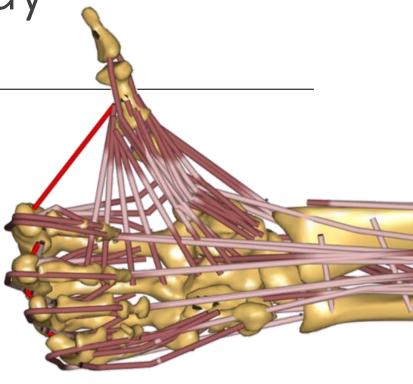


The webcast will begin shortly...

# A new musculoskeletal AnyBody<sup>TM</sup> detailed hand model

December 1<sup>st</sup> , 2020





# Outline

- General introduction to the AnyBody Modeling System
- Presentation by Lucas Engelhardt and Maximilian Melzner
  - A new musculoskeletal AnyBody<sup>™</sup> 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

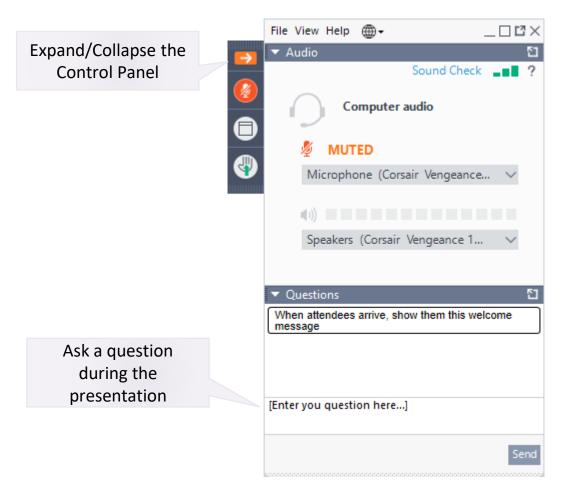


# Control Panel

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





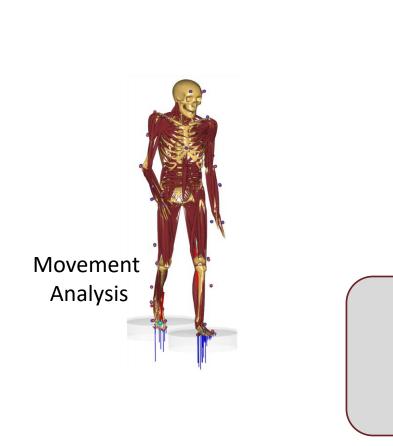


#### **Body Loads**

- Joint moments
- Muscle forces
- Joint reaction forces

AnyBody - License - C:\Users\ki\Documents\	amm/Application/Examples/StandingPosturePredictionWithLoad/StandingPosturePrediction.main.any	- 🗆 ×
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Active Tools: Main.HumanModel: Configurat	on	
1odel → # ×	StandingPosturePrediction.main.any	★ # ×
Model Operations Files	//This is a model which can predict the posture as a consequence of applied loads in hands.	
$\leftarrow \rightarrow \frac{\alpha}{2} \downarrow \odot \bullet$	//T does this by mininizing joint torques and apply balance drivers which account for external //Applied loads.	
G-■ Min → ■ HumanNodel → ■ HumanNodel → ■ NeumanNodel → ■ Model → ■ Model → ■ Model → ■ Model → ■ Model → ■ Standy → ■ Standy → ■ Standy → ■ DrawSettings	<pre>//// //The model is driven by a combination of the following drivers: //* horivers which miniatize the joint moments (arising from gravity and applied loads in hands) in el * Oriver which miniatize the joint moments (arising from gravity and applied loads in hands) in el * Oriver which miniatize the joint moments (arising from gravity and applied loads in hands) in el * Oriver which miniatize the joint moments (arising from gravity and applied loads in hands) in el * Oriver which miniatize the joint moments (arising from gravity and applied loads in hands) in el * Oriver which miniatize the joint moments are altered using widgets //* Hands are linked to an object, of which position can be controlled by widgets //* the current model has a force vector splied on the object and/or a force vector //* To run the model will run the analysis #include "linder.any" #include #incl</pre>	
nformation	sinclude "Jointlinit/Blance_teeplate_foot_area.aw" sinclude "MinTorqueClass/MinTorqueClass.aw"	
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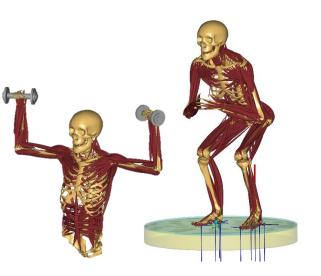
#### December 1<sup>st</sup>, 2020





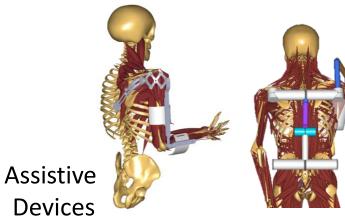
Product optimization design

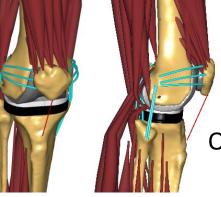
**ANYBODY** Modeling System



ANY BODY

Sports

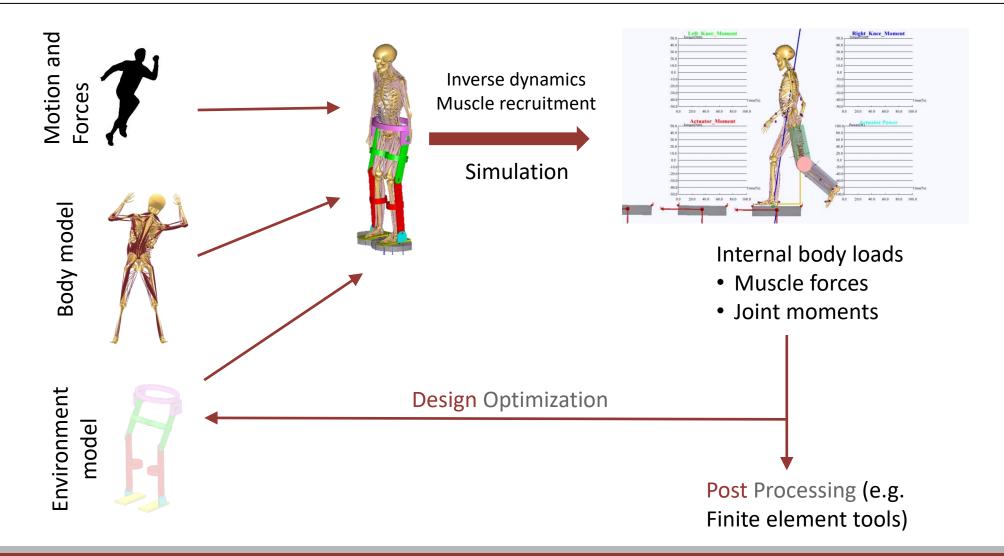




Orthopedics and rehab



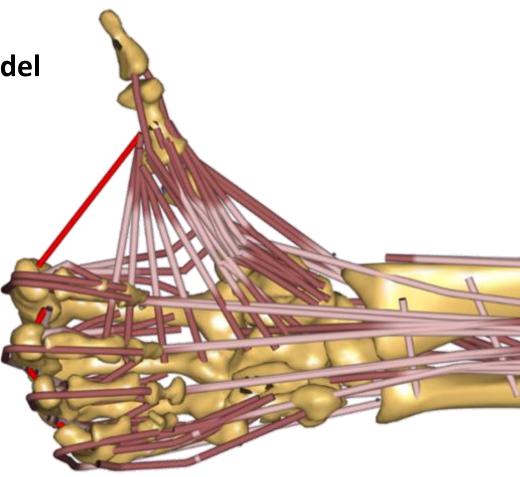
# AnyBody Modelling System





#### A new musculoskeletal AnyBody<sup>™</sup> detailed hand model

Presented by Lucas Engelhardt and Maximilian Melzner









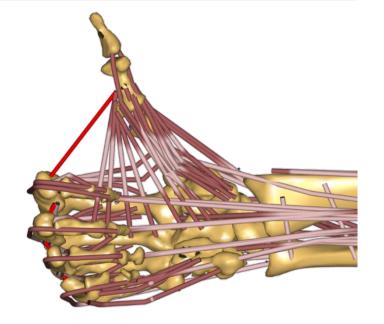
#### Europäische Union Evropská unie

Europäischer Fonds für regionale Entwicklung Evropský fond pro regionální rozvoj





The new ANŶBODY™ detailed hand model\*



# EHzürich

# **VINSEL**SPITAL

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**DFG** 



\*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<sub>FX</sub> Project is gratefully acknowledged. Funding from the EFRE and ETZ and BayWISS is gratefully acknowledged. IFNSNE





#### Regensburg-Ulm-Hand-Model (RUHM)







OSTBAYERISCHE TECHNISCHE HOCHSCHULE REGENSBURG



LABORATORY FOR BIOMECHANICS



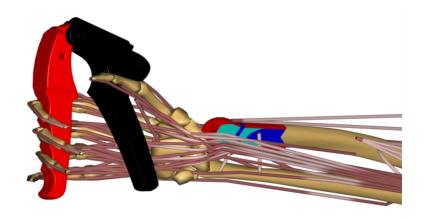




## Planned applications

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





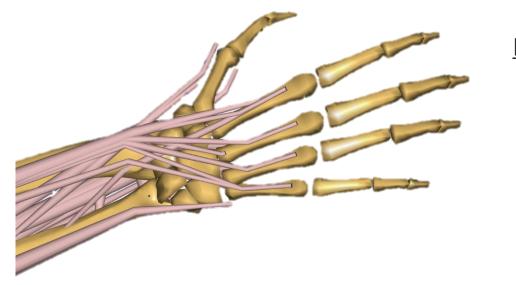
 Local remodelling and mechanoregulation of bone fracture healing in healthy, aged, and osteoporotic distal radius fractures





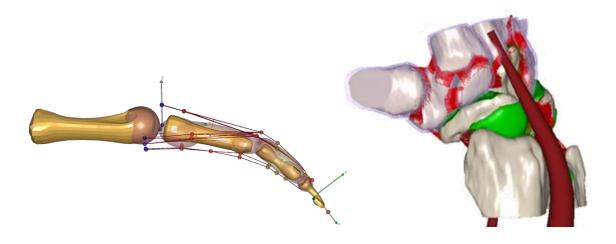


## Current **ANYBODY** hand model



#### 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





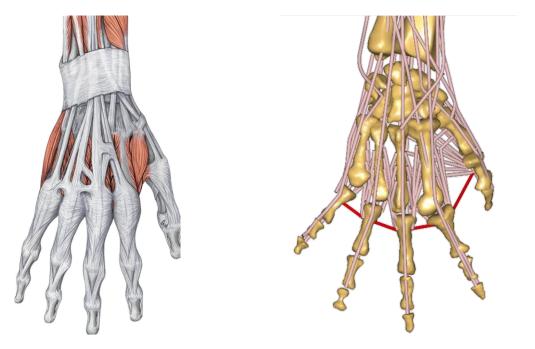
Havelkova L, Zitka T, Fiala P, Rybarova M, Tupy R, Kalis V, Ismail KM. 2020. Data for: Hand muscles attachments: A Geometrical model. 10.5281/zenodo.3954024: en. https://zenodo.org/record/3953592.

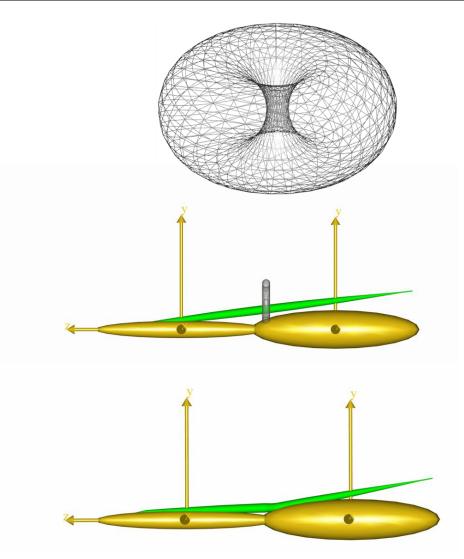




## Muscle pathing and skin resistance

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





• Skin resistance during abduction modeled by ligaments

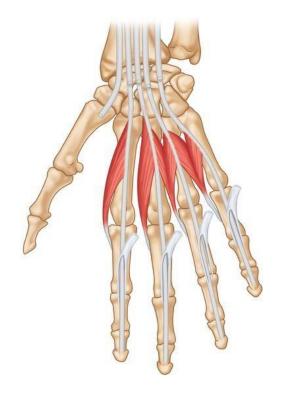
Tillmann, Bernhard. *Atlas der Anatomie des Menschen: mit Muskeltrainer*. Springer-Verlag, 2006. Havelková, L.: Biomechanical musculoskeletal model. Dissertation, University of West Bohemia, Plzeň. (2016)

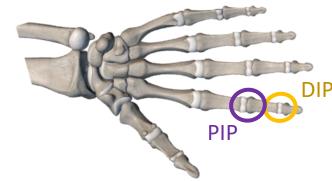


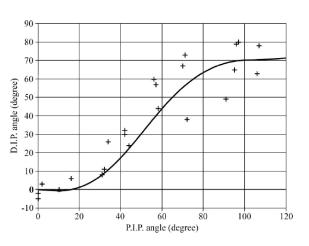


## **DIP-PIP relationship and Lumbricale origin**

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

Fingers	DP	MP	РР	МСР
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

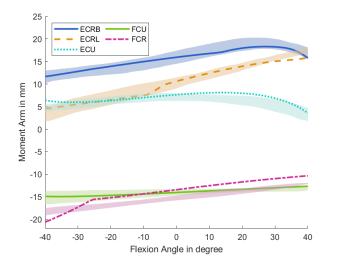






## Validation process

- 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):

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

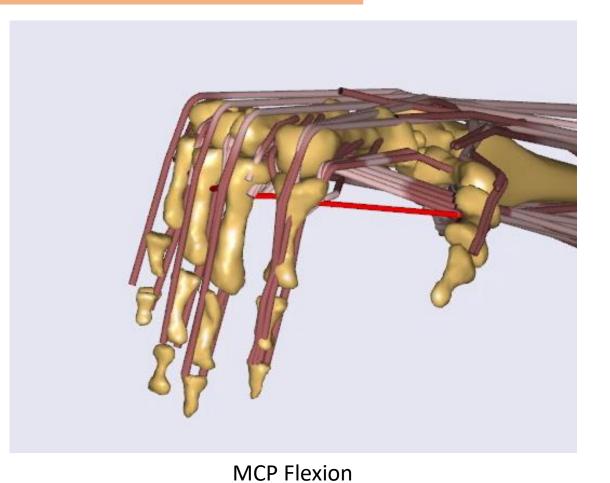
 The moment arm of each muscle in a joint, according to its movement

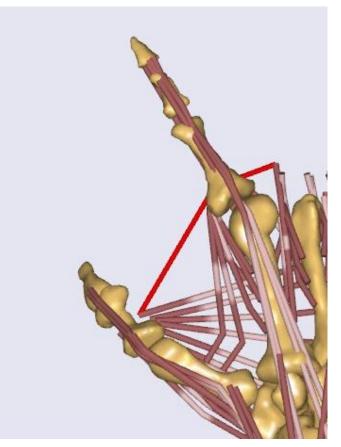
- An et al. (1983)
  - Cadaver study on the index MCP joint
  - Flexion and Ad/Abduction
- Smutz et al. (1998)
  - Cadaver study on the thumb
  - CMC, MCP, DIP joint
- Franko et al. (2011)
  - Cadaver study on all extrinsic muscles of all digits





#### Index Finger MCP Joint





MCP Ad/Abduction



ECRB FCU

ECRL ---- FCR

-10

0

Flexion Angle in degree

10

20

ECU

25

20

15

10

-5

-10 -15

-20

-40

-30

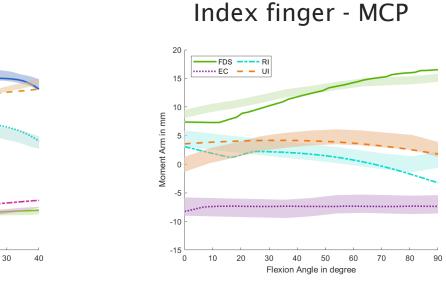
-20

Moment Arm in mm

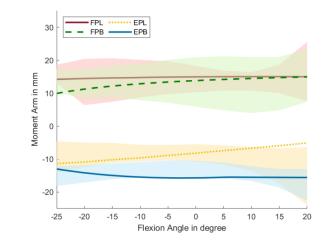


#### **Moment Arm Studies - Results**

Wrist



Thumb - CMC



Computer Methods in Biomechanics and Biomedical Engineering



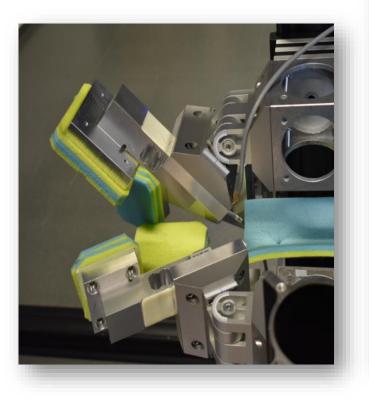
A new musculoskeletal AnyBody<sup>™</sup> detailed hand model in the Journal of Computer Methods in Biomechanics and Biomedical Engineering (DOI 10.1080/10255842.2020.1851367)

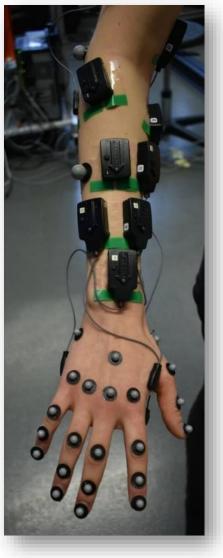




## **Experimental setup**

- 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



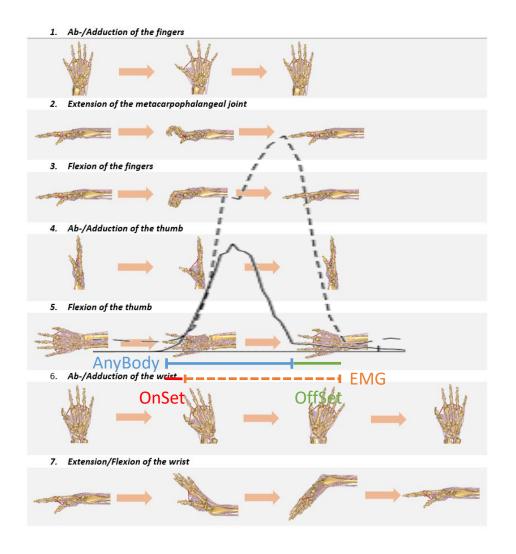






## **Experimental setup**

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

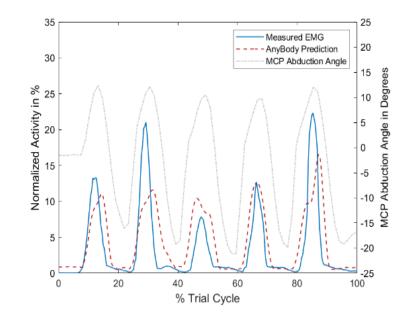






## **Experiment - Results**

- 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

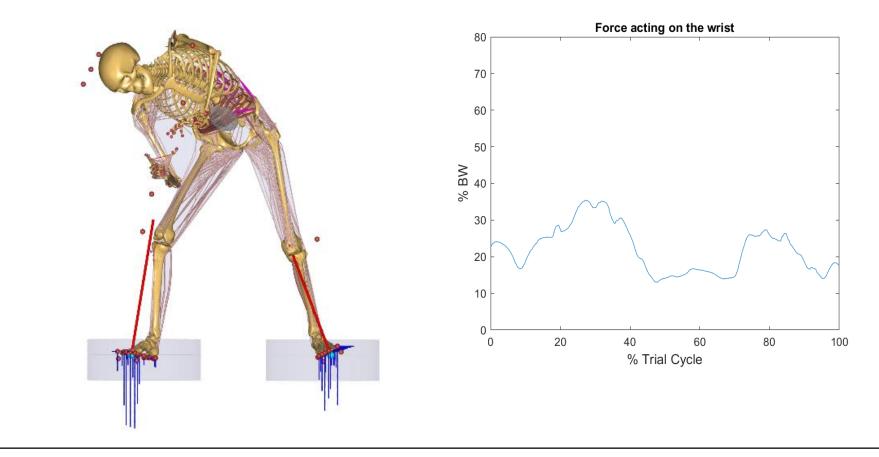




## Application - manual perineal protection

#### measurement of real deliveries

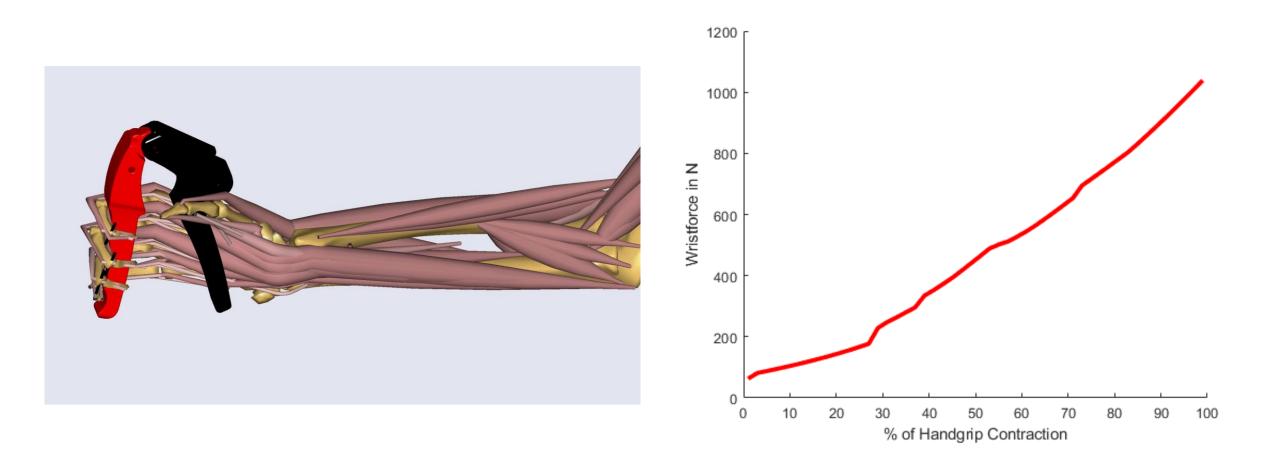








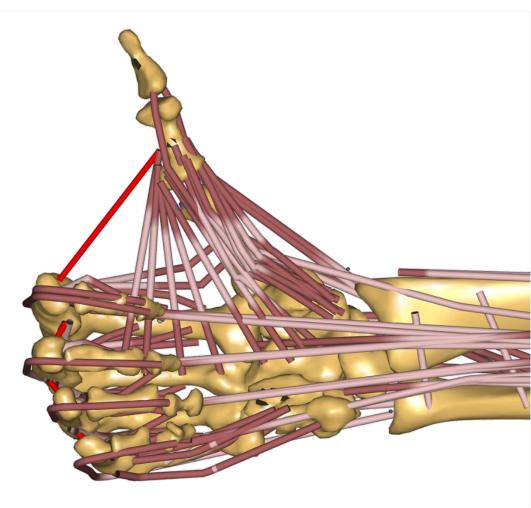
## **Application – gripping tool**







# Thank you for your attention!







## Affiliations, Partners and Sponsors



**Evropská unie** Europäischer Fonds für regionale Entwicklung Evropský fond pro

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**Europäische Union** 















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#### www.anybodytech.com

• Events, Dates, Publication list, ...

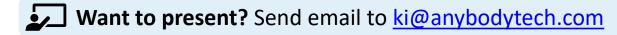
#### www.anyscript.org

• Wiki, Repositories, Forum

#### **Upcoming Webcasts**

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

Meet us? Send email to <a href="mailto-sales@anybodytech.com">sales@anybodytech.com</a>



#### 10 Dec: Physical stresses on caregivers when repositioning patients in bed

Repositioning patients in bed is the most common patient handling activity and is associated with musculoskeletal disorders in caregivers. Repositioning aids may mitigate the risk of injury. The current study investigated the effects of commonly used repositioning aids on the physical stress on caregivers.

Your presenter is Jie Zhou, Ergonomics researcher at Hillrom; Ph.D, AEP. Jie's presentation will be made twice:

Sign up for 1st presentation 10 December at 16:00 CET Sign up for 2nd presentation 10 December at 21:00 CET



#### 12 Jan: Biomechanical investigation of a passive upper extremity exoskeleton for manual material handling – A computational parameter study

Manual material handling tasks at supermarket stores is a very common activity and it is associated with the development of work-related musculoskeletal disorders. This presentation will show how on-site data recordings can be used together with the AnyBody Modeling System to assess the benefits of a passive upper extremity exoskeleton as a protective device. Additionally, it will provide an interesting computational parameter approach to investigate how to adjust an exoskeleton to fit a specific task.

Presented twice by Bo E. Seiferheld, M.Sc. Sports Technology, Department of Health Science and Technology, Aalborg University, Denmark:

Sign up for 1st presentation 12 January at 9:00 CET Sign up for 2nd presentation 12 January at 17:00 CET



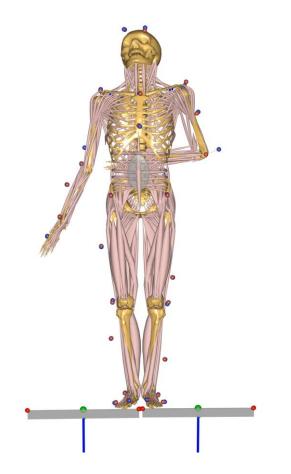


#### December 1<sup>st</sup>, 2020

Find us: 🖸 in 🈏 f



# Time for questions:



December 1<sup>st</sup>, 2020