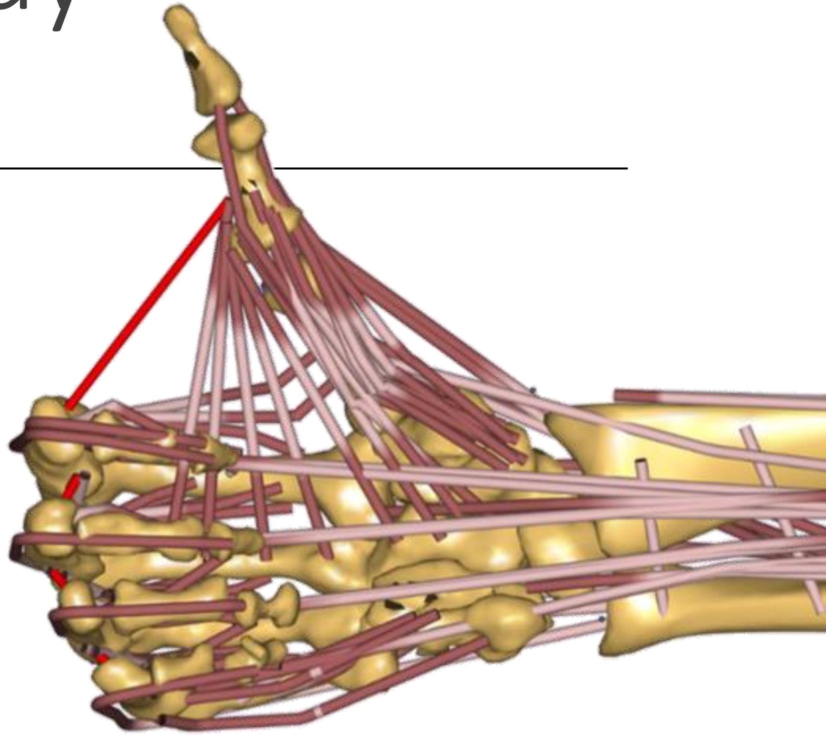
The webcast will begin shortly…

A new musculoskeletal AnyBody™ detailed hand model

December 1st , 2020



Outline

- General introduction to the AnyBody Modeling System
- Presentation by Lucas Engelhardt and Maximilian Melzner
  - *A new musculoskeletal AnyBody™ detailed hand model*
- Question and answer session

Presenters:
Lucas Engelhardt,
Scientific Computing Centre Ulm,
Germany

Maximilian Melzner
Laboratory for Biomechanics,
Ostbayerische Technische Hochschule
Regensburg, Germany

Host:
Kristoffer Iversen
R&D Engineer
AnyBody Technology

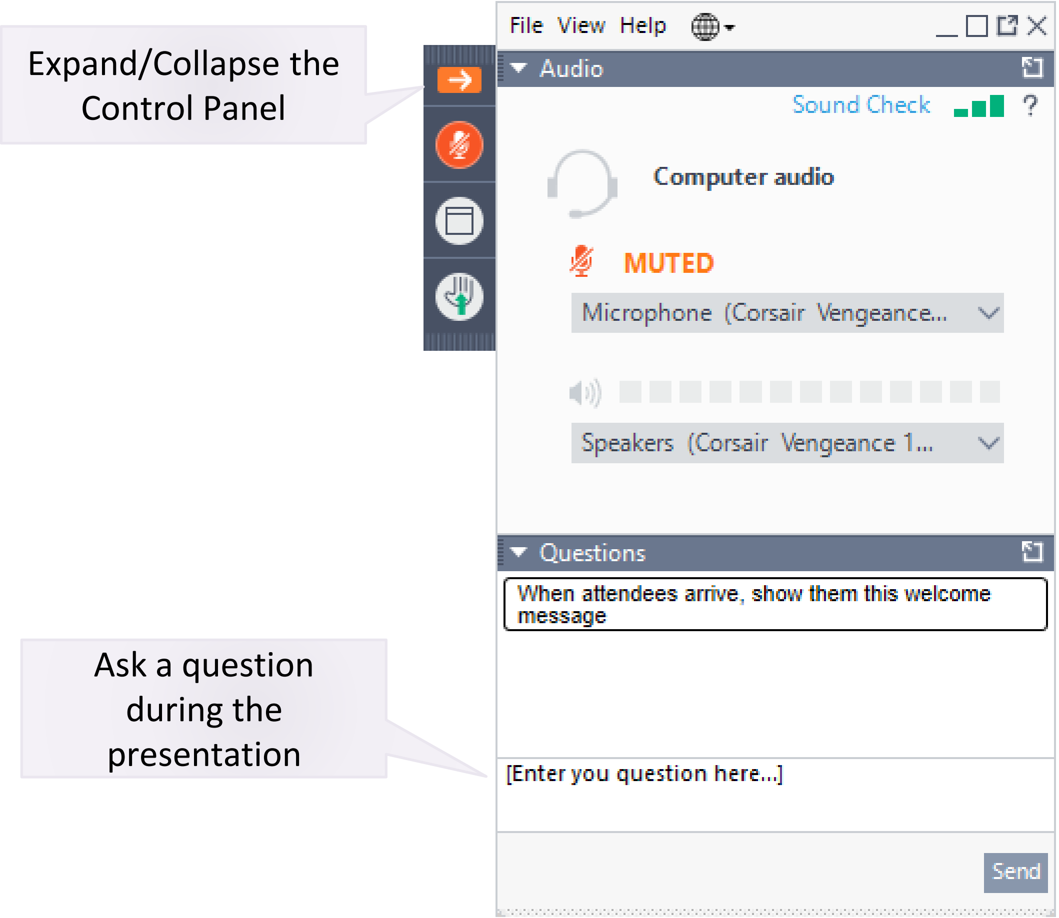
ANYBODY TECHNOLOGY

Control Panel

The Control Panel appears on the right side of your screen.

Submit questions and comments via the Questions panel.

Questions will be addressed at the end of the presentation. If your question is not addressed, we will do so by email.



Musculoskeletal Simulation

Motion Data

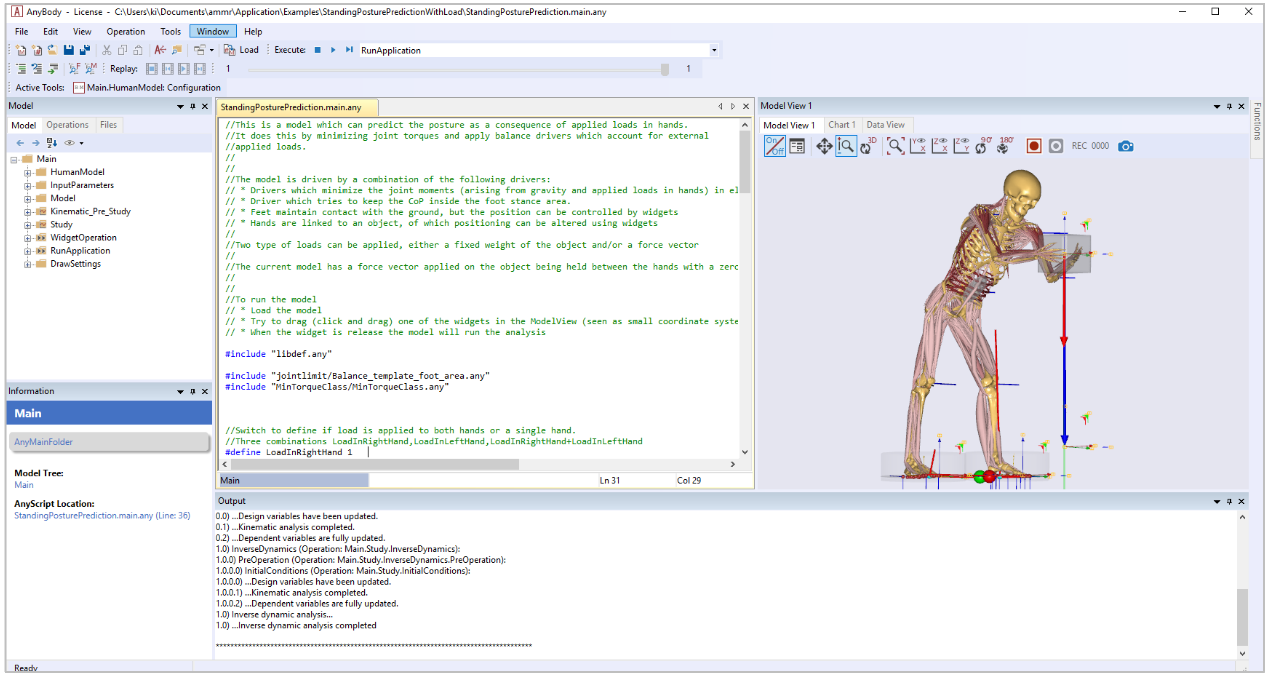
Kinematics and Forces

ANYBODY

Modeling System

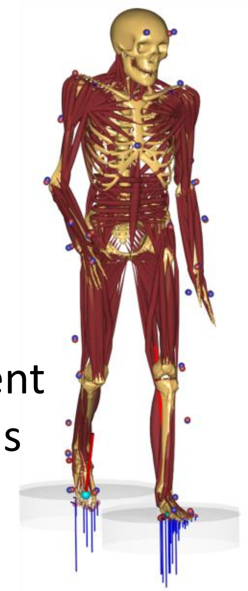
Body Loads

- Joint moments
- Muscle forces
- Joint reaction forces

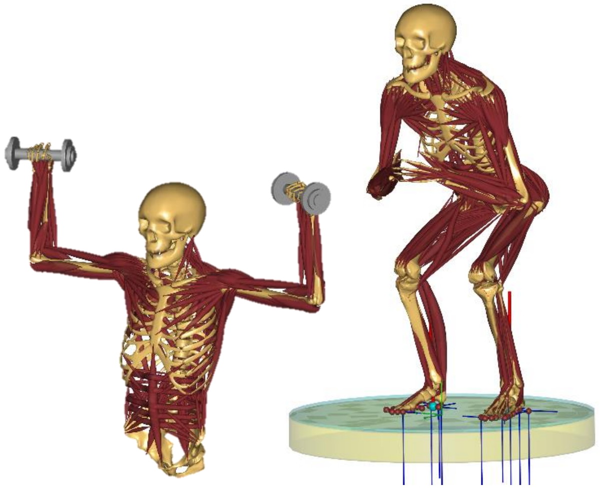


ANYBODY TECHNOLOGY

Product optimization design



Movement Analysis



Sports

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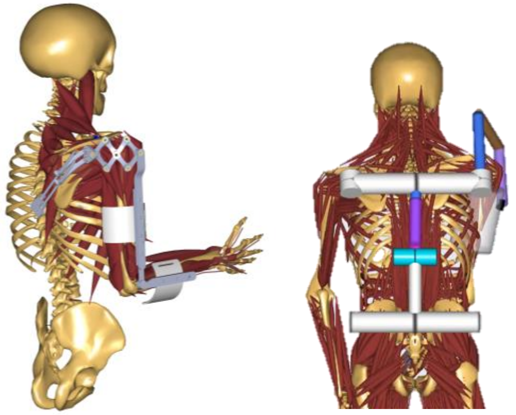
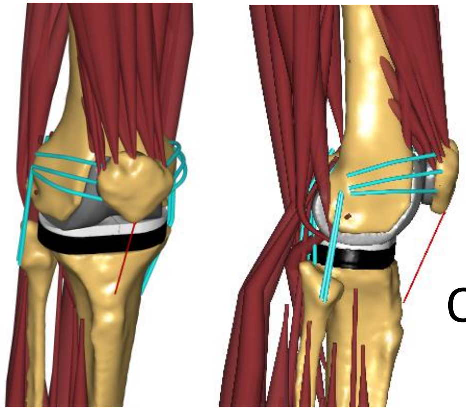
Modeling System

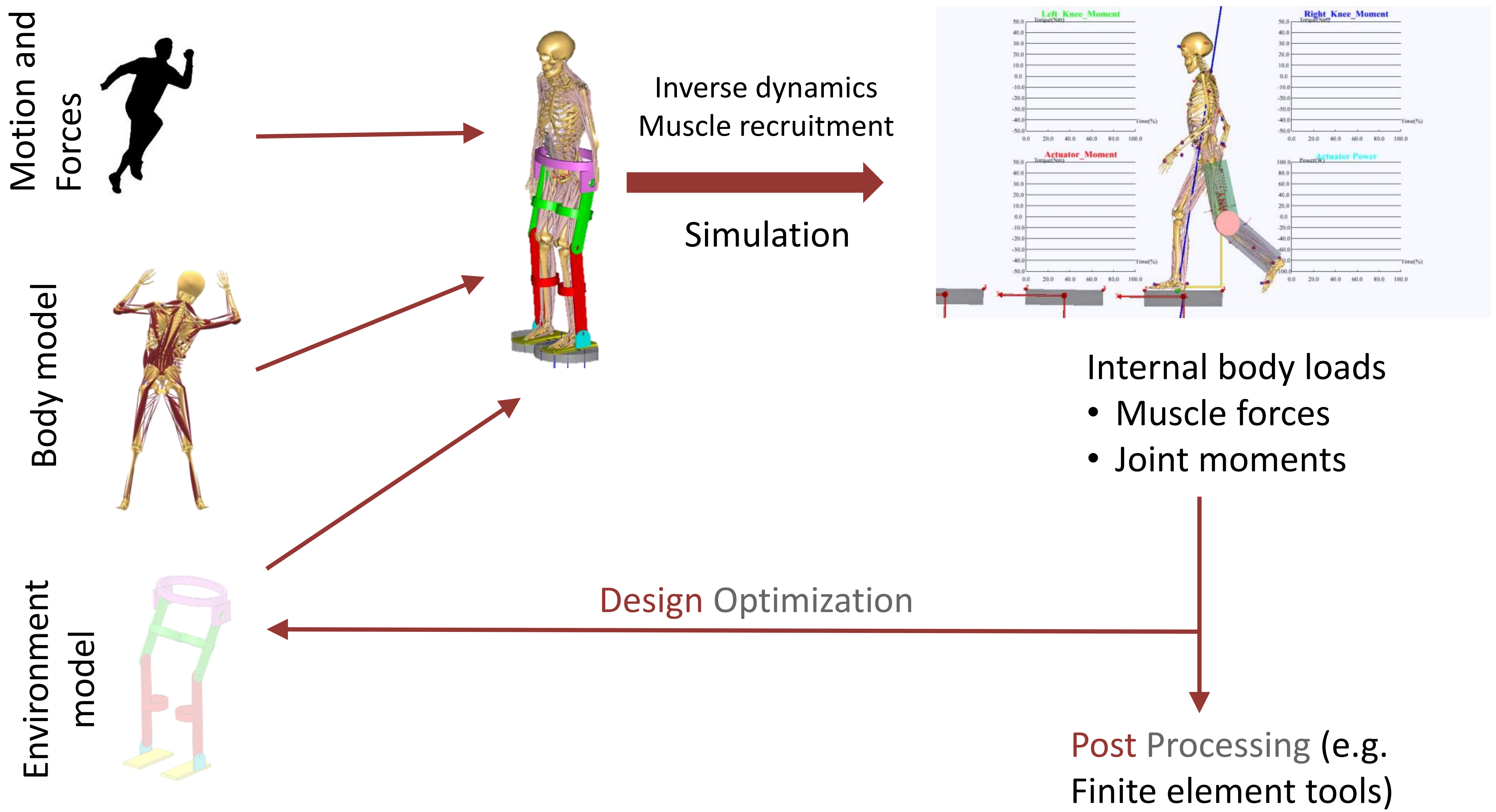


Assistive Devices



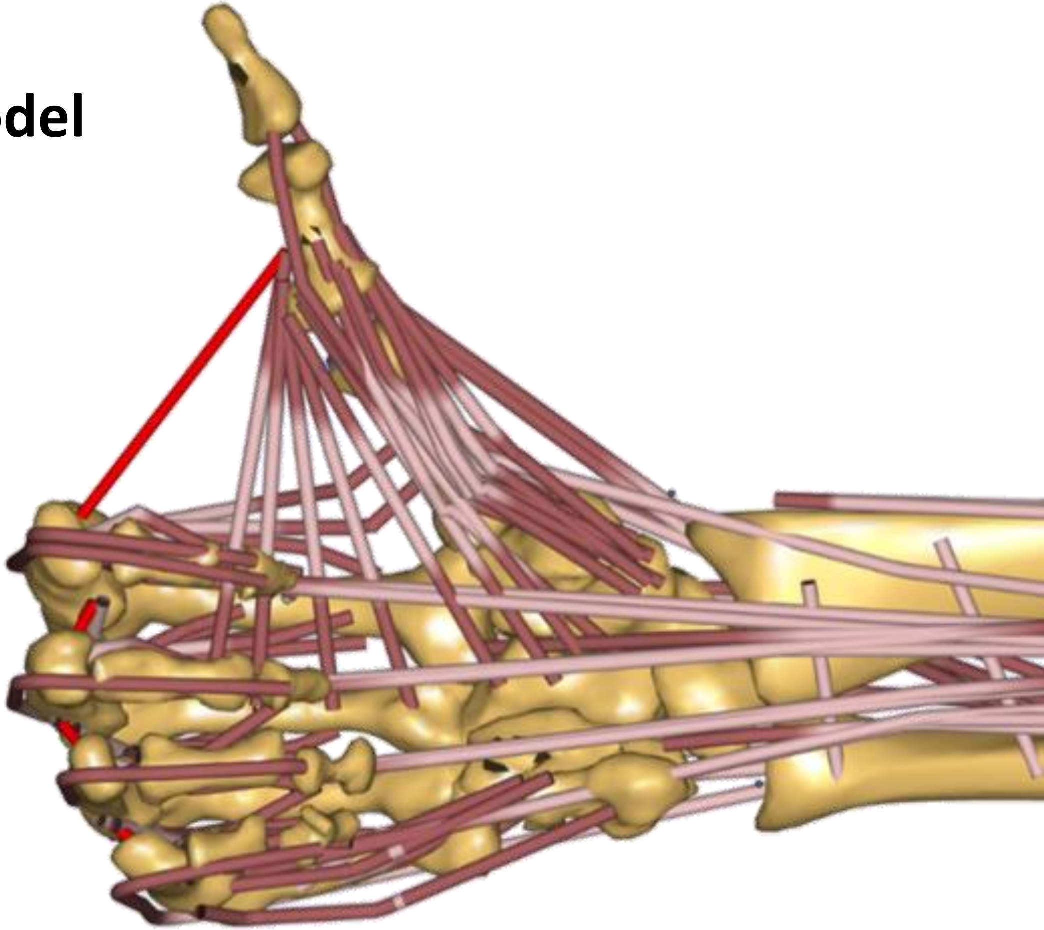
Orthopedics and rehab

AnyBody Modelling System



A new musculoskeletal AnyBody™ detailed hand model

Presented by Lucas Engelhardt and Maximilian Melzner



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ZIEL ETZ
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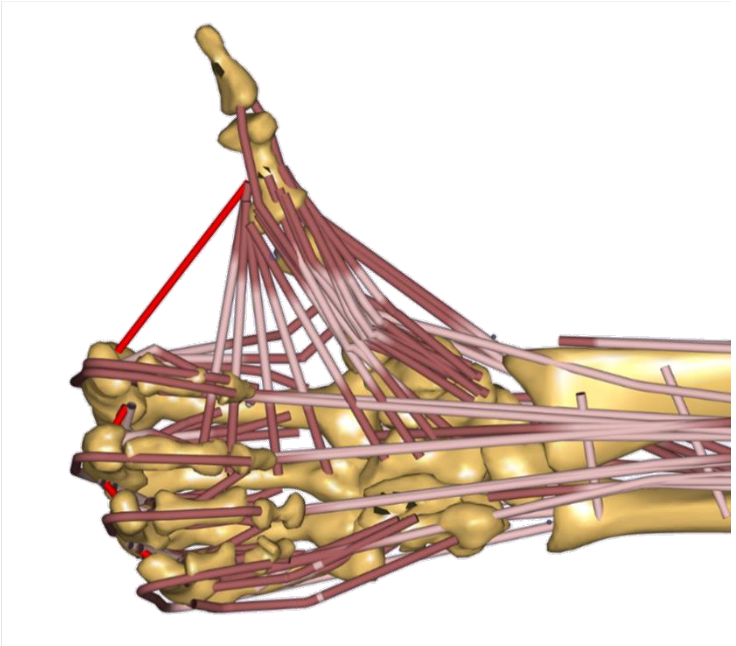
The new ANYBODY™ detailed hand model*



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DFG FWF FNSNF

***joint work of the Laboratory of Biomechanics, Regensburg and the Scientific Computing Center, Ulm**

Funding from the SNF (320030L_170205), DFG (SI 2196/2-1, IG 18/19-1) and FWF (I 3258-B27) for the DACH$_{FX}$ Project is gratefully acknowledged.
Funding from the EFRE and ETZ and BayWISS is gratefully acknowledged.

Regensburg-Ulm-Hand-Model (RUHM)

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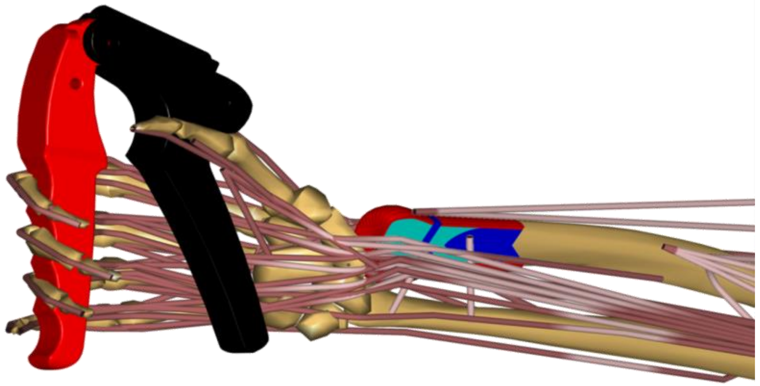
LBM LABORATORY FOR BIOMECHANICS

Planned applications

- Simulation and optimization of the manual perineal protection to decrease long-term damages for expectant mothers and obstetricians

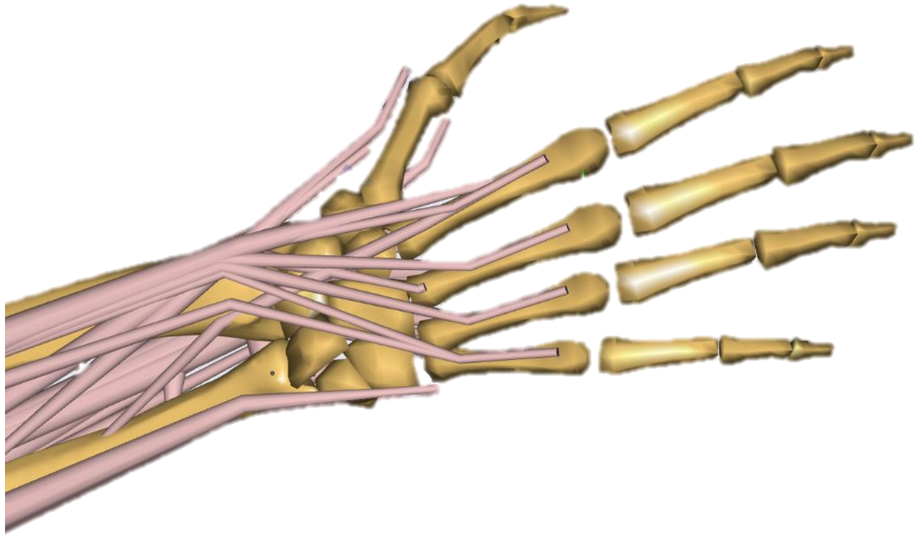


- Local remodelling and mechanoregulation of bone fracture healing in healthy, aged, and osteoporotic distal radius fractures

Need for a sufficient hand model

https://ematrona.com/2017/02/hands-on-vs-hands-offpoised-proteger-no-proteger-esa-la-cuestion/

Current ANYBODY™ hand model

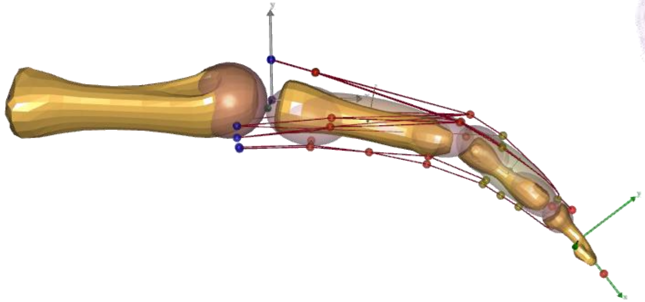


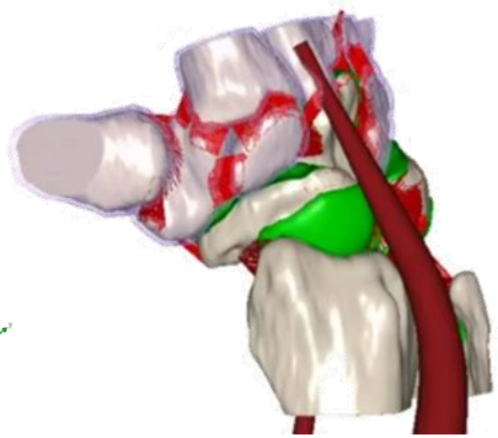
Drawbacks:

- No intrinsic muscles
- Extrinsic muscles end at the metacarpal bones
- Missing abduction/adduction of fingers
- Wrist as one rigid body

AnyBody models

- Modeling of single fingers and parts (Wu et al. 2008, Eschweiler et al. 2014)

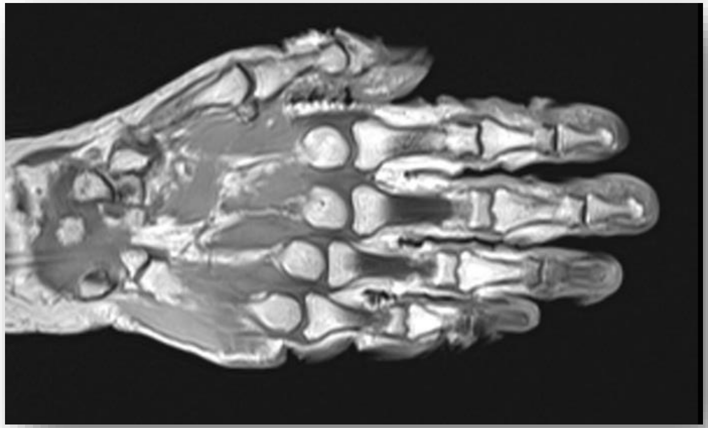




Anatomical data

- Determination of the anatomical data based on studies of 16 cadaveric forearms
  (P. Fiala, M. Rybarova - Charles University, Pilsen)
  - Muscle and tendon alignment
  - Muscle properties
  - Bone structure and surface

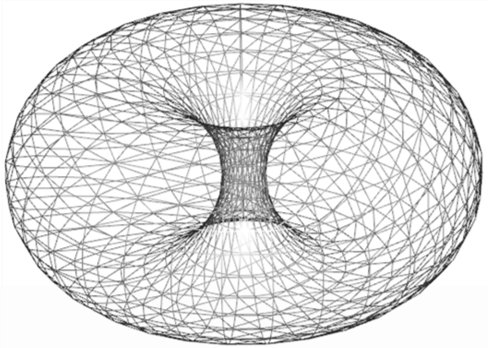
- MRI scans

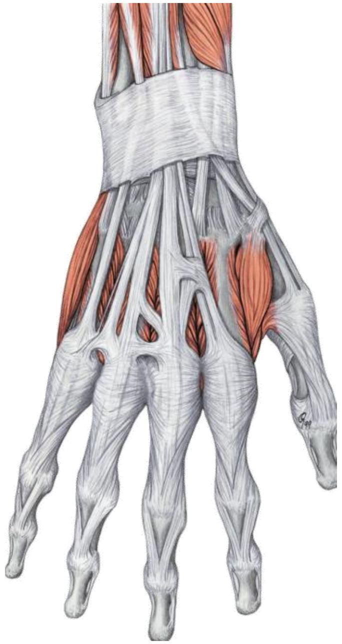


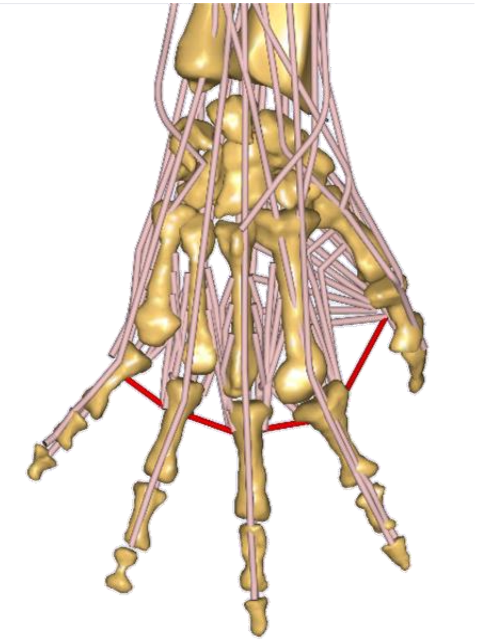
Havelkova L, Zitka T, Fiala P, Rybarova M, Tupy R, Kalis V, Ismail KM. 2020. Data for: Hand muscles attachments: A Geometrical model. 10.5281/zenodo.3954024: en. https://zenodo.org/record/3953592.

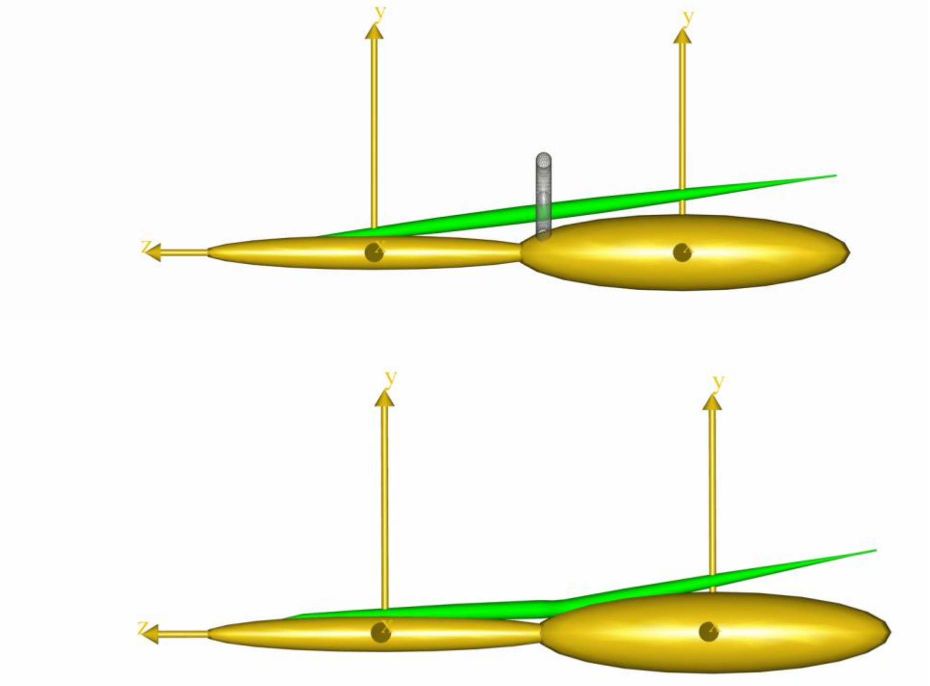
Muscle pathing and skin resistance

- Implementation of geometrical wrapping surfaces (tori) as annular ligaments in the finger joints and the wrist







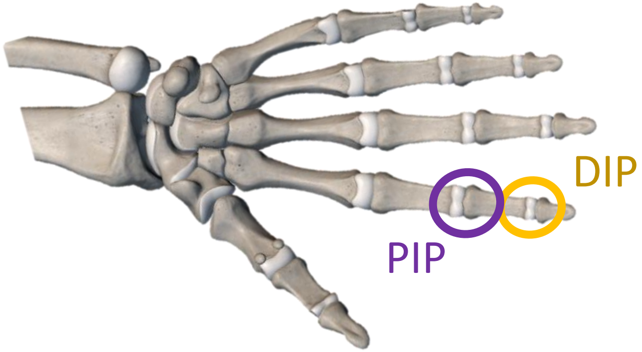


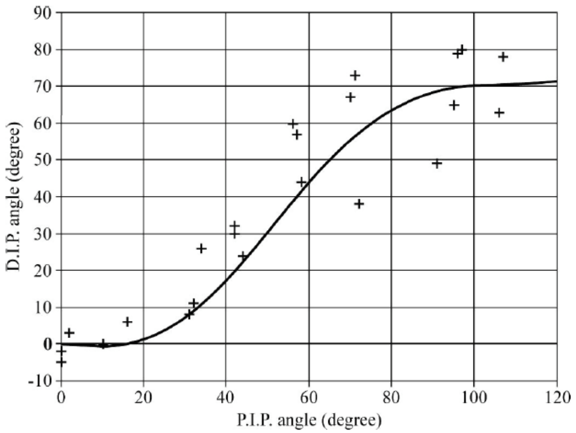
- Skin resistance during abduction modeled by ligaments

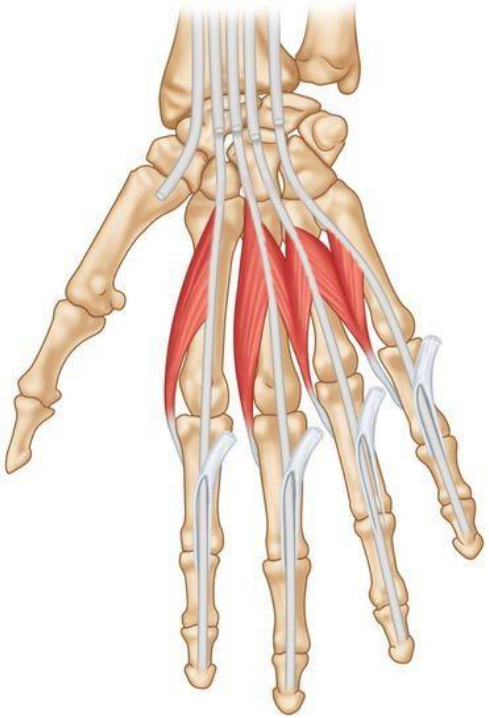
Tillmann, Bernhard. *Atlas der Anatomie des Menschen: mit Muskeltrainer*. Springer-Verlag, 2006.
Havelková, L.: Biomechanical musculoskeletal model. Dissertation, University of West Bohemia, Plzeň. (2016)

DIP-PIP relationship and Lumbricale origin

- Implement the strong relationship of distal interphalangeal and proximal interphalangeal joint







- Lumbricale muscles originate from the flexor digitorum profundus – not from a bone as usual

➡ Implement a way so the origin point of a muscle lies on another muscle

Right: van Zwieten, Koos Jaap, et al. "An analytical expression for the DIP–PIP flexion interdependence in human fingers." (2015).
Bernhard Hirt, Harun Seyhan, Michael Wagner, Rainer Zumhasch. *Hand and Wrist Anatomy and Biomechanics.* Georg Thieme Verlag, 2017
Left: Gnecchi, Sébastien, and François Moutet. *Hand and Finger Injuries in Rock Climbers*. Springer, 2015.

Patient specific scaling

- Patient specific geometry:

  Define segment lengths by characteristic lengths:

  - Hand length
  - Hand breadth

  ➢ Correlation between hand length/ breadth and each segment length

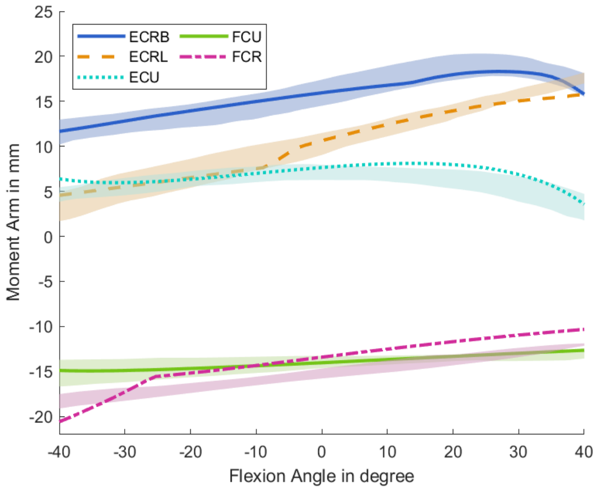
Fingers	DP	MP	PP	MCP
Thumb	11.53	-	15.71	23.34
Index	8.88	11.65	19.99	34.54
Middle	9.33	14.21	22.13	33.03
Ring	9.64	13.51	20.71	28.85
Small	8.65	9.51	16.43	26.84

Relative segment length to handlength

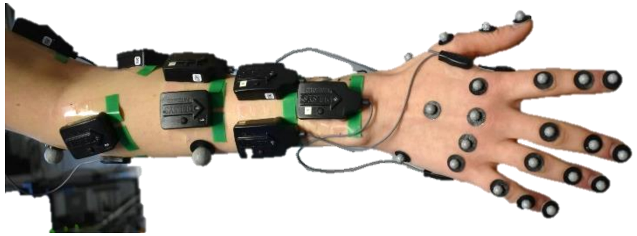
- Patient specific muscles:
  - Uniform or non-uniform scaling
  - Mass-fat scaling

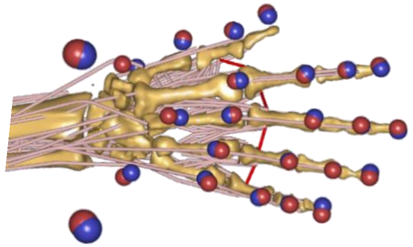
Validation process

1. Theoretical validation
   - Comparison with moment arms from literature



2. Experimental validation
   - Comparison of measured and numerical gained muscle activities





Moment Arm Studies

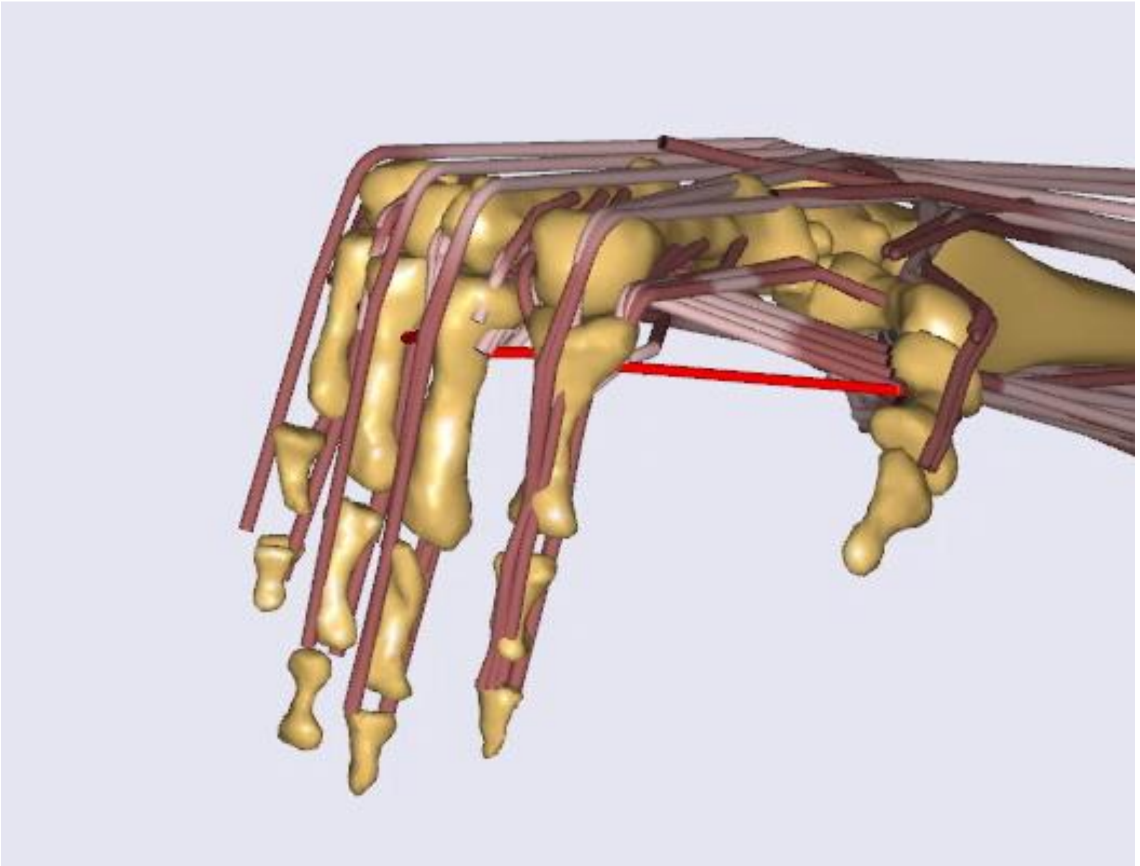
- Moment arm study means:
  - By Landsmeer (1961):

$$\frac{dx}{d\phi} = M$$

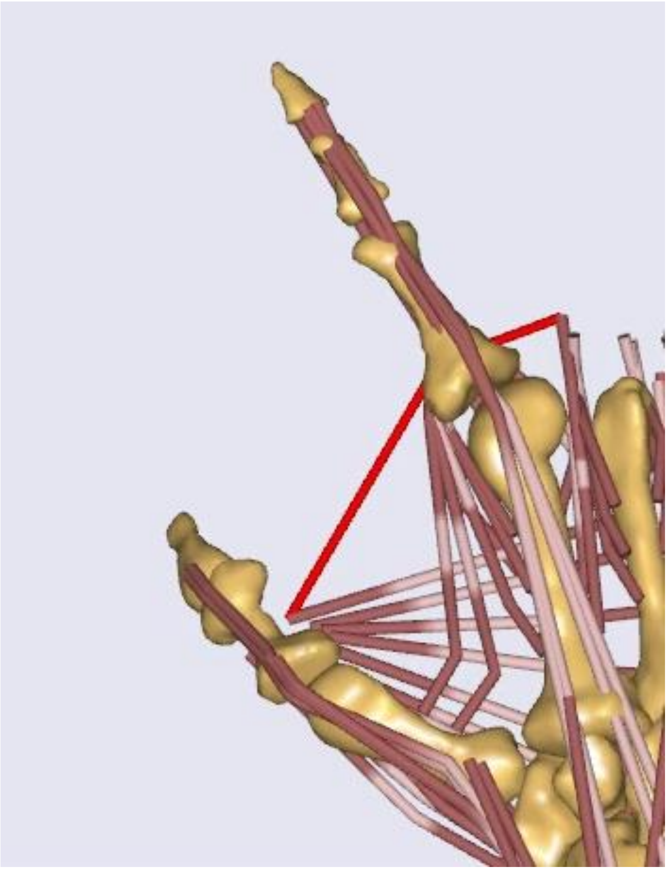
  - The moment arm of each muscle in a joint, according to its movement

- An et al. (1983)
  - Cadaver study on the index MCP joint
  - Flexion and Ad/Abduction
- Smutz et al. (1998)
  - Cadaver study on the thumb
  - CMC, MCP, DIP joint
- Franko et al. (2011)
  - Cadaver study on all extrinsic muscles of all digits

Index Finger MCP Joint



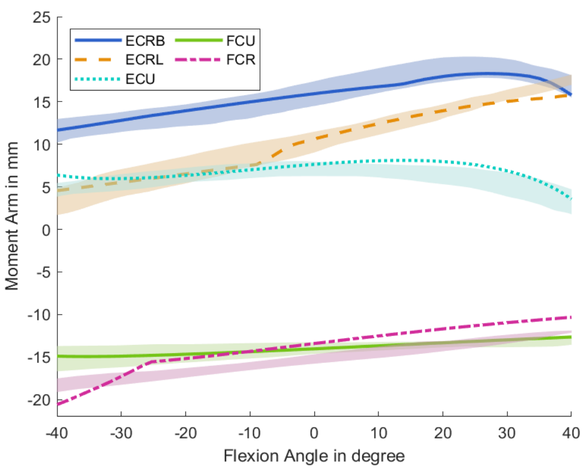
MCP Flexion



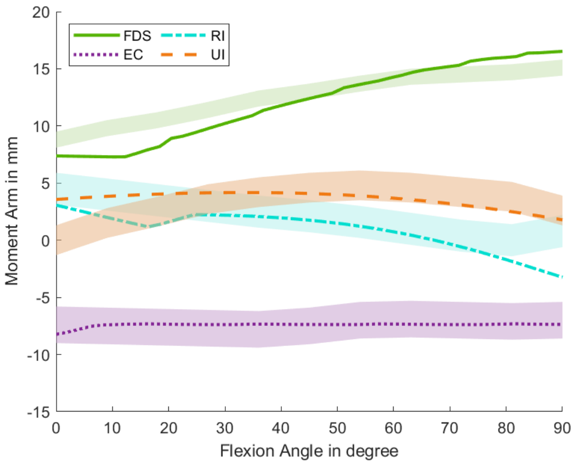
MCP Ad/Abduction

Moment Arm Studies - Results

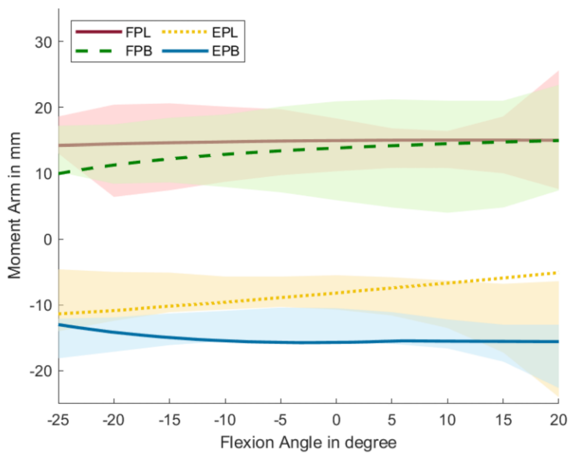
Wrist



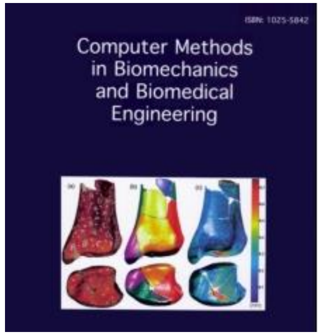
Index finger - MCP



Thumb - CMC

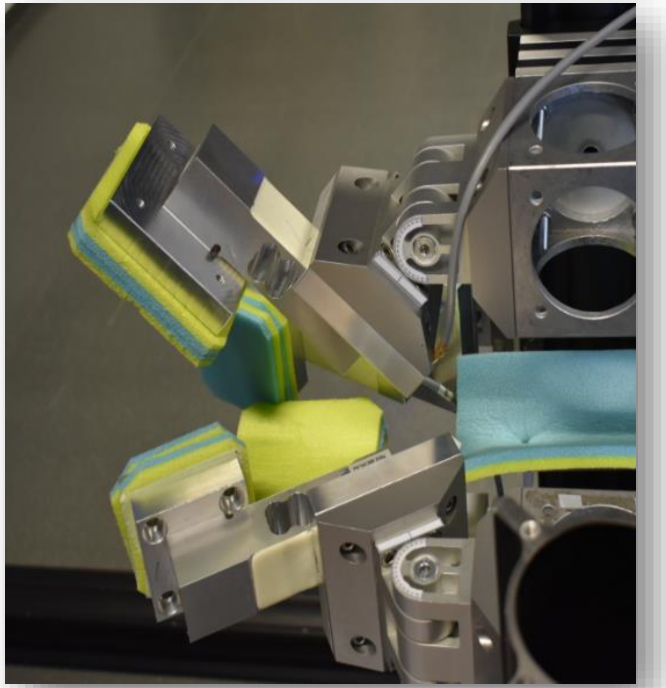


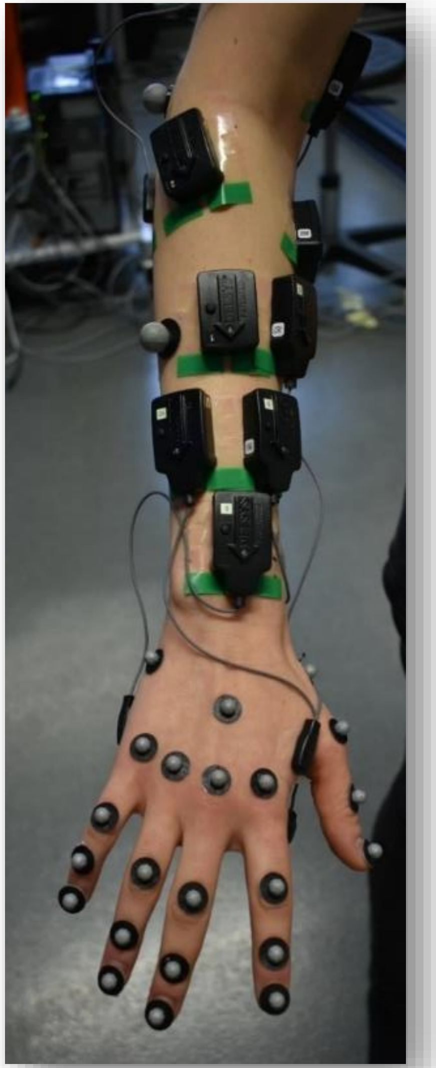
A new musculoskeletal AnyBody™ detailed hand model in the **Journal of Computer Methods in Biomechanics and Biomedical Engineering** (DOI 10.1080/10255842.2020.1851367)



Experimental setup

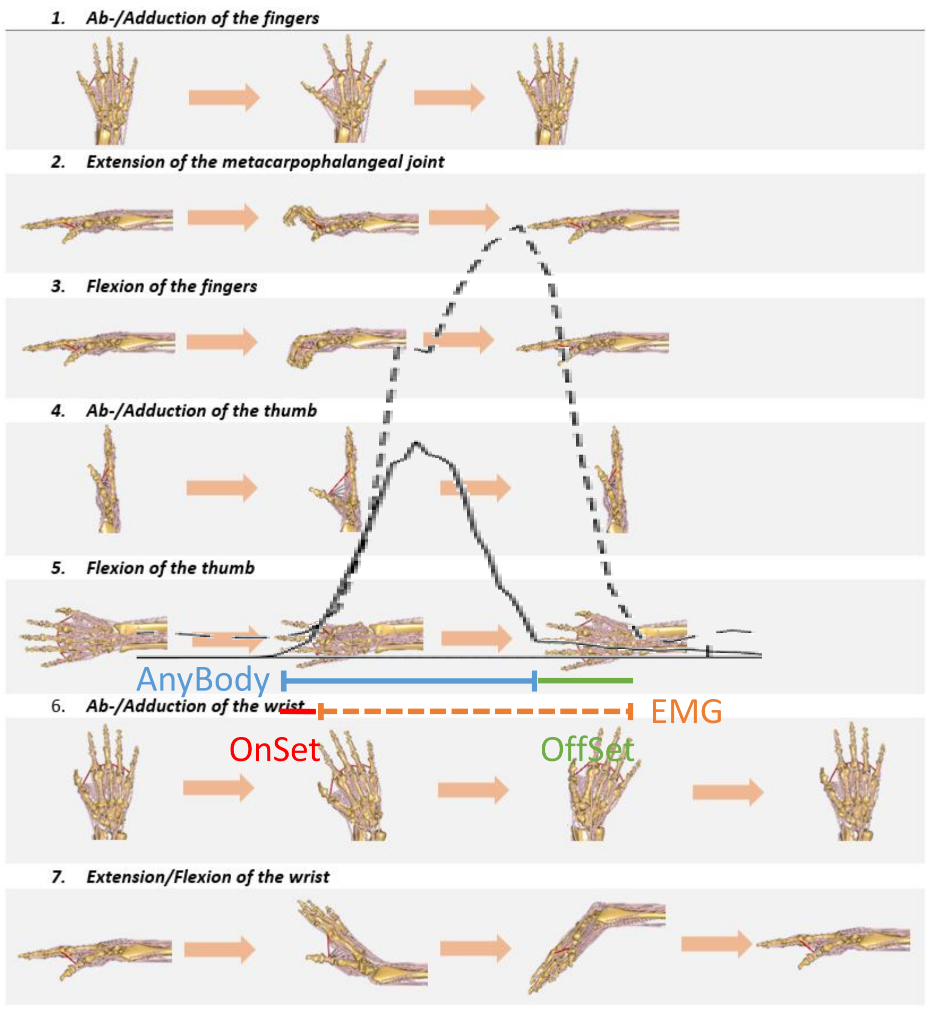
- 5 subjects
- New created marker set for the forearm, wrist and hand (including 22 markers on the hand)
- Electromyography measurements of the activity of 10 intrinsic and extrinsic hand muscles
- Maximum voluntary contraction (MVC) measurements





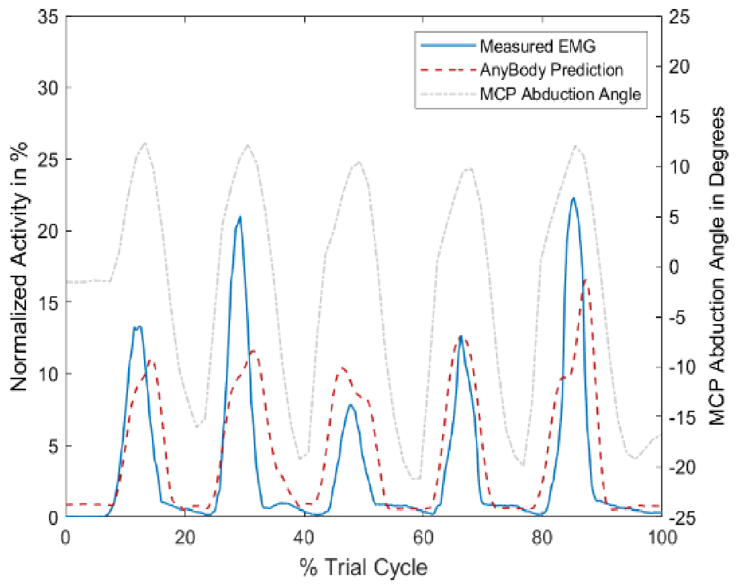
Experimental setup

- Recording of muscle specific activation movements
- Numerical simulation of muscle activities and calculation of the on- and offset time points



Experiment - Results

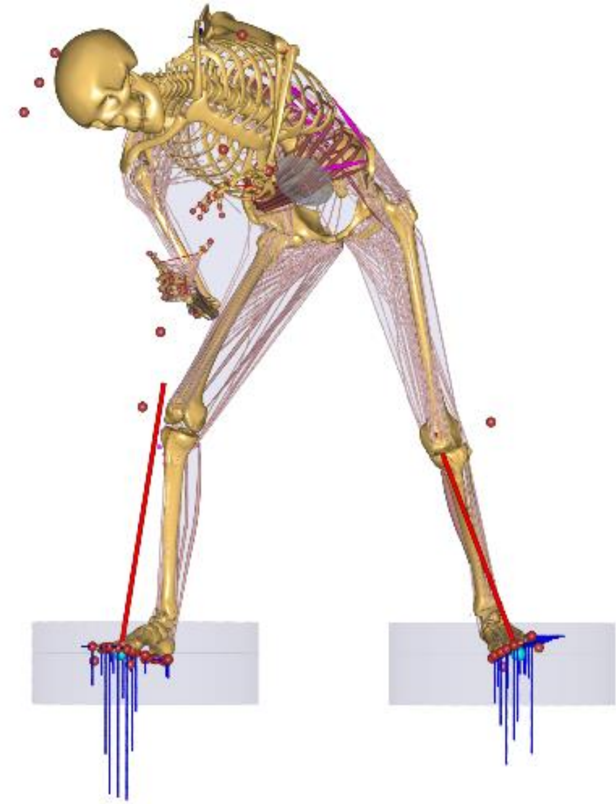
- mean on- and off-set time difference of 0.58 s between the experimental data and the model
- Crosstalk as main drawback during the measurement

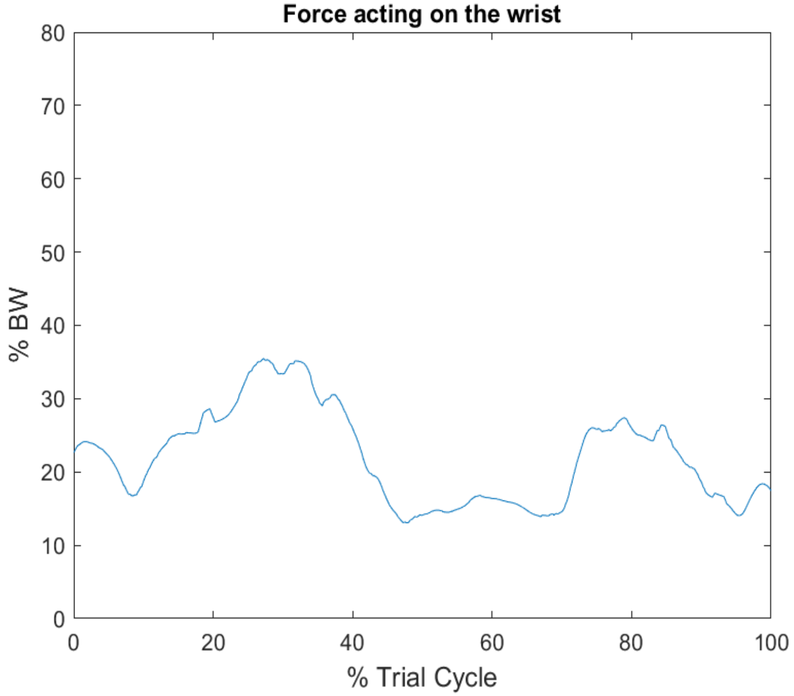


Paper submitted to (*"Electromyography based validation of a musculoskeletal hand model"*) to the **Journal of Biomechanical Engineering**

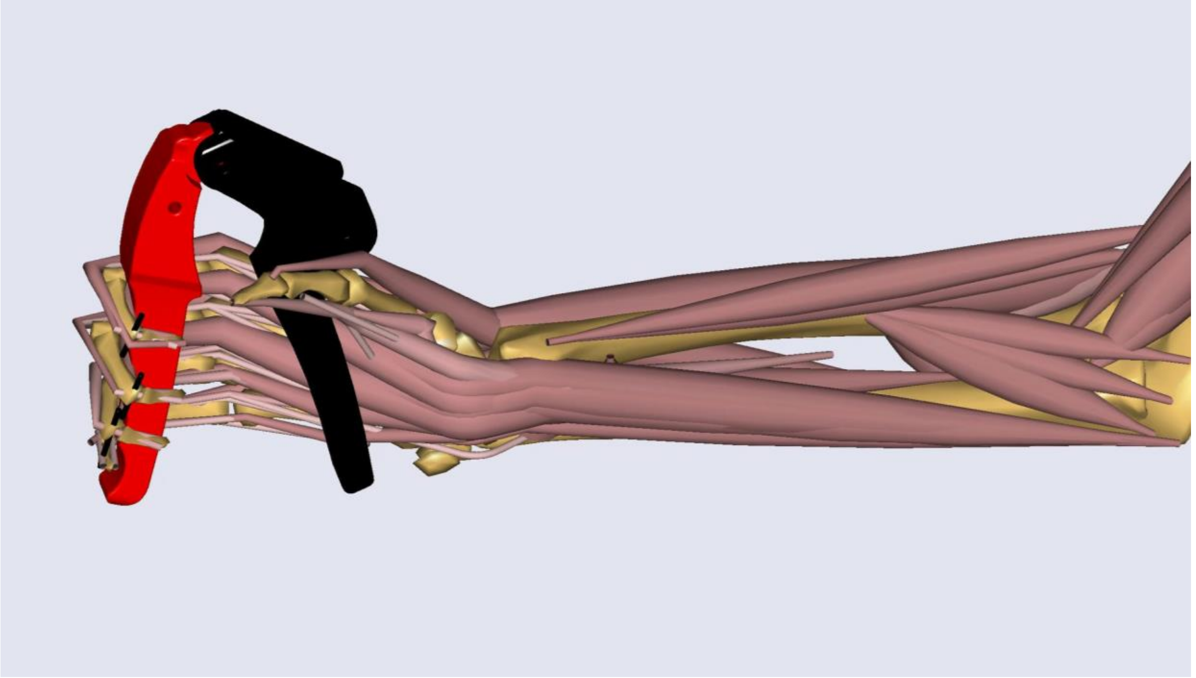
Application – manual perineal protection

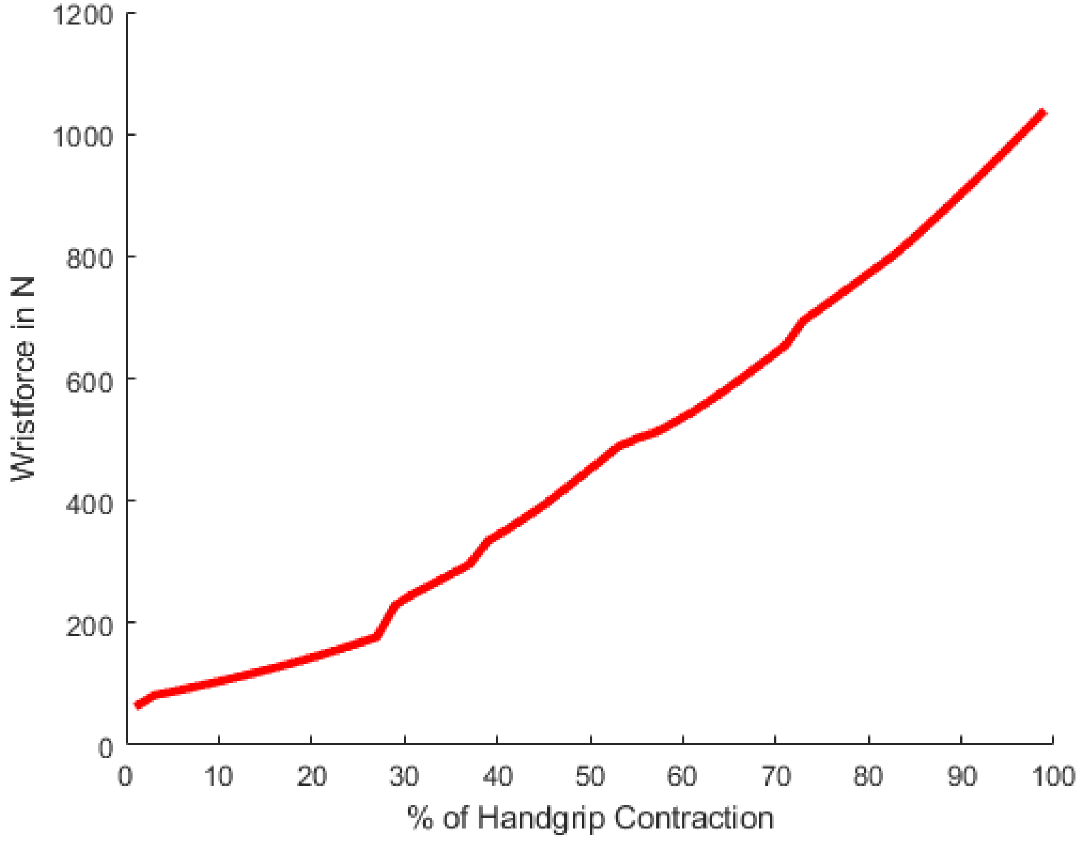
- measurement of real deliveries





Application – gripping tool





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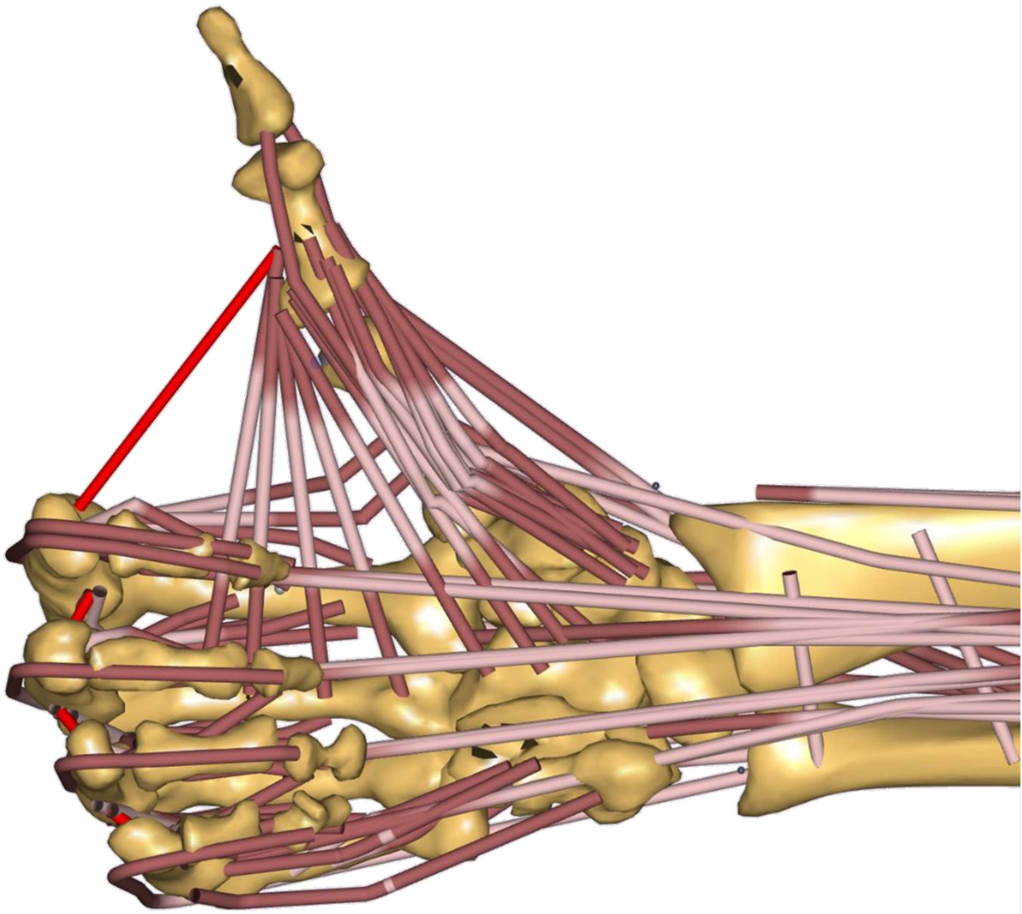

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Upcoming Webcasts

- December 10th - The effects of hospital bed features on physical stresses on caregivers when repositioning patients in bed
- January 12th - Biomechanical investigation of a passive upper extremity exoskeleton for manual material handling – A computational parameter study

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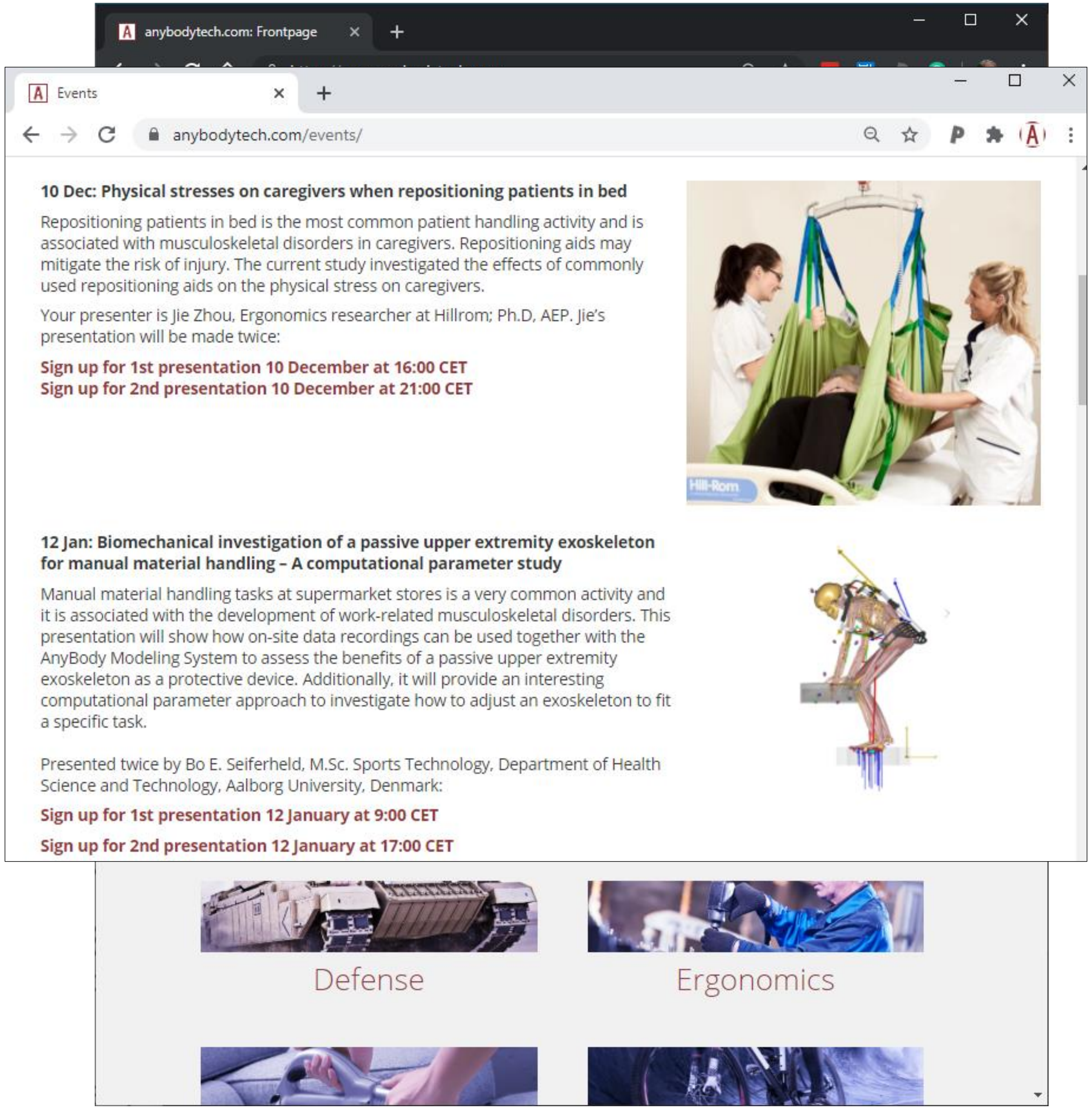

Time for questions: