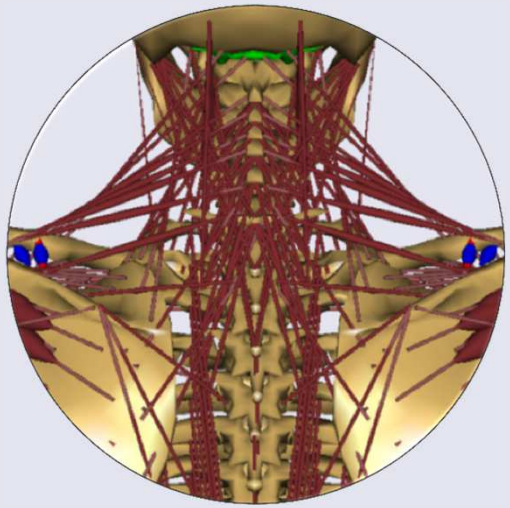
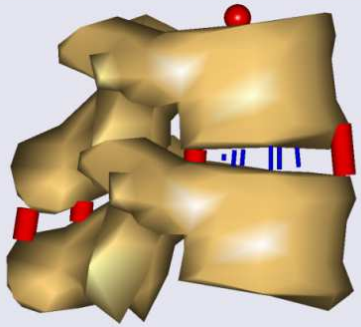
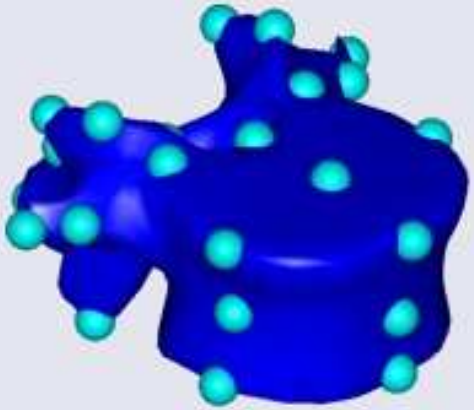
ANYBODY TECHNOLOGY

Orthopaedic AnyBody Applications for the Spine







The webcast will begin in a few minutes…

Agenda & Presenters

- Who is AnyBody?
- AnyBody Modeling System (AMS)
- AMS Applications in Spine Biomechanics
- Q & A (submit questions anytime)

Tony Petrella
AnyBody Technology, Inc.
Senior Consultant, USA
(***Presenter***)

Associate Professor, Mechanical Engineering
Director, Computational Biomechanics Group
Colorado School of Mines

Manager, Computational Biomechanics
DePuy Orthopaedics, Inc. (2000-2006)

Arne Kiis
(*Host/Panelist*)

Pavel Galibarov
(*Panelist*)

AnyBody Technology

- Software licenses
- Consulting
- Training
- Support
- US Office
- AnyGait

2002

2006

2010

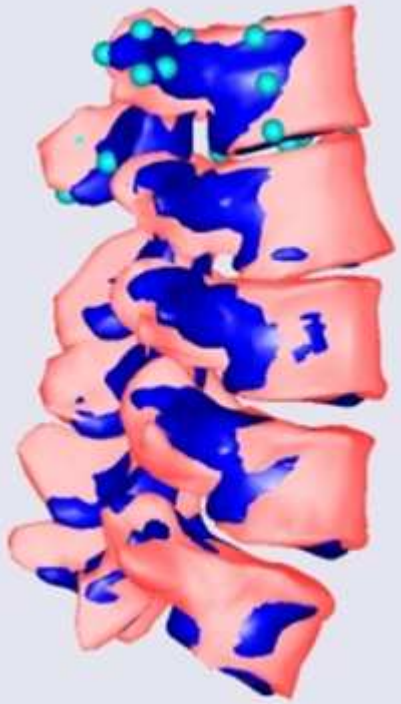
2011

2012

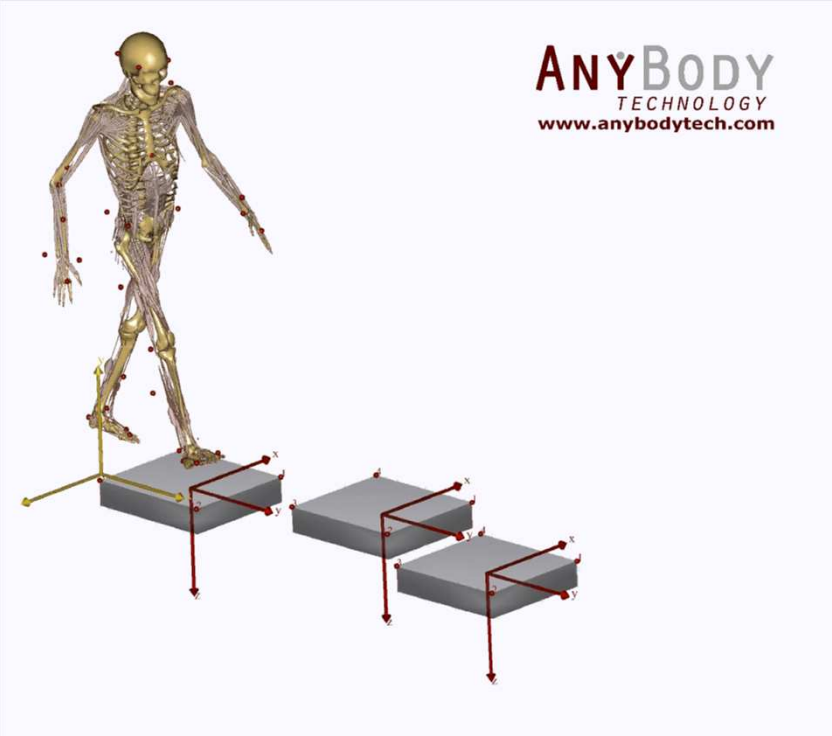
ANYBODY TECHNOLOGY

AnyBody Modeling System

- Developed in-house for musculoskeletal analysis
- Self-contained system
- Interfacing to…
  - motion capture
  - image-based bone and muscle data
  - finite-element software
  - CAD systems
  - office systems
- Open body model
- Broad and deep model validation
- API for imbedded use

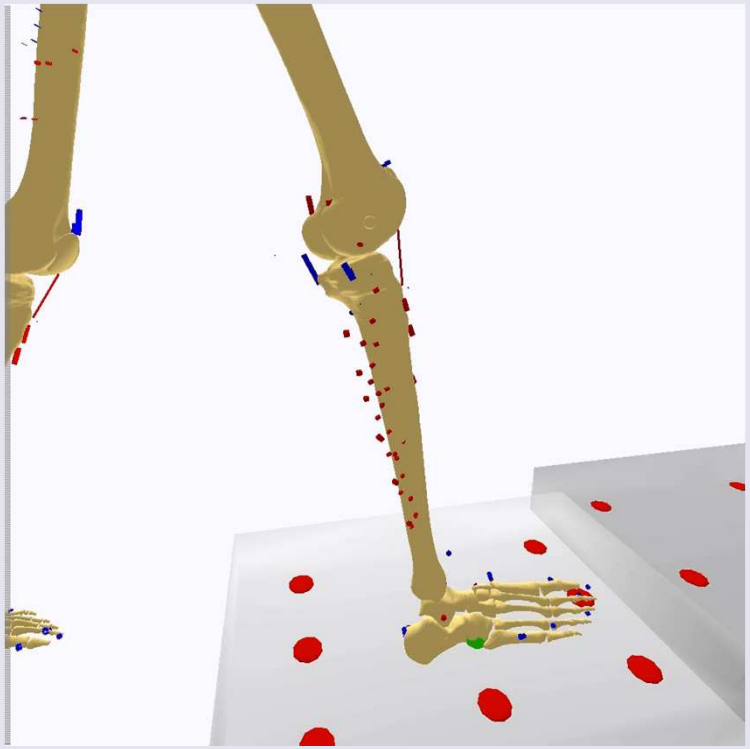


AnyBody Modeling System



Motion & ext Forces as Input:

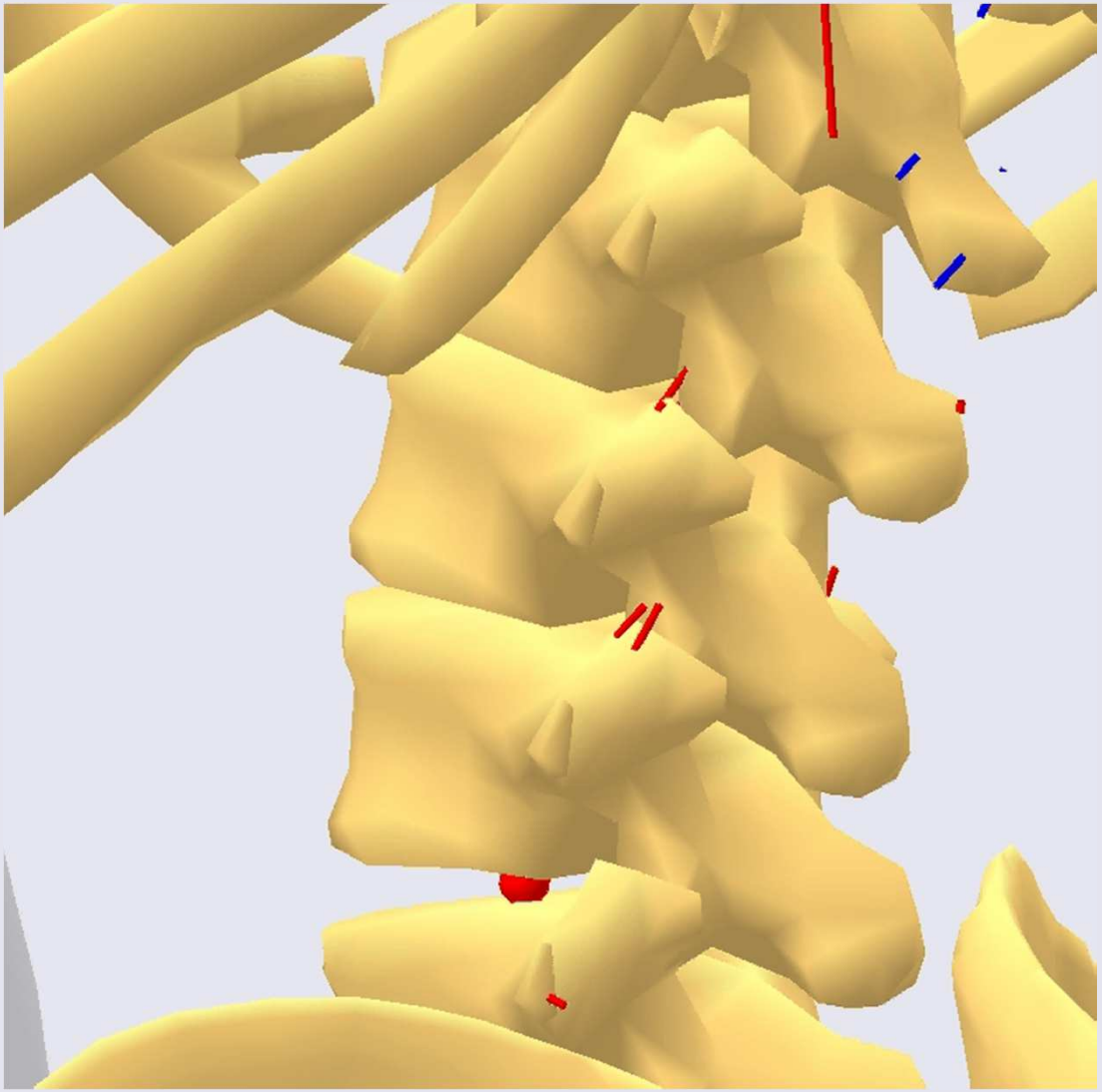
- Motion Capture (Vicon, Qualisys, ...)
- Joint Angle Input



Forces as Output:

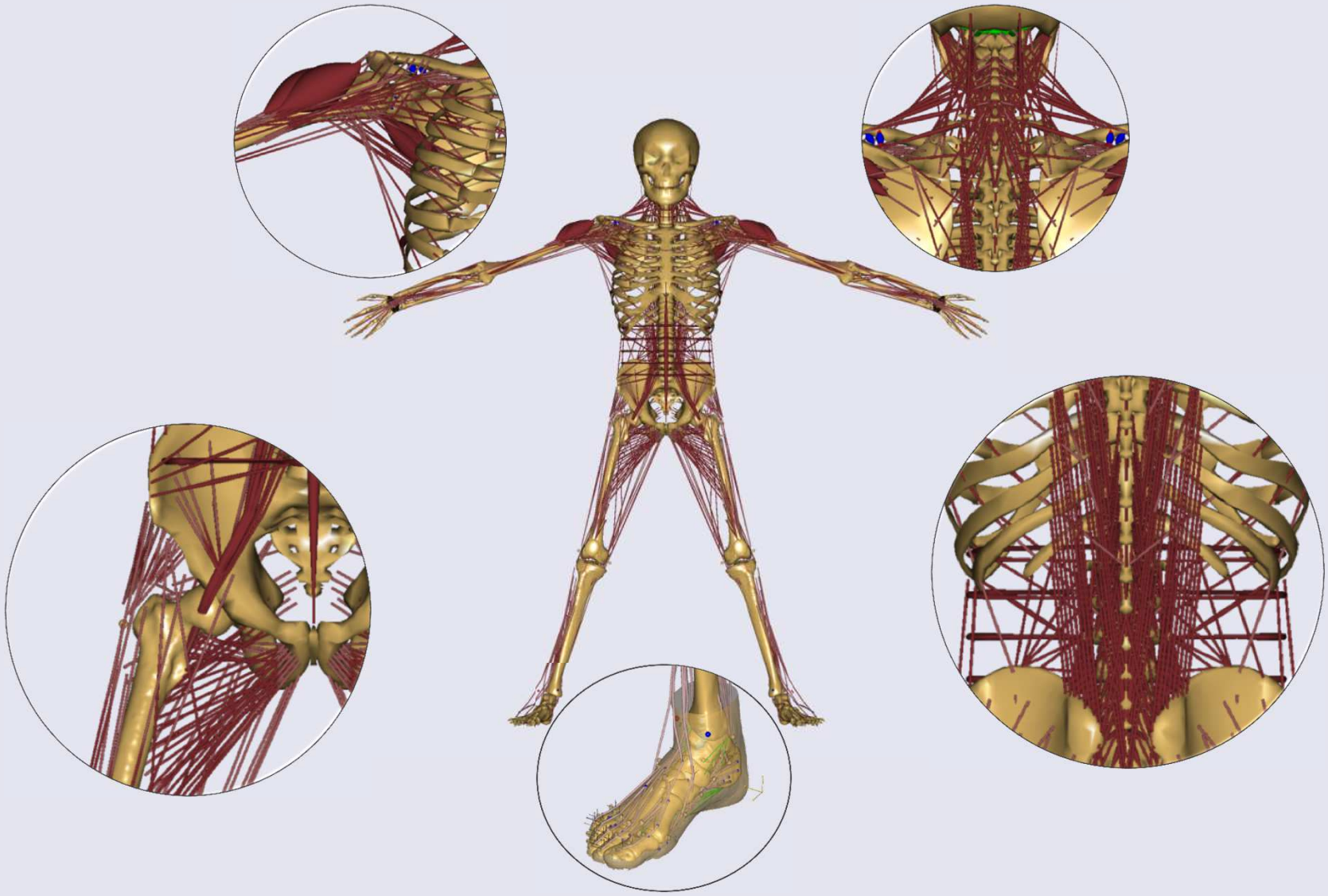
- Muscle Forces (activations)
- Joint Reaction Forces

Dynamic physiological loads



ANYBODY TECHNOLOGY

Model Repository

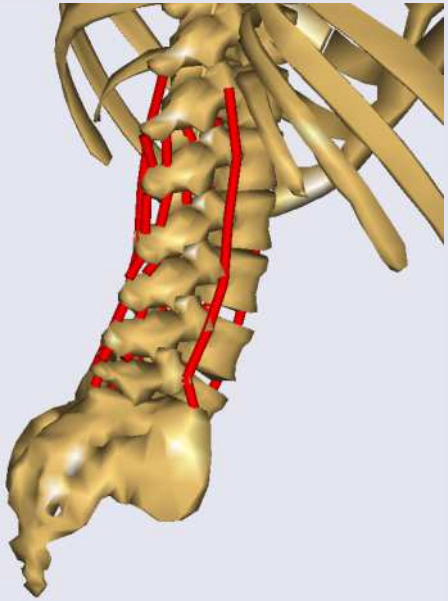


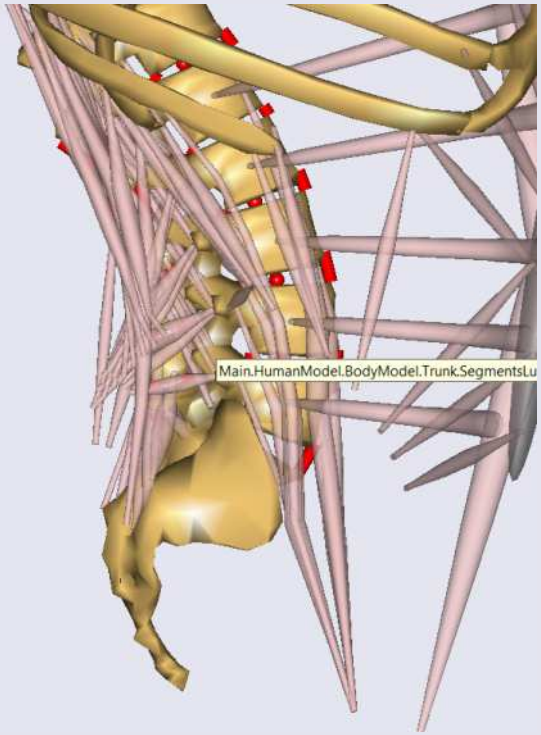
Spine models

Cervical spine

- 7 vertebra
- 136 muscle fascicles

De Zee et al. 2007: J. Biomech.40, S284





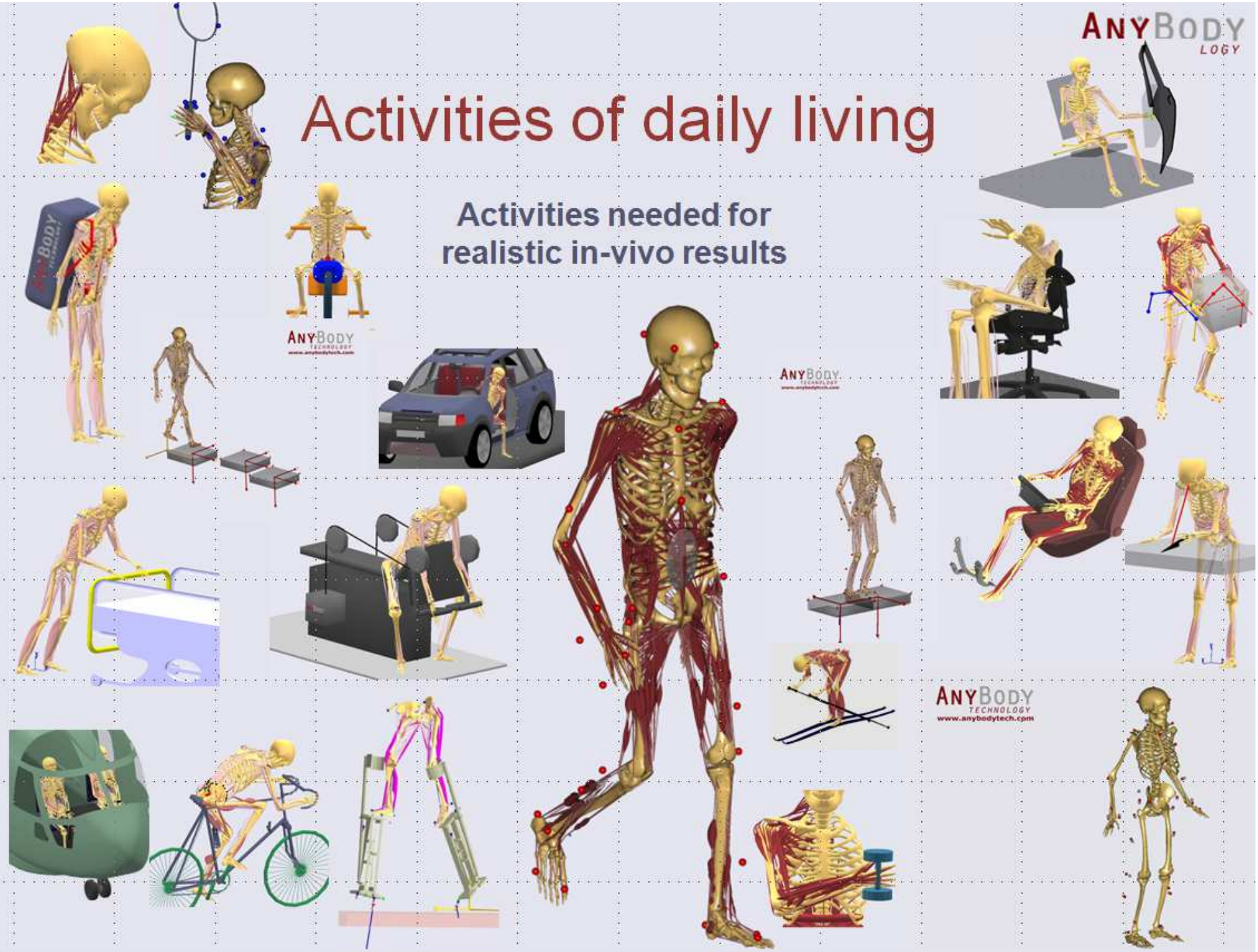
Lumbar spine

- 5 vertebra
- 188 muscle fascicles
- ligaments (intertransverse, anterior/posterior, ligamenta flava, interspinous, supraspinous)
- Intra abdominal pressure
- facet joints
- Non-linear IVD stiffness

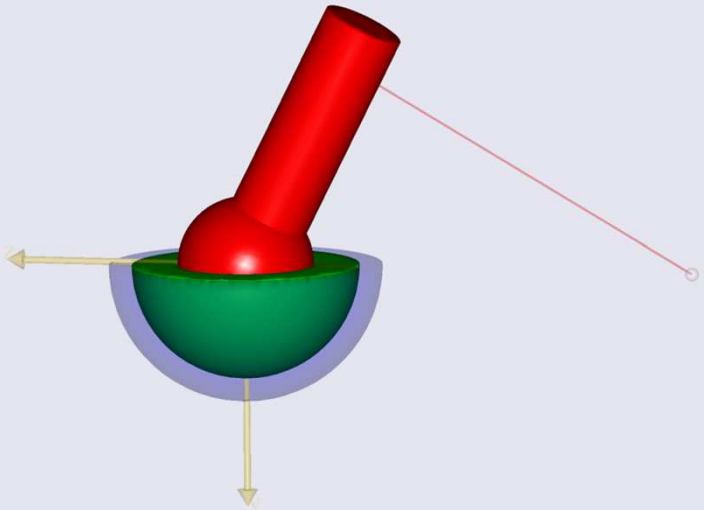
Hansen et al. 2006: Spine 31, 1888-99
De Zee et al. 2007: J. Biomech. 40, 1219-27
Galibarov et al. 2011,
Han et al., Med Eng Phys, 2011

Activities of daily living

Activities needed for realistic in-vivo results



Contact with Force Dependent Kinematics (FDK)



see previous Webcasts on FDK from:
- John Rasmussen
- Michael S Andersen
- Michael Damsgaard

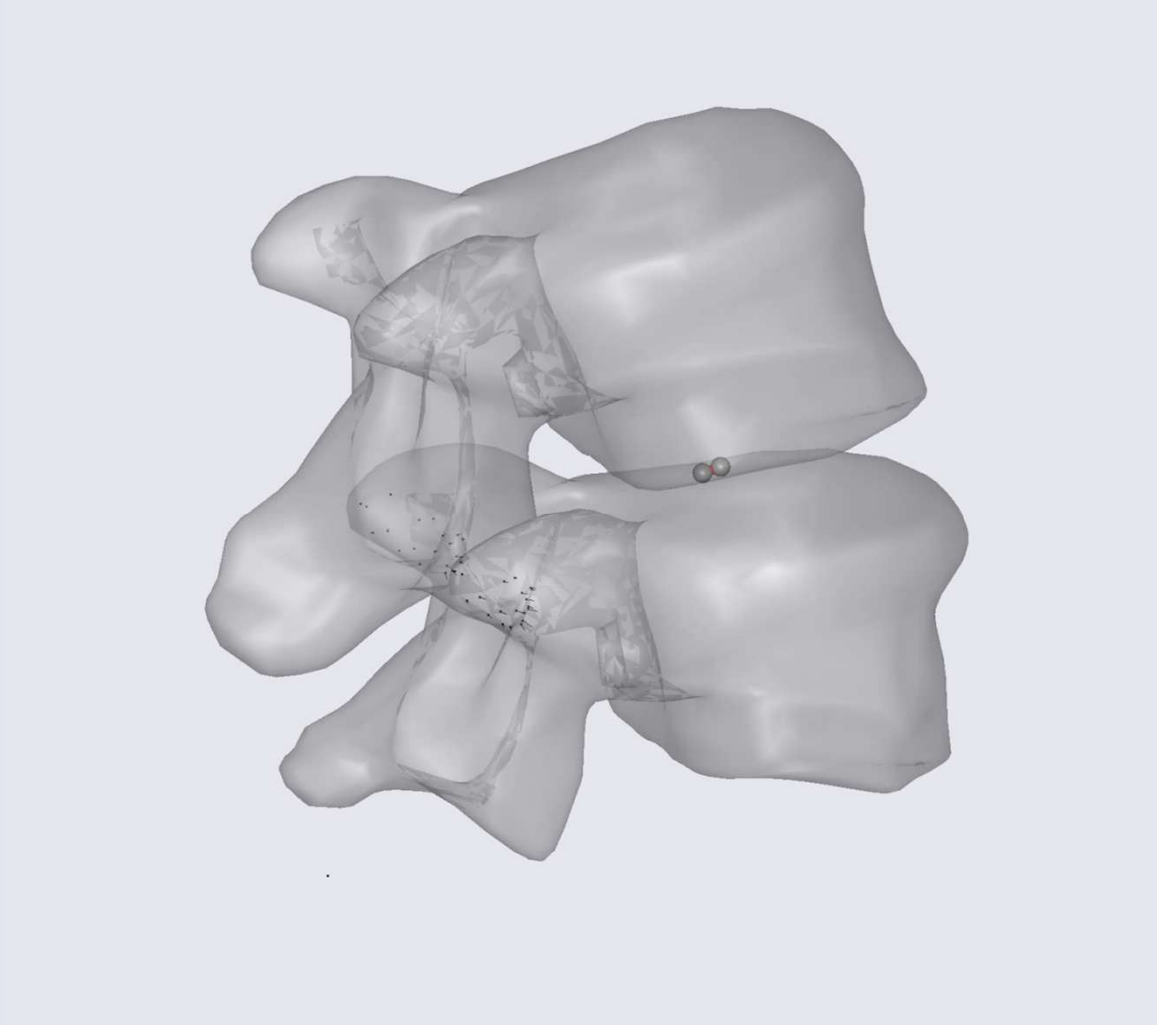
at *www.anybodytech.com*

Andersen et al., 2011

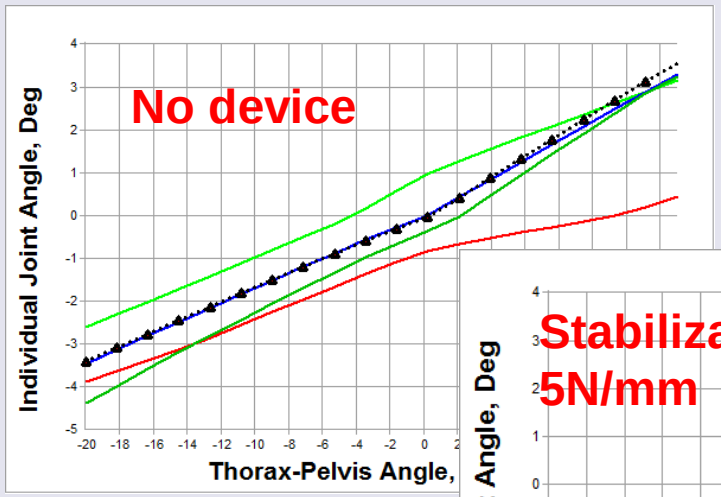
see previous Webcasts from:
- Michael S Andersen

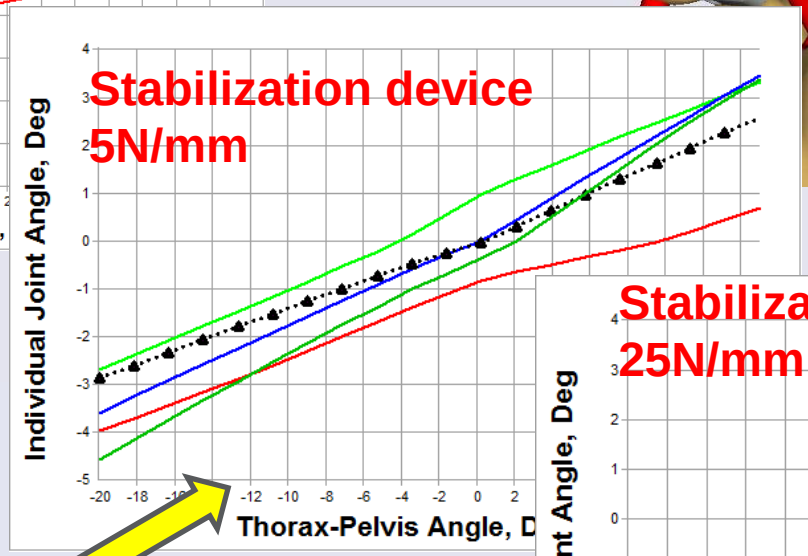
at *www.anybodytech.com*

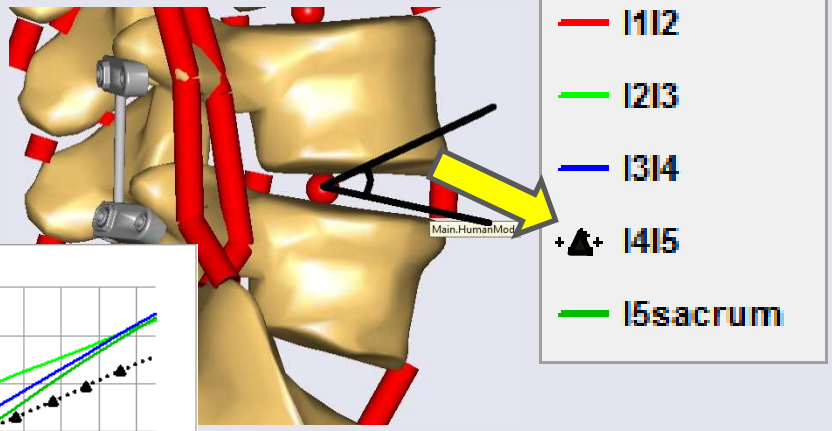
Contact with
Force Dependent Kinematics (FDK)

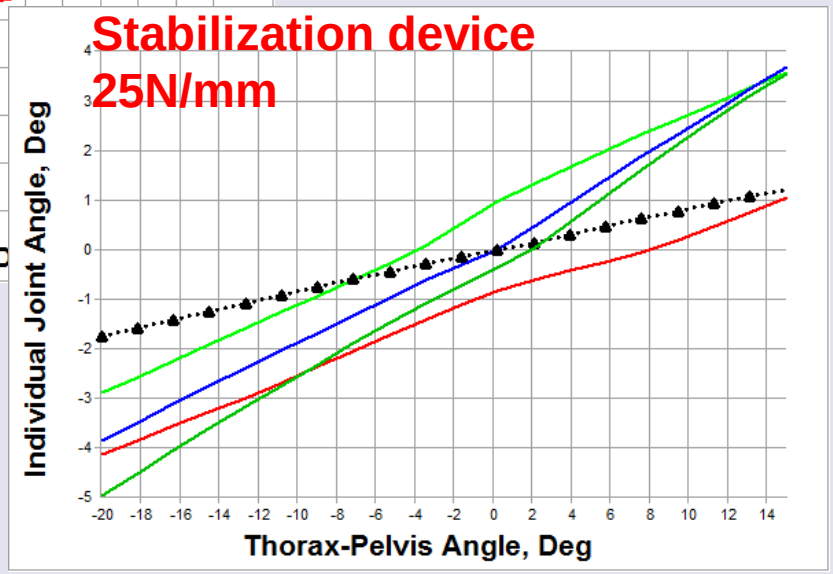


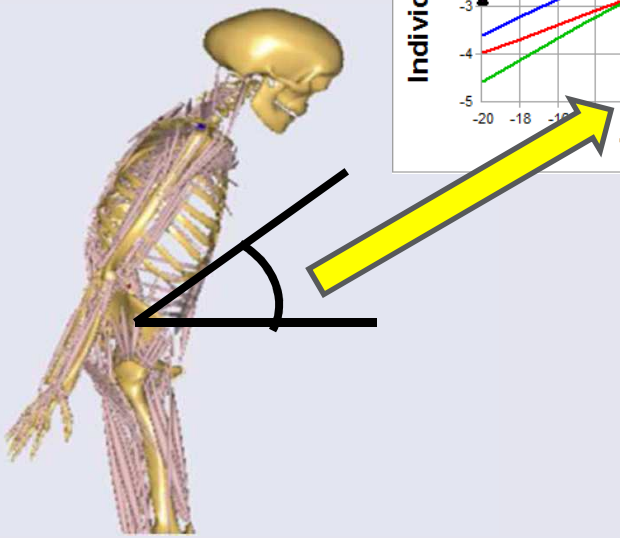
Device design alters spine kinematics







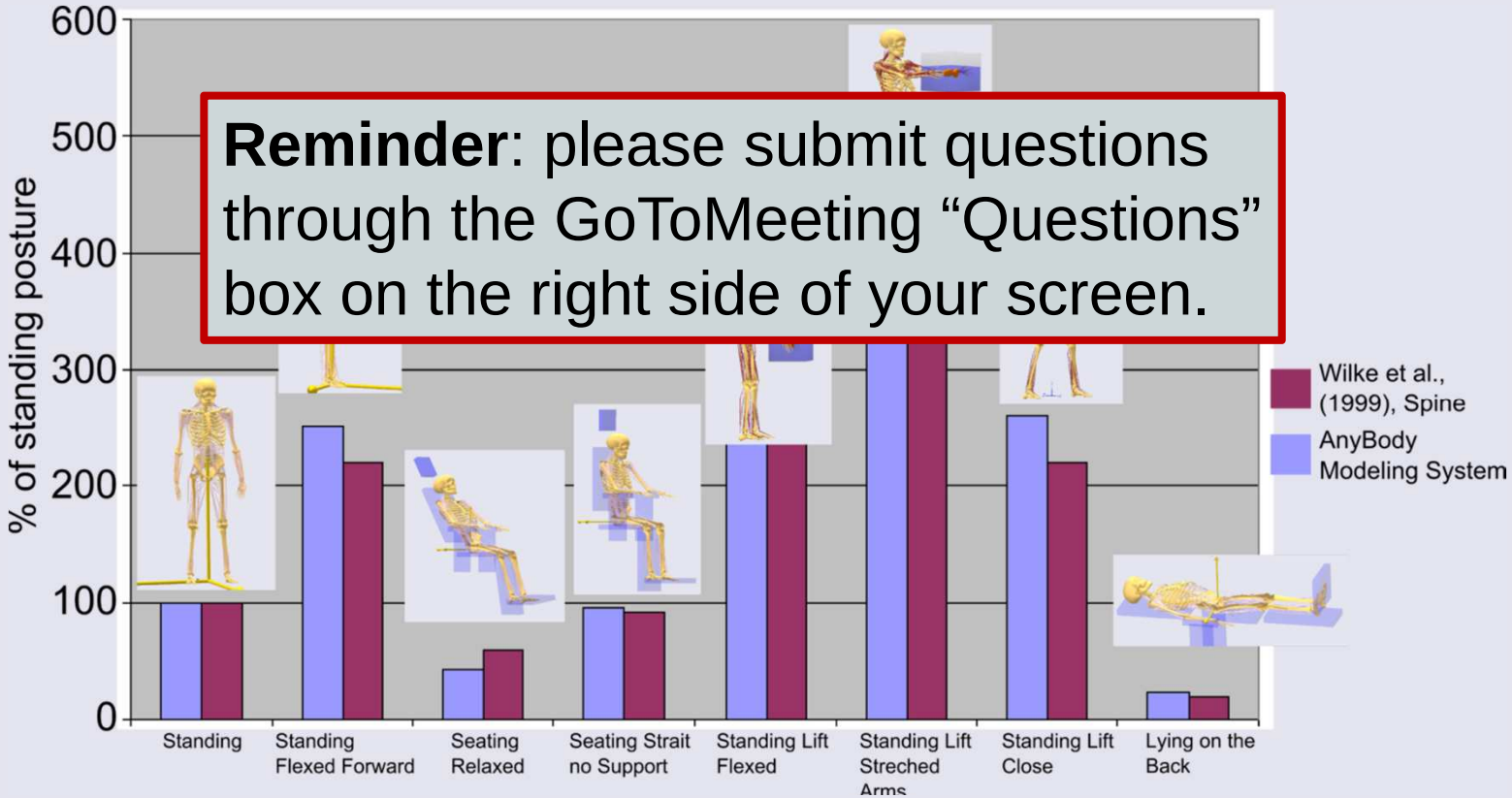




Validation

- Direct: In-vivo Forces
  - Magnitude + Phase
- Indirect: Muscle activations
  - Onset/Offset + Trend
- Clinical
- AnyBody vs. Other Model

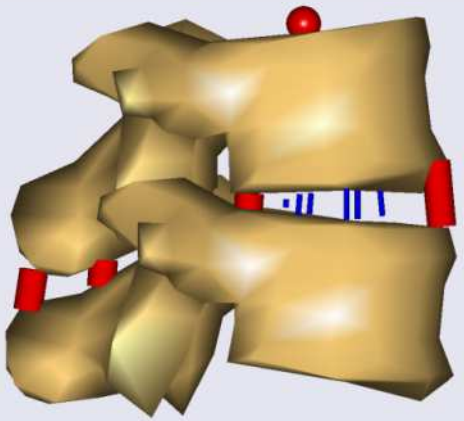
Validation: In-vivo intra-discal pressures



Reminder: please submit questions through the GoToMeeting "Questions" box on the right side of your screen.

Rasmussen et al. 2009

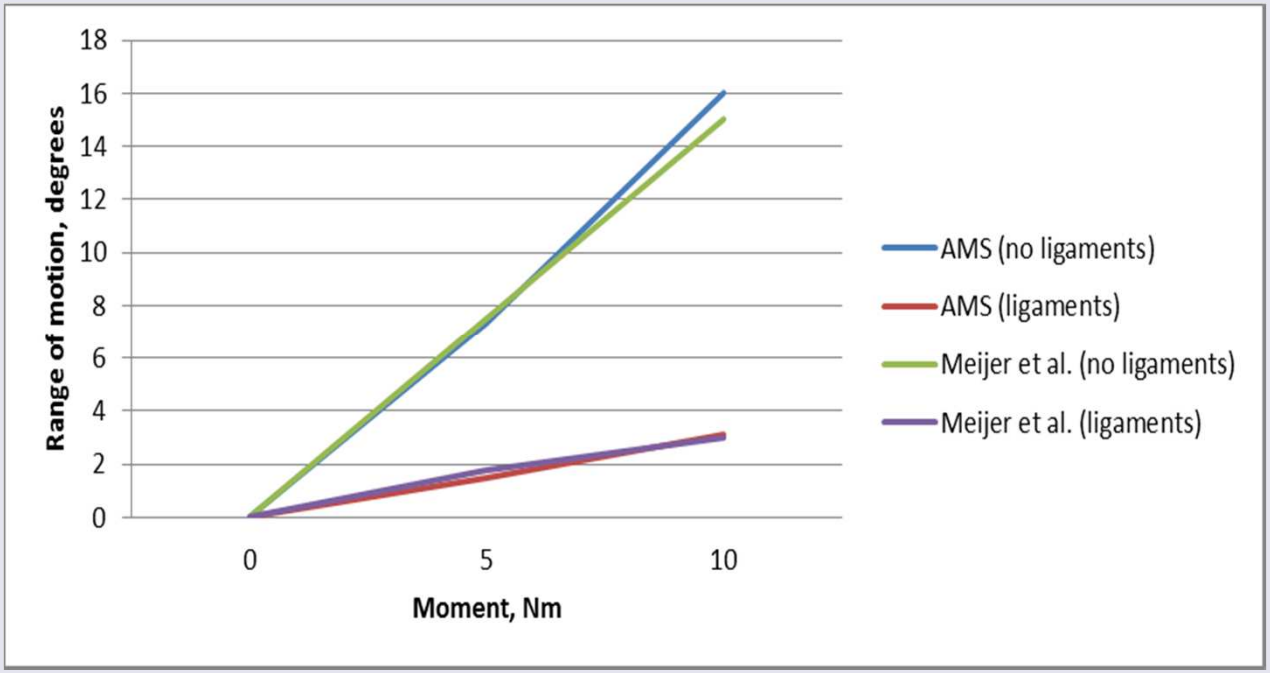
Spinal motion segment validation



- **Ligaments (IT, ALL, PLL, LF, IS, SS)**
- **Facet joints**
- **Non-linear IVD stiffness**

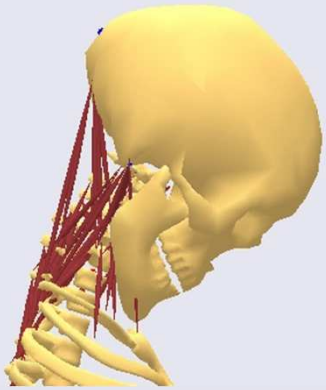
Comparison of motion in one spinal motion segment between a validated FE model and AnyBody model

January, 13th-16th ORS meeting, Long Beach, CA: Galibarov, P. et al., Two Computational Models of the Lumbar Spine: Comparison and Validation, POSTER #: 0786

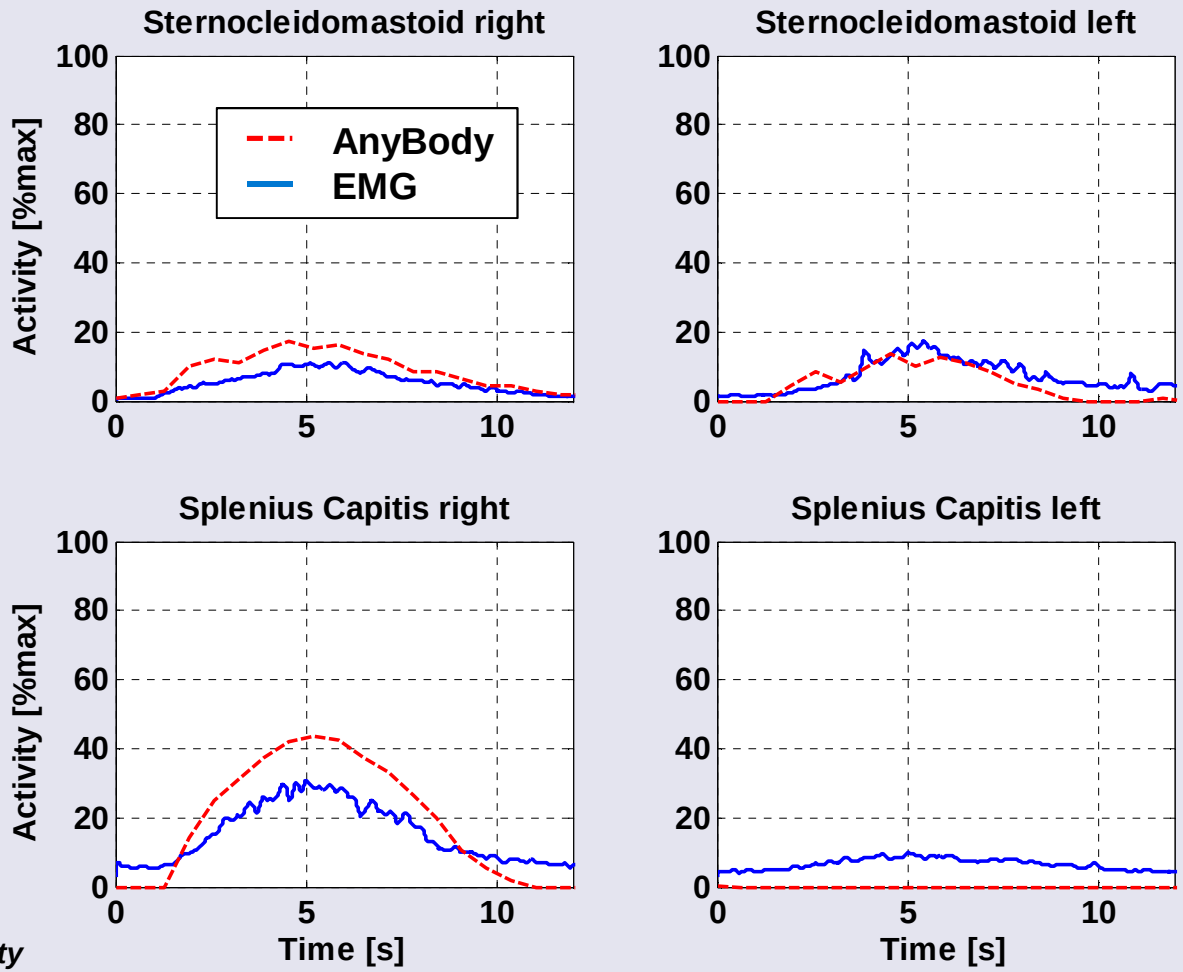


Meijer et al. J Biomech, Vol. 43(8), 2010, pp. 1590-1597

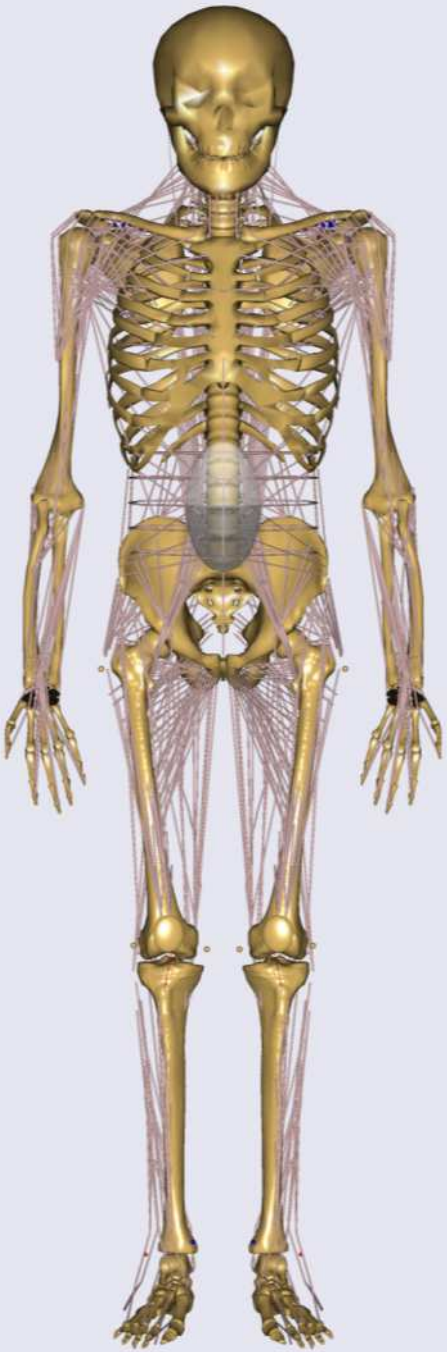
Preliminary EMG results: isometric lateral flexion

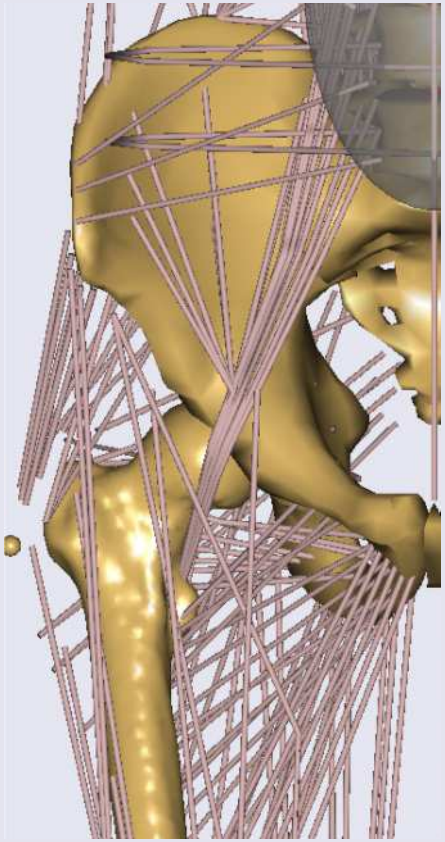


de Zee, unpublished, Aalborg University

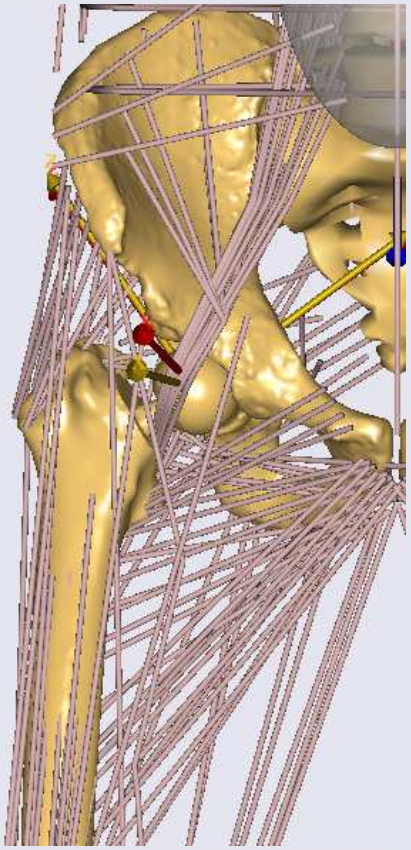


Subject-Specific Modeling

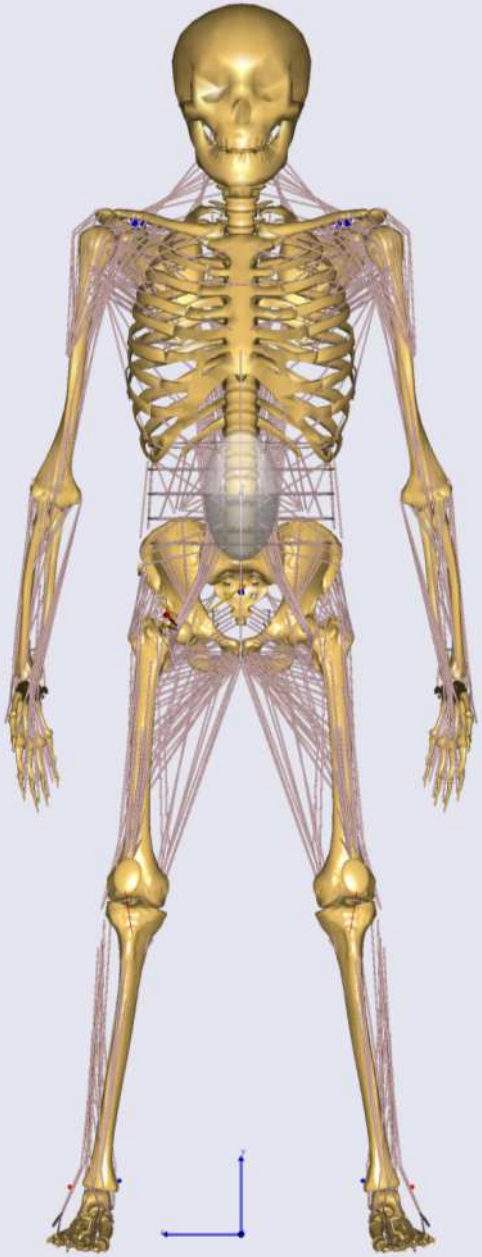




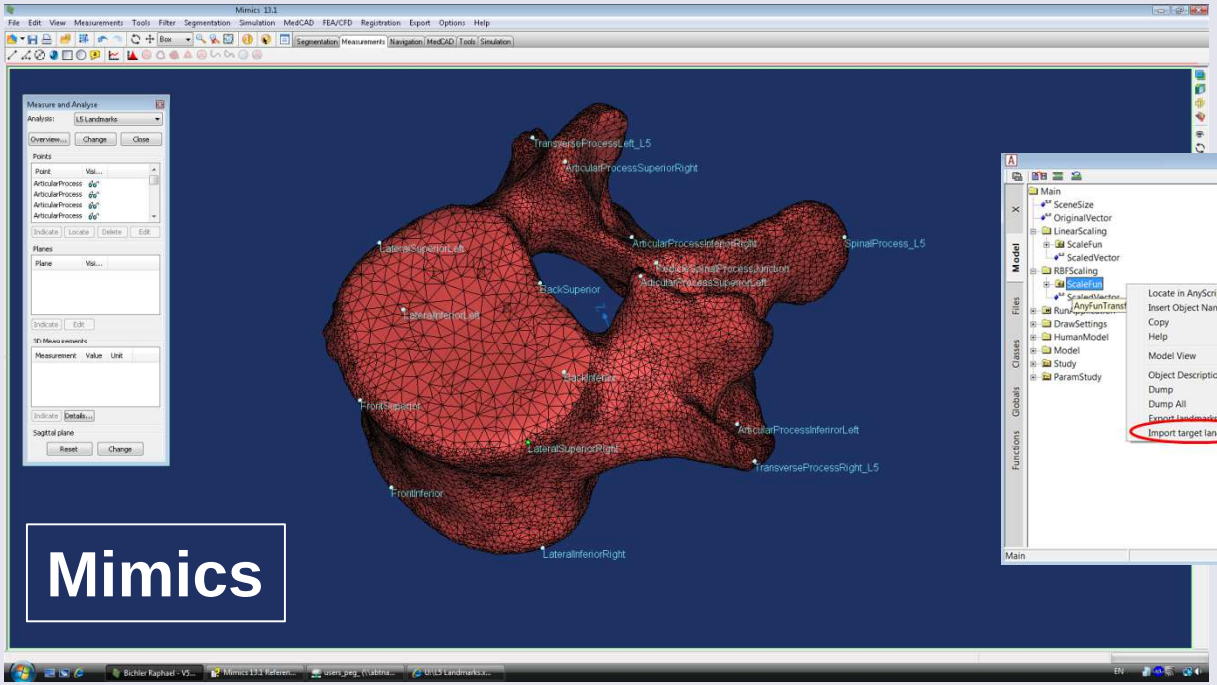
Generic

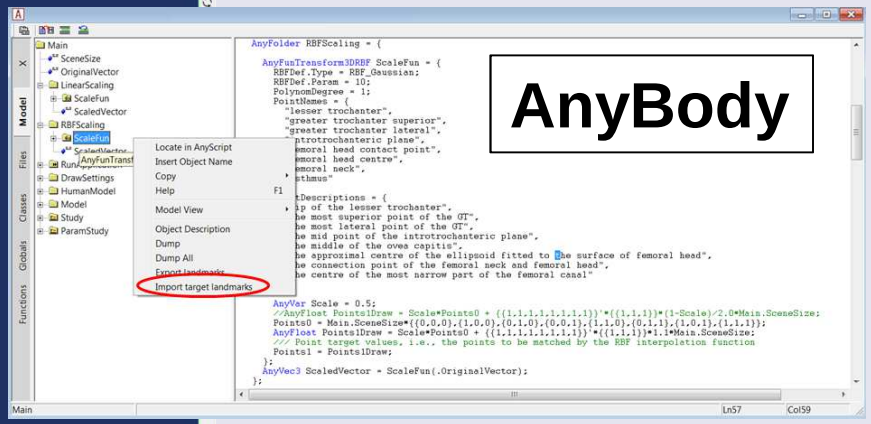


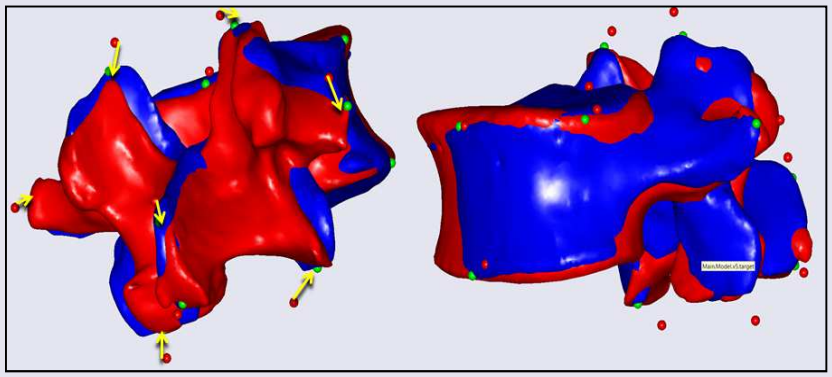
Subject-Specific

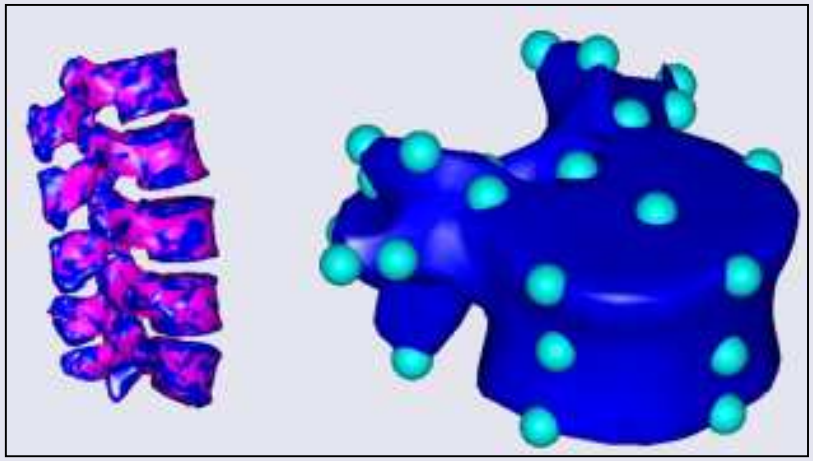


Subject Specific Scaling







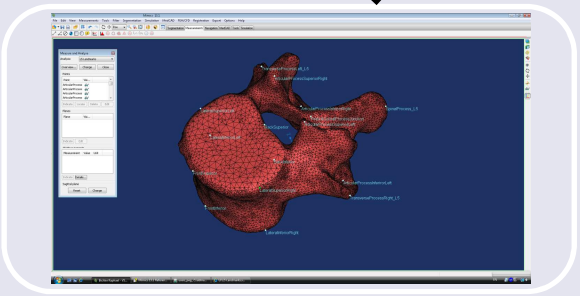


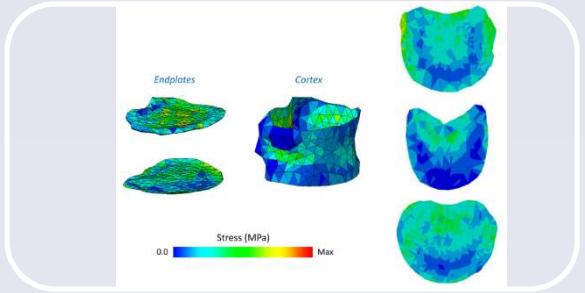
Subject-Specific Modeling Workflow

More information on subject-specific modeling is available in the archived webcast…

The New Release of the AnyBody Modeling System, version 5.2
28 June, 2012

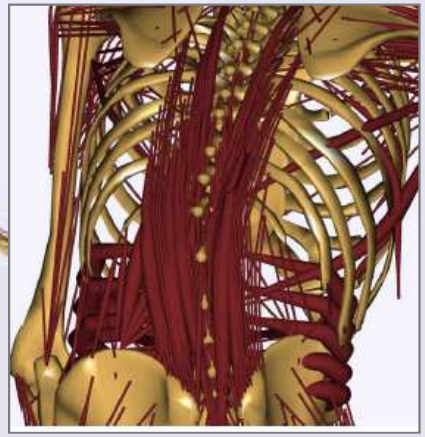
at *www.anybodytech.com*

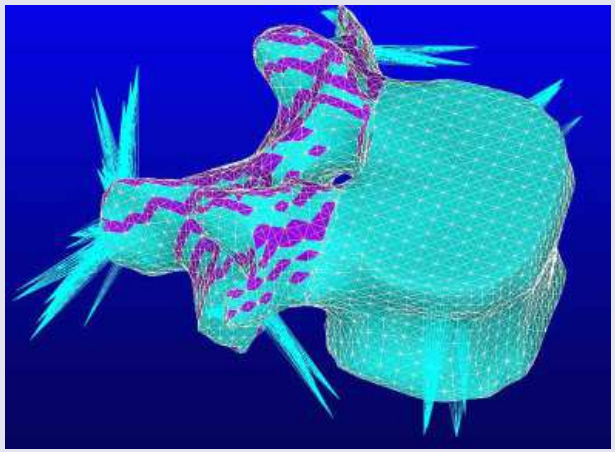




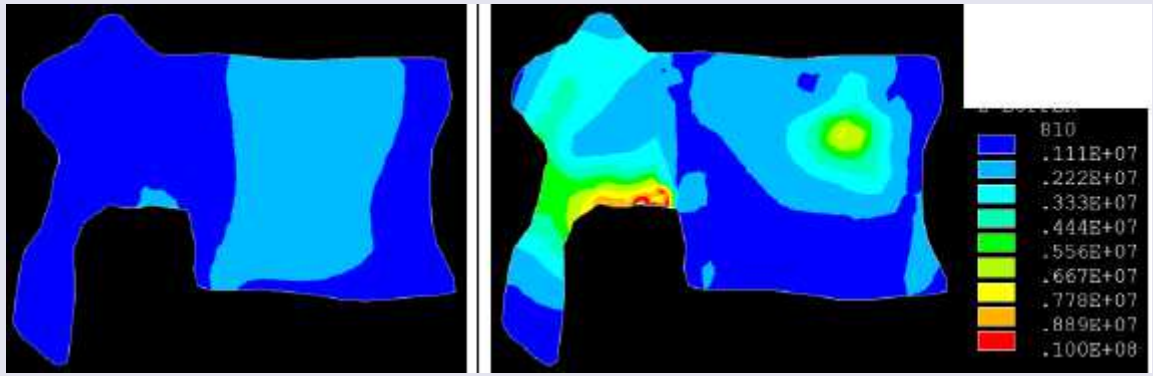
Importance of Muscle Loading

- 5 kg in each hand and a posture of 60º flexion, 15º lateral bending, and 25º axial rotation; FE model of L4





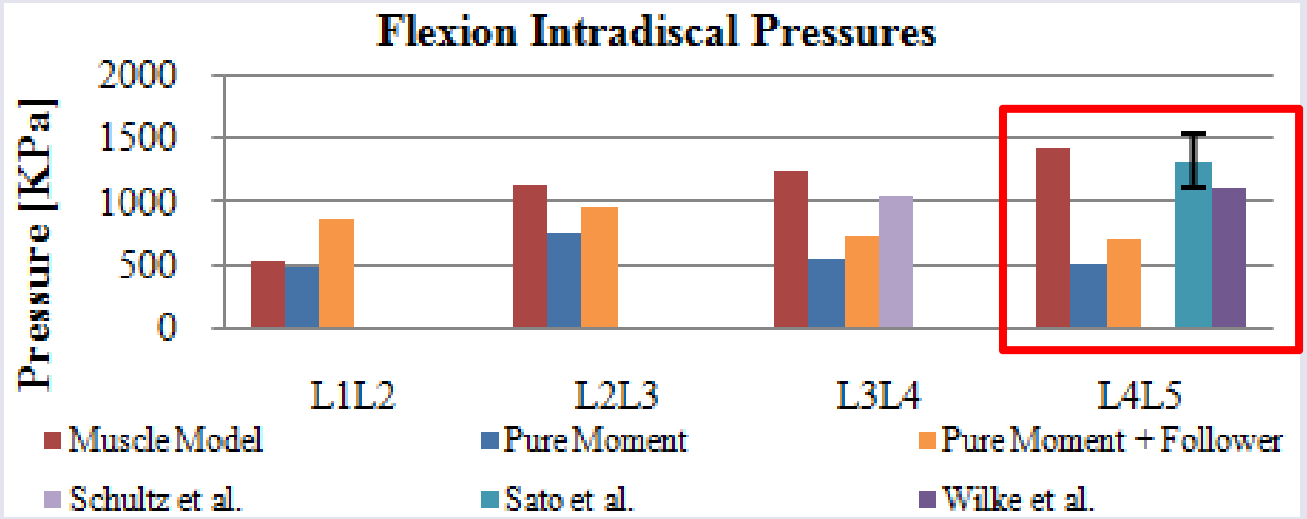
30% increase in von Mises stress due to muscle loading

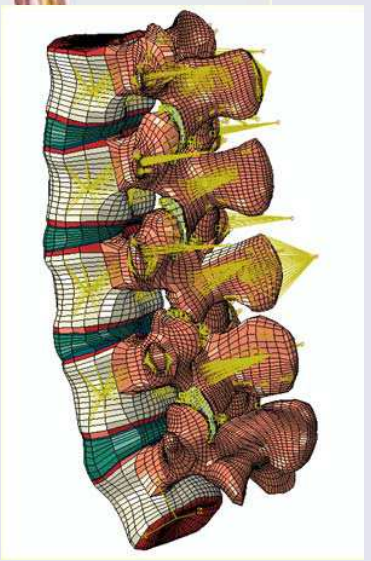


Wong et al., Open Spine Journal, 2011

Importance of Muscle Loading

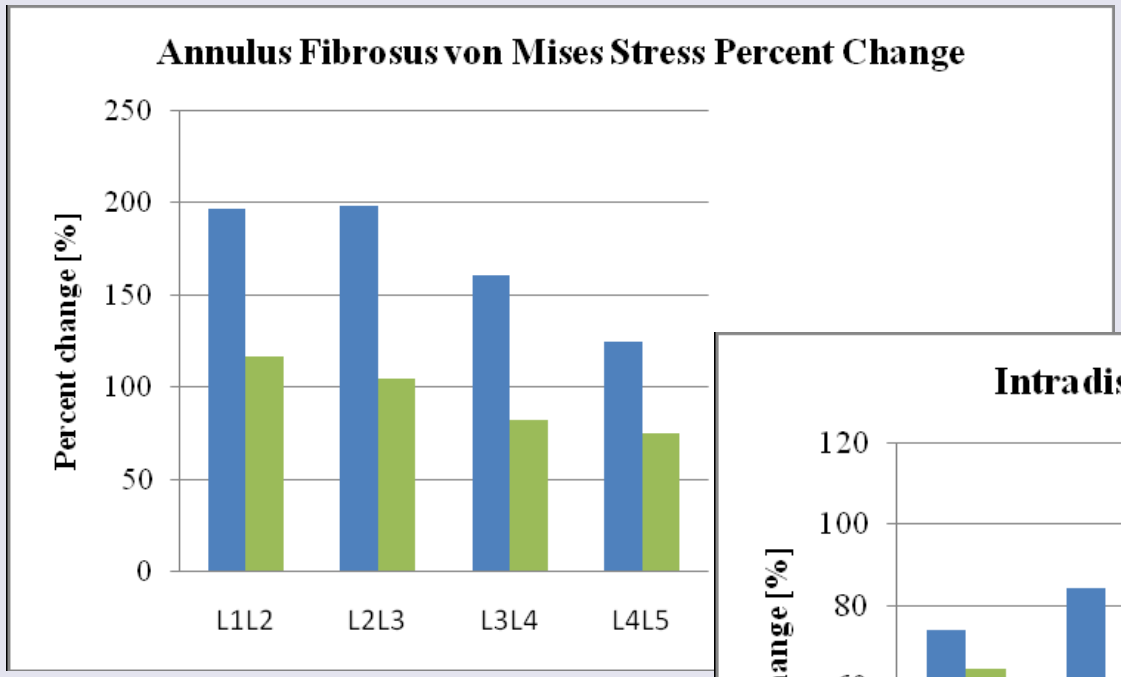
- Muscle loaded model exhibits good agreement with experiment

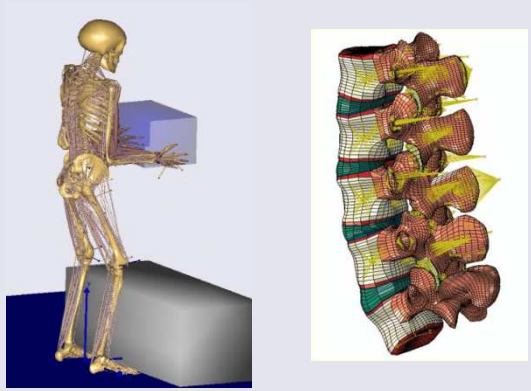


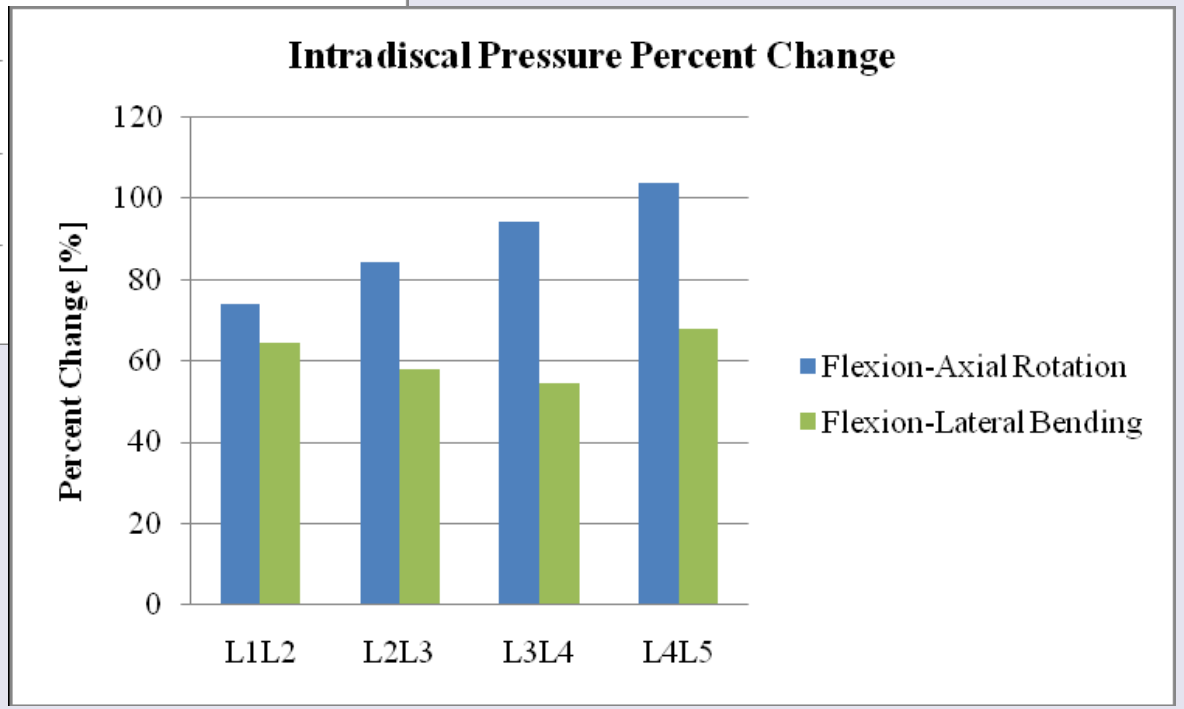


Gadomski et al., ORS 2011

Effect of Lifting 15kg Load



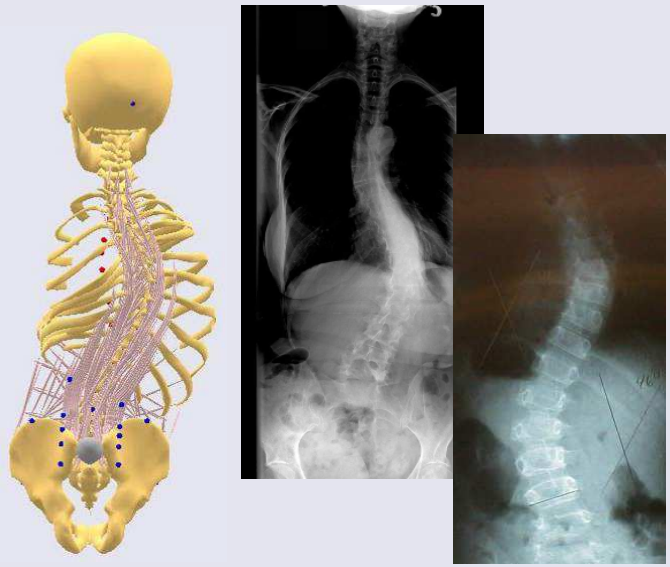


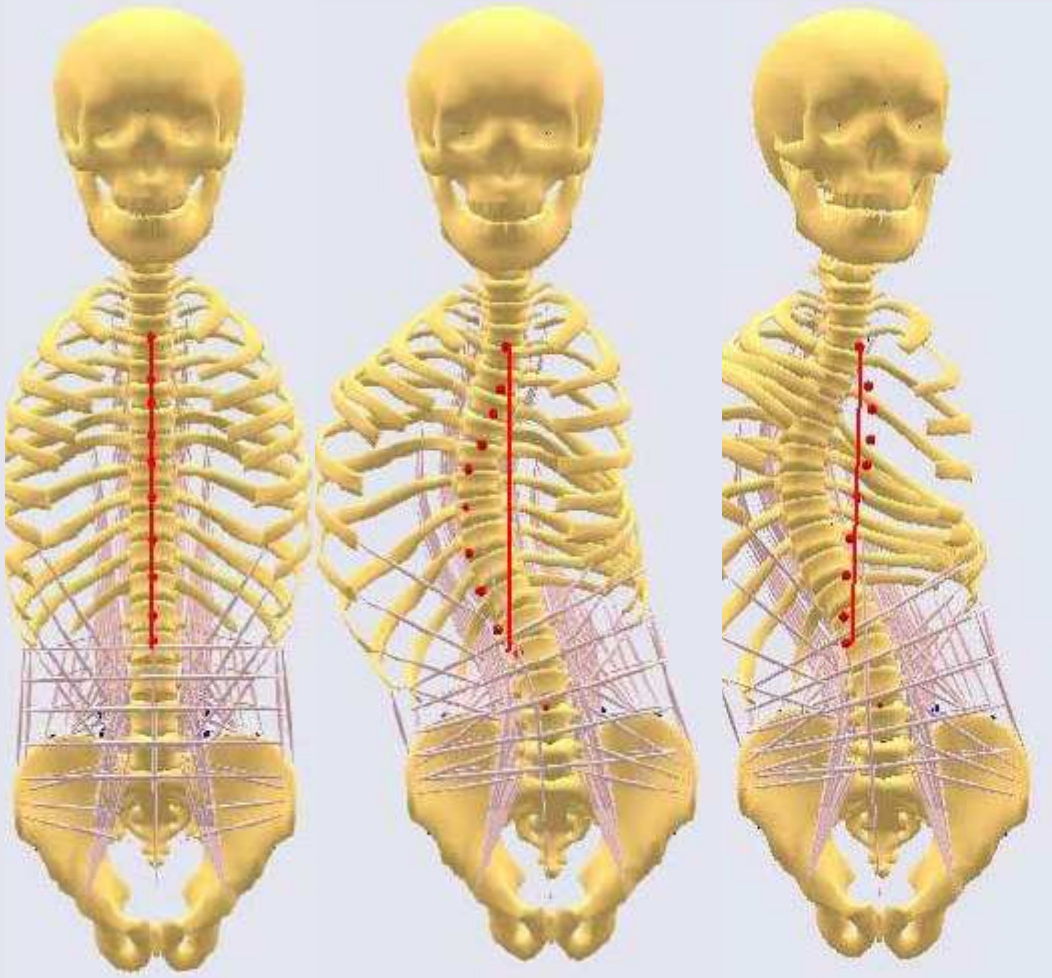


Gadomski et al., ISB 2011

Studying Scoliosis

- Axial twisting caused by rigidity of the sternum

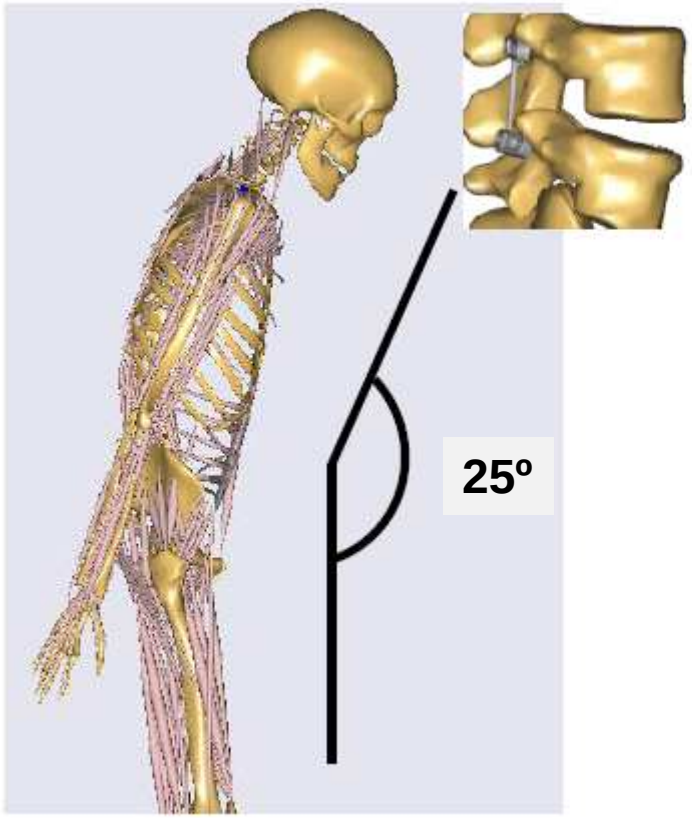


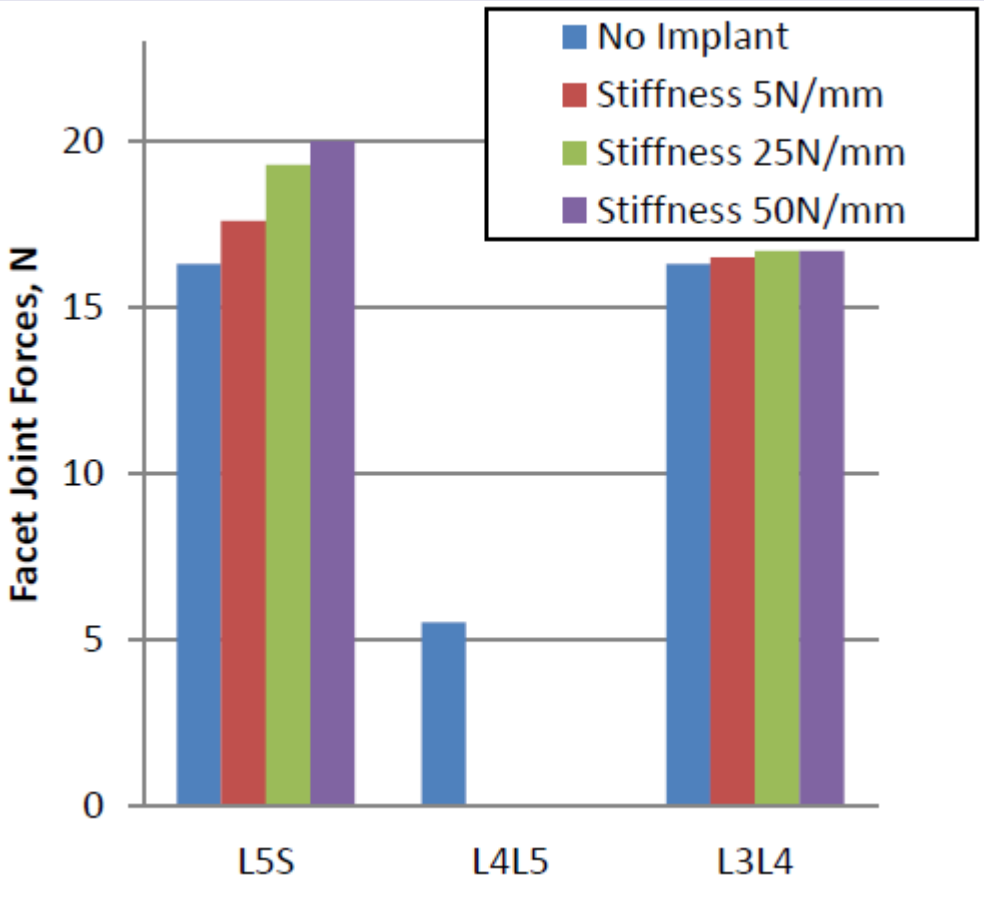


Nominal | No Sternum | Sternum Present

Andre et al., 2006

Fusion – Impact on Adjacent Levels

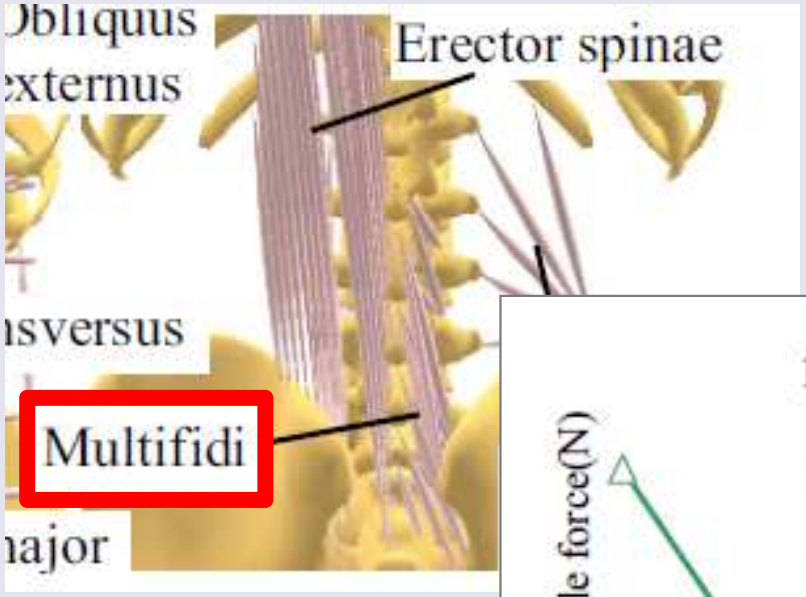


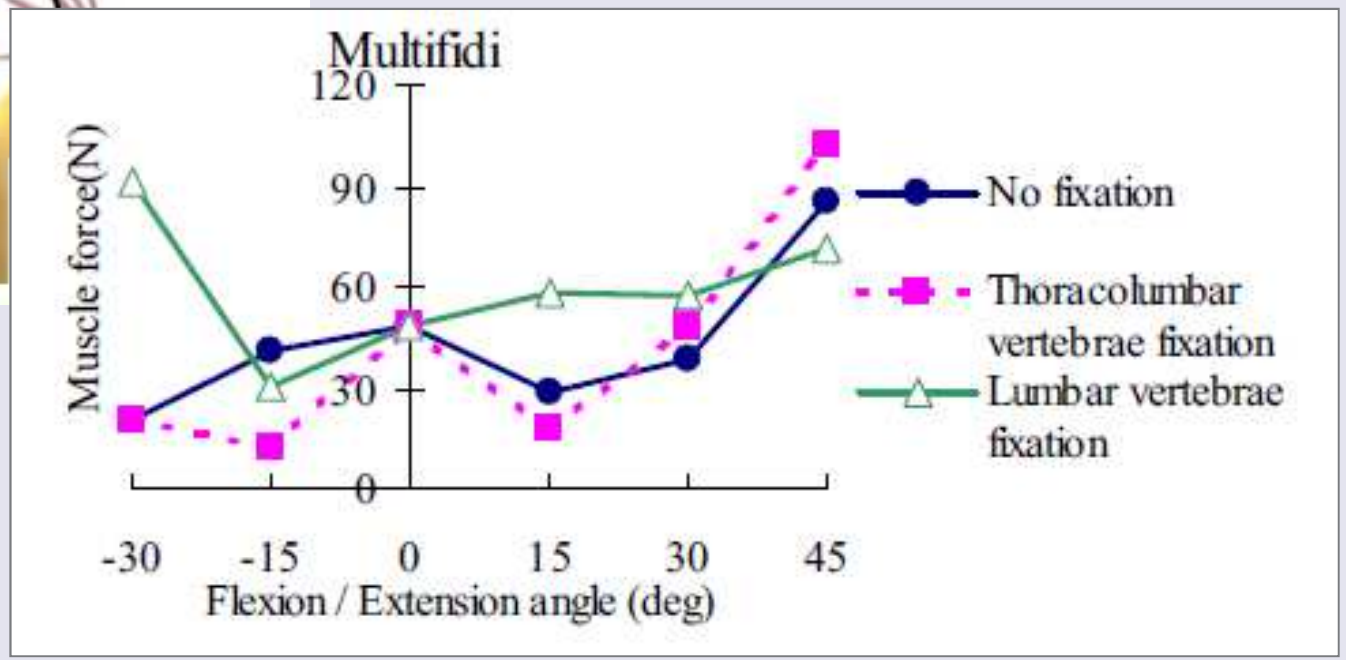


Galibarov et al., 2001

Fusion – Impact on Adjacent Levels

- Thoracolumbar fusion levels: T12-L1-L2
- Lumbar fusion levels: L3-L4-L5

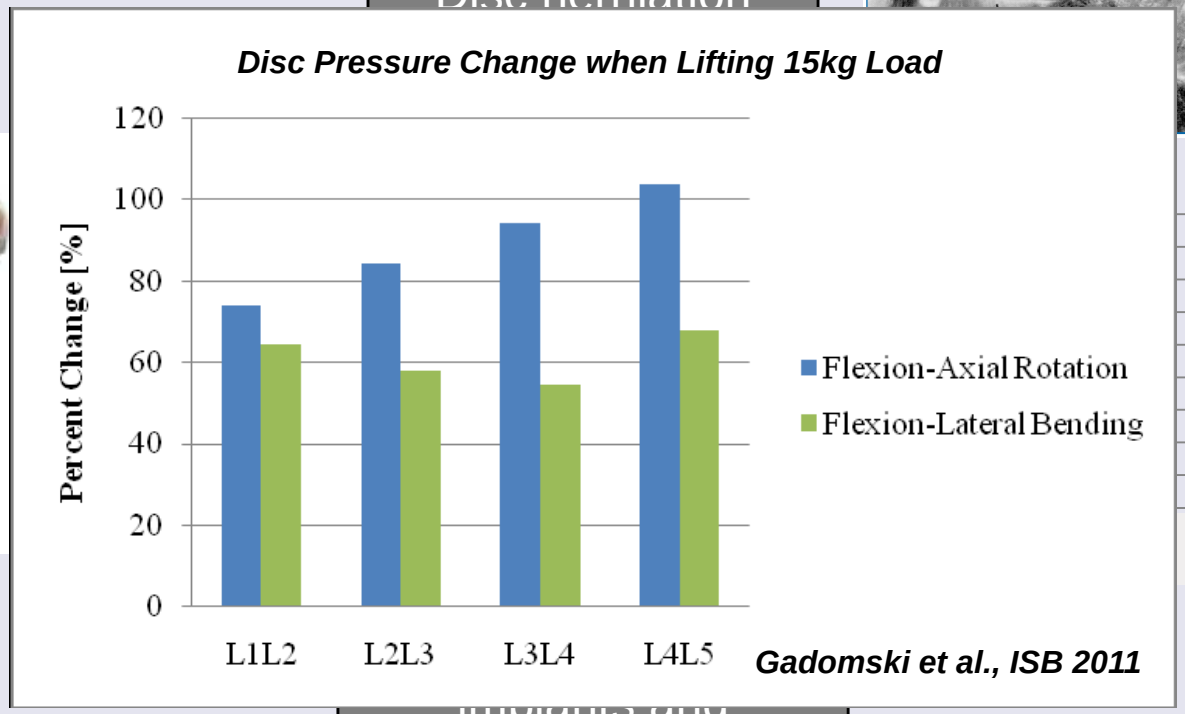


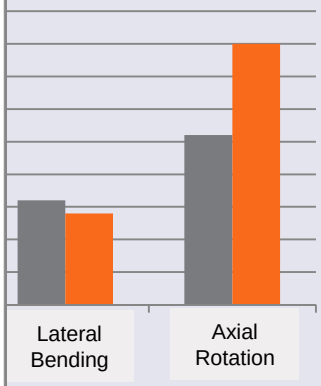


Fukui et al., 2009

Spine degeneration, cascading effects

Disc herniation





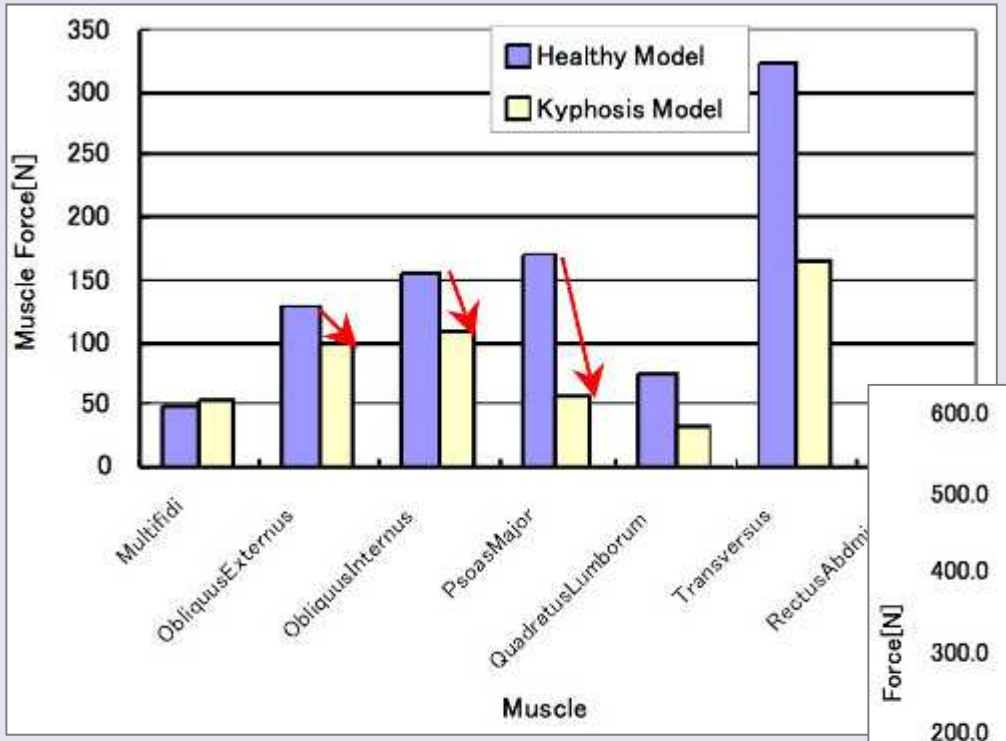
implants and adjacent levels

up to 120% increase in shear forces

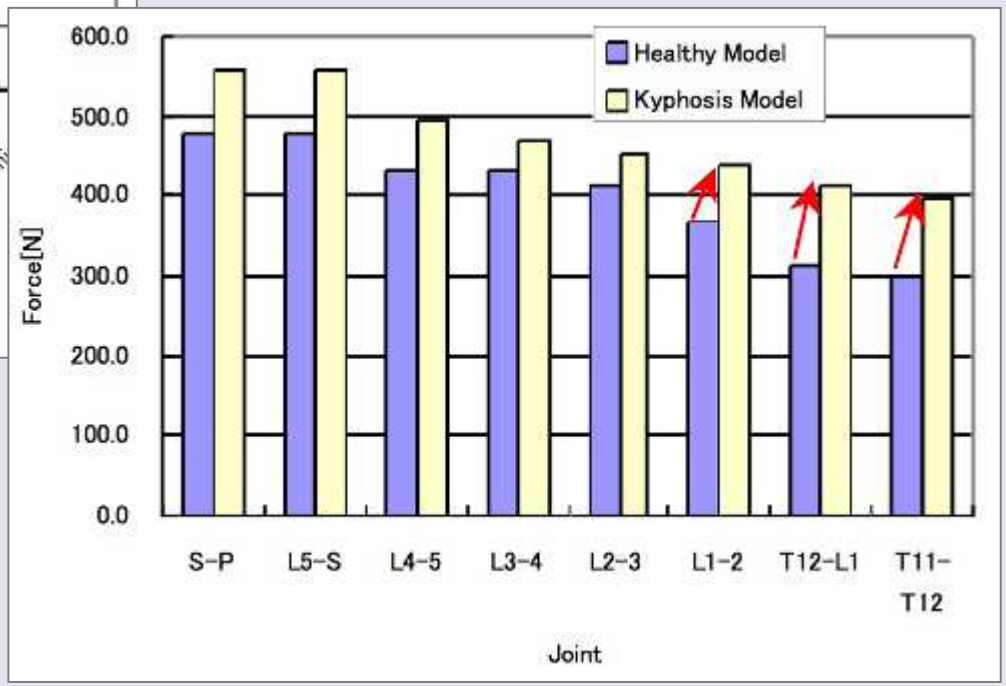
Dendorfer et al. ORS Meeting, 2010
Robie et al. SAS meeting, 2010

ARO Medical

Kyphosis: Compression Fracture at T12

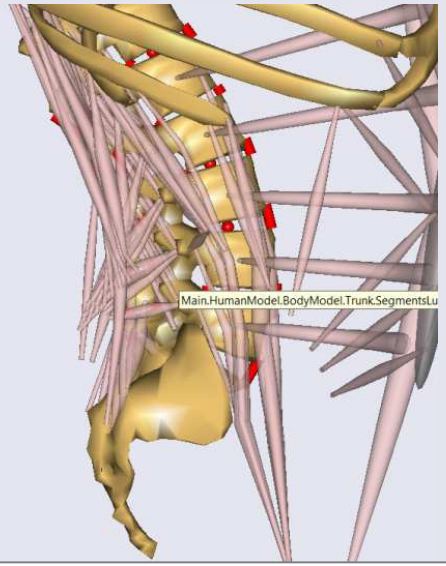


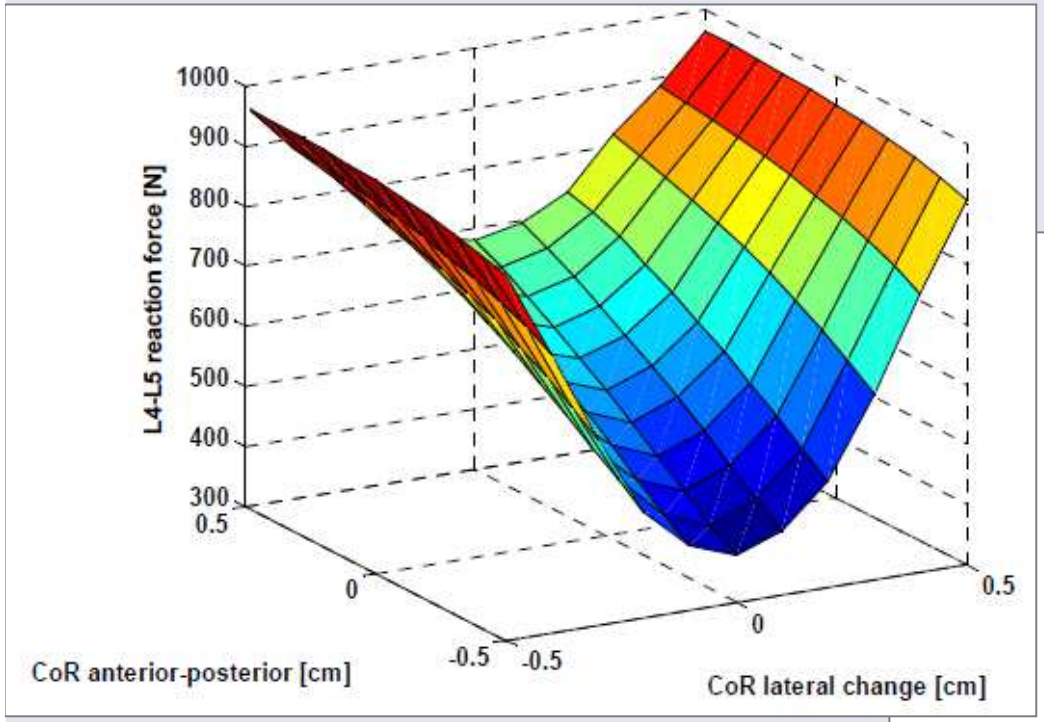
Healthy *Kyphosis*

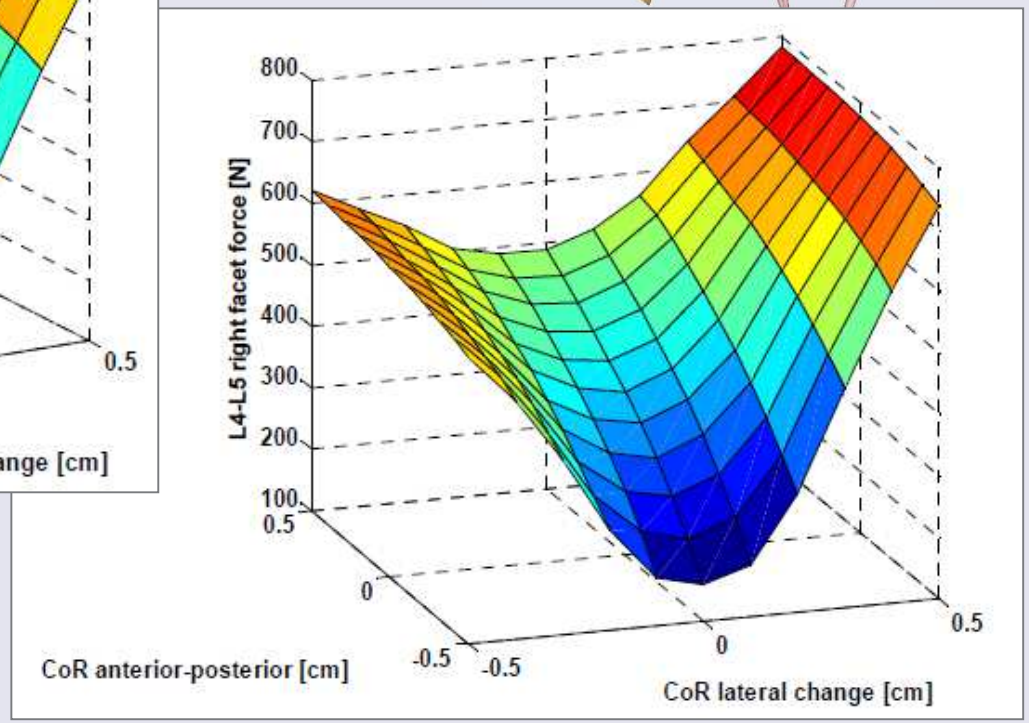


Sakamoto et al., IFMBE Proceedings, 2009
Sakamoto et al., ISB Comp Sim Biomech, 2009

Effect of CoR: Reaction and Facet Forces



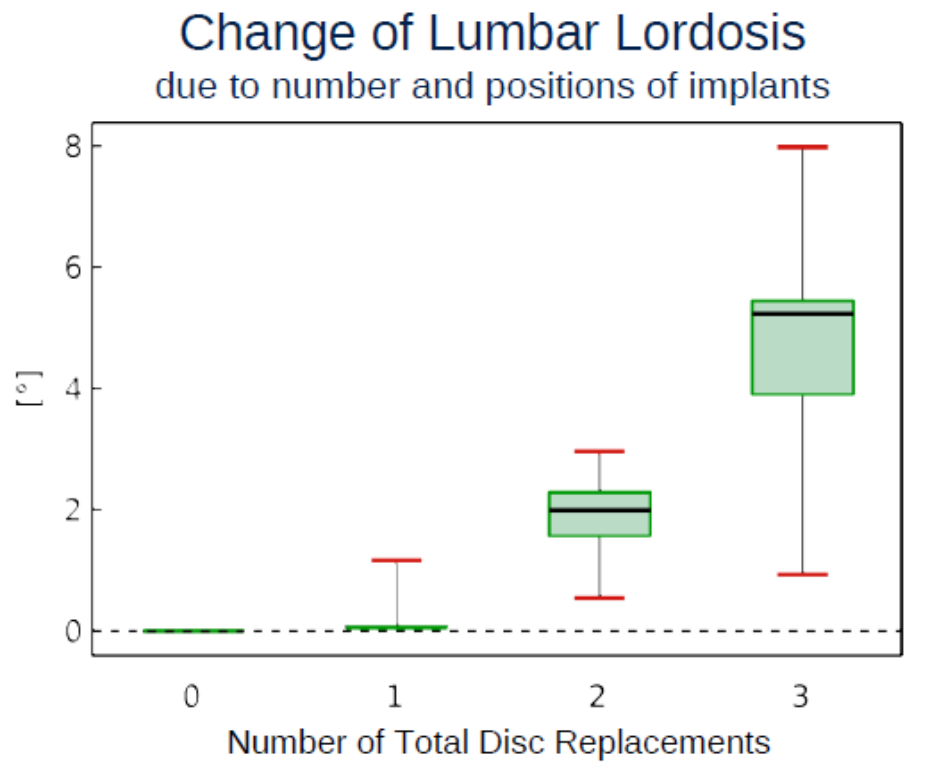


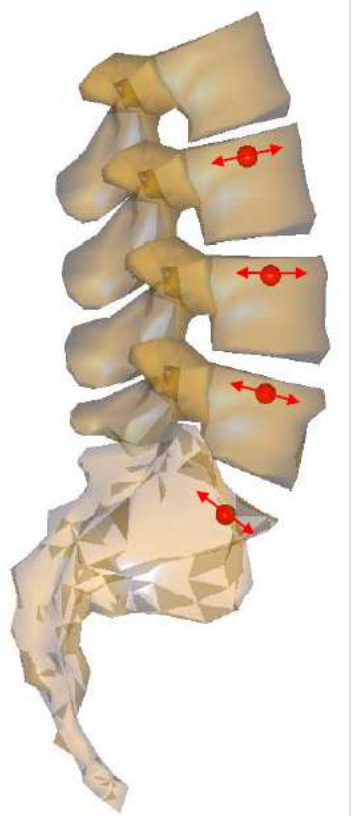


de Zee et al., ORS Meeting, 2009

TDR: Effects of Surgical Parameters on Posture

- DoE with latin hypercube sampling
- Number of implants (1-3) and AP position (±3mm) varied



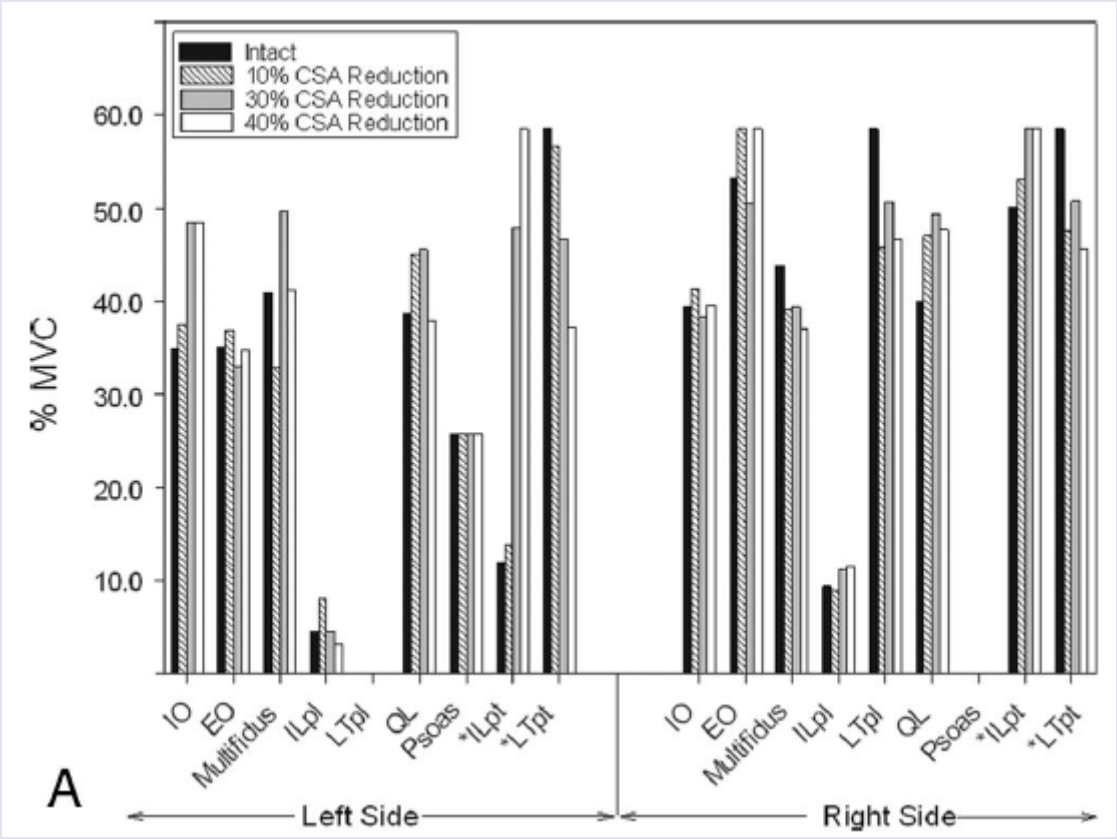


Zander et al., 2009
Zander et al., Eurospine 2011

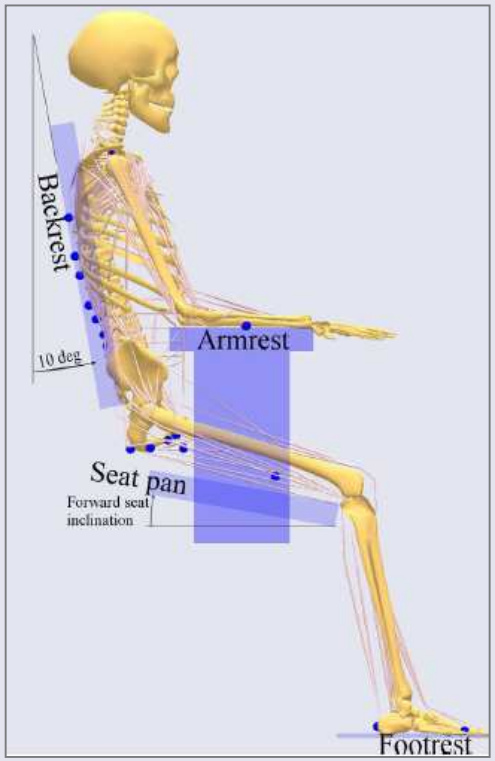
Surgical Damage Changes Muscle Activity

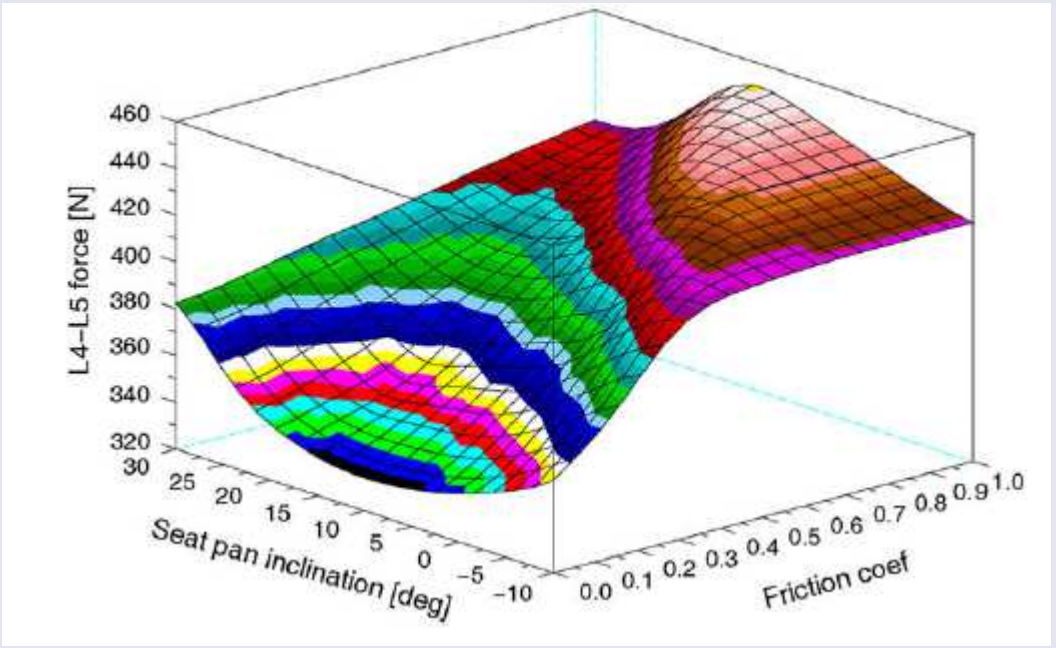
- Surgery: reduction in CSA in range L3-L5
- Finding: lat bending and axial rotation greatest

Bresnahan et al., 2010



Effect of Seating Parameters on Muscle Activity

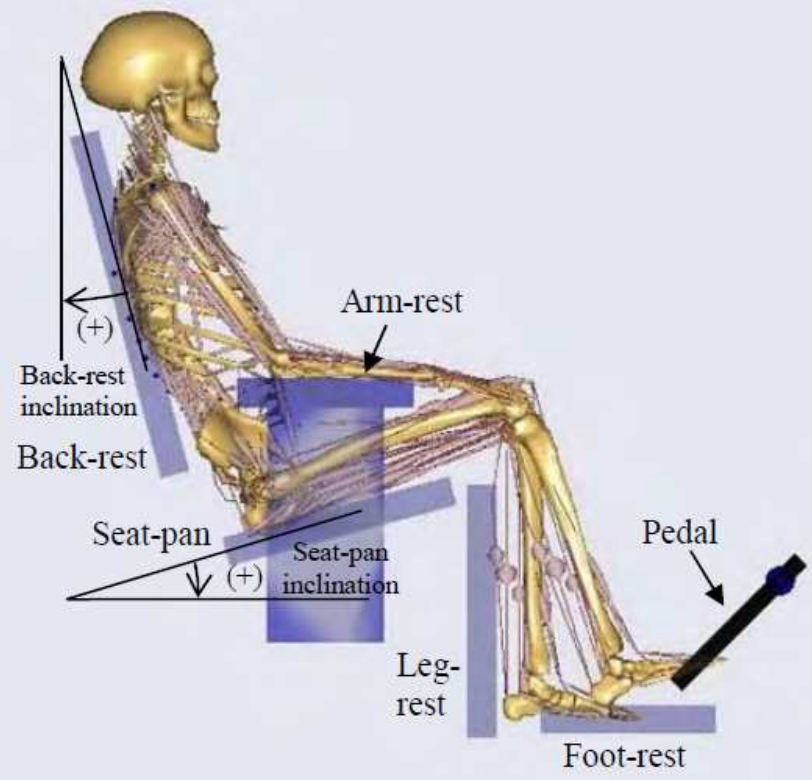




- No obvious optimum… reclined seat pan high friction → low fatigue, but high spinal loads; converse conditions also true

Rasmussen et al., 2009

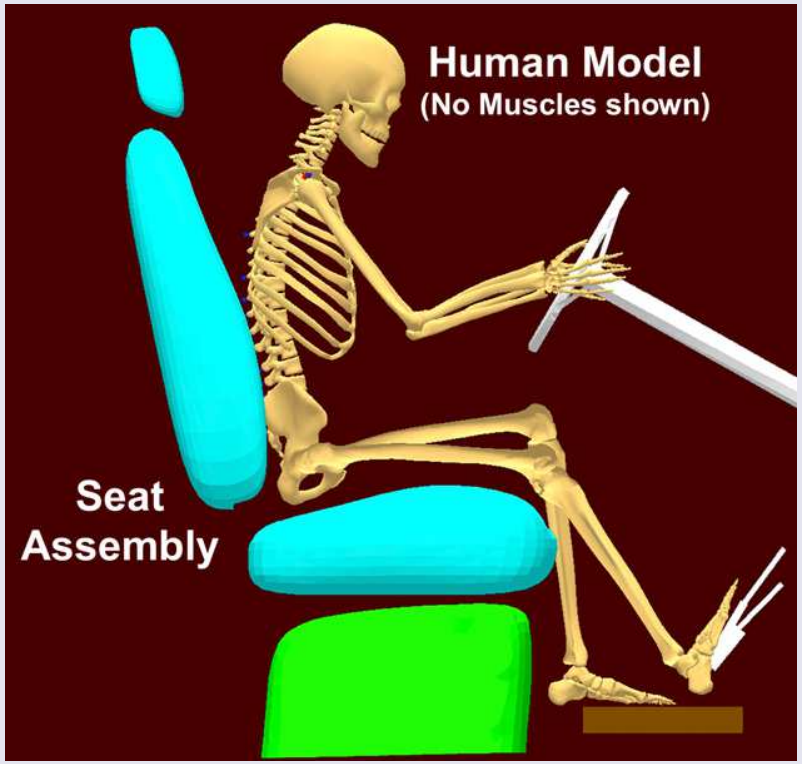
Effect of Seat Parameters on Driver Fatigue



- Relationships among muscle activity, joint loads, and seat parameters complex
- Approx 20º of back and pan inclination as well as modest pedal resistance of 20 Nm/rad produced good compromise of comfort and low fatigue

Majid et al., 2011, 2011a

Effect of Seat Parameters on Driver Fatigue



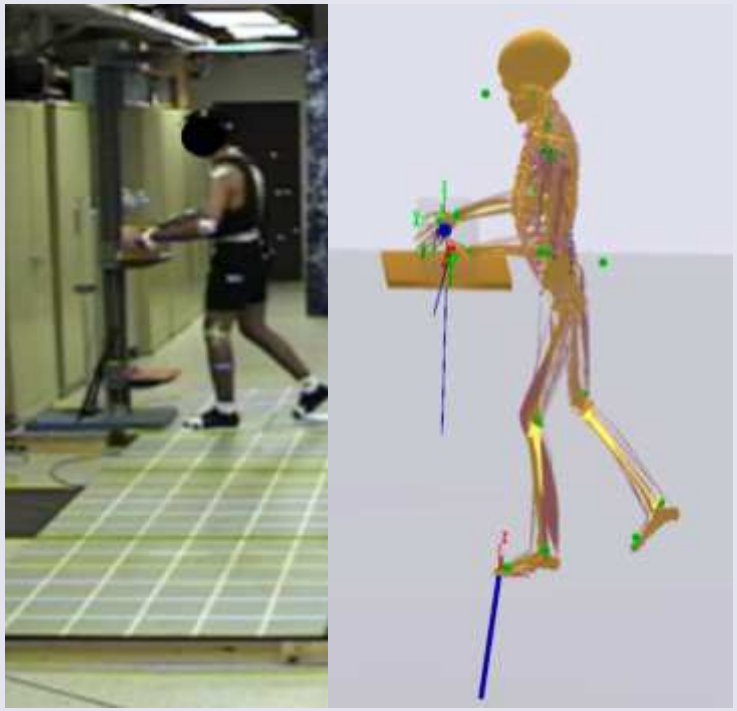
$$LDDFF = 5.0\left(\frac{CMA}{0.0045}\right)^2 + 1.0\left(\frac{CNF}{1.0}\right)^2 + 1.5\left(\frac{CSF}{0.5}\right)^2$$

- LDDFF = long distance driver fatigue function
- CMA = cumulative muscle activity
- CNF = contact normal force
- CSF = contact shear force

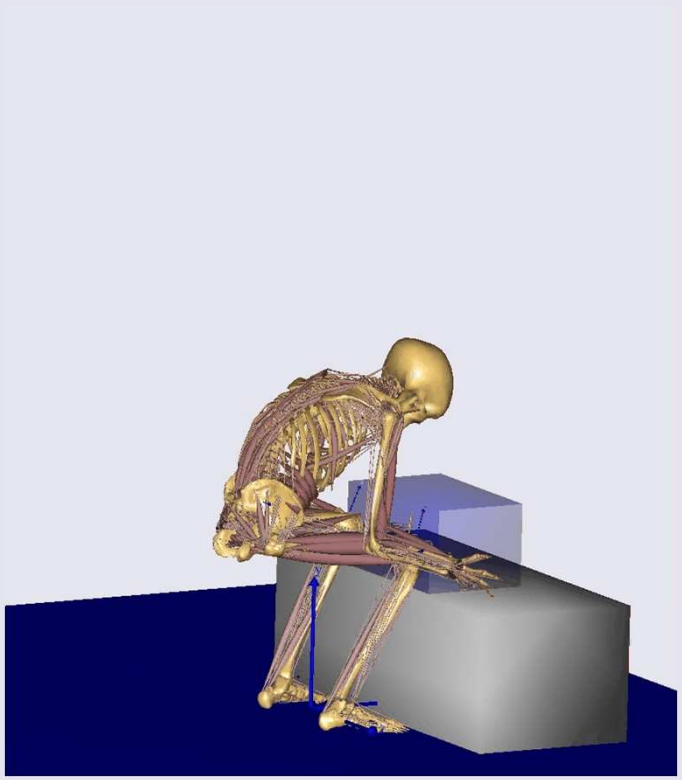
Grujicic et al., 2010

Workplace Ergonomics

- Lifting tasks…



Wagner and Reed, 2007



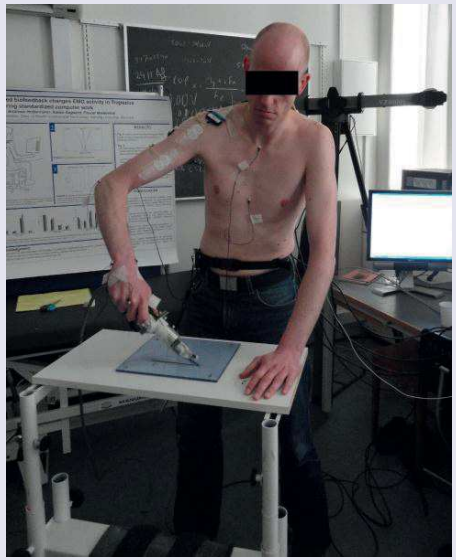
Workplace Ergonomics

- Design of pre-fabricated wall panels to mitigate risk of injury during assembly

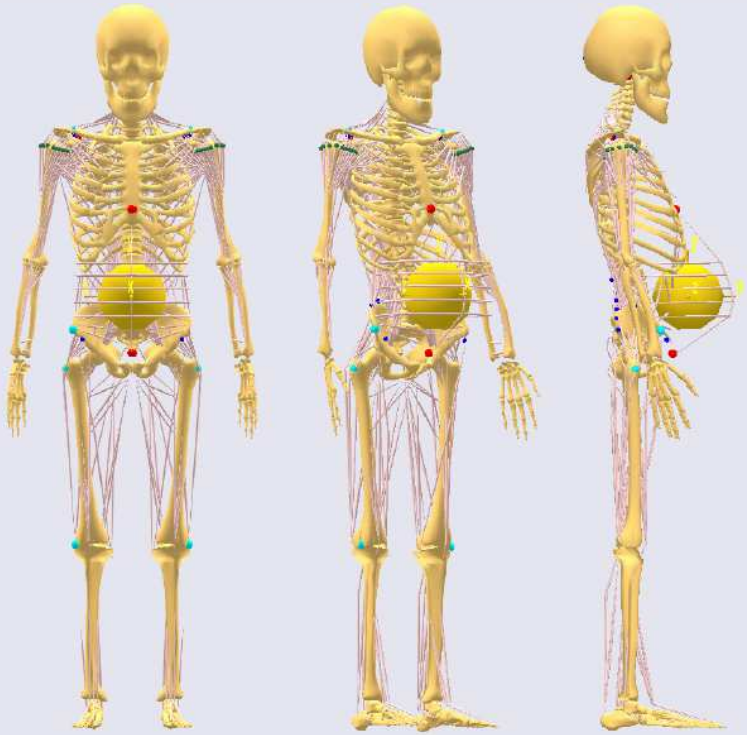
Jia et al., 2011

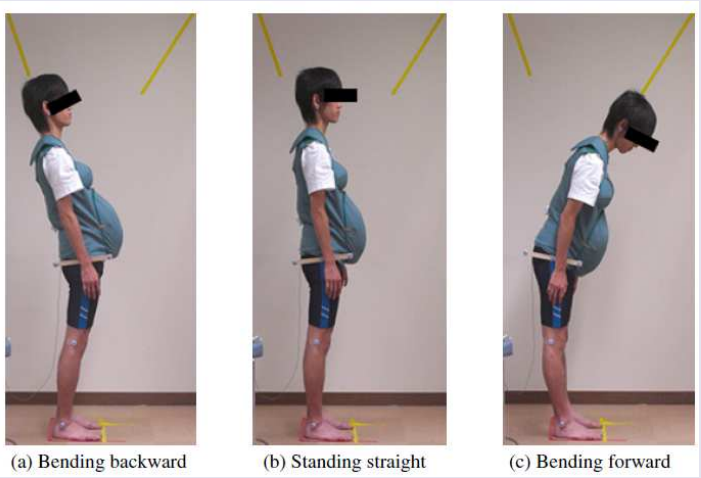
- Best practices for meat cutting to reduce fatigue and injury

Pontonnier et al., 2011

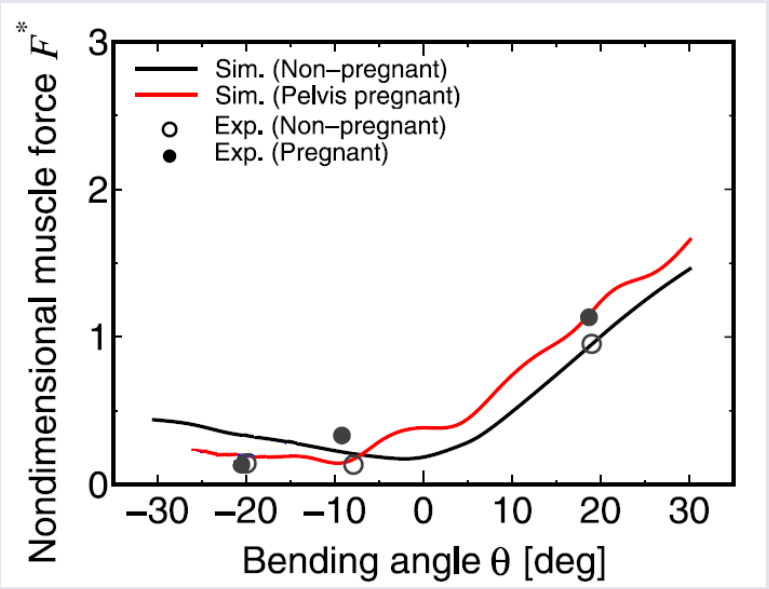


Spinal Loads in Pregnancy





Erector spinae muscle force



Nakashima and Komura, 2010

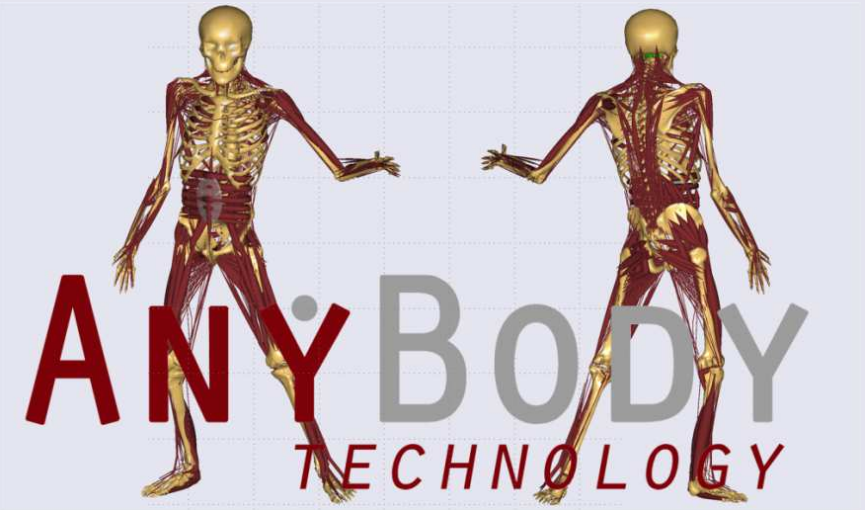
Summary

AnyBody Modeling System is used for:

- Patient Specific Models
- Device Design/Evaluation
- Surgical Planning
- Biomechanics & Device Interaction
- Automotive & Workplace Seating Applications
- Workplace Ergonomics & ADL Applications

Please find full list of publications at
www.anybodytech.com

Q & A



- www.anybodytech.com
- www.anyscript.org
- Please see our updated publication list at... http://www.anybodytech.com/index.php?id=publications

Webcast

- This is the final webcast of 2012. Wishing you the best for the new year and see you in Q1 2013! Stay tuned!

Meet AnyBuddies at:

- Pre-ORS and ORS, San Antionio, Texas, 25-29 Jan