

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

January 17th, 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

AnyBody - License - C/L/Sers/kh/Documents/ammr/Application/Examples/StandingPosturePrediction/WithLoad/StandingPosturePrediction.main.any		- 🗆 X
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Model Operations Files	//Inis is a model which can predict the posture as a consequence of applied loads in hands. A Model View Chart Uata View //It does this by minimizing joint torques and apply balance drivers which account for external	lions
$\leftarrow \rightarrow \frac{1}{2}$ $\bullet \bullet$	//applied loads.	
HumanModel		
InputParameters	//The model is driven by a combination of the following drivers:	
🟚 📹 Model	// * Drivers which this to keep the CoP inside the foot stance area.	
Kinematic_Pre_Study	//* Feet maintain contact with the ground, but the position can be controlled by widgets	
WidgetOperation		
RunApplication	//Two type of loads can be applied, either a fixed weight of the object and/or a force vector	
DrawSettings	//The current model has a force vector applied on the object being held between the hands with a zerc	
	//To run the model	
	// * Try to drag (click and drag) one of the widgets in the ModelView (seen as small coordinate syste	
	// * When the widget is release the model will run the analysis	
	#include "libdef.any"	
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Main		
AmAdainFolder	//Switch to define if load is applied to both hands or a single hand.	
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Product optimization design

ANYBODY **Modeling System**



ANY BODY

Sports



Assistive Devices



Orthopedics and rehab



AnyBody Modelling System





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

Presented by Jonas Stoltze









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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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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• Events, Dates, Publication list, ...

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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

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Thank you for your attention - Time for questions

