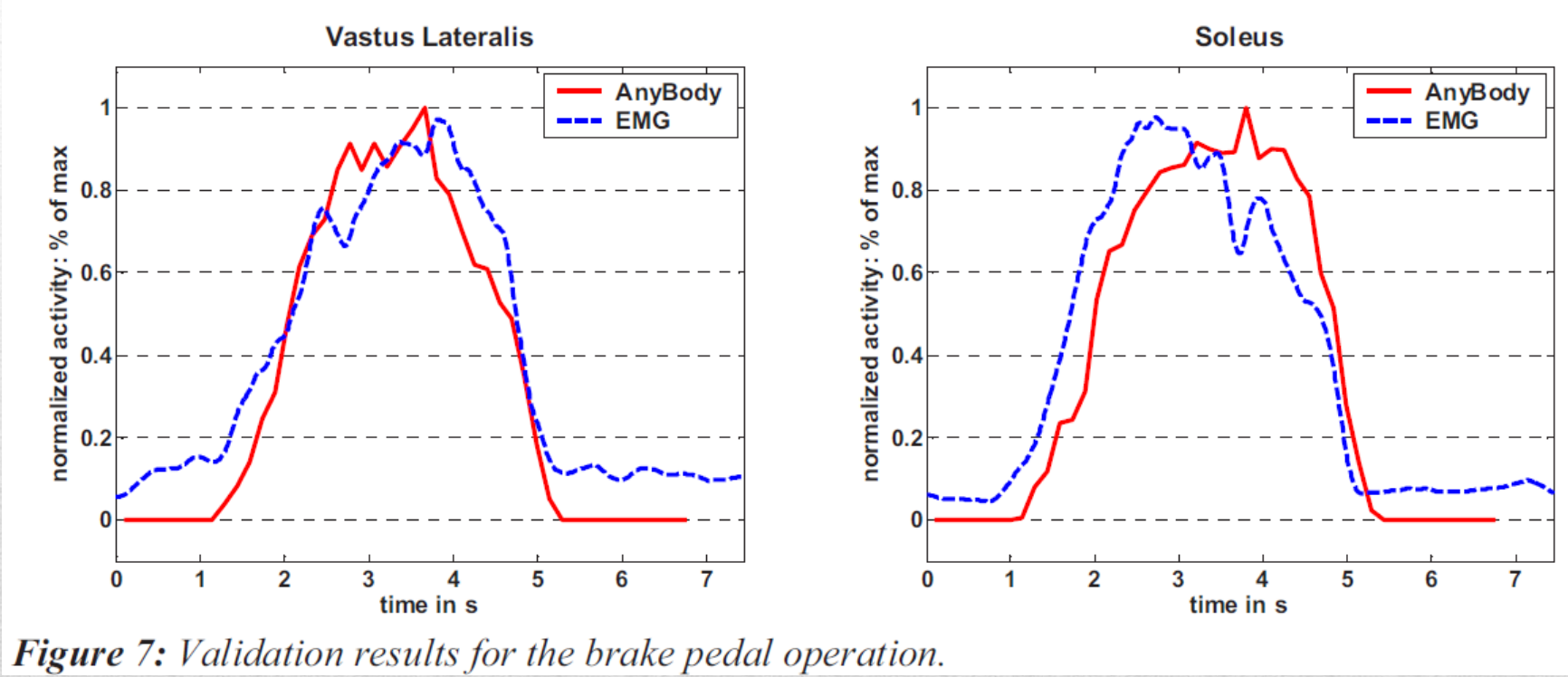


Figure 7: *Validation results for the brake pedal operation.*

Rausch & Siebertz (2008), FISITA 2008

Validation Study: Braking - hand

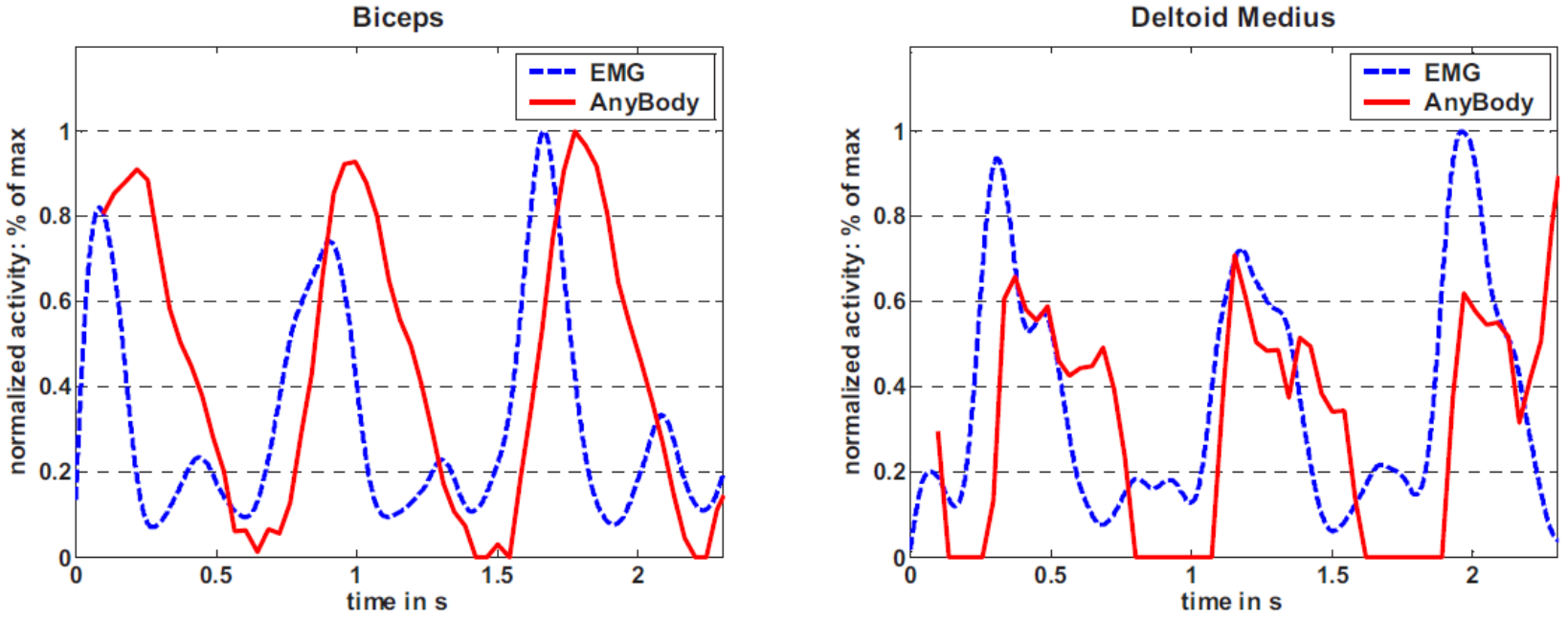
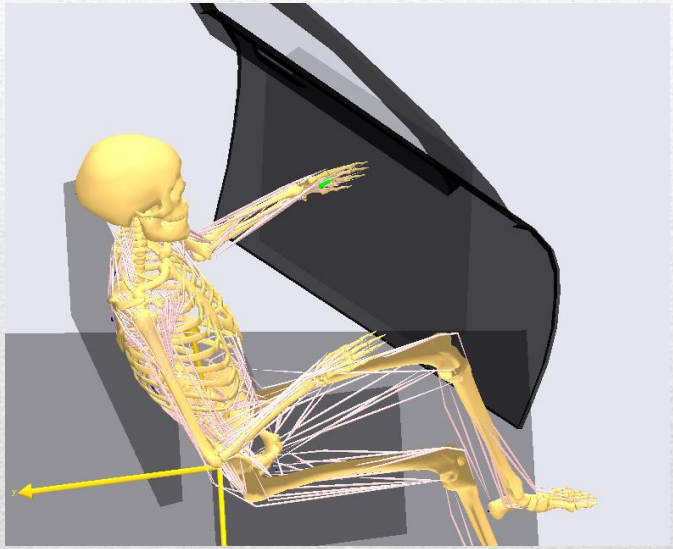
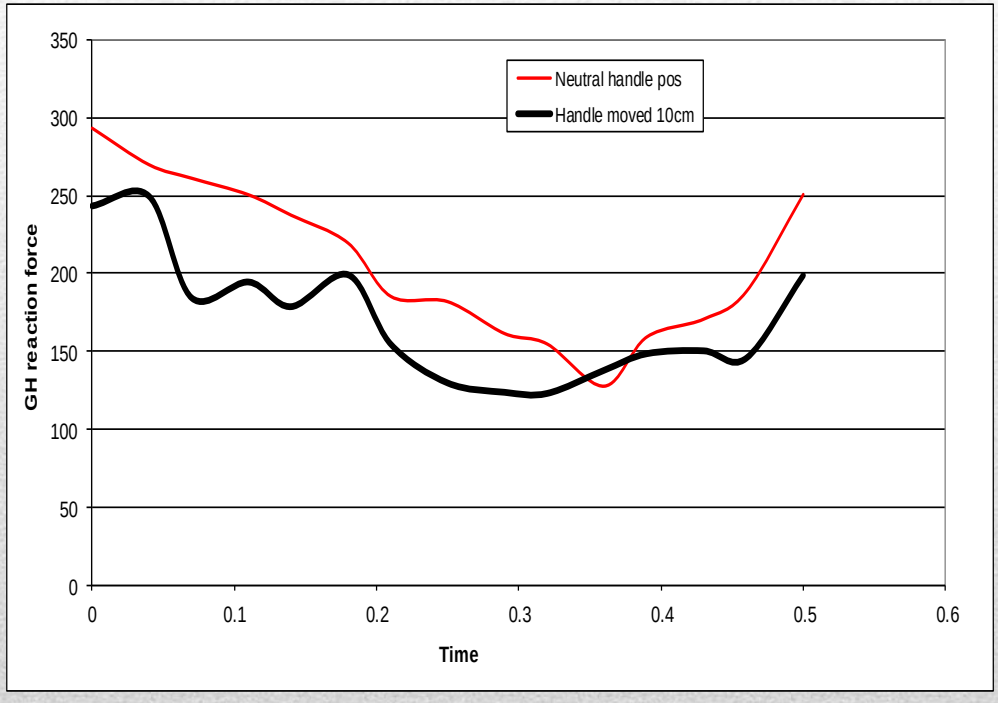


Figure 6: *Validation results for the steering task. The maximum activity during this task was far below 100%. This results in a low signal to noise ratio of the EMG signal compared to signal during maximum voluntary force.*

Rausch & Siebertz (2008), FISITA 2008

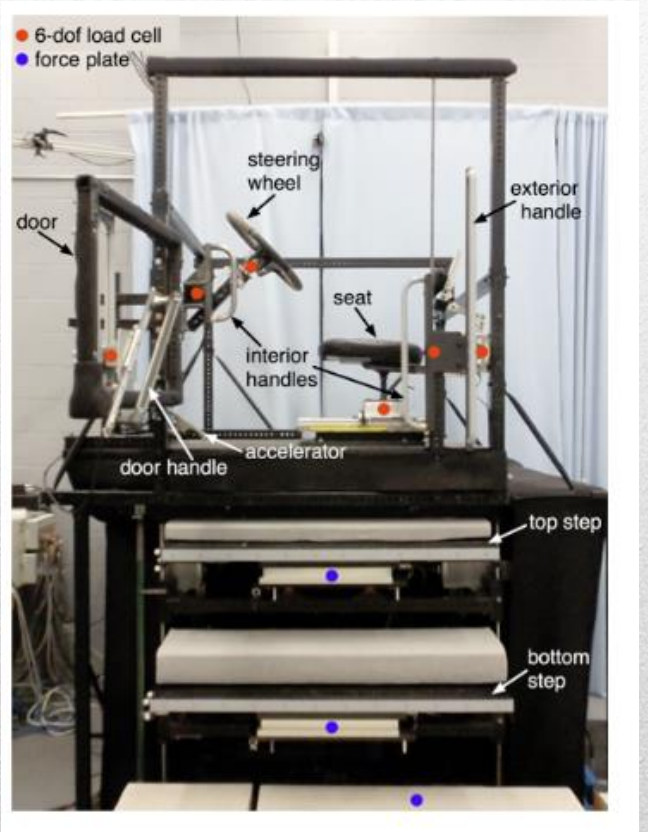
Position of door handle on shoulder

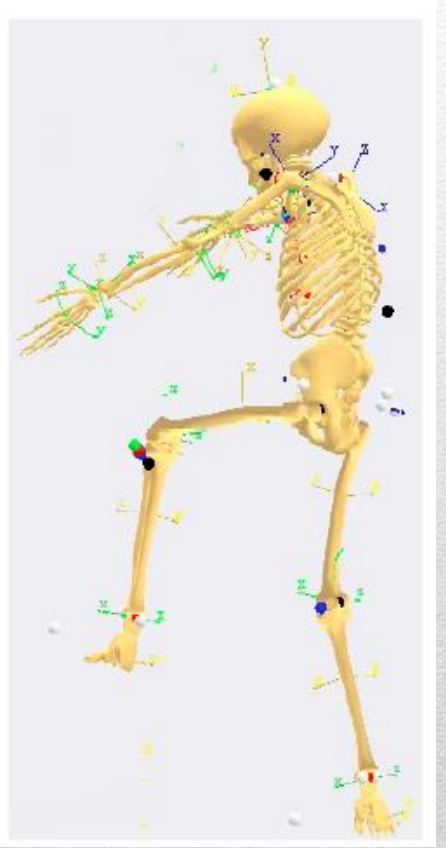




- **Automotive Application**
  - **Package design**
  - ***Ingress/egress***
  - ***Seat comfort***
  - ***others***

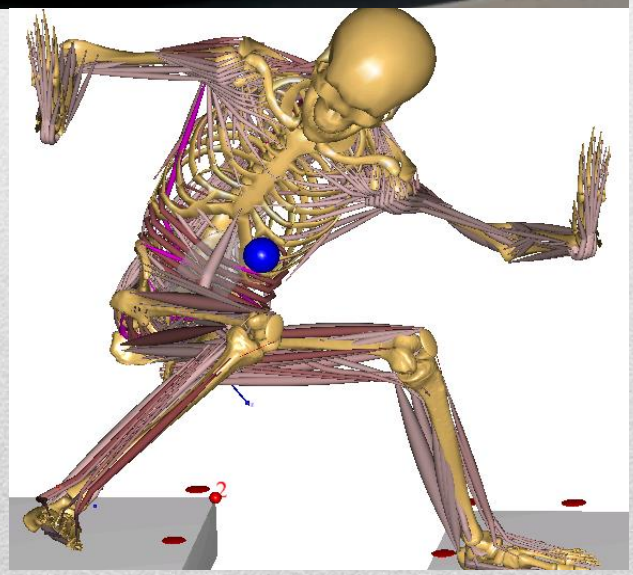
CREW INGRESS/EGRESS FOR VEHICLES

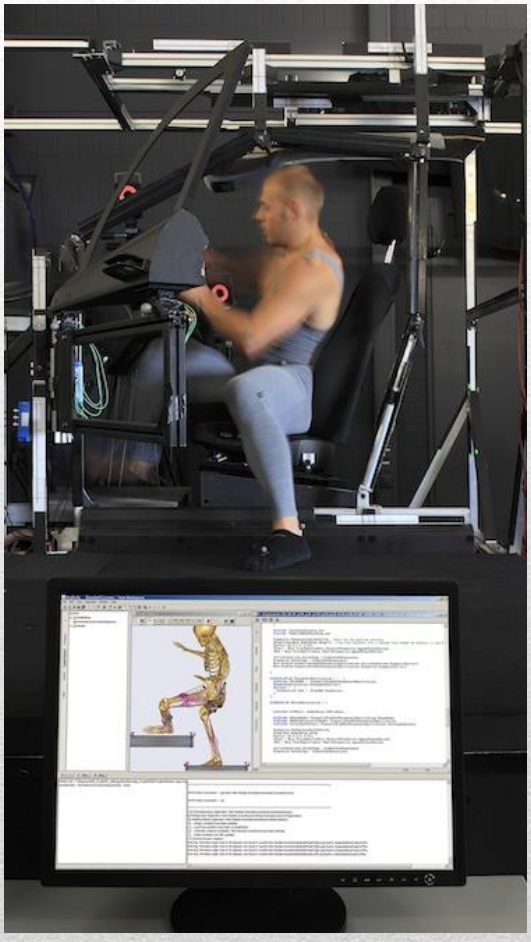




Reed et al. 2009

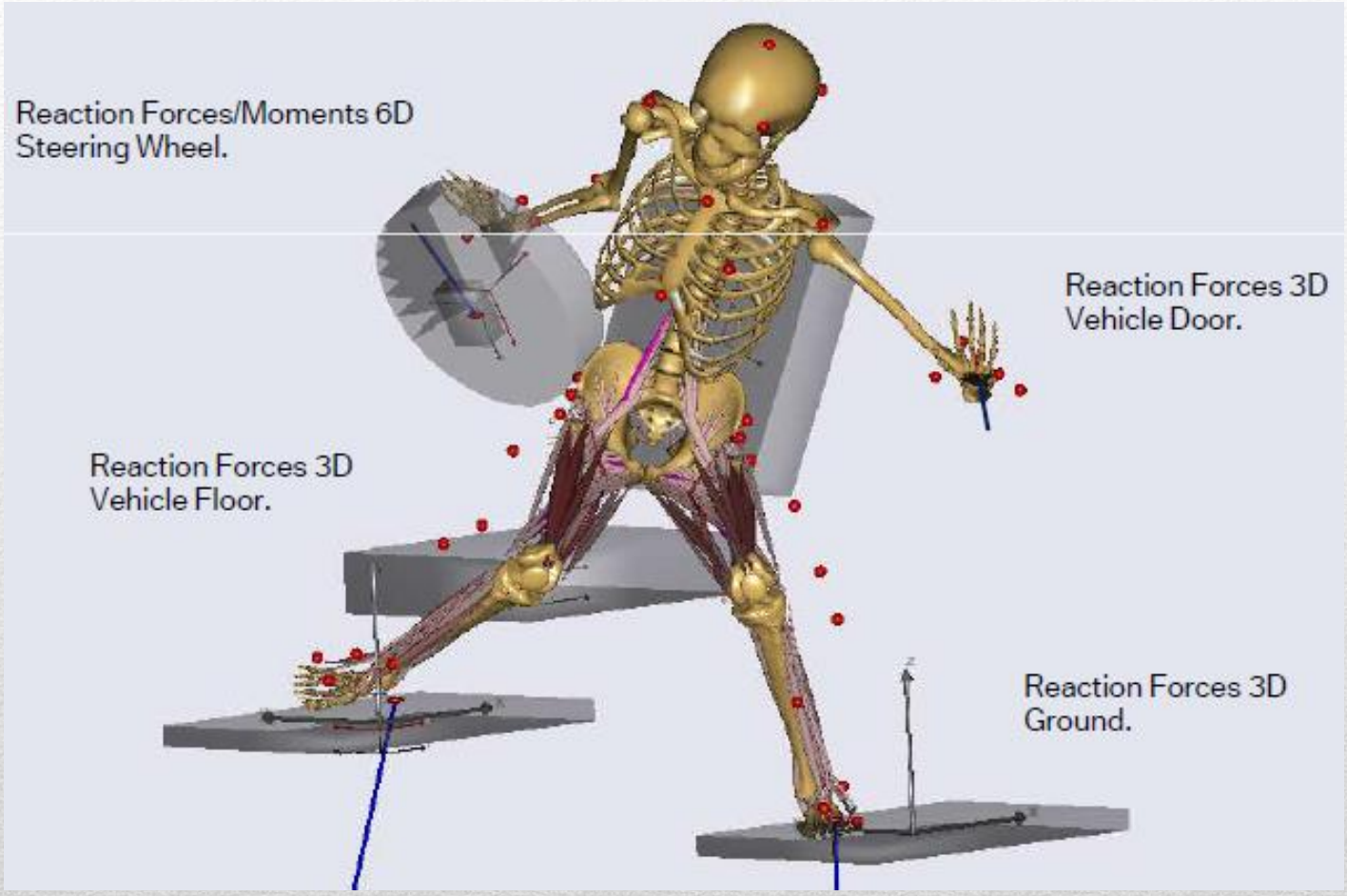
Ingress/egress comfort





http://www.e90post.com/forums/showthread.php?t=594473

ANYBODY TECHNOLOGY



Rasmussen et al. 2011, ORS
R. Bichler 2010, webcast 28Apr

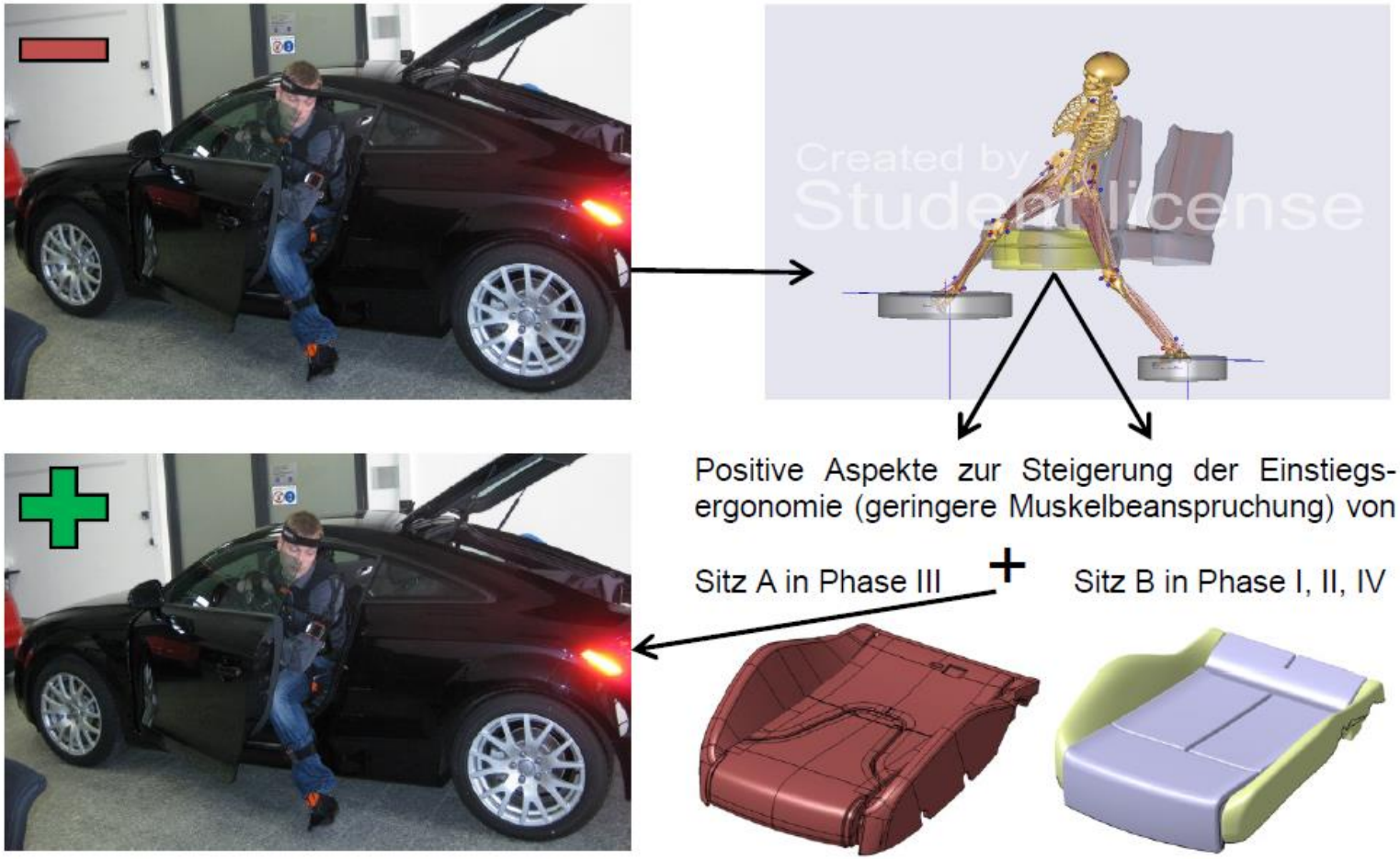
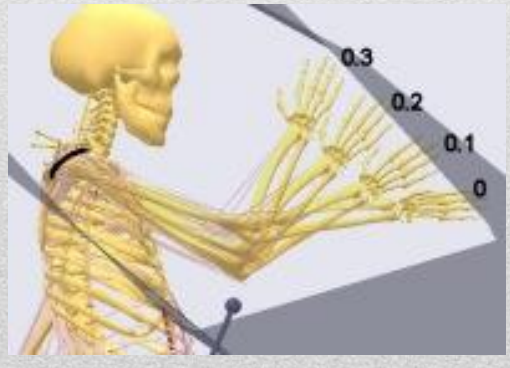
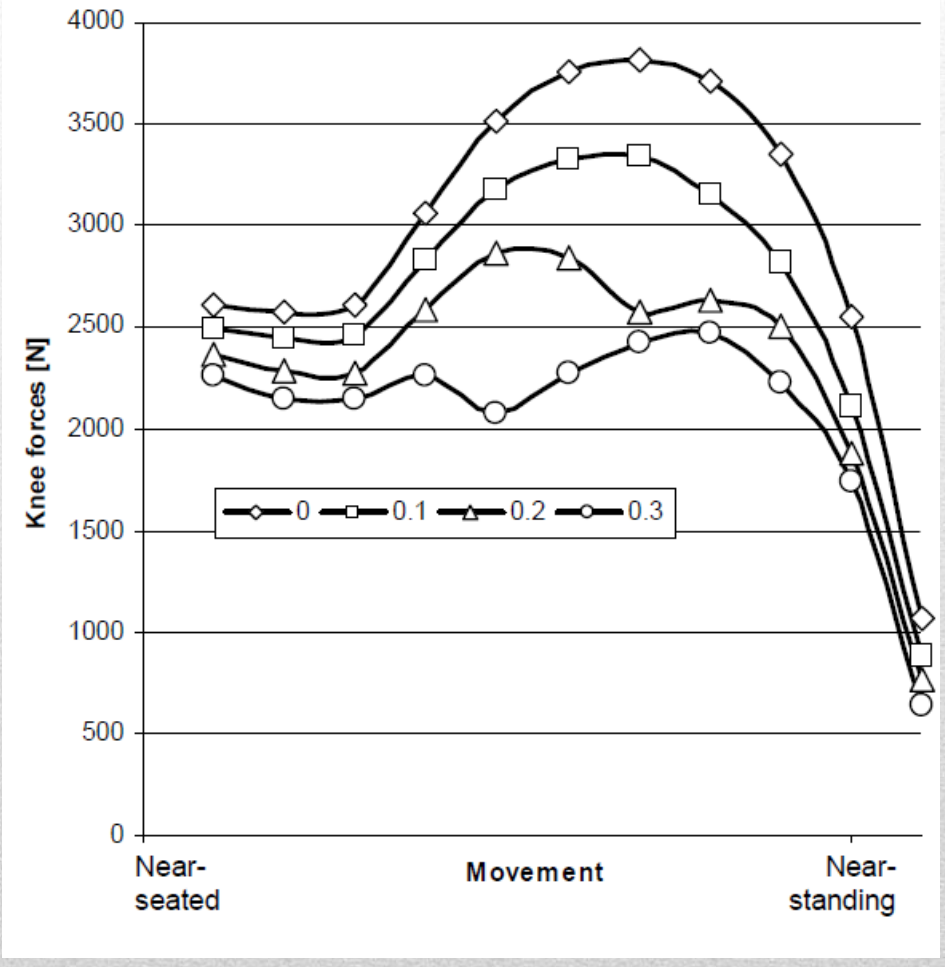


Abbildung 72: Lösungsweg zu den Sitzkonstruktionsrichtlinien für einen ergonomischeren Einstieg in den Audi TT.

Buchner et al. 2013, Master Thesis

Optimum placement of an assistive handle for egress



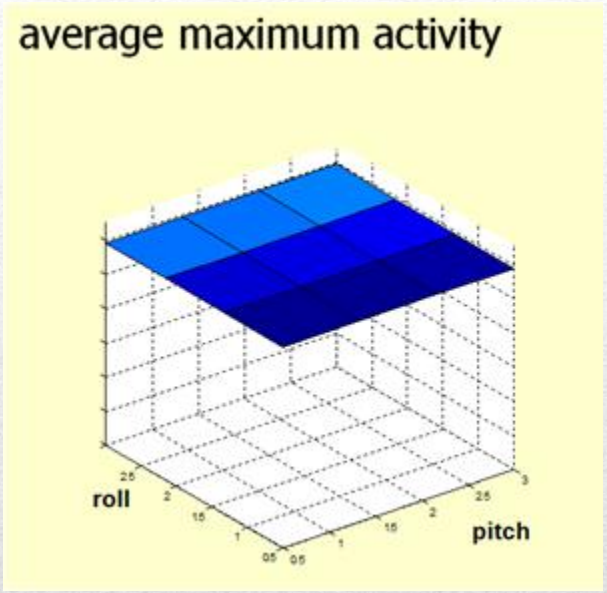


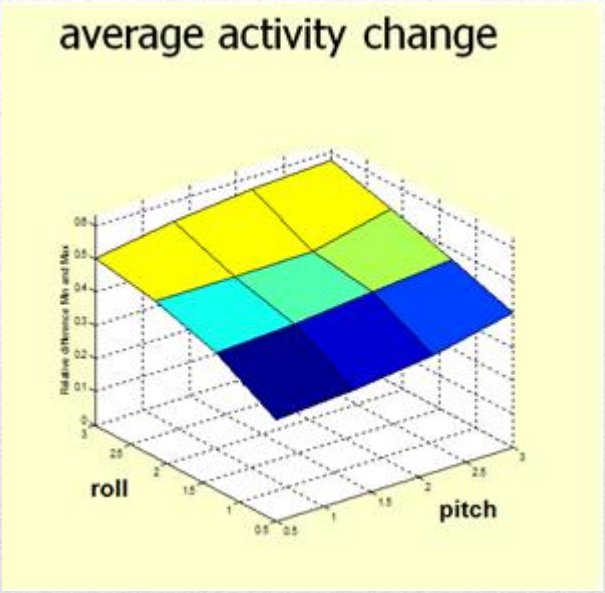
ANYBODY TECHNOLOGY

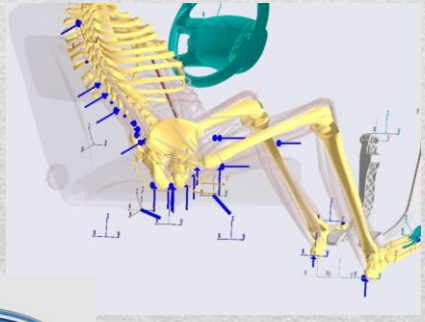
Rasmussen & Tørholm Christensen 2005, SAE Technical Paper 2005-01-272

- **Automotive Application**
  - **Package design**
  - ***Ingress/egress***
  - ***Seat comfort***
  - ***others***

Active MotionTM seating



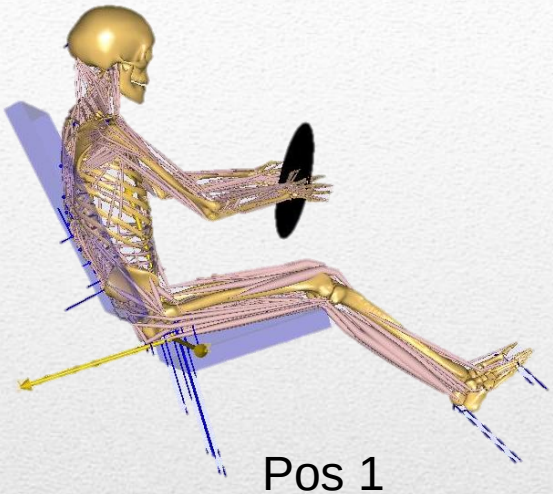


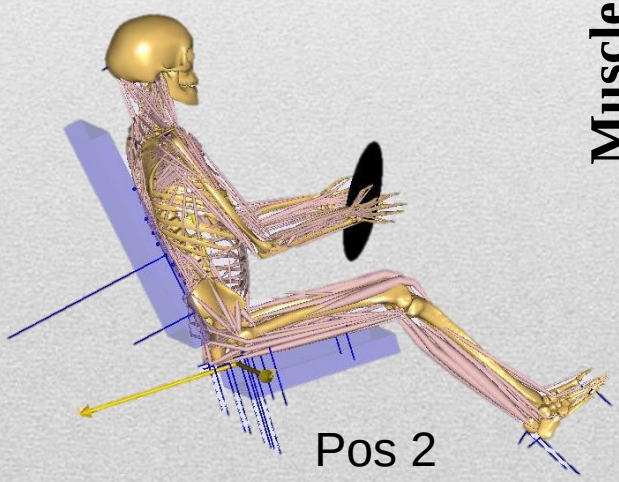


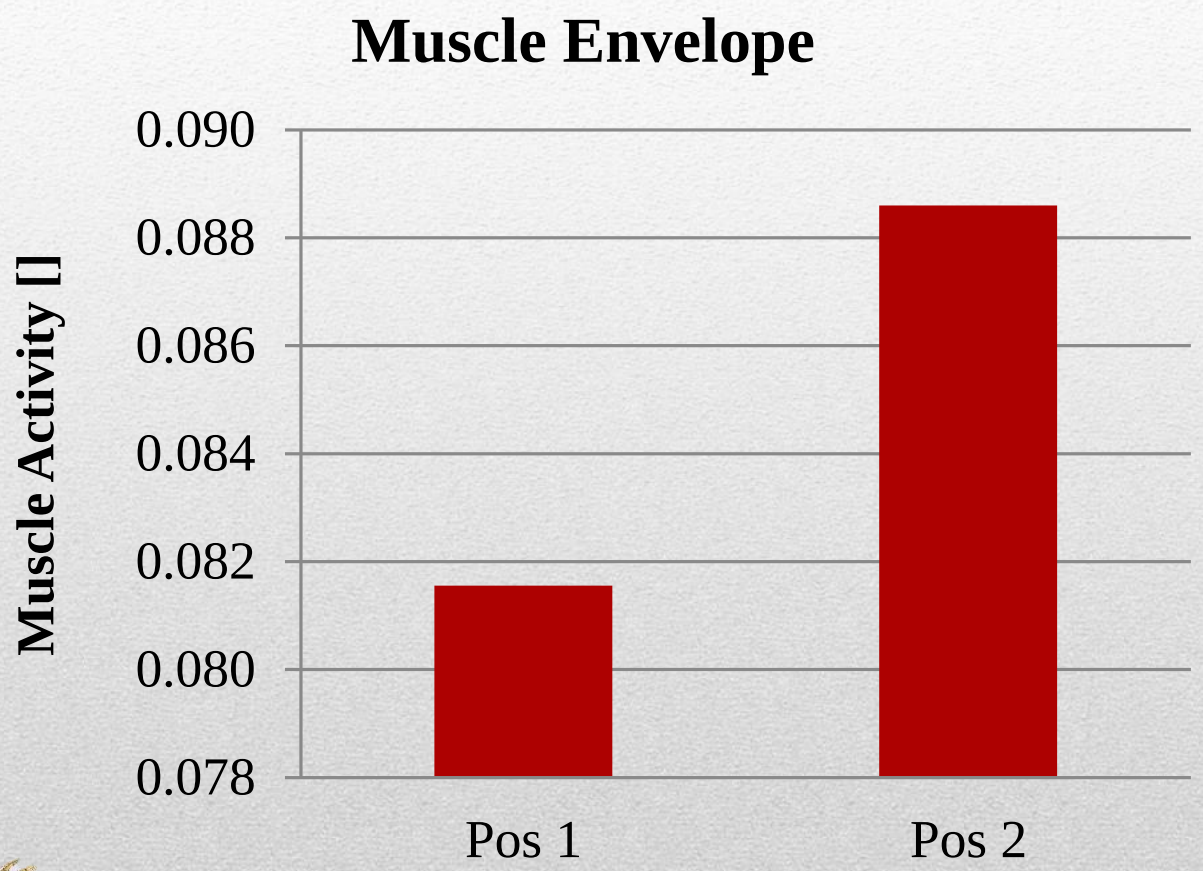
Parameter
frequency ratio, pitch vs. roll
roll amplitude
pitch amplitude
phase shift roll vs. pitch

de Zee et al. 2005, SAE Technical Paper 2005-01-2705

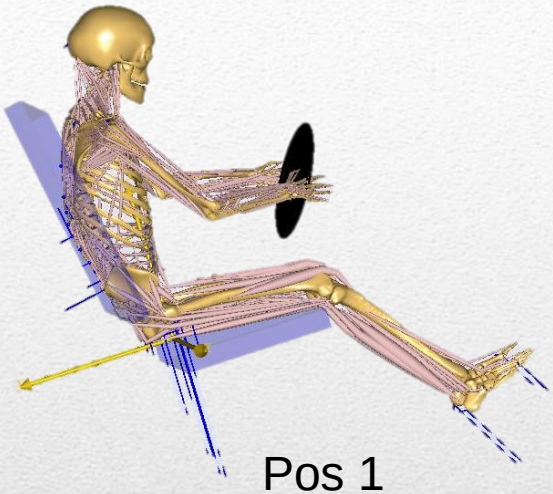
Analysis of different postures



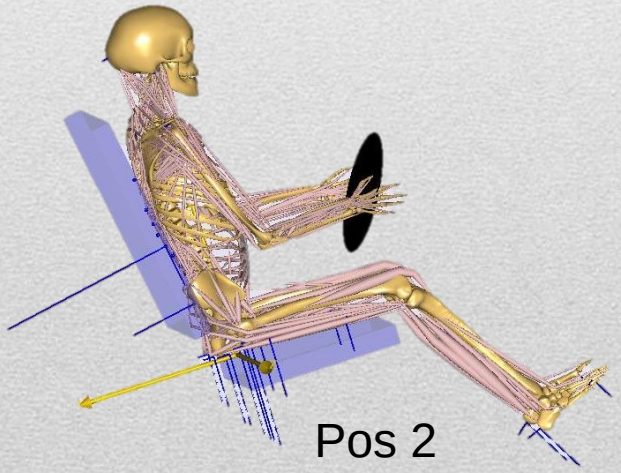




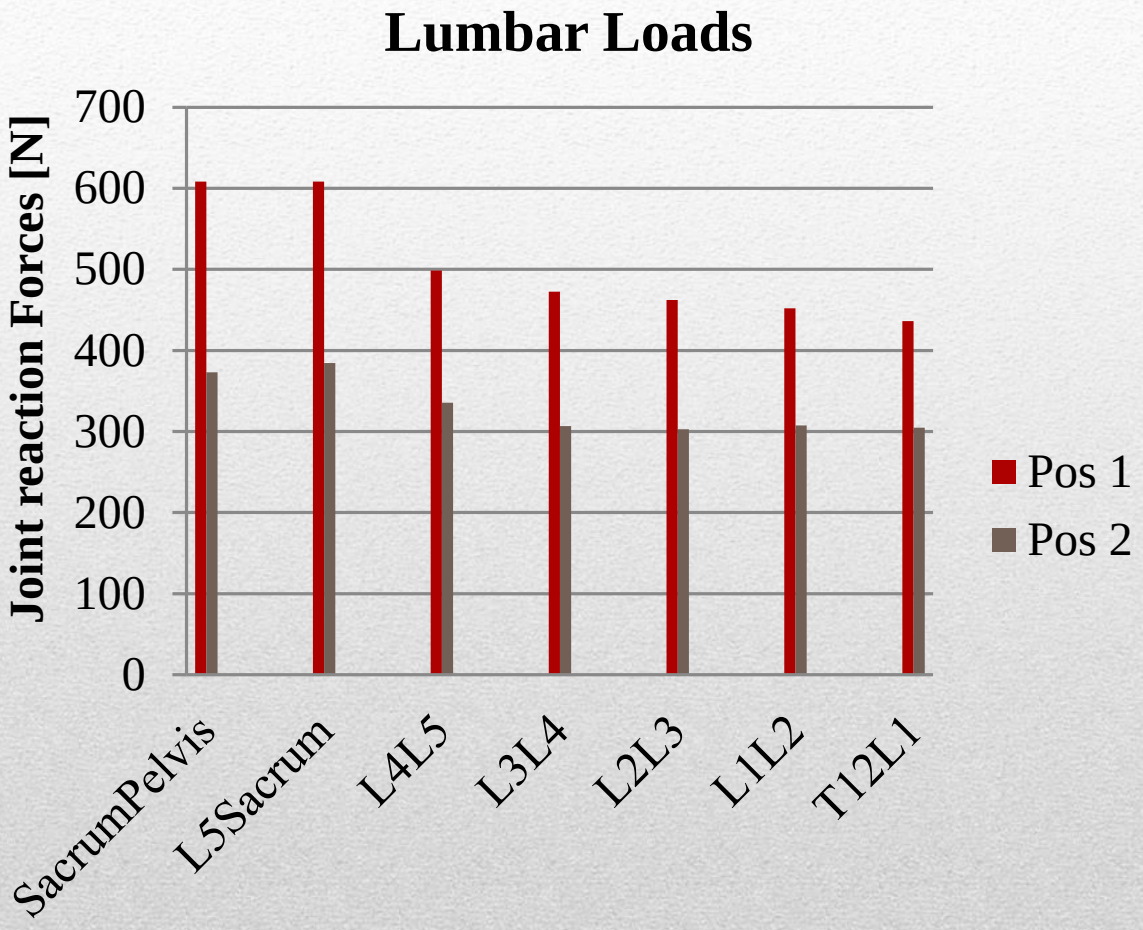
Loading of lumbar spine for different postures



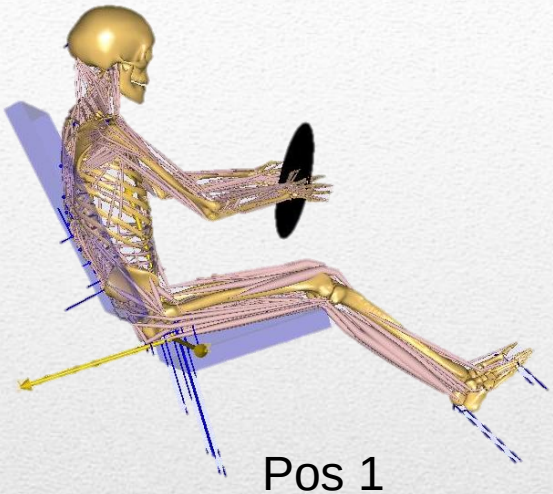
Pos 1



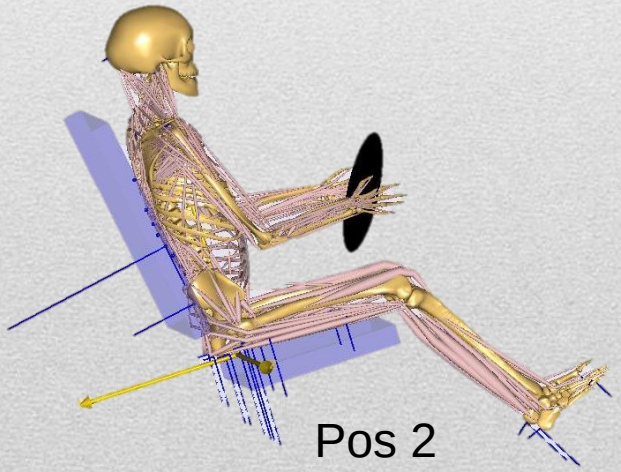
Pos 2



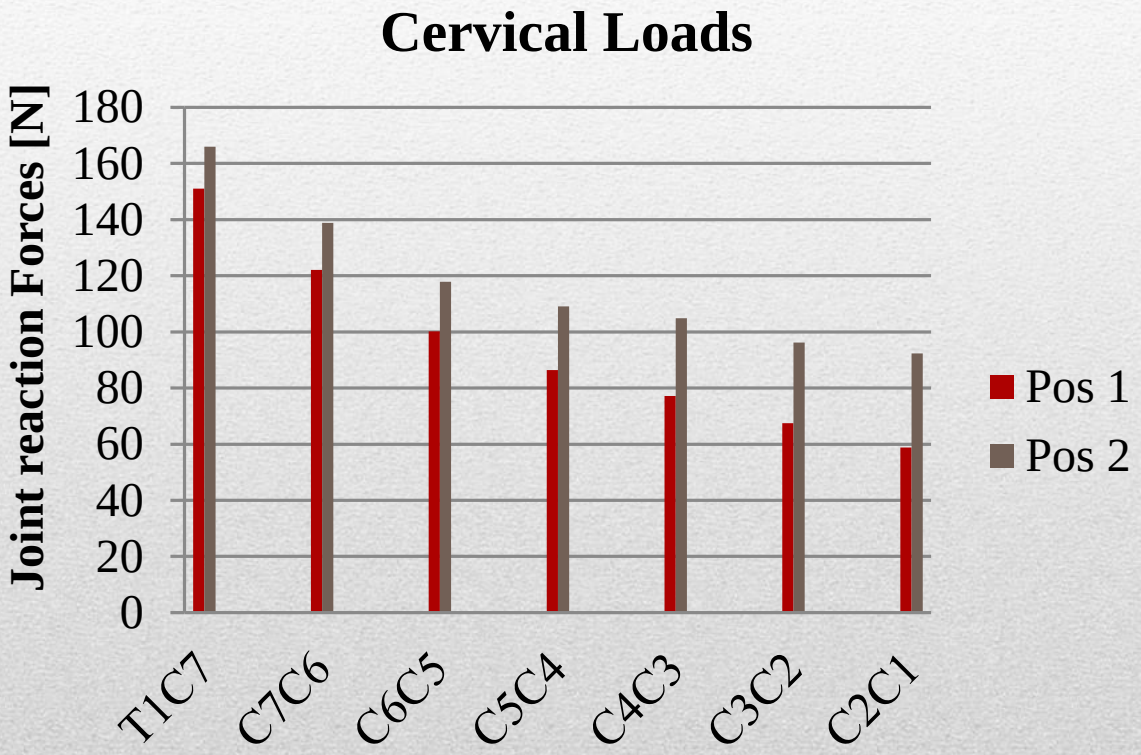
Loading of cervical spine for different postures



Pos 1



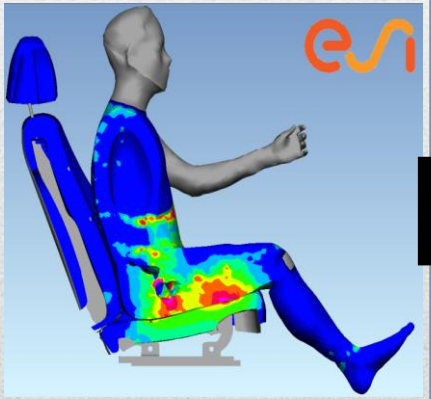
Pos 2



Data exchange between digital human models

ESI
Virtual Seat
Solution

Seating of the driver



Predicted H-Point

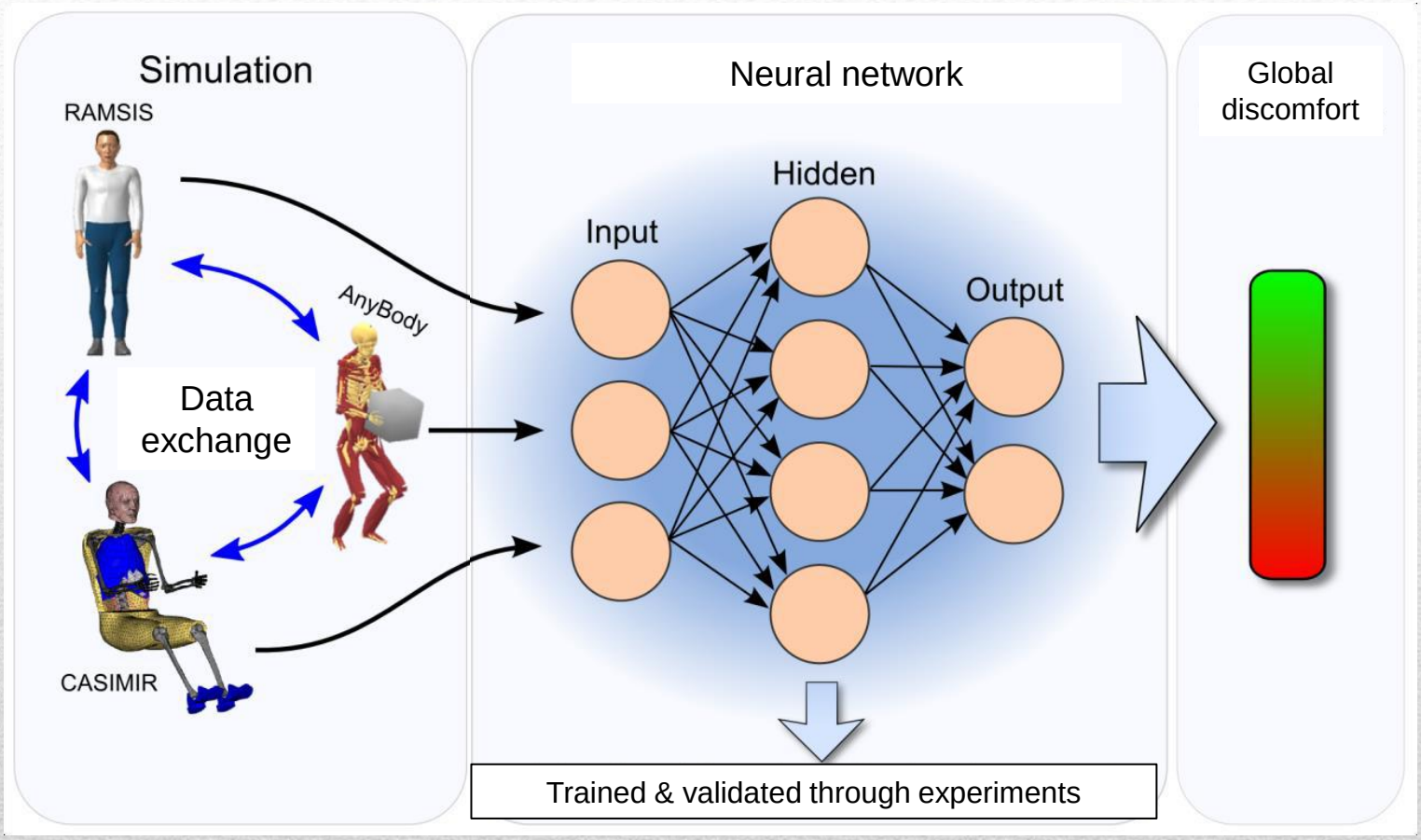
Seat & Human deformation

ESI Courtesy

Muscle activation / loads
Joint forces

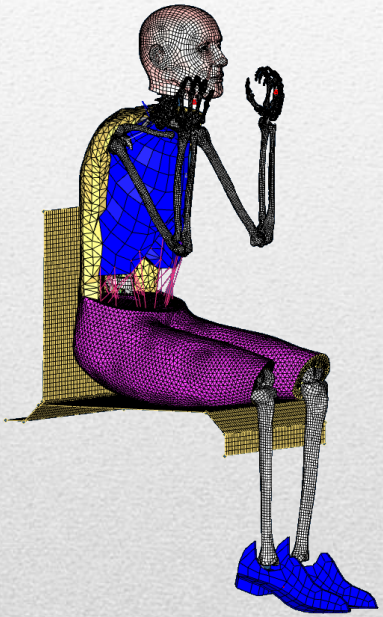
the muscle fatigue computed with exact external loading along the motion

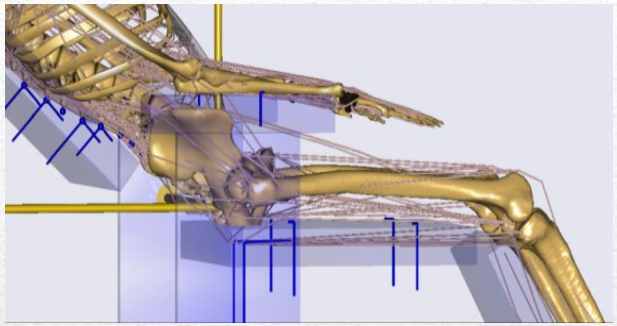
UDASim – Data exchange of digital human models



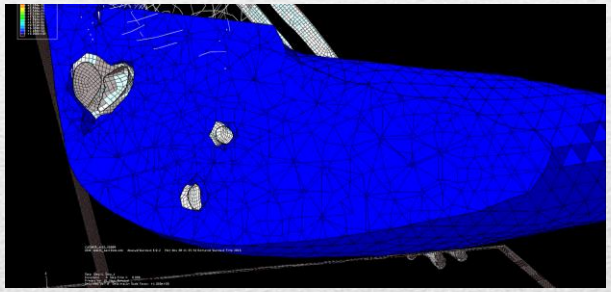
Bonin, D., Wischniewski, S., Wirsching, H.-J., Upmann, A., Rausch, J. & Paul, G. (2014), "**Exchanging data between Digital Human Modelling systems: a review of data formats**", 3rd International Digital Human Modeling Symposium, Tokyo, Japan.

Sitting-acquired deep tissue necrosis

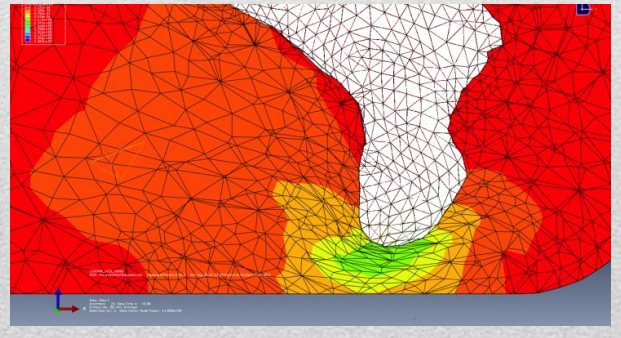




AnyBody Seated Human
Boundary conditions



CASIMIR
Non-linear
material & geometry

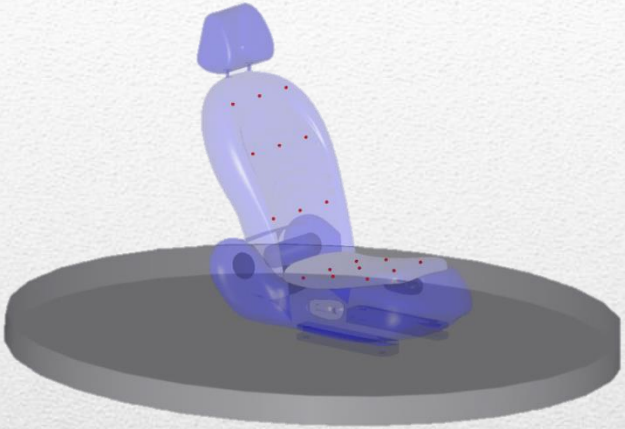


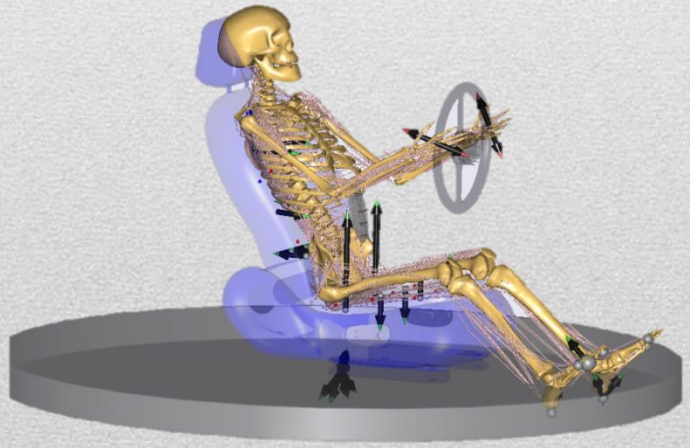
Abaqus
Buttock strain

Cell necrosis
Pressure ulcer

PhD Thesis, Olesen et al., 2012
http://www.anybodytech.com/download.html?did=publications.files&fname=Olesen_2012_The%20Influence%20of%20Sitting%20Conditions%20on%20Soft%20Tissue%20Loads.pdf

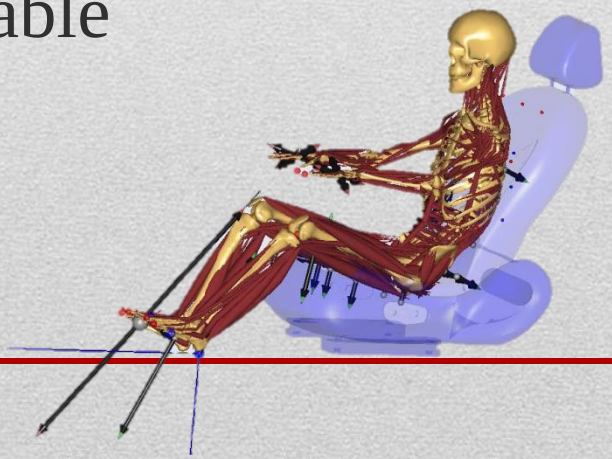
AnyBody Seat Model





Package design – elastic seat:

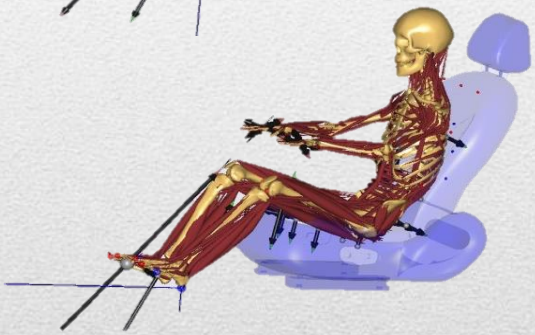
- Seat & backrest stiffness adjustable
- Pedal & stearing wheel position adjustable
- Forces in pedal & stearing wheel adjustable

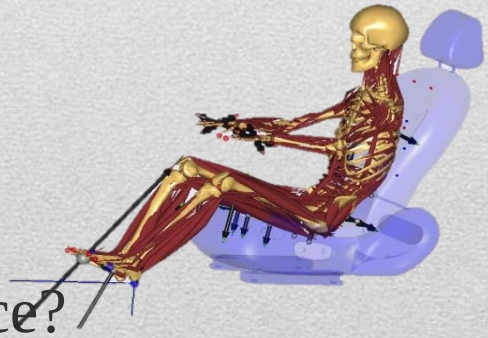


AnyBody Seat Model

Driver, passenger:

- Size/ anthropometry
- Individual muscle strength





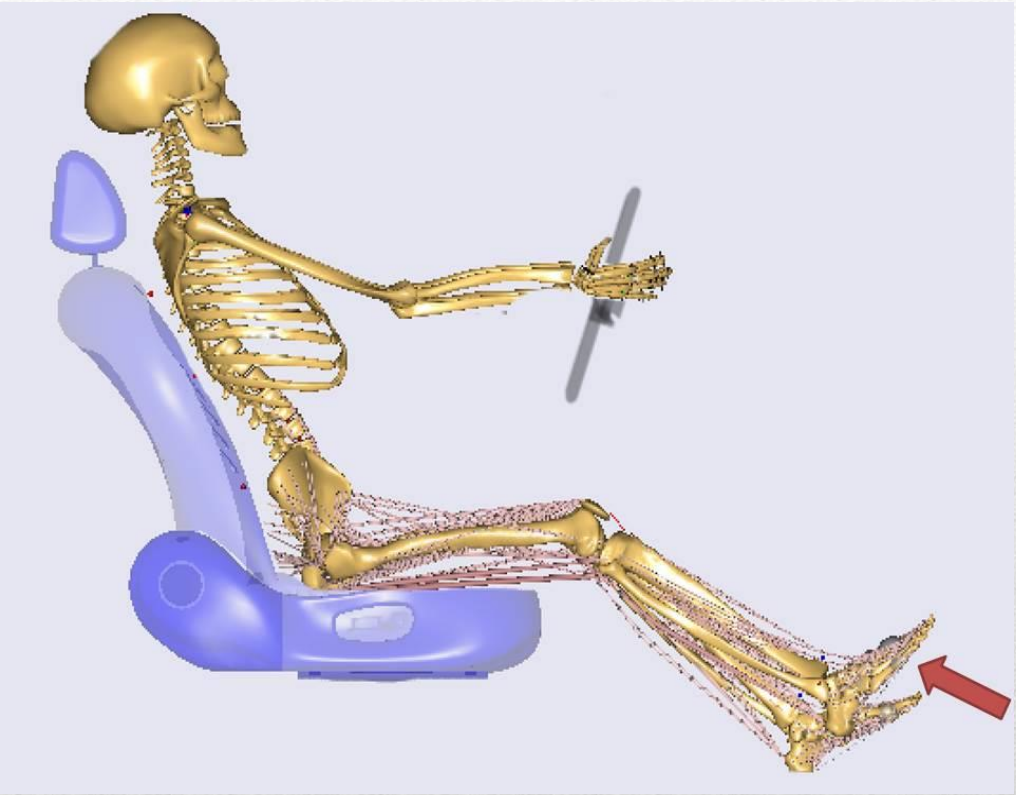
Compute:

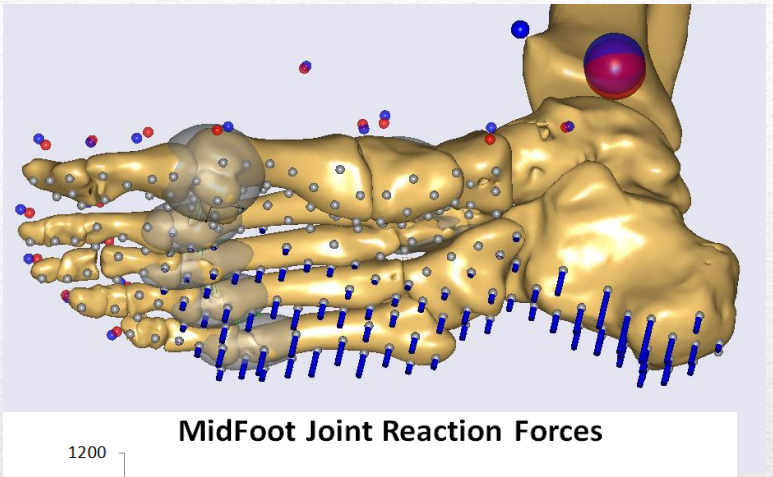
- Muscle activation
- Joint loads
- Sinking-In:

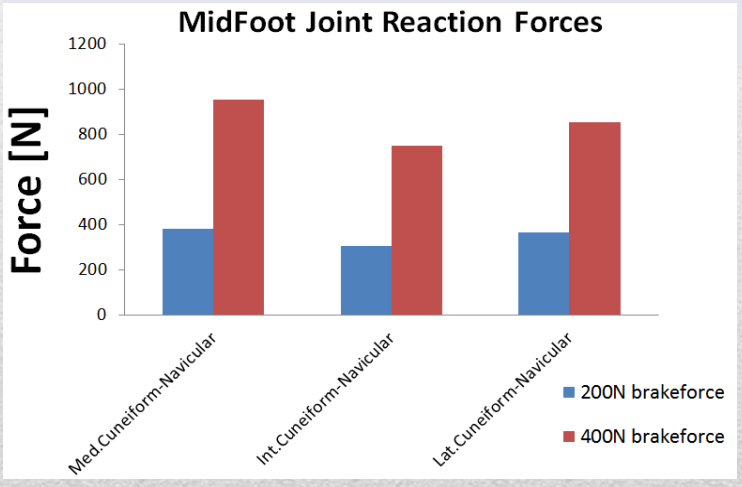
  Where is the H-Point?
- Braking:

  How reacts driver on increasing pedal force?

Hard pedal push







- How does H-point change?
- What forces are in individual foot bones/joints?

Rasmussen et al. 2014

Al-Munajjed et al. 2014

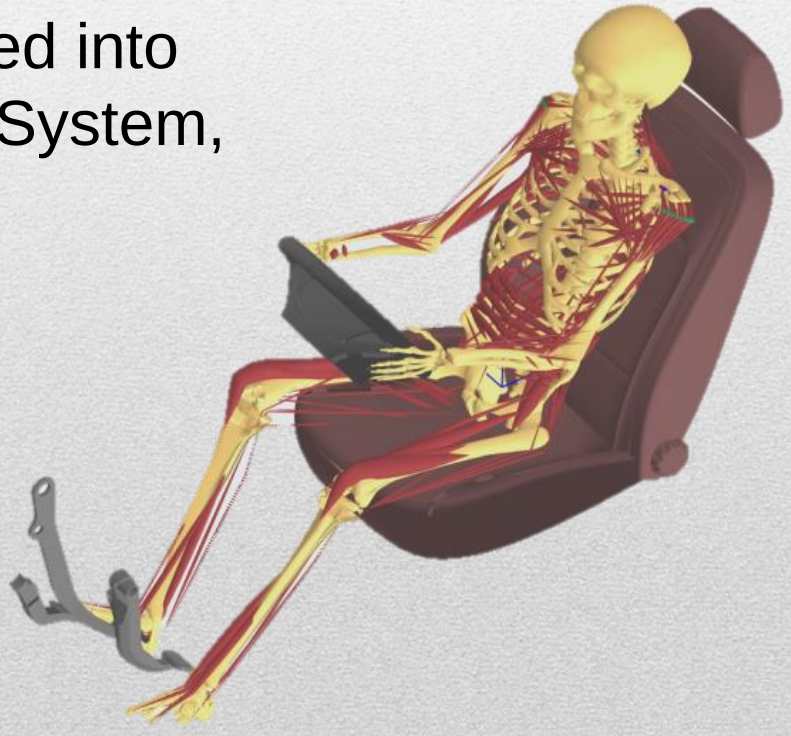
Long term sitting

- Fatigue

  => Very individual

- Comfort

  Not fully implemented into AnyBody Modeling System, but can be done for individual tasks!



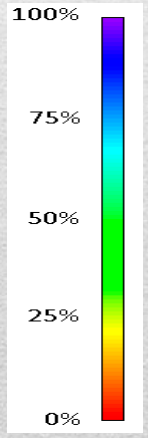
- **Automotive Application**
  - **Package design**
  - ***Ingress/egress***
  - ***Seat comfort***
  - ***others***

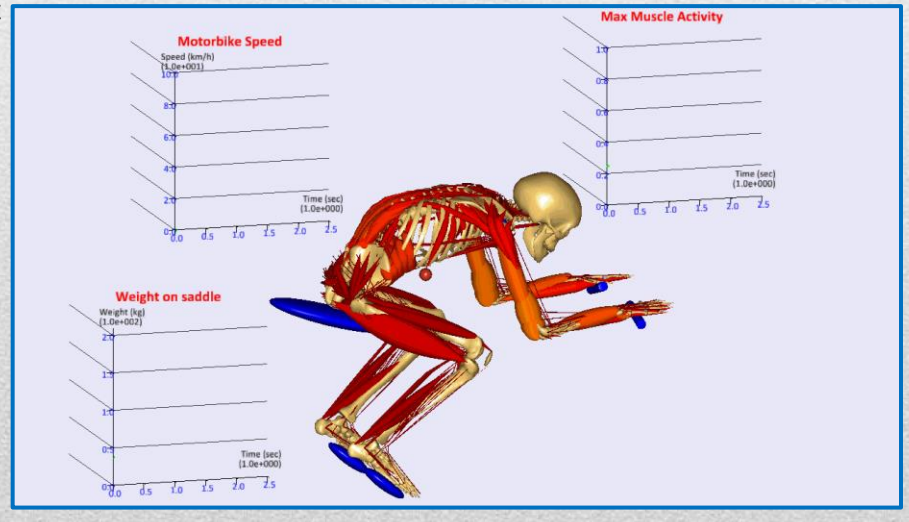
Effects of acceleration on the driver

- Motorbike/ car / truck/ train / ...

- Positive acceleration
- Braking/ neg acceleration

MaxMuscleAct scale



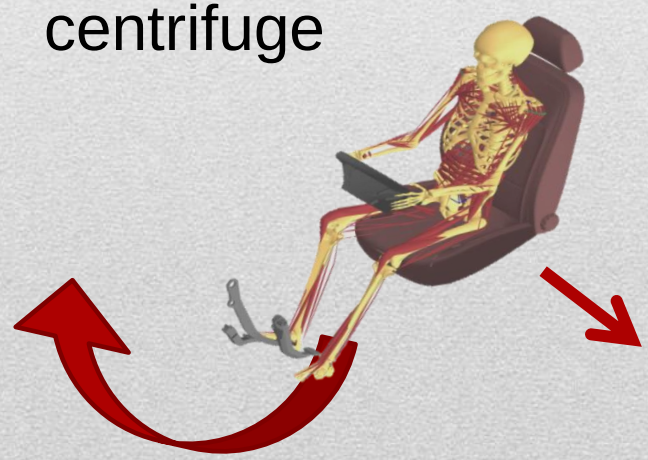


Previous Webcast on commuting in Tokyo!
www.anybodytech.com

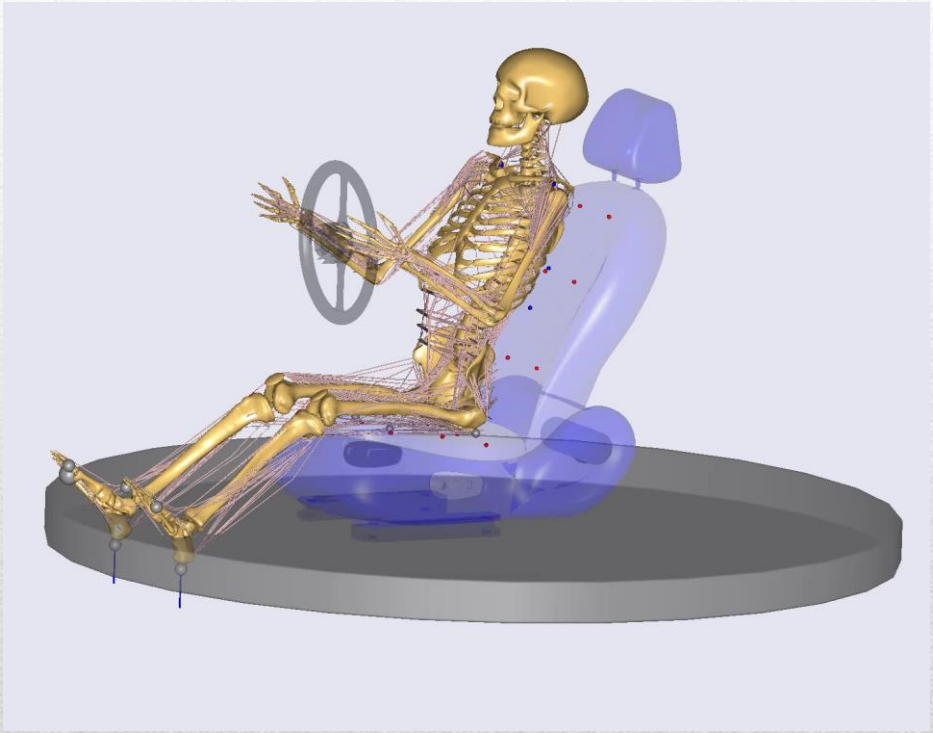
J. Groud/ Terrabyte, Japan

Effects of side force on the driver

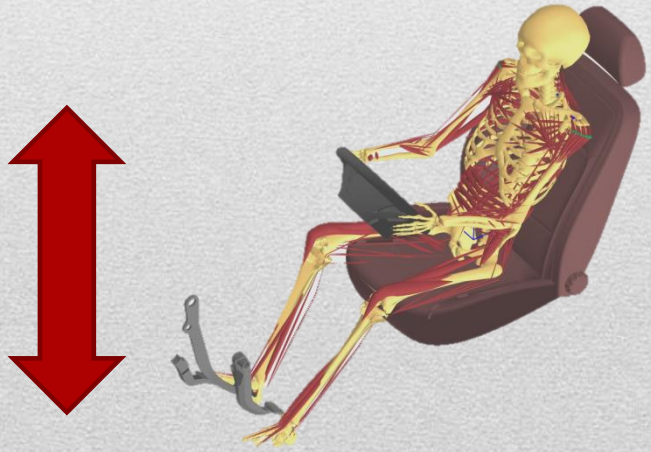
- Driving in a curve
- Amusement park:
  Roller coaster
- Space application:
  centrifuge



Effects of bumps on the driver

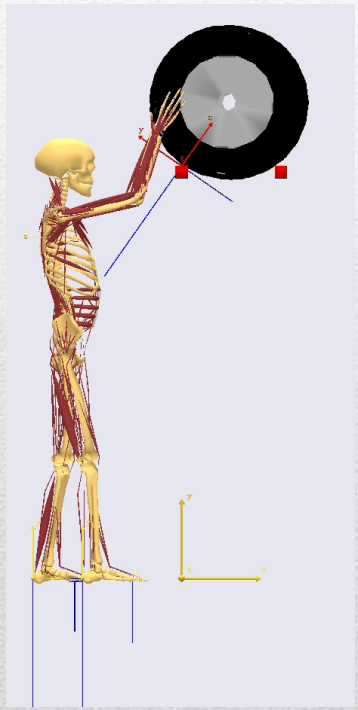


- Speed bumps
- Vibration
- Road types

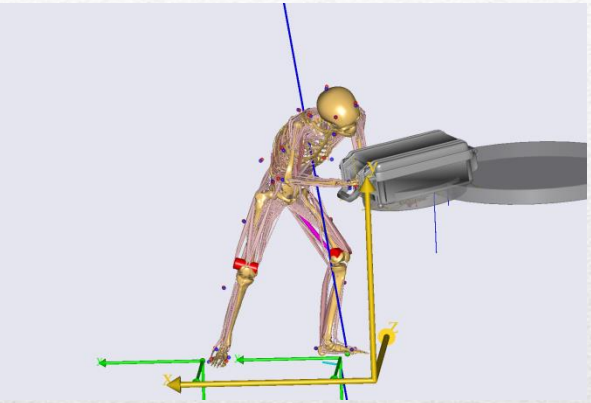


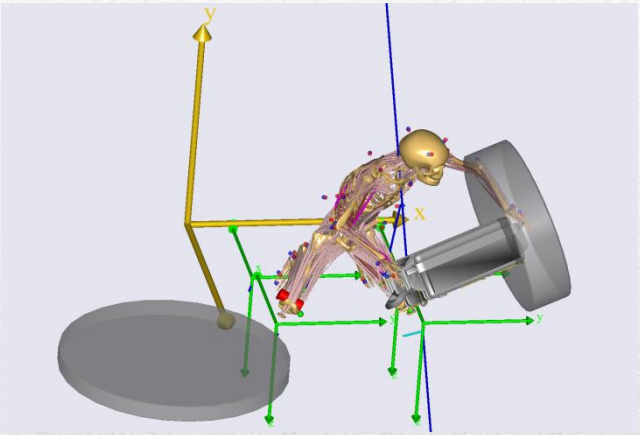
Work Ergonomics: manufacturing/ assembly lines

- Lifting heavy objects, risk of overloading joints or muscles
- Repetitive tasks, risk of injuries due to muscle fatigue



Work Ergonomics

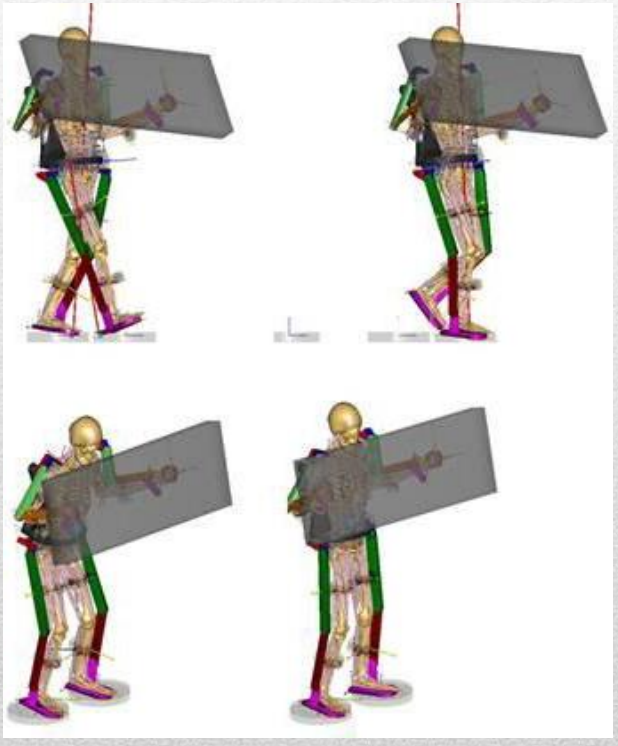




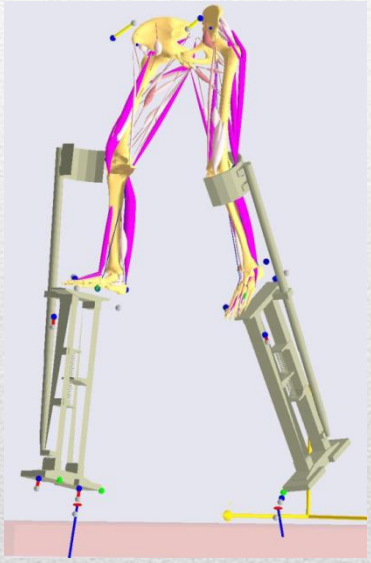
Webcast coming soon!

Koblauch et al. *THE MODELING OF TWO AIRPORT BAGGAGE HANDLER WORK TASKS;* **ISCSB 08/ 2013, Natal, Brazil**

Work Environment: Exoskeletons/ assistive devices



Cho et al. 2012



Wu et al. 2009

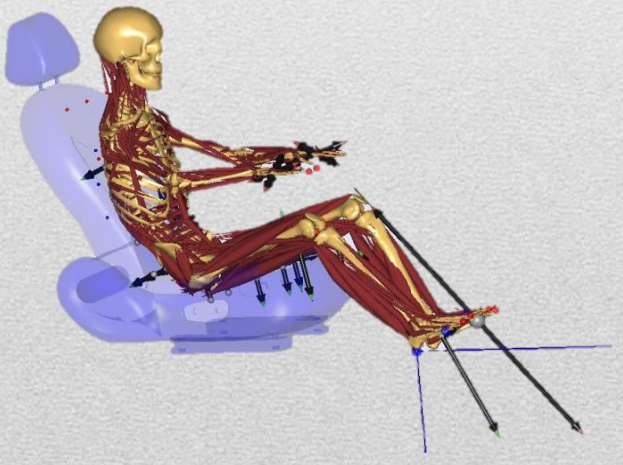
Previous Webcast on Exoskeletons!
www.anybodytech.com

Conclusion

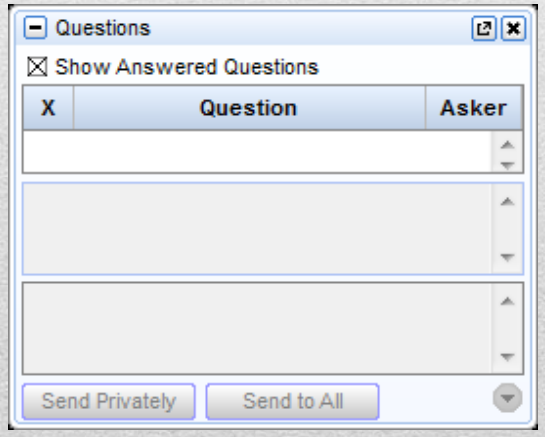
Overview of Application using AnyBody for Automotive Engineering:

- Package design
  - Optimize parameters to minimize loads in joints or muscles
- Ingress/egress
  - What loads are in joints or muscles during different ingress/egress trials
- Seat development
  - What muscle activations occur on different seats
  - Interaction with other digital human models
- Others
  - Acceleration/ occupational health/ assambly lines

- www.anybodytech.com
  - Events, dates, publication list, ...
- www.anyscript.org
  - Wiki, Forum
- www.youtube.com/anybodytech
  - Videos, help, demos, tips & tricks
- inquiry@anybodytech.com



You can write your questions in the Q&A panel.



ANYBODY TECHNOLOGY