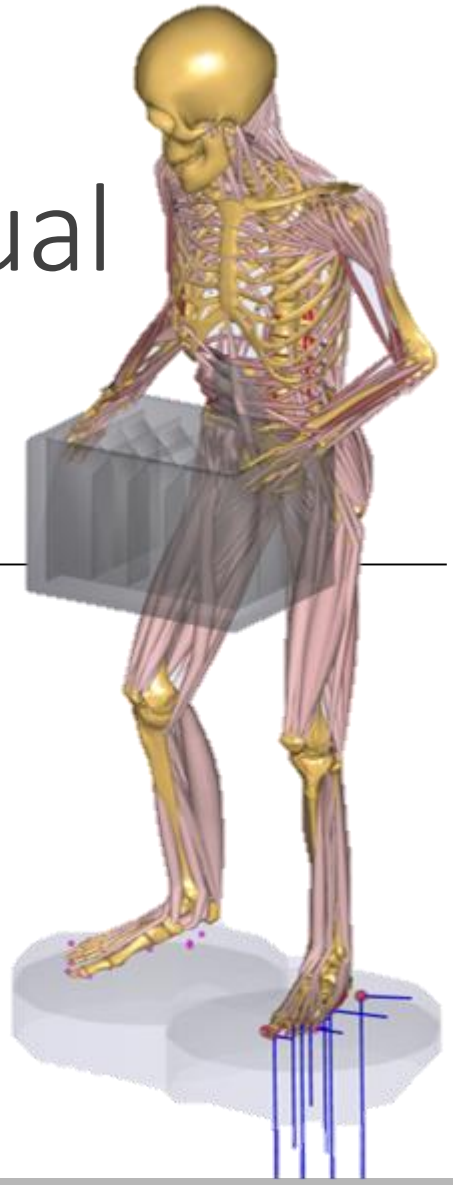
The webcast will begin shortly…

Musculoskeletal modeling of manual materials handling in the Danish supermarket sector

July 28th, 2020



Outline

- General introduction to the AnyBody Modeling System
- Presentation by Sebastian Laigaard Skals
  - *Musculoskeletal modeling of manual materials handling in the Danish supermarket sector*
- Question and answer session

Presenter:
Sebastian Laigaard Skals
Ph.D. student at the National Research Centre for the Working Environment (NRCWE) / Aalborg University, Denmark

National Research Centre for the Working Environment

AALBORG UNIVERSITET

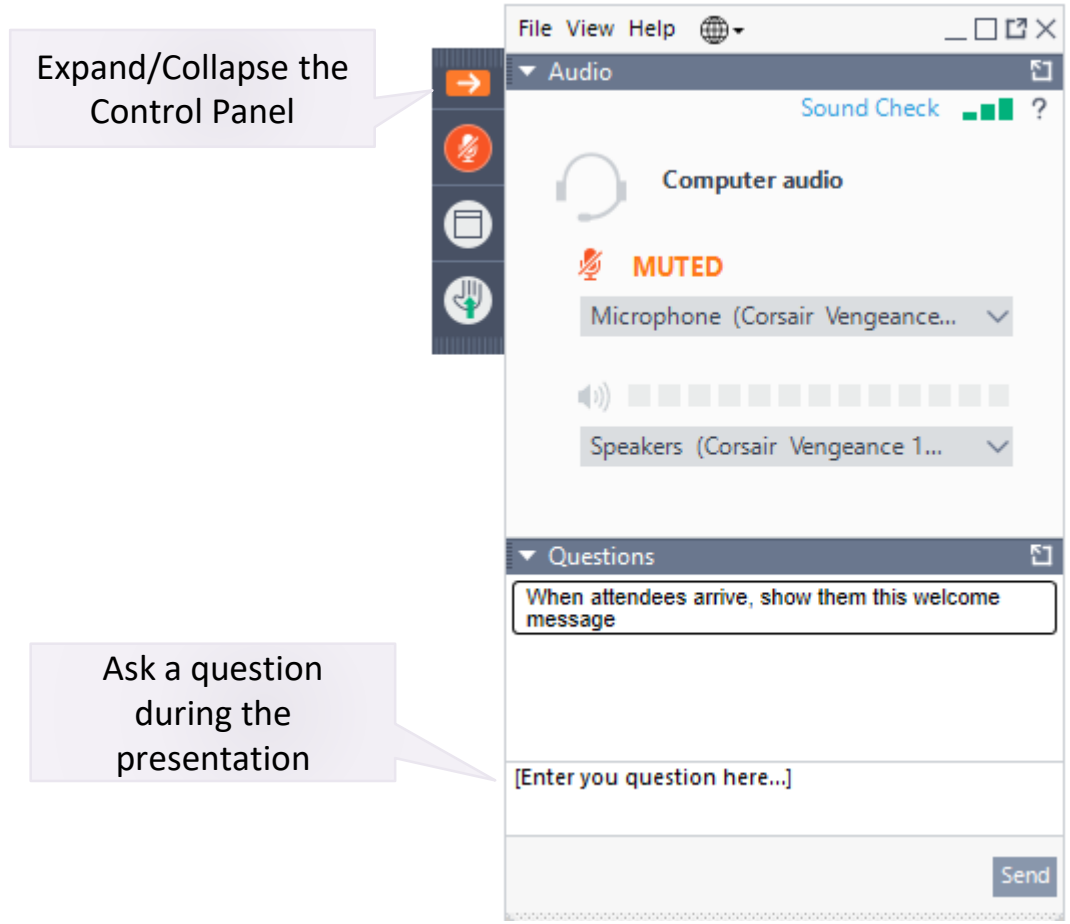
Host:
Kristoffer Iversen
R&D Engineer
AnyBody Technology

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.



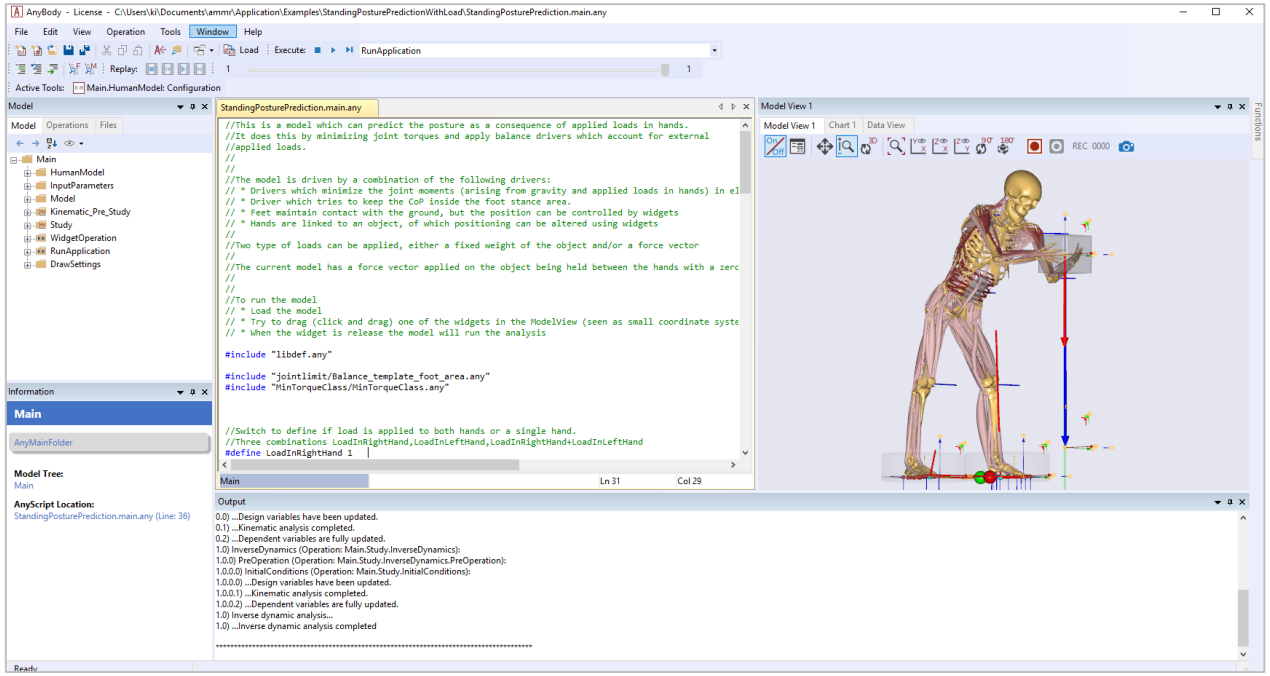
Musculoskeletal Simulation

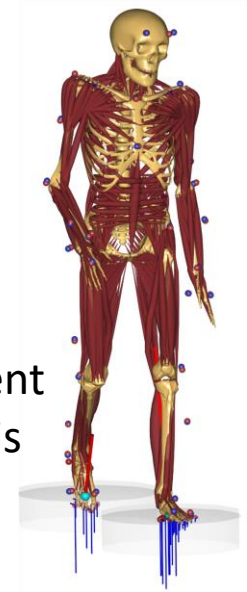
Motion Data
Kinematics and Forces

ANYBODY
Modeling System

Body Loads

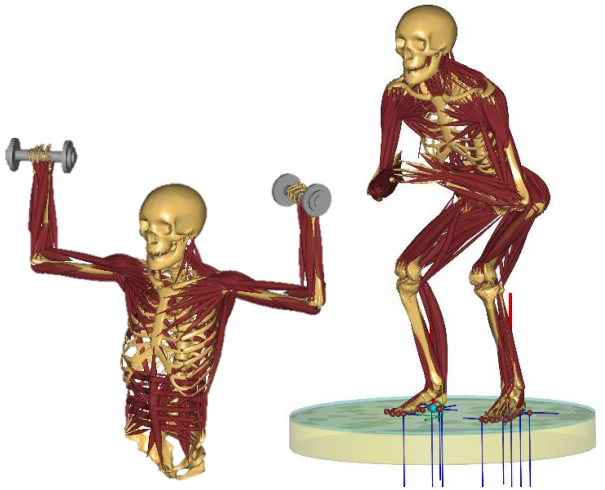
- Joint moments
- Muscle forces
- Joint reaction forces





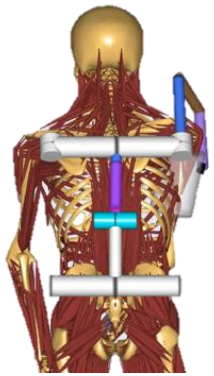
Movement Analysis

Product optimization design

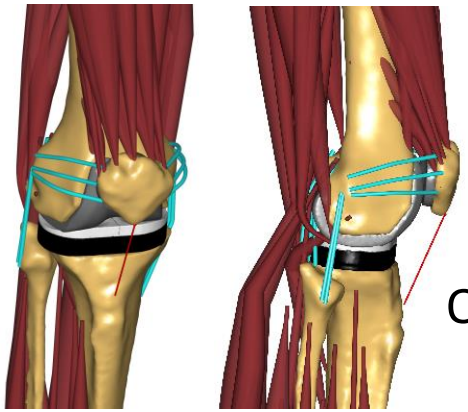


Sports

ANYBODY Modeling System



Assistive Devices



Orthopedics and rehab

AnyBody Modelling System

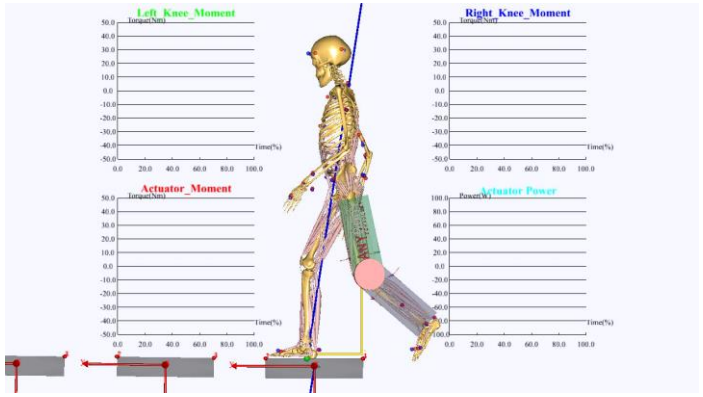
Motion and Forces

Body model

Environment model

Inverse dynamics
Muscle recruitment

Simulation



Internal body loads
- Muscle forces
- Joint moments

Design Optimization

Post Processing (e.g. Finite element tools)

Musculoskeletal modeling of manual materials handling in the Danish supermarket sector

By Sebastian Laigaard Skals,
Ph.D. student at NRCWE /
Aalborg University, Denmark

National Research Centre for the Working Environment

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AALBORG UNIVERSITY

INDEPENDENT RESEARCH FUND DENMARK

Sebastian Skals
Ph.D. student
28/7 - 2020

Musculoskeletal modeling of manual materials handling in the Danish supermarket sector

Sebastian Skals[1,2], Rúni Bláfoss[1,3], Michael S. Andersen[4], Mark de Zee[1] & Lars L. Andersen[1,2]

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[4]*Department of Materials and Production, Aalborg University, Aalborg, Denmark*

Introduction

Musculoskeletal disorders in the supermarket sector

Work-related musculoskeletal disorders (WRMD) are highly prevalent in the supermarket sector[1,2]

- Lower back
- Shoulders
- Wrists

Majority of workers are primarily engaged in the receiving, stocking and re-arranging of groceries

Not much is known about the biomechanical loads these workers are subjected to during their daily work

However, it is well-documented that manual materials handling (MMH) is associated with the development of WRMD, particularly to the lower back

Introduction

Assessing the risk of injury during MMH

Task-based analysis of MMH has involved many different approaches

- Self-reports
- Observational methods
- Direct measurements (e.g. EMG or motion analysis)
- Biomechanical models

Several ergonomic tools have been developed to assess injury risks during MMH, as for instance:

- NIOSH Lifting Equation[3]
- Snook Lifting Tables[4]

…many of which apply biomechanical models to estimate joint loads

Introduction

Limitations of biomechanical models and recent advances

Simplified exposure and biomechanical models (static or quasi-static):

- Loads are only known for idealized lifting situations
- Considerable underestimation of loads compared with dynamic models

Musculoskeletal modelling may be the tool to overcome these challenges:

- Prediction of ground reaction forces
- Inertial motion capture (*Xsens Technologies B.V.*)

AIM:

Identify work tasks and ergonomic exposures that may pose a risk for the development of WRMD in the supermarket sector based on state-of-the art methods for inertial-based motion analysis and musculoskeletal modelling.

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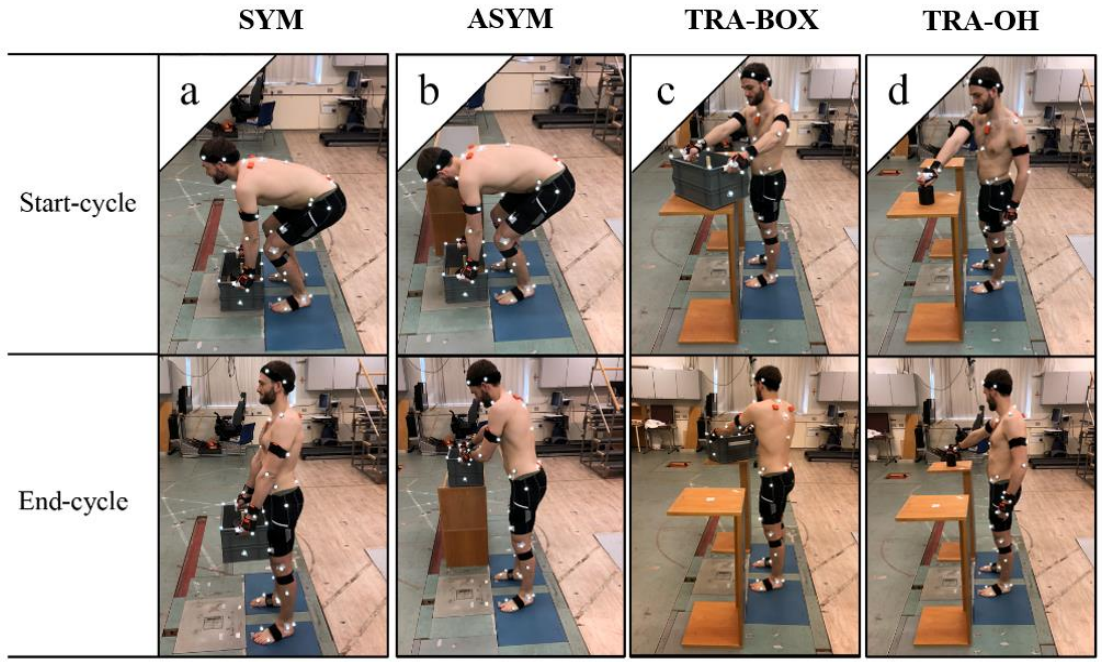
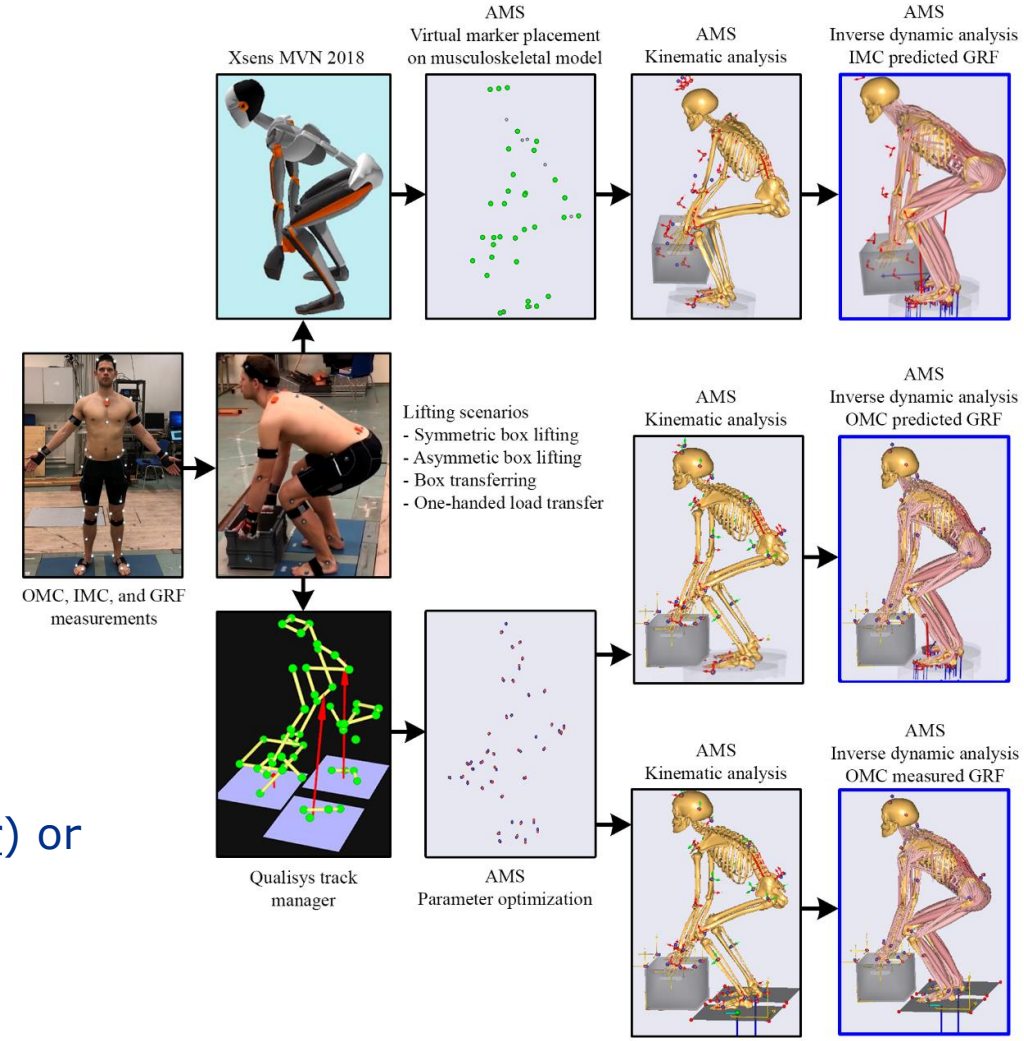
Methods

Evaluate methodology against silver standard





See previous webcast (https://www.youtube.com/watch?v=QwA1hnqpqXgor) or journal paper[5] for more information.

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Methods

Experimental procedures

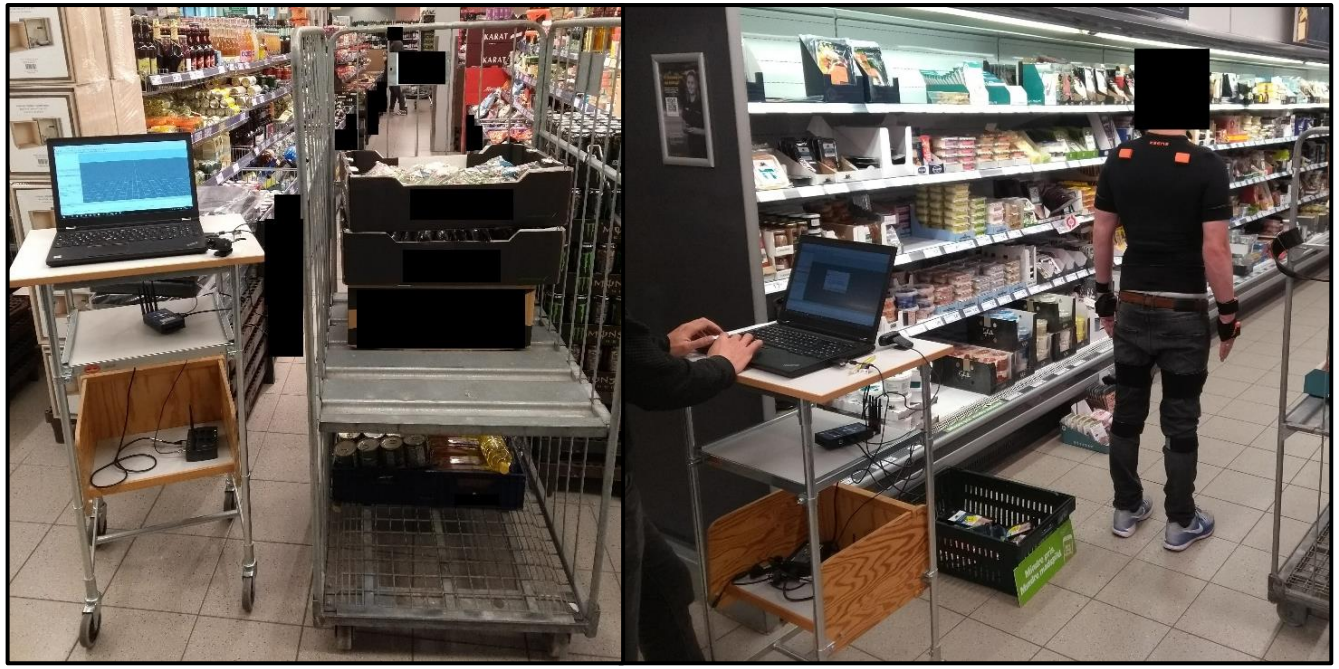
17 healthy full-time workers from two supermarkets were recruited

12 common MMH tasks were included in the study, e.g. the handling of

- Bananas
- Milk crates
- Cucumbers

Multiple start and end postions were included

- 50 lifting conditions
- 4 repetitions per condition



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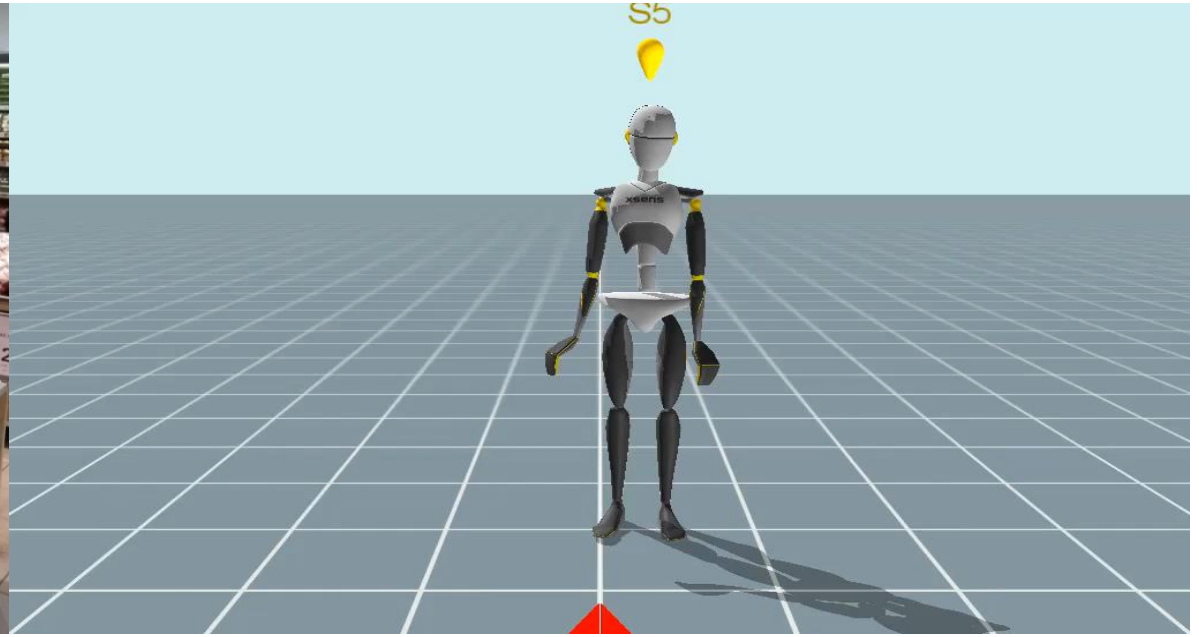
Methods

Experimental procedures

Full-body kinematics obatained using the Xsens MVN Awinda wireless motion-tracker

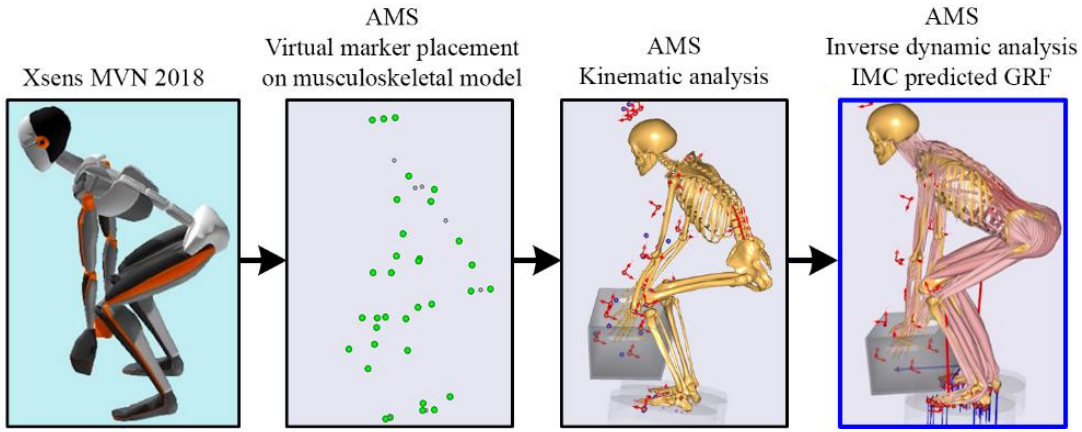


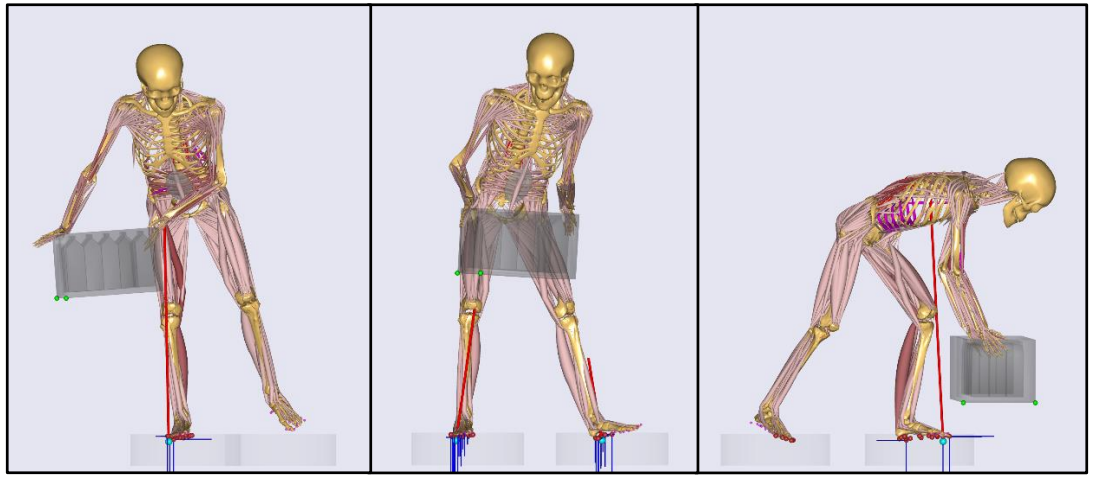
Methods

Musculoskeletal modelling

Models developed in The AnyBody Modeling System 7.2 based on the BVH_Xsens template from AMMR 2.2.3

- Scaling based on manual measurements
- Kinematics solved using concept of virtual markers[6]
- GRFs predicted using embedded tool in AnyBody[7]
- Box kinematics driven by position of hands
- Hand-box contact modelled with muscle-like contact elements





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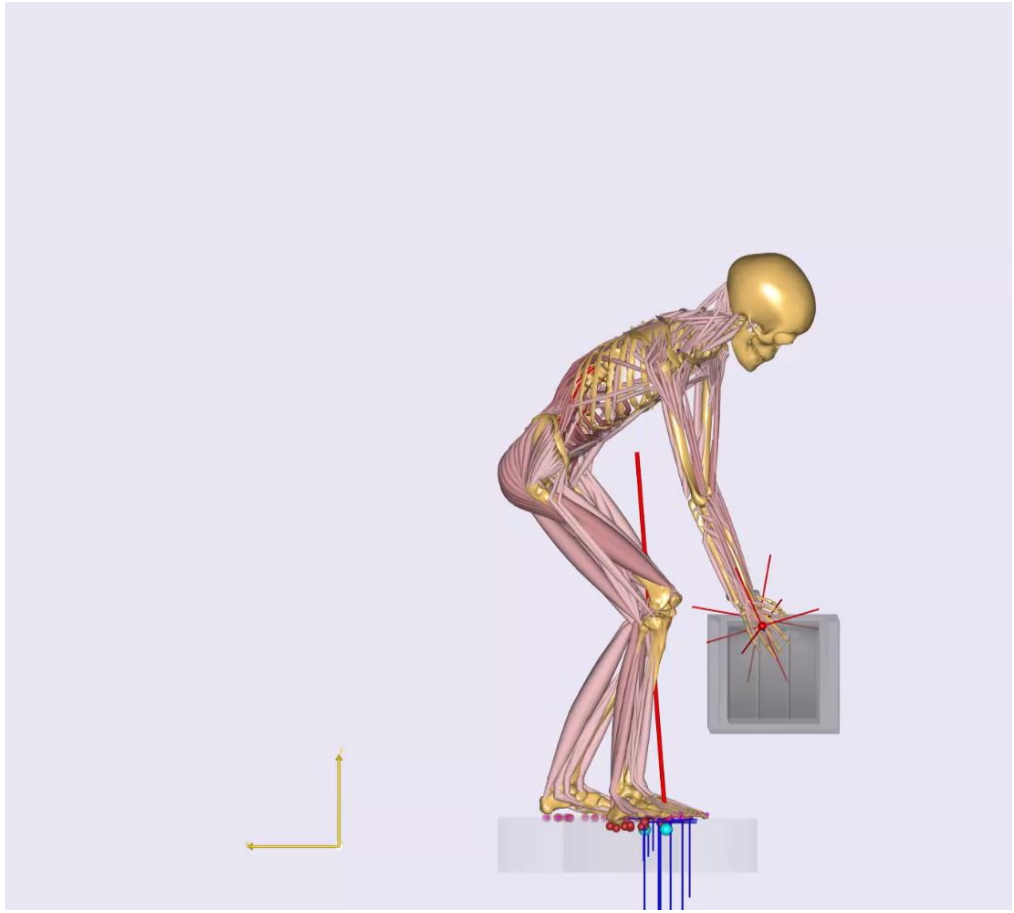
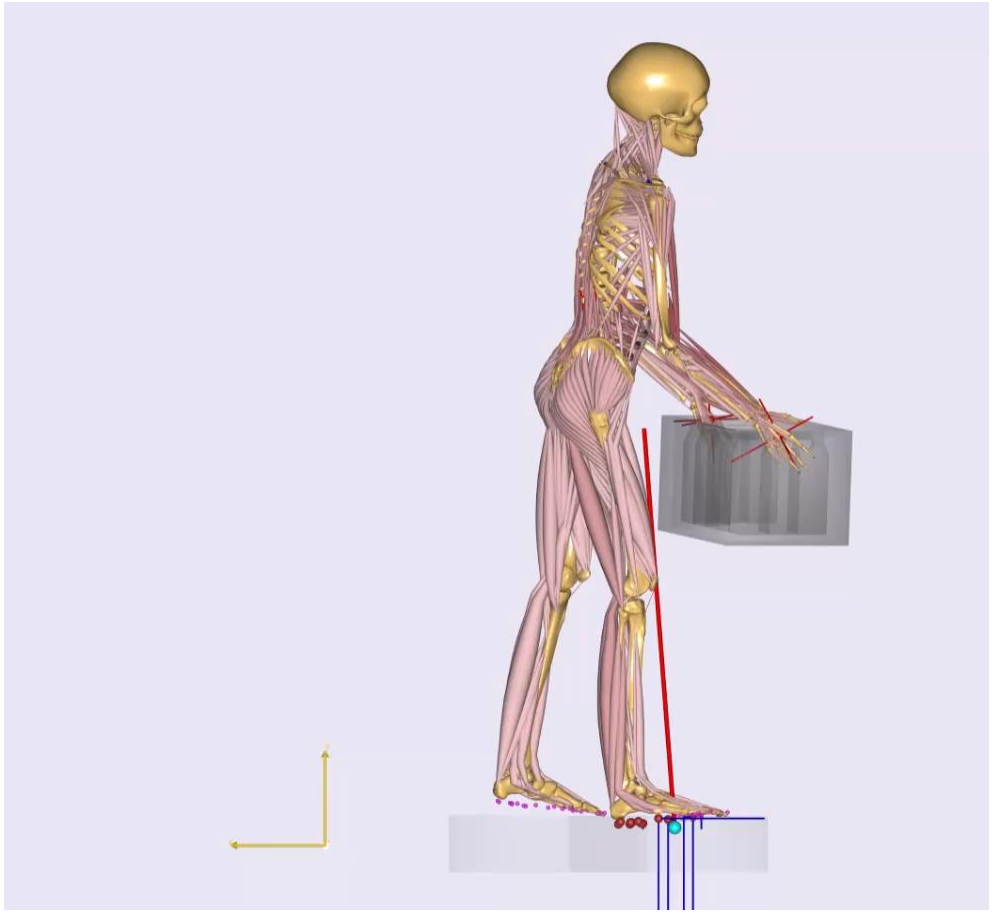
Results

Milk-LowToLow



Milk-HighToHigh



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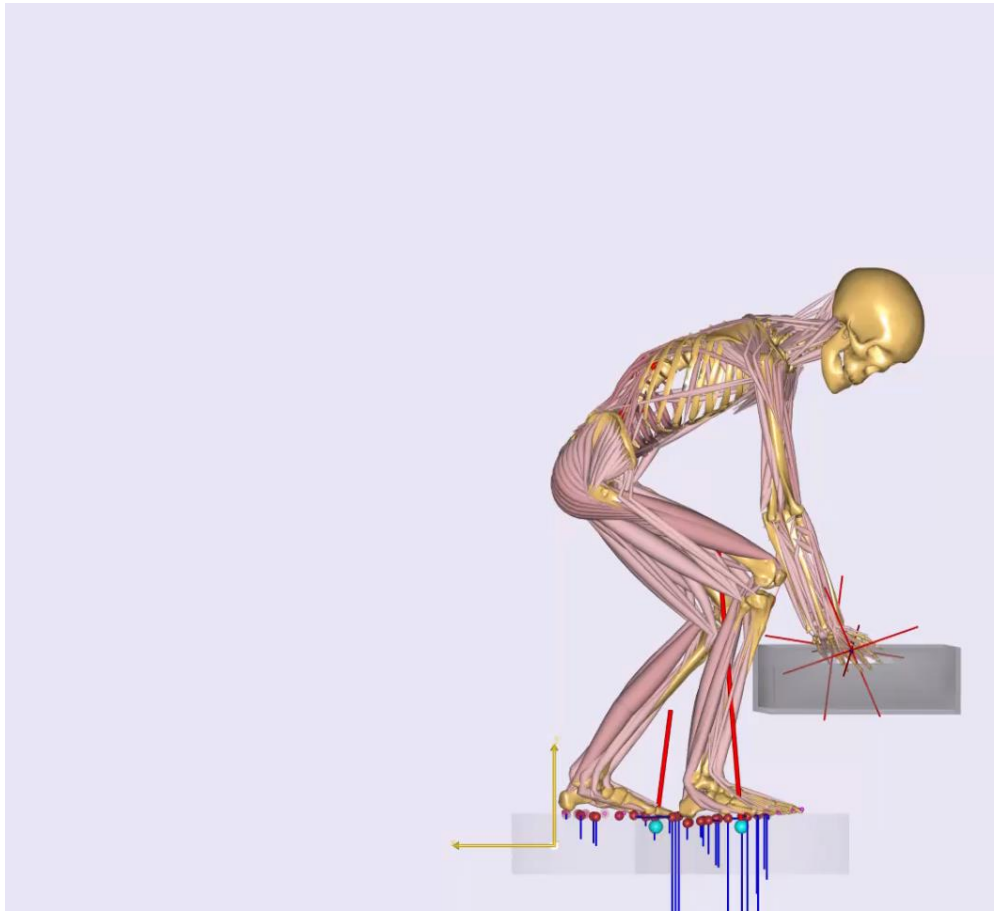
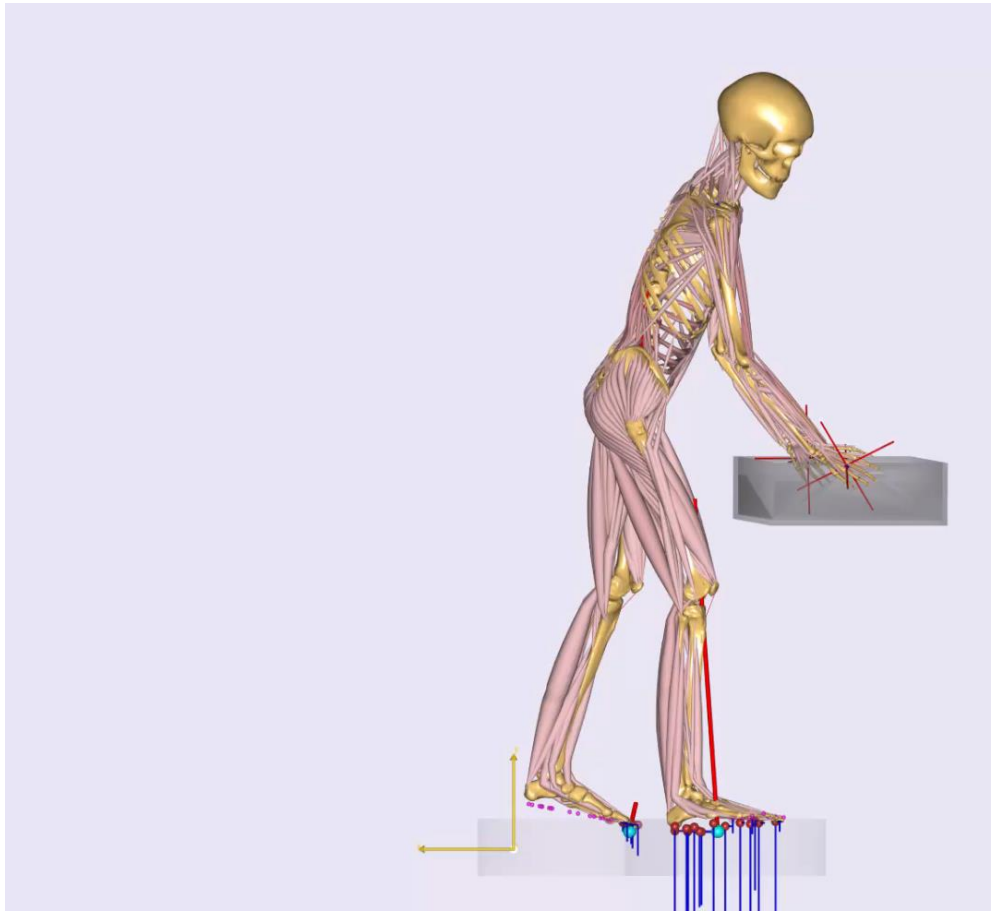
Results

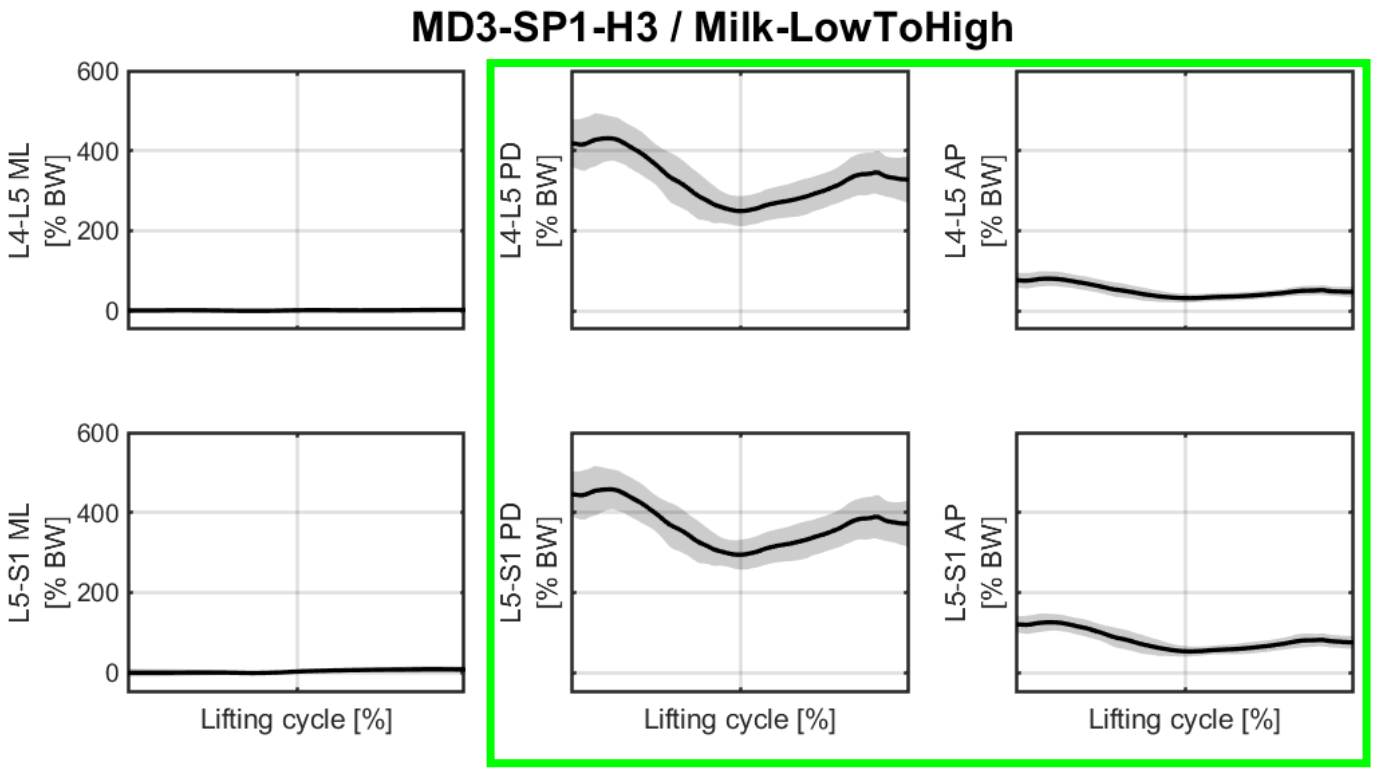
Bread-LowToLow

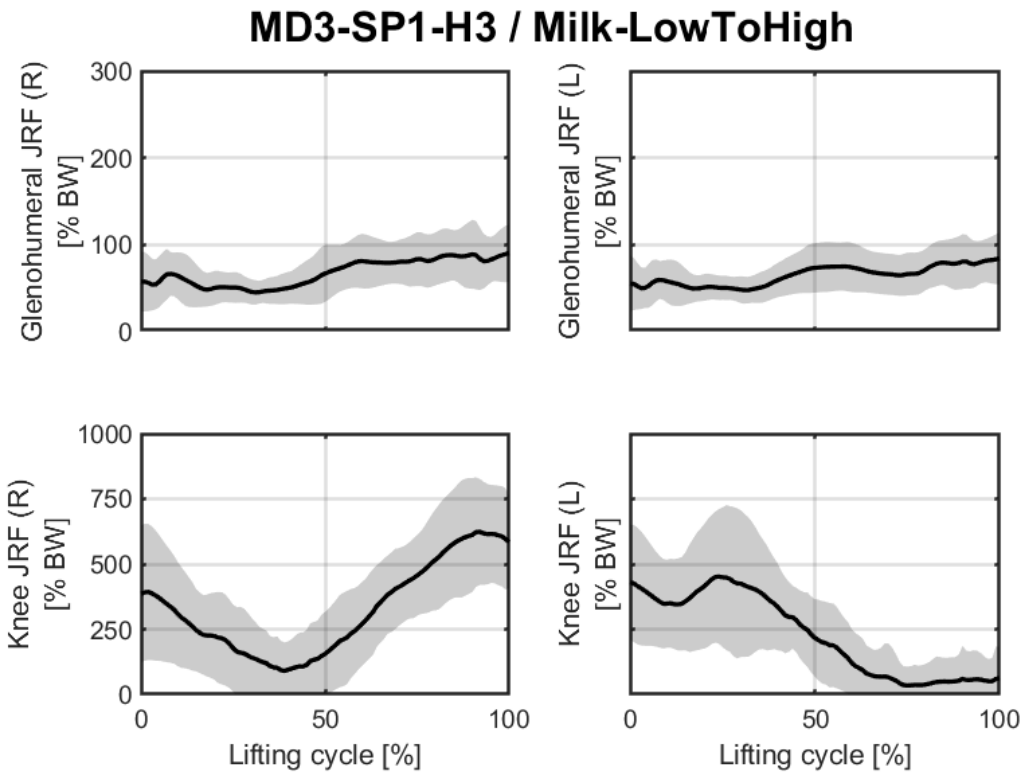


Bread-HighToHigh



Results





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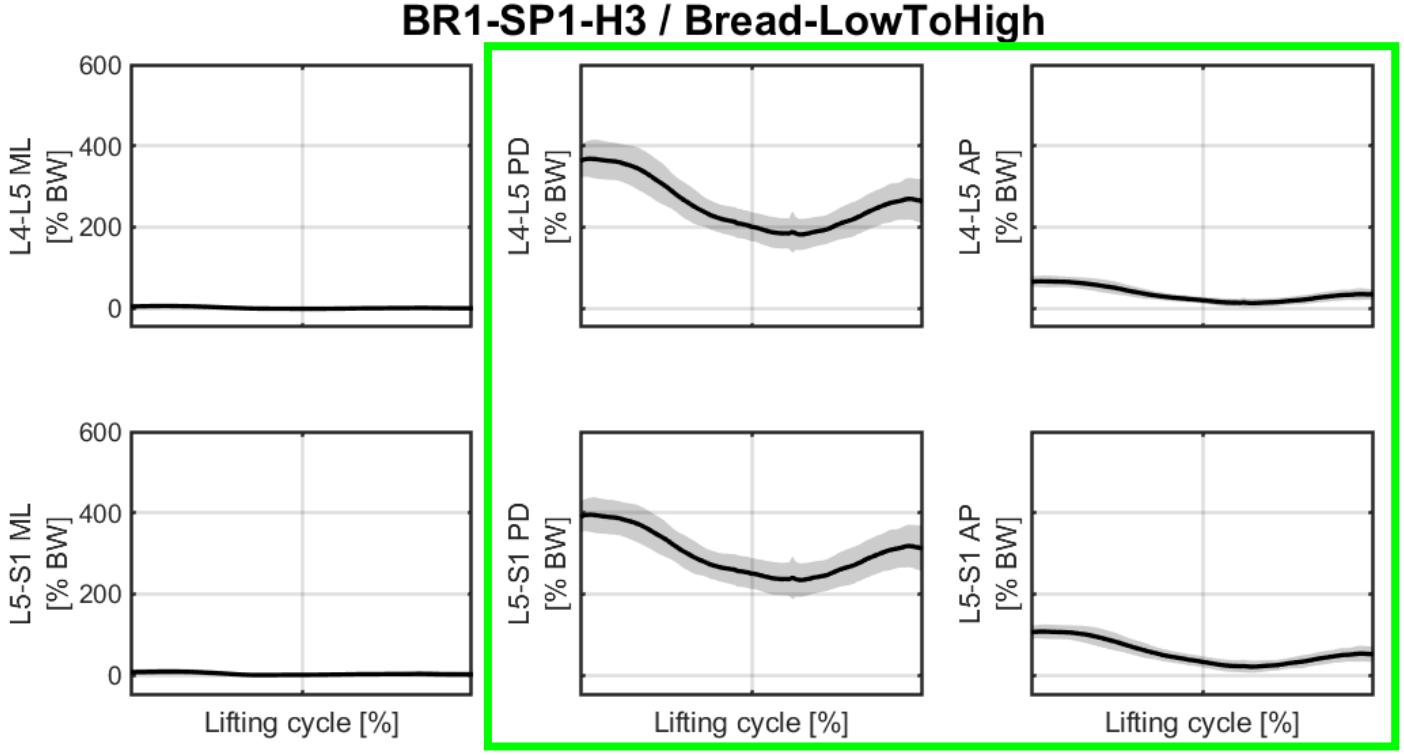

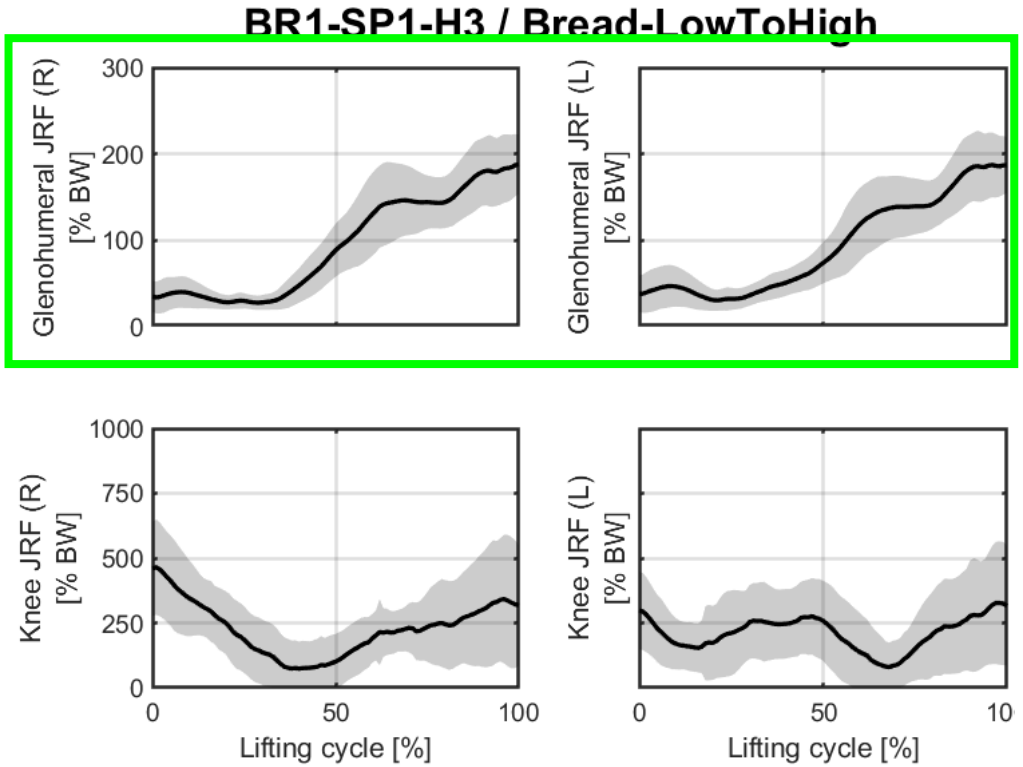

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Results

	L5-S1 axial compression force		L5-S1 anteroposterior force	
Rank	**Task**	**Newton**	**Task**	**Newton**
1	Bananas-LowToLow	3961 (3734 – 4188)	Bananas-LowToLow	1114 (1036 – 1191)
2	Bananas-HighToLow	3862 (3635 – 4088)	Milk-LowToLow	1035 (958 – 1113)
3	Milk-LowToLow	3627 (3401 – 3854)	Bananas-HighToLow	1020 (942 – 1097)
4	Milk-LowToMid	3584 (3357 – 3811)	Milk-LowToMid	992 (915 – 1069)
5	Milk-LowToHigh	3548 (3322 – 3775)	Milk-LowToHigh	985 (908 – 1062)
6	Milk-HighToLow	3516 (3289 – 3742)	Milk-HighToLow	964 (887 – 1041)
7	Milk-HighToMid	3350 (3123 – 3577)	Cucumbers-LowToHigh	901 (824 – 978)
8	Cucumbers-LowToHigh	3215 (2988 – 3442)	Cucumbers-LowToMid	888 (810 – 966)
9	Cucumbers-LowToMid	3170 (2942 – 3398)	Bread-LowToLow	858 (781 – 935)
10	Bread-LowToLow	3060 (2833 – 3287)	Bread-MidToLow	848 (770 – 925)

Compression tolerance limit: 3400 N[3,8]

Anteroposterior shear tolerance limit: 1000 N[9,10]

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Discussion
Main findings

- First study to estimate dynamic spinal loading based on field measurements
- Spinal loads exceed tolerance limits for bananas (20.2 kg), milk (17.3 kg) and cucumbers (10.2 kg)
- Weight, start and end position all had considerable influence on spinal forces
- Lifting cucumbers (10.2 kg) to high shelves resulted in the highest shoulder forces
- The weight of the merchandise was the main predictor of high knee forces

Discussion
Practical implications

- Handling of milk crates and bananas should be avoided
- Bread (7.9 kg) and cucumbers (10.2 kg) should only be placed below shoulder height or stocked individually
- Highest shelves should be lowered to avoid working above shoulder height
- Technical assistive devices are adviced to limit hazardous exposures
- Individual factors (age, sex and health) should be considered in relation to job demands

Discussion

Limitations and future applications

- Trunk forward flexion angle and anteroposterior shear force underestimated considerably
- Very time-consuming approach that require specialized skills
- Only estimates acute loading, but accumulated loads are important
- Errors in kinematic data led to the exclusion of a large proportion of the collected trials

- Estimating dynamic joint loads based on field measurements is a great leap forward
- Abundance of information providing valuable reference material for industrial stakeholders

References

… and thank you for your time!

1. Forcier L, Lapointe C, Lortie M, Buckle P, Kuorinka I, Lemaire J, et al. Supermarket workers: Their work and their health, particularly their self-reported musculoskeletal problems and compensable injuries. Work 2008;30(4):493-510.
2. Anton D, Weeks DL. Prevalence of work-related musculoskeletal symptoms among grocery workers. Int. J. Ind. Ergonomics 2016;54:139-45. DOI: 10.1016/j.ergon.2016.05.006.
3. Waters TR, Putz-Anderson V, Garg A, Fine LJ. Revised NIOSH equation for the design and evaluation of manual lifting tasks. Ergonomics 1993;36(7):749-76. DOI: 10.1080/00140139308967940.
4. Snook SH, Ciriello VM. The design of manual handling tasks: revised tables of maximum acceptable weights and forces. Ergonomics 1991;34(9): 1197-1213.
5. Skals S, Rasmussen K, Bendtsen K, Yang J, Andersen M. A musculoskeletal model driven by dual Microsoft Kinect Sensor data. Multibody Syst. Dyn. 2017;41(4):297-316. DOI: 10.1007/s11044-017-9573-8
6. Karatsidis A, Bellusci G, Schepers HM, de Zee M, Andersen MS, Veltink PH. Estimation of ground reaction forces and moments during gait using only inertial motion capture. Sensors 2017;17(1):75. DOI: 10.3390/s17010075.
7. Larsen FG, Svenningsen FP, Andersen MS, de Zee M, Skals S. Estimation of spinal loading during manual materials handling using inertial motion capture. Ann. Biomed. Eng. 2020;48(2):805-21. DOI: 10.1007/s10439-019-02409-8.
8. Nelson GS, Wickes H, English JT. Manual Lifting: The NIOSH Work Practices Guide for Manual Lifting Determining Acceptable Weights of Lift. NIOSH Technical Report No. 81-122. Cincinnati, OH, USA: U.S. Department of Health and Human Services; 1981.
9. McGill SM, Norman RW, Yingling VR, Wells RP, Neumann P. Shear happens! Suggested guidelines for ergonomists to reduce the risk of low back injury from shear loading. In: Proceedings of the 30th annual conference of the human factors association of Canada: 1998 Oct; Mississauga, Ontario, Canada.
10. Gallagher S, Marras WS. Tolerance of the lumbar spine to shear: a review and recommended exposure limits. Clin. Biomech. 2012;27(10):973-8. DOI: 10.1016/j.clinbiomech.2012.08.009.

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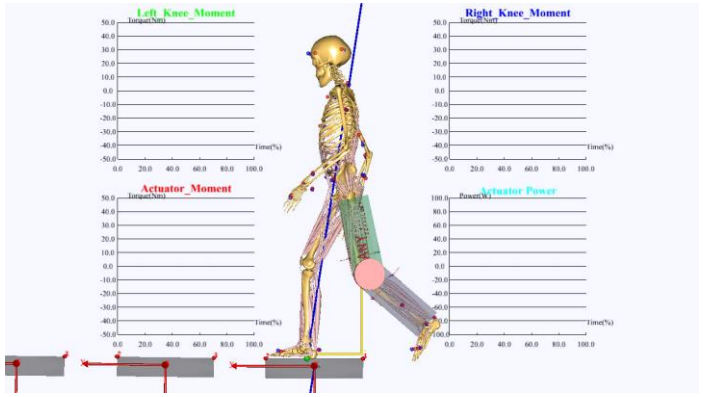
Simulation



Internal body loads
- Muscle forces
- Joint moments

Design Optimization

Post Processing (e.g. Finite element tools)

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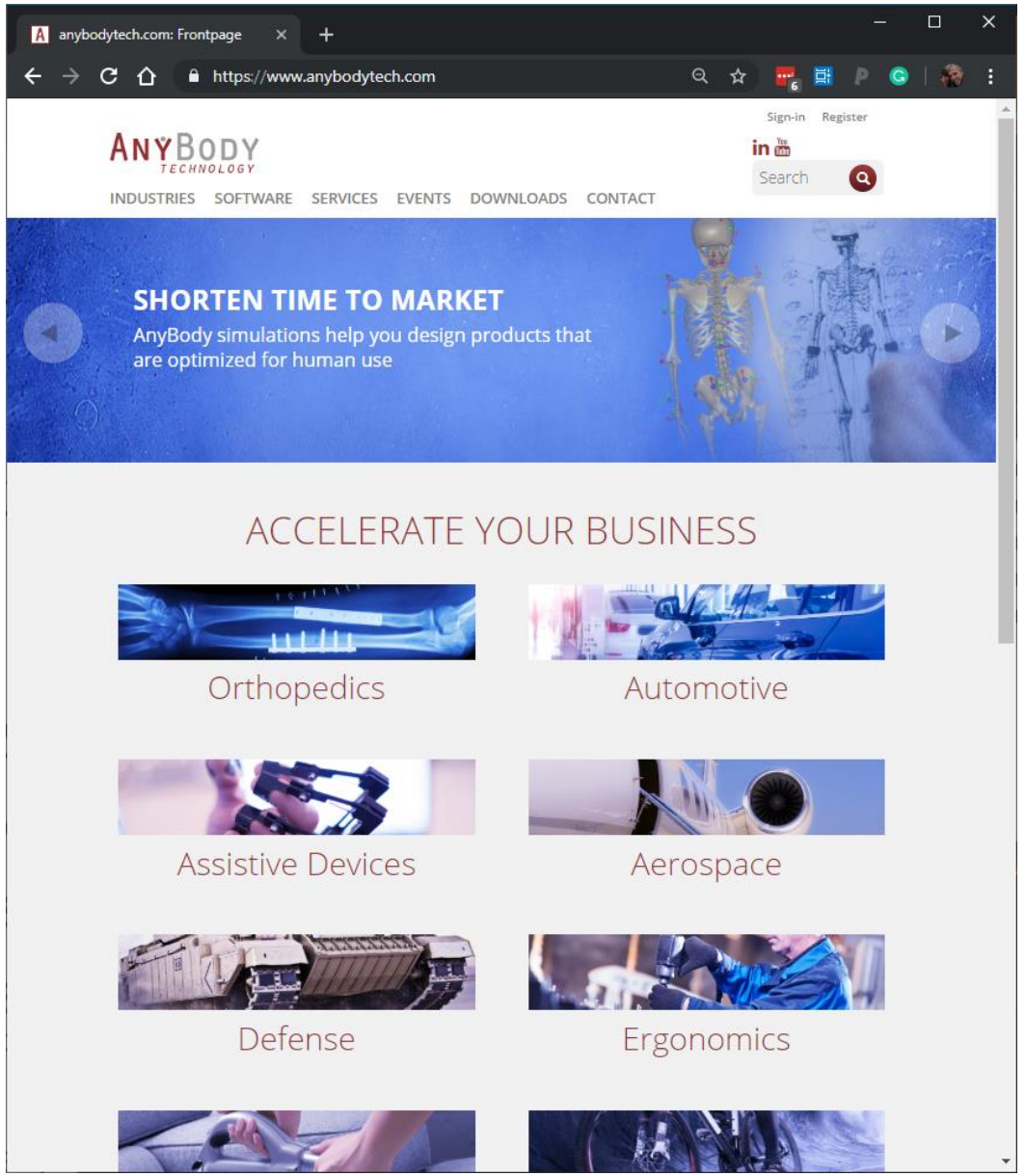

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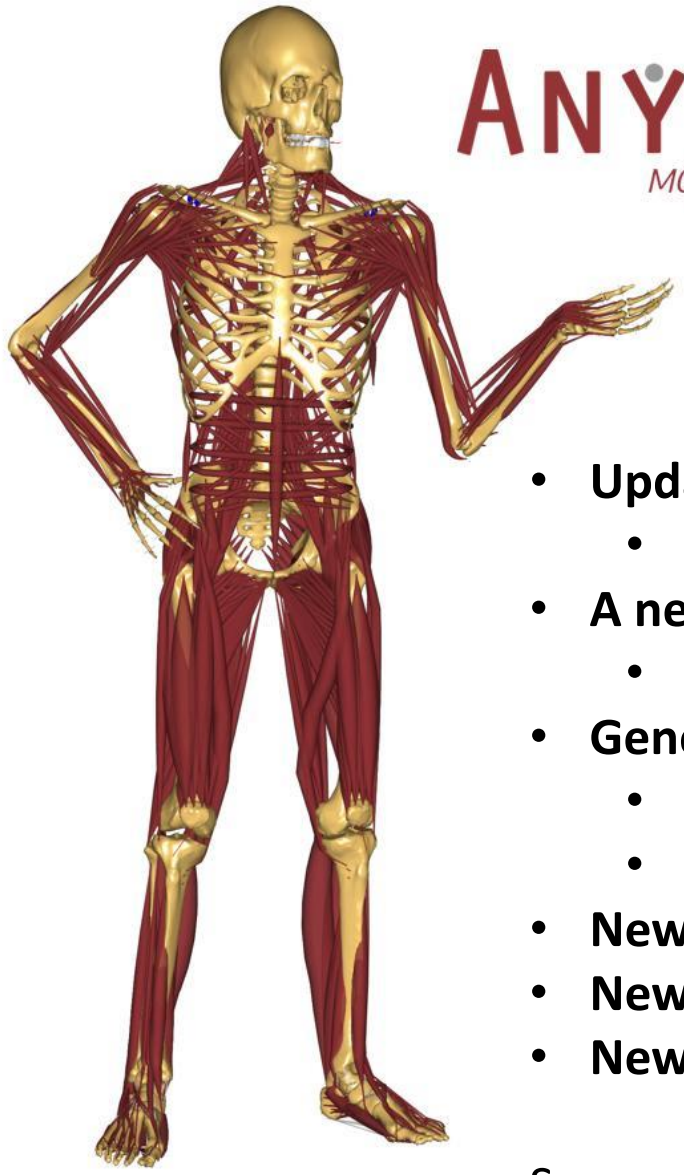

ANYBODY™ MODELING SYSTEM V. 7.3

- **Updated model repository AMMR v. 2.3**
  - A large-scale gait MoCap example
- **A new faster experimental wrapping algorithm, 5-100 faster than the previous**
  - Inspired by the work of Lloyd, Stavness and Fels (2019).
- **General faster load and simulation times**
  - Load time for models is reduced by 25%
  - Simulation time is also faster in all models which includes tri-axial ellipsoids.
- **New improved model view performance**
- **New class list**
- **New reference manual**

See more:https://forum.anyscript.org/t/anybody-modeling-system-v-7-3-0-released/5706

Time for questions: