

# Investigation of bracing to unload muscle and knee contact forces for knee osteoarthritis patients

January 17<sup>th</sup>, 2022





### Outline

- General introduction to the AnyBody Modeling System
- Presentation by PhD Candidate Jonas Stoltze
  - Investigation of bracing to unload muscle and knee contact forces for knee osteoarthritis patients

**Presenter**: Jonas Stoltze PhD Candidate

Aalborg University



A A L B O R G U N I V E R S I T Y

- Upcoming events
- Question and answer session



Host(s): Bjørn Keller Engelund R&D Engineer

Kristoffer Iversen Technical Sales Executive



## 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

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Product optimization design

ANYBODY **Modeling System** 



ANY BODY

Sports



Assistive Devices



Orthopedics and rehab

JANUARY 2022



## AnyBody Modelling System



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#### Investigation of bracing to unload muscle and knee contact forces for knee osteoarthritis patients

Presented by Jonas Stoltze



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#### Individualized Osteoarthritis Interventions

# Investigation of bracing to unload muscle and knee contact forces for knee oteoarthritis patients

#### Jonas S. Stoltze, John Rasmussen and Michael S. Andersen

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### Motivation – Knee Osteoarthritis (KOA)







- Multi-factoral disease
  - Genetic
  - Previous ligament ruptures
  - Underloading
  - Overloading



#### Non-invasive treatments of KOA



Modified picture from (Pollo et al. 2002)

- Skin surface displacement
- MCL may be too stiff
- Shifts load but not reducing







# Develop a subject-specific knee brace to unload the knee joint for KOA patients





### Study I: Moment study

How to unload the knee?

 Investigate how internal knee compressive forces (KCF) depend on external moments





Jonas S. Stoltze, John Rasmussen and Michael S. Andersen Development and Design Workflow of a Subject-Specific Knee Brace Individualized

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### Study I: Moment study – Method





Apply external joint moments to simulate a brace in-silico

• **40**% compensation of muscle moment → Reducing joint load





### Study I: Moment study – Method





Apply external joint moments to simulate a brace in-silico

Compensating muscle work → Reducing joint load





#### Study I: Moment study – Method





Example of knee flex-ext





#### Study I: Moment study – Results







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### Study I: Moment study – Findings





- Muscle contraction  $\rightarrow$  Joint compressive force
  - First peak: Knee and hip compensation
  - Second peak: Ankle compensation
- Published in Stoltze et al. 2018

On the biomechanical relationship between applied hip, knee and ankle joint moments and the internal knee compressive forces, International Biomechanics, **5**(1) DOI: 10.1080/23335432.2018.1499442

• Take home message:

Muscle compensation might be a more efficient approach for joint load reduction than external KAM compensation







#### AIM: Reduce first peak with applied knee extension moment

- Levitation brace (passive)
   Spring Loaded Technology
- Ascend Brace (active)
   Roam Robotics
  - Subject-specific



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- Individually adjustable (subject-specific)
- Only applied during first peak
- No actuators for applying the moment
  - Store potential energy in springs
- What type of springs?
- Depends on the size (and shape) of the moment





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#### MoCap of 5 gait trials (healthy subject)









#### Muscle moment during gait (healthy subjects)



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Development and Design Workflow of a Subject-Specific Knee Brace









### Study II: Brace prototype – Simulation Jone Study II: Brace prototype – Study II: Brace prototype – Simulation Jone Study II: Brace prototype – St

#### Individual adjustment



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### Study II: Brace prototype – Simulation & Innovation Fund Denmark

#### Individual adjustment

- 1. Parameter study: Vary  $L_{TL}$ ,  $L_{SL}$  and K  $L_{TL}$  = 22-26 cm  $L_{SL}$  = 22-26 cm
  - K = [7.1, 7.92, 8.91 9.91, 11.09] N/mm
- Choose optimal brace parameters (peak KCF, impulse, ...)





Individualized

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### Study II: Brace prototype – Simulation June Value Construction Fund Denmark

#### **Brace simulation**





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#### Test on one healthy subject











#### Test on one healthy subject

























- Reduced EMG → Reduction of compression forces?
- Evaluating the effect in AnyBody – AnyExp4SOLIDWORKS
- Apply the measured spring force









#### AnyBody simulation of experimental tests













### Study II: Brace prototype – Findings





- Reduces EMG and knee compressive forces
- Published in Stoltze et al. 2021

Development and Functional Testing of An Unloading Concept for Knee Osteoarthritis Patients: A Pilot Study, Journal of Biomechanical Engineering, **144**(1) DOI: 10.1115/1.4051847

- Influence on pain?
  - Requires KOA patient analyses
- Who is suited for this intervention?





#### Study III: KOA patients – Gait trials







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#### Study III: KOA patients – Gait trials









#### Study III: KOA patients – Gait trials








# Study III: KOA patients – Simulation











# Study III: KOA patients – Simulation







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• KOA patient tests (N=1)



































# Study III: KOA patients – Findings

- Potential to reduce peak EMG and peak KCF
  - For some patients
- No influence in pain was detected
- Placebo trials are important for brace tests

• Take home message:

An applied knee extension moment in early stance has the potential to reduce KCF in KOA patients, but not all patients are suited for this treatment









# Discussion

- Only tested one KOA patient
  - More patient tests are required
- Applicaple for more activities than gait
  - Advanced control is needed
- Very bulky and heavy
  - Still needs to apply a large moment
- Vertical migration over time



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# Thank you - Questions







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• Wiki, Blog, Repositories, Forum

### **Events**

- Orthopedic Research Society Annual meeting Booth #146
  - $\,\circ\,$  Feb 4 8, 2022 in Tampa, FL
- Webcast: Automatic ergonomics whole-body motion analysis and physical human-robot interaction
  - Feb 28, 2022

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

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# Thank you for your attention - Time for questions



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