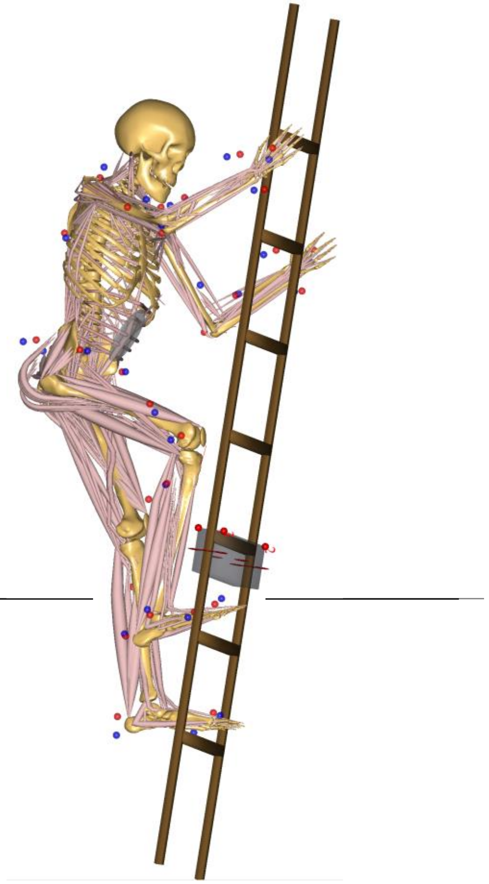
ANYBODY TECHNOLOGY

The webcast will start in a few minutes….



Loads analysis of the hip joint for occupational activities

PATRICK VARADY, DIPL.-ING.,

TRAUMA CENTER MURNAU AND
PARACELSUS MEDICAL UNIVERSITY SALZBURG

Outline

- Introduction
- Webcast: Loads analysis of the hip joint for occupational activities
- Conclusions
- Questions and answers

Patrick Varady
(Presenter)

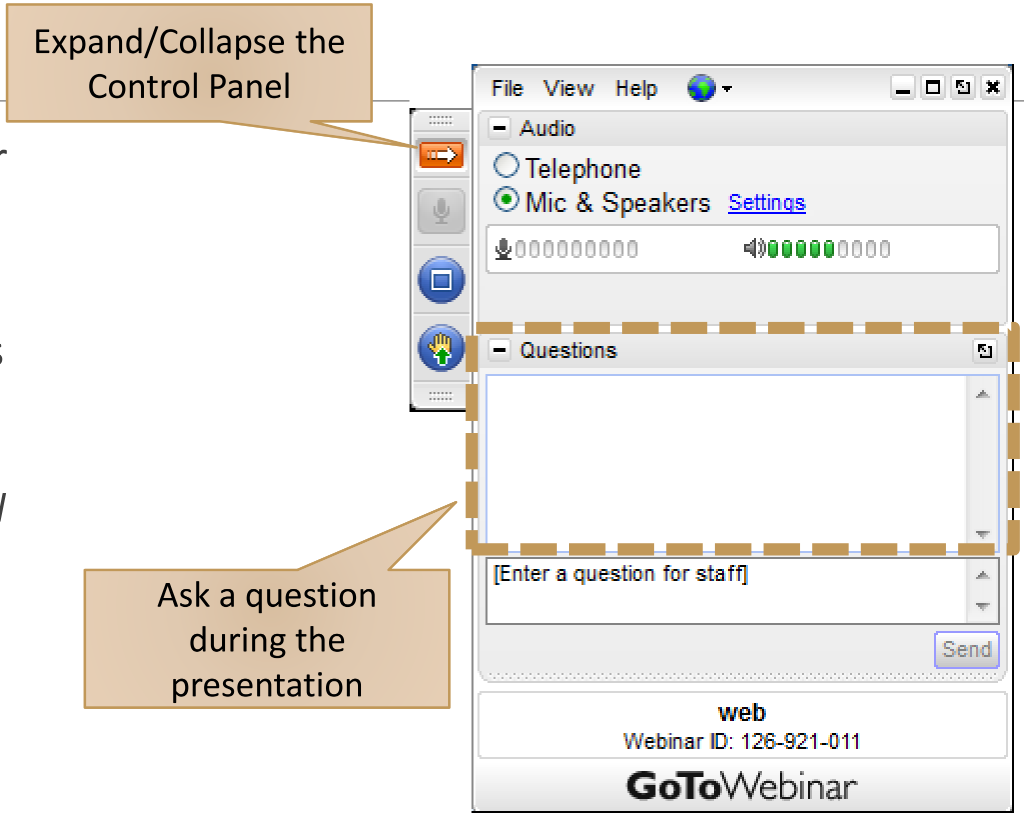
Pavel Galibarov
(Host)

Control Panel

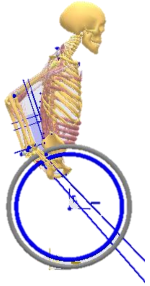
The Control Panel appears on the right side of your screen.

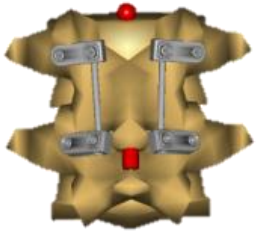
Submit questions and comments via the Questions panel.

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



Who is AnyBody?



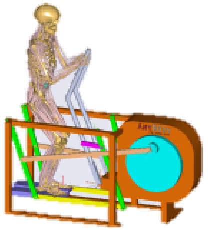


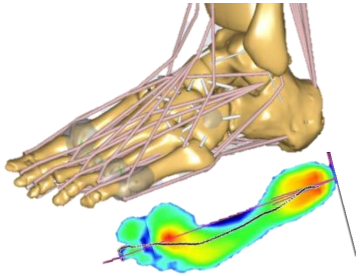
<u>AnyBody Technology</u>
(Aalborg, DK; Boston, US)

- *AnyBody Modeling System*
- *Licenses, Training, Support*
- *Consulting*

<u>AnyBody Research Group</u>

- *DK: Aalborg University - Prof. Rasmussen*
    - *Biomechanics, Ergonomics, Sport, Automotive*





- *US: Colorado School of Mines – Prof. Petrella*
    - *Biomechanics, Orthopedics, Sport*
- *GER: OTH Regensburg – Prof. Dendorfer*
    - *Biomechanics, Orthopedics, Gait*

What is AnyBody?

A nyBody
M odeling
S ystem

A nyBody
M anaged
M odel
R epository

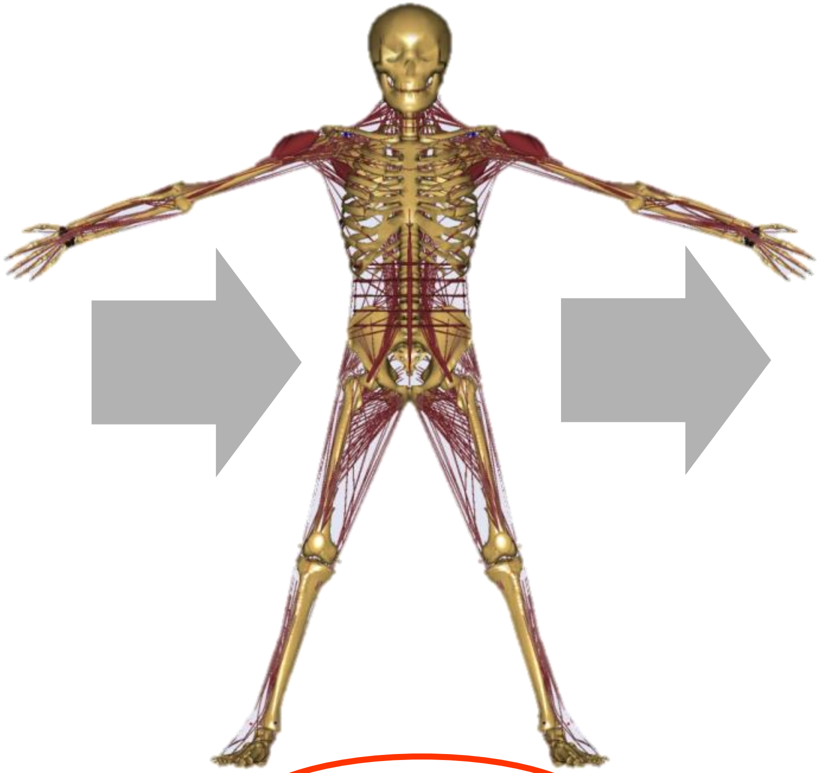
- Software/tool

- Body Model
- Library of applications

Musculoskeletal Simulation

Input

Activity/
Motion



Body Model

Bones

Joints

Muscles

Ligaments

Output

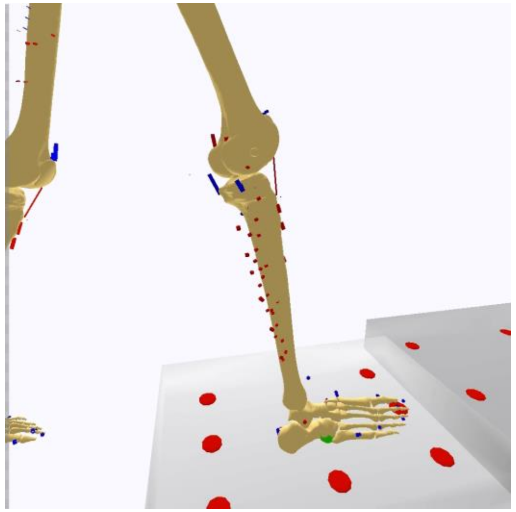
Muscles:
forces, activity, power
Joints:
forces, moments,
...

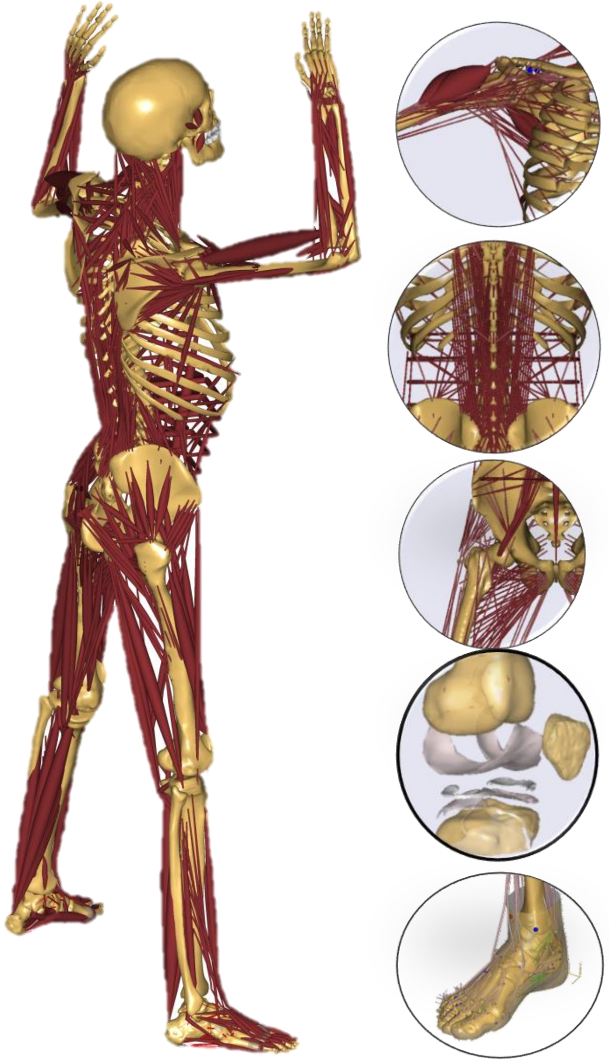
Inverse Dynamic Analysis

Input:

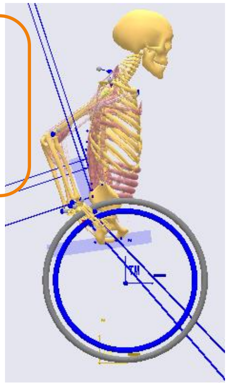
Motion & ext Forces:
- Motion Capture (Vicon, Qualisys, ...)
- Joint Angle Input

Output:
- Muscle Forces (activations)
- Joint Reaction Forces





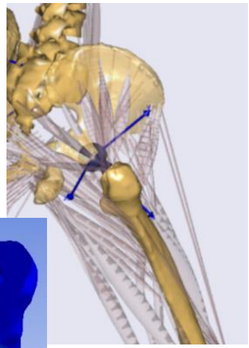
Product Design
Optimization

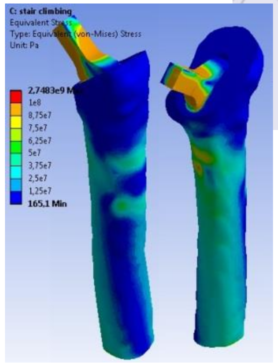


Gait Application
AnyGait

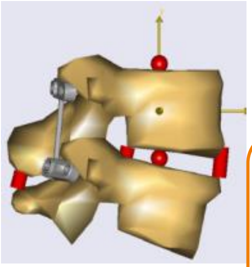
Ergonomic Analysis
and Documentation

ANYBODY
Modeling System



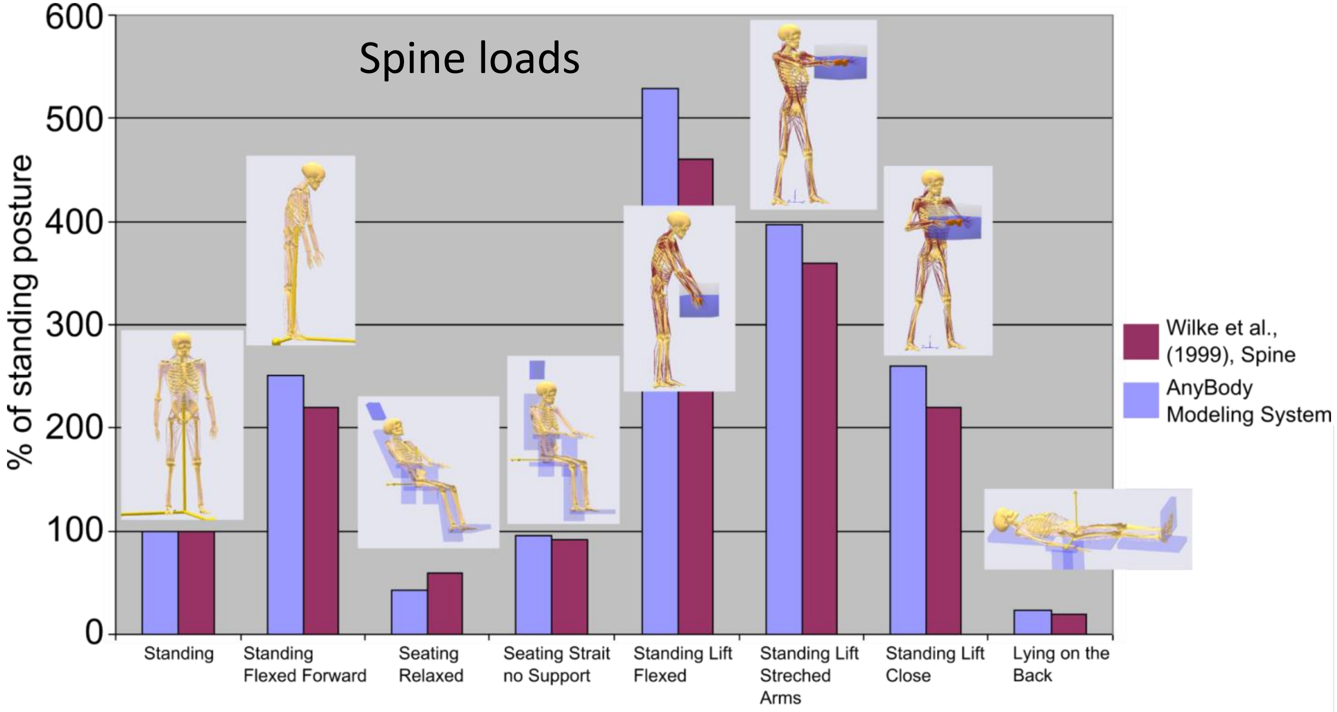


Physiological Loads
for FEA



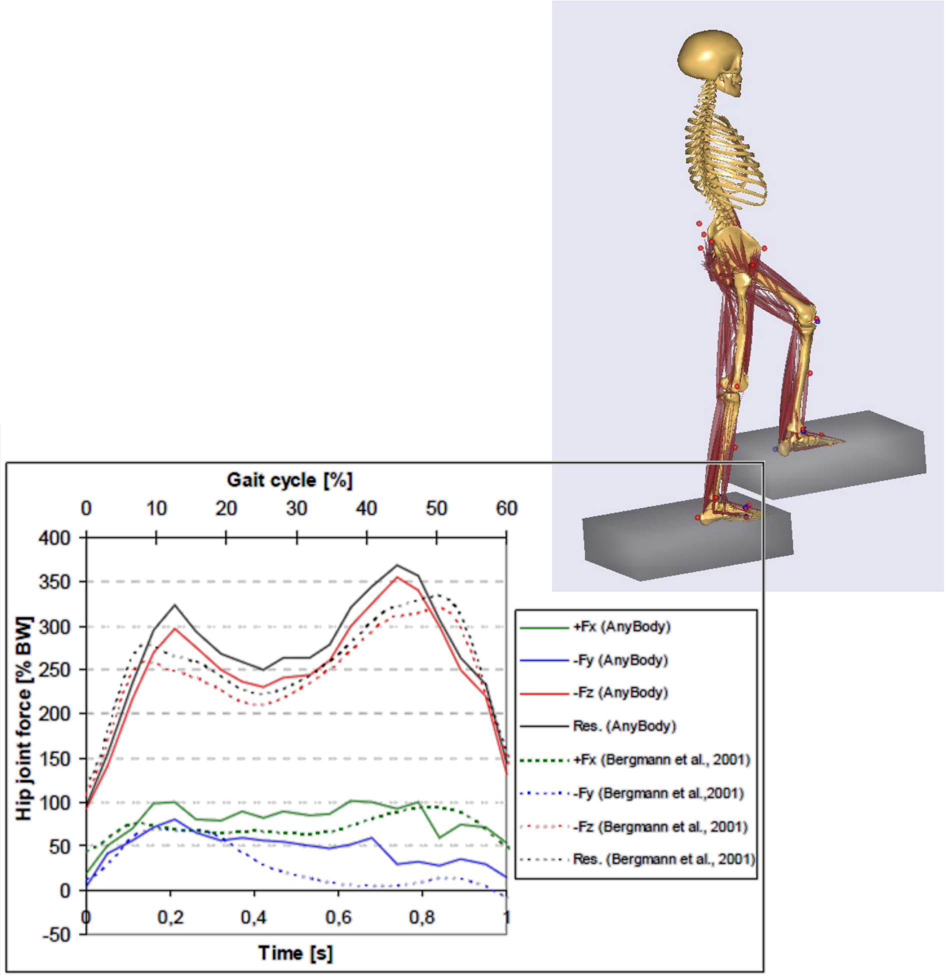
Surgical Planning, -
Evaluation & -Failure
Analysis

Validation



Rasmussen et al., 2009,

Thielen et al. 2009



anybodytech.com/index.php?id=publications, 300+ papers

Patrick Varady

2006 - 2011 Leibniz University Hannover, Germany Diploma (Dipl.-Ing.) in Mechanical Engineering

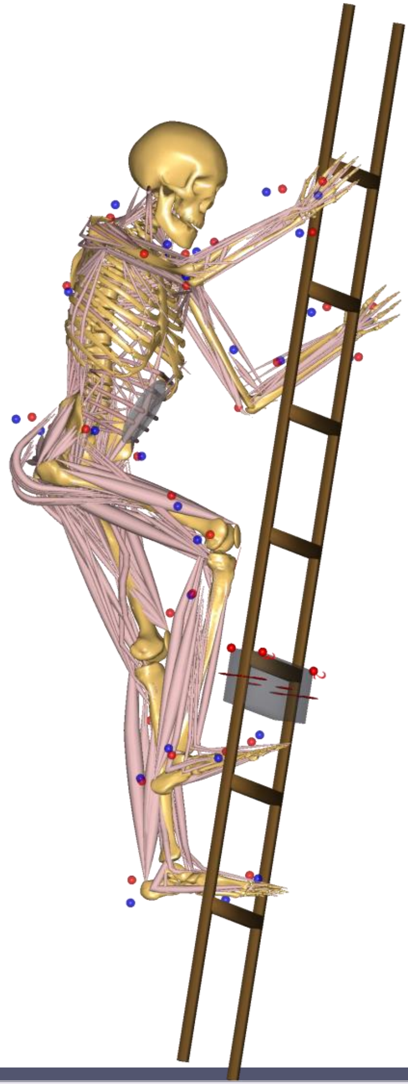
since 2012 Research Associate at the Institute of Biomechanics, Trauma Center Murnau, Germany

since 2013 Paracelsus Medical University Salzburg, Austria Postgraduate Program in Medical Science

Webcast:

Loads analysis of the hip joint for occupational activities

Patrick Varady, Dipl.-Ing.,
Trauma Center Murnau and
Paracelsus Medical University Salzburg



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Paracelsus Medizinische Privatuniversität Salzburg

Load Analysis of the Hip Joint for Occupational Activities

Varady, P. A.[1].; Glitsch, U.[2]; Augat, P.[1]

[1] Institute of Biomechanics, Trauma Center Murnau, Germany, and Paracelsus Medical University, Salzburg, Austria

[2] Institute for Occupational Safety and Health of the German Social Accident Insurance, Sankt Augustin, Germany

IFA
Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung

PARACELSUS
MEDIZINISCHE PRIVATUNIVERSITÄT

Structure

Introduction	• Main Question
Motion Capture	• Methods
Multibody Simulation	• Methods • Results
Finite Element Analysis	• Methods • Results
Discussion	• Limitations • Discussion • Conclusion

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Motivation: Hip Osteoarthritis

- prevalence 10.9%[1]
- 2.6 million work incapacity days in 2011[2]
- €7.6 billion direct costs in the German health care system in 2008[2] (including all osteoarthritic diseases)
- additional costs from early retirements

→ **high socioeconomic relevance**

- Is there an association between occupational activities and the osteoarthritis of the hip?
- epidemiological evidence can be found in the literature[3]

[1] D. Pereira, B. Peleteiro, et al. The effect of osteoarthritis definition on prevalence and incidence estimates: A systematic review. *Osteoarthritis and Cartilage* 2011, 19(11):1270-1285.
[2] Robert Koch-Institut (2013) Arthrose, *Reihe Gesundheitsberichterstattung des Bundes*, Volume 54. Berlin. www.gbe-bund.de. Accessed: 24.10.2013
[3] Sulsky, S. I., Carlton, L., Bochmann, F., Ellegast, R., Glitsch, U., Hartmann, B., … Sun, Y. (2012). Epidemiological evidence for work load as a risk factor for osteoarthritis of the hip: a systematic review. PloS One, 7(2), e31521.

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Analysis of occupational and everyday activities

Will certain occupational activities generate higher hip joint loads than everyday activities?

risk associated activities:

- lifting, carrying and transferring weights (25kg, 40kg, 50kg)
- stair climbing (without weight, with 25kg)
- ladder climbing (angle of 70° and 90°)

⟷

activities of daily living:

- walking
- sitting down, getting up

Structure

Introduction	• Main Question
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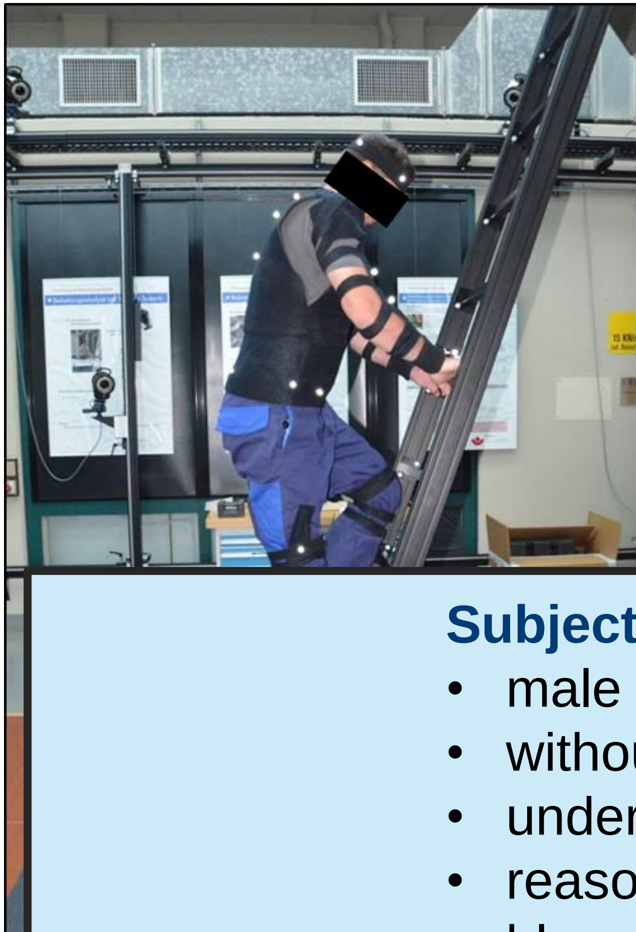
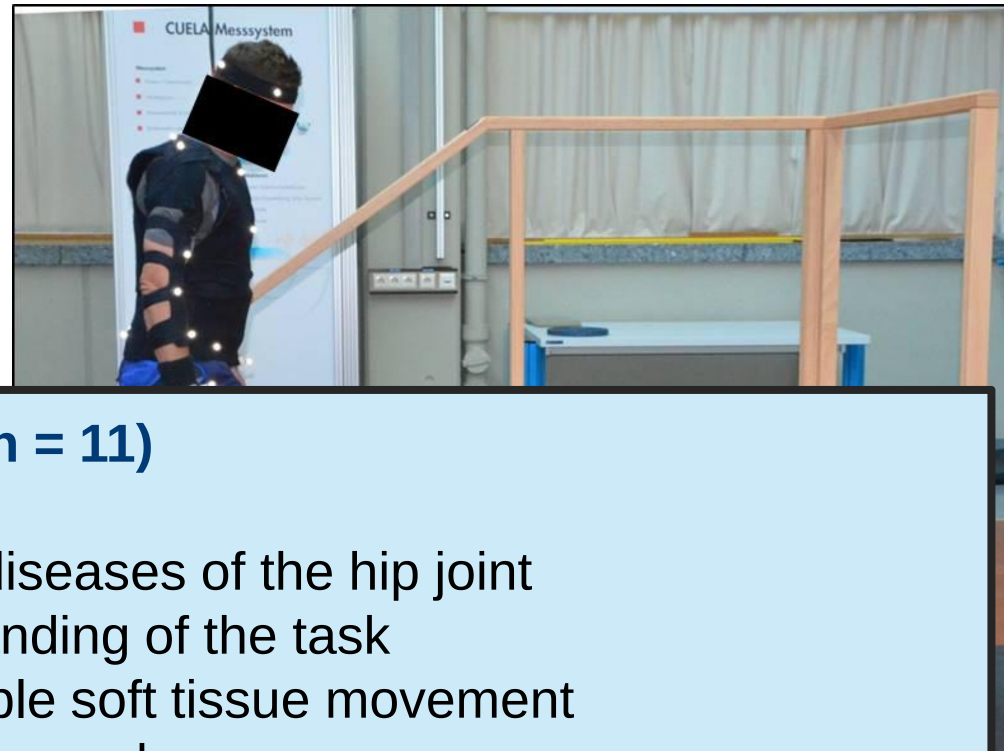
Motion capture, ground reaction forces



- 12-camera-system (Vicon Motion Systems, Oxford, GBR)
- force plates (Kistler Instrumente AG, Winterthur, CH)
- instrumented staircase and ladder (Kistler Instrumente AG, Winterthur, CH)



Subjects (n = 11)

- male
- without diseases of the hip joint
- understanding of the task
- reasonable soft tissue movement
- blue collar workers

Structure

Introduction	• Main Question
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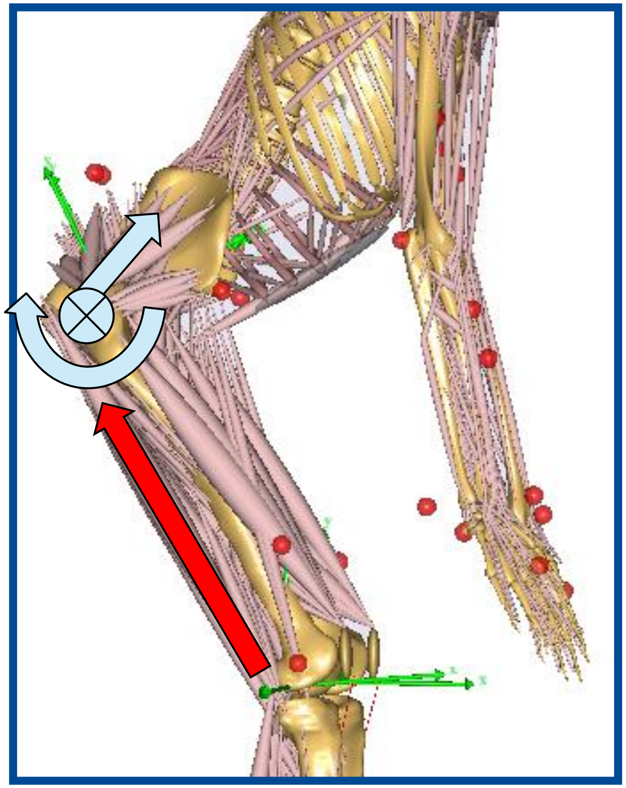
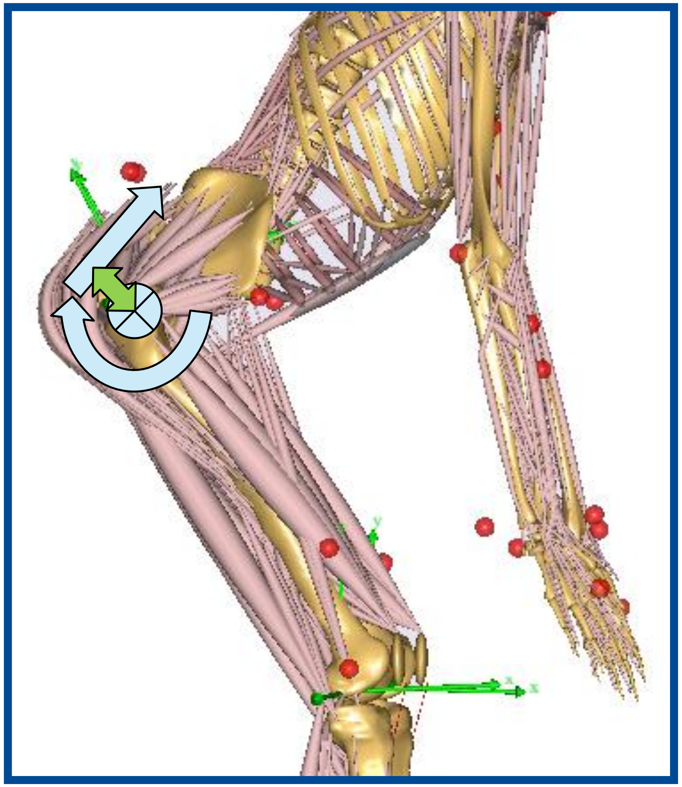
AnyBody model

- human multibody simulation with AnyBody 6.01 (AnyBody Technology A/S, Aalborg, DK)
- AMMR v1.6: MocapModel_FullBody
- modified hip extensors
- anthropometric scaling
- limitation of parametric optimisation
- save data in H5-file format

AnyBody model: wrapping extensors

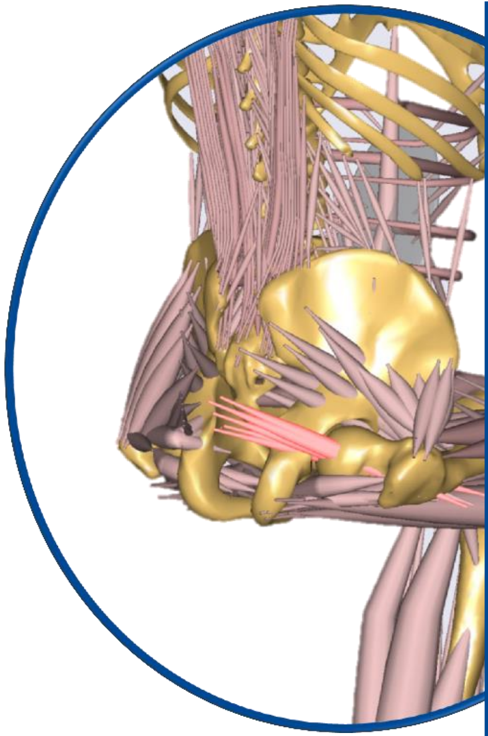


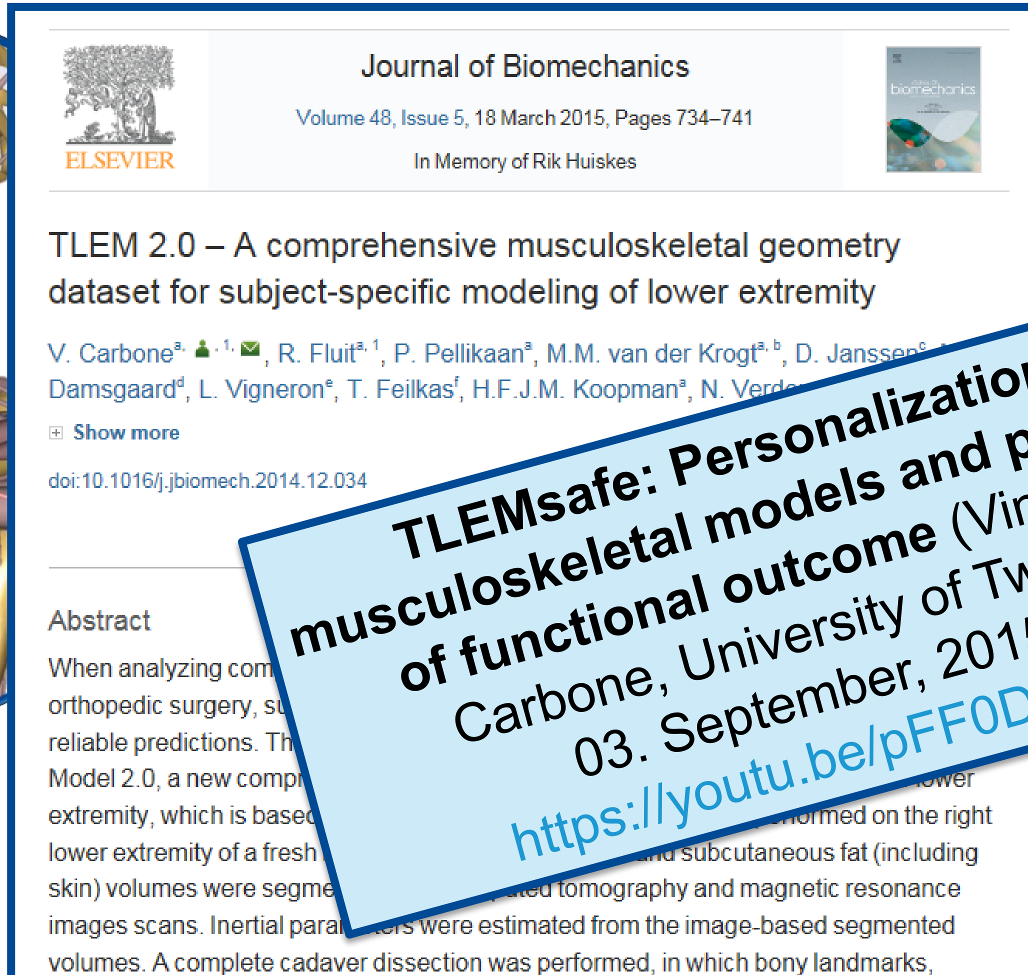
standard model



modified model

AnyBody model: wrapping extensors





Journal of Biomechanics

Volume 48, Issue 5, 18 March 2015, Pages 734–741

In Memory of Rik Huiskes

TLEM 2.0 – A comprehensive musculoskeletal geometry dataset for subject-specific modeling of lower extremity

V. Carbone[a, 1], R. Fluit[a, 1], P. Pellikaan[a], M.M. van der Krogt[a, b], D. Janssen[c], ... Damsgaard[d], L. Vigneron[e], T. Feilkas[f], H.F.J.M. Koopman[a], N. Verd...

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doi:10.1016/j.jbiomech.2014.12.034

Abstract

When analyzing com... orthopedic surgery, su... reliable predictions. Th... Model 2.0, a new compr... ...ower extremity, which is based ...ormed on the right lower extremity of a fresh ... subcutaneous fat (including skin) volumes were segme... ...ted tomography and magnetic resonance images scans. Inertial para... ...ers were estimated from the image-based segmented volumes. A complete cadaver dissection was performed, in which bony landmarks,

TLEMsafe: Personalization of musculoskeletal models and prediction of functional outcome (Vincenzo Carbone, University of Twente, 03. September, 2015)
https://youtu.be/pFF0DIqtrvg

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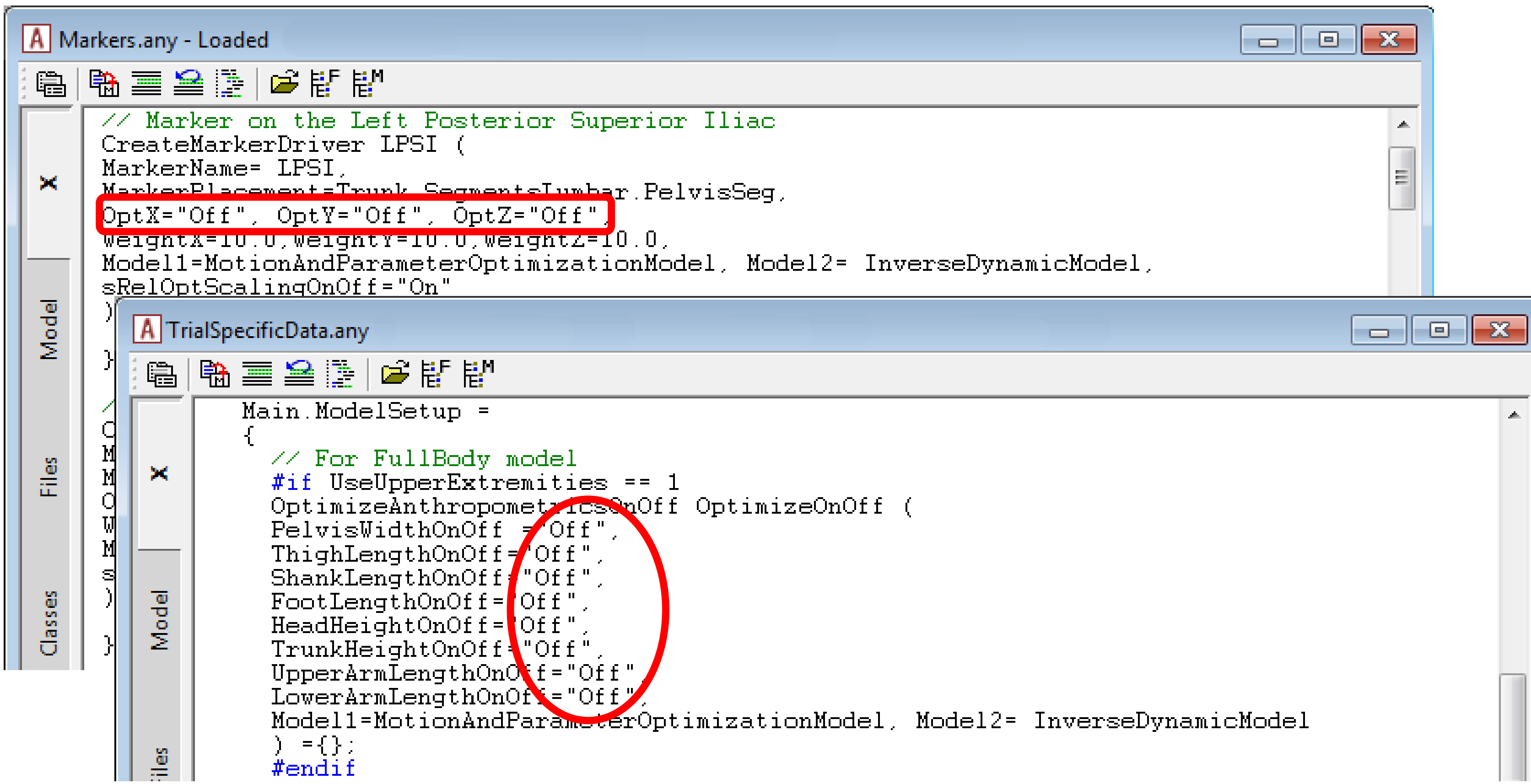
AnyBody model: parameter optimisation

- for one test person the same anthropometry and marker placement was used for every trial



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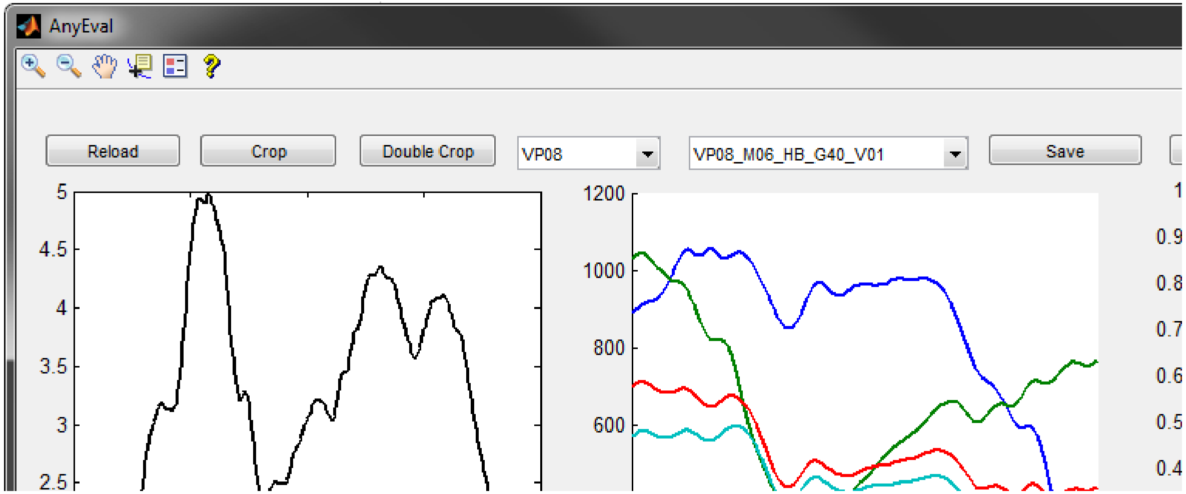
Processing H5-files

- Matlab R2014a (Mathworks Inc., Natick, US-MA)
- import hip joint forces of every H5-file of every test person
- trim the trials to functional time intervalls (e.g. gait cycle, step)
- find maximum loads, calculate means, export for dynamic time warping[4]



graphical user interface in Matlab

[4]Bender A., Bergmann G., Determination of Typical Patterns from Strongly Varying Signals, Comput Methods Biomech Biomed Engin. 2012;15(7):761-9

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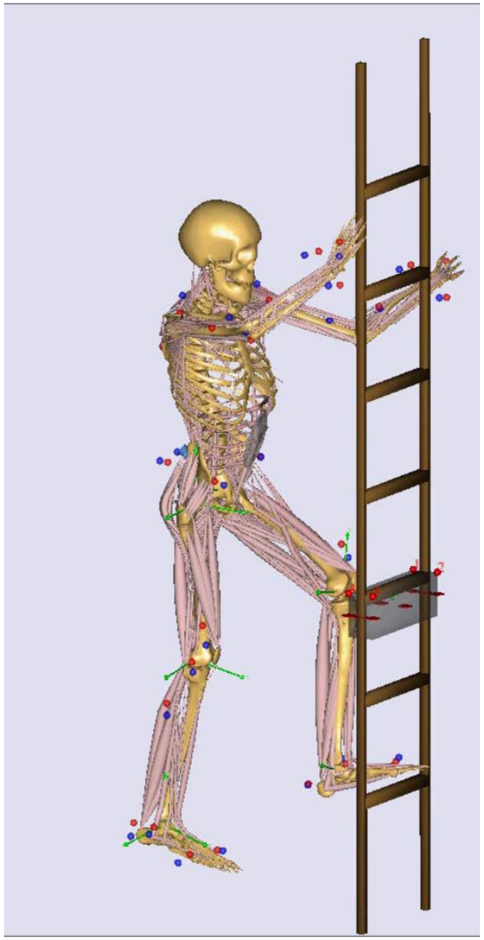
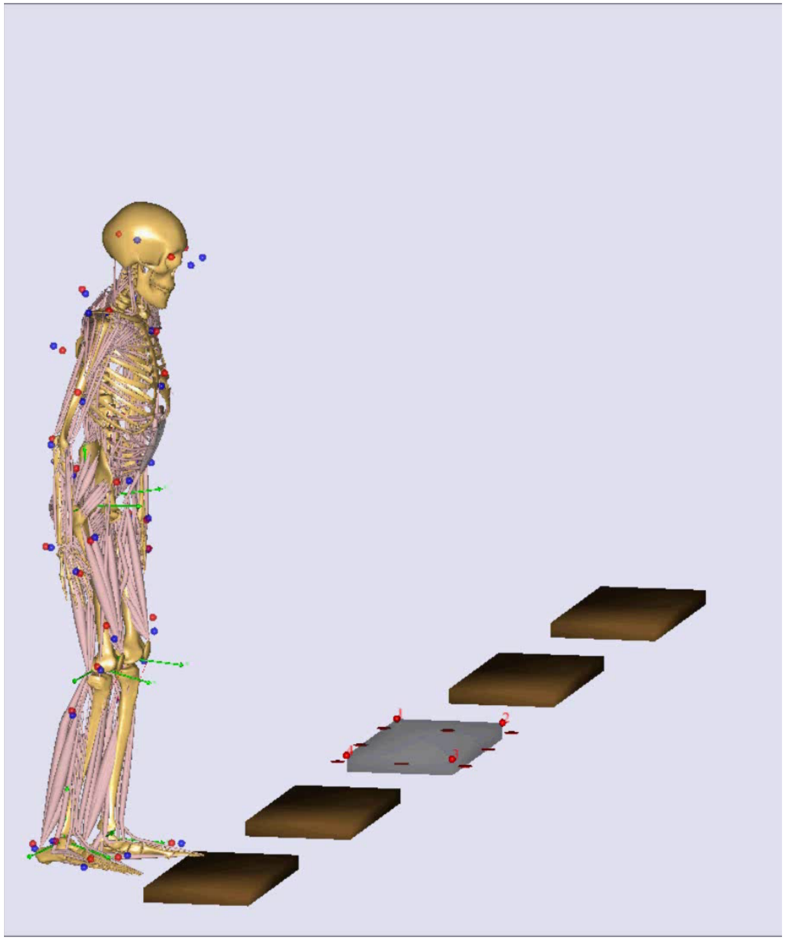
AnyBody multibody simulation

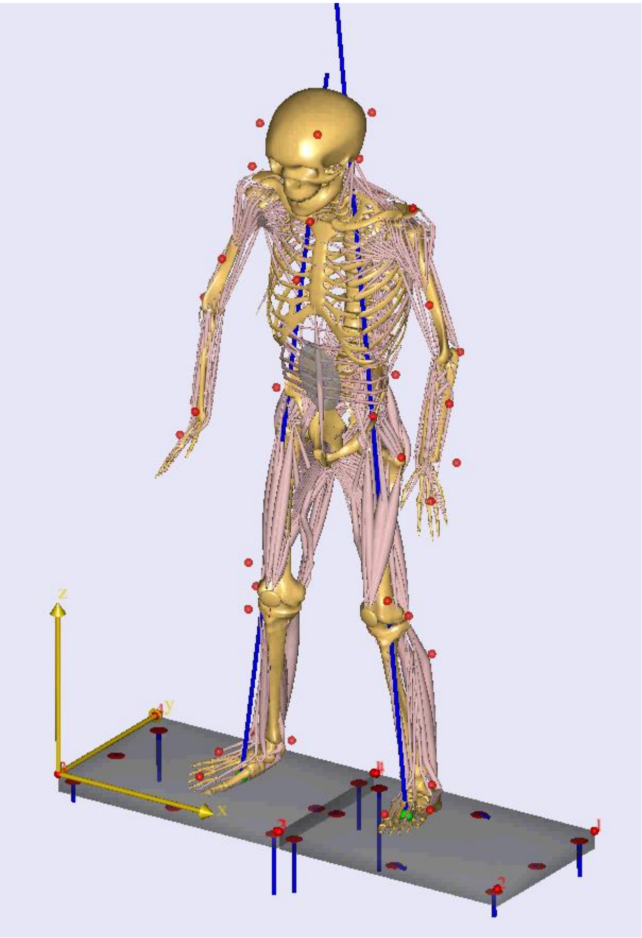


ladder climbing in AnyBody



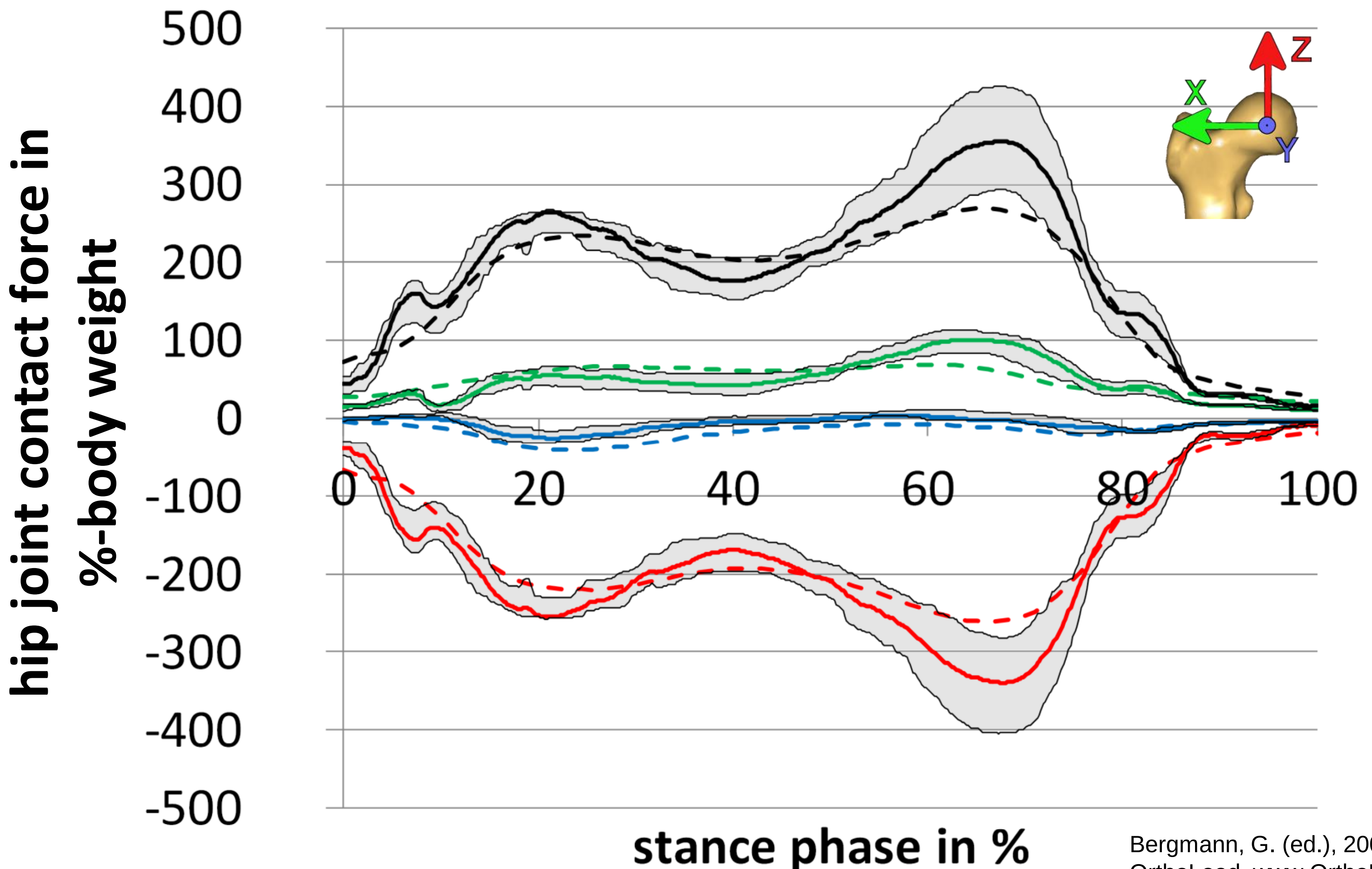
stair climbing in AnyBody

AnyBody multibody simulation



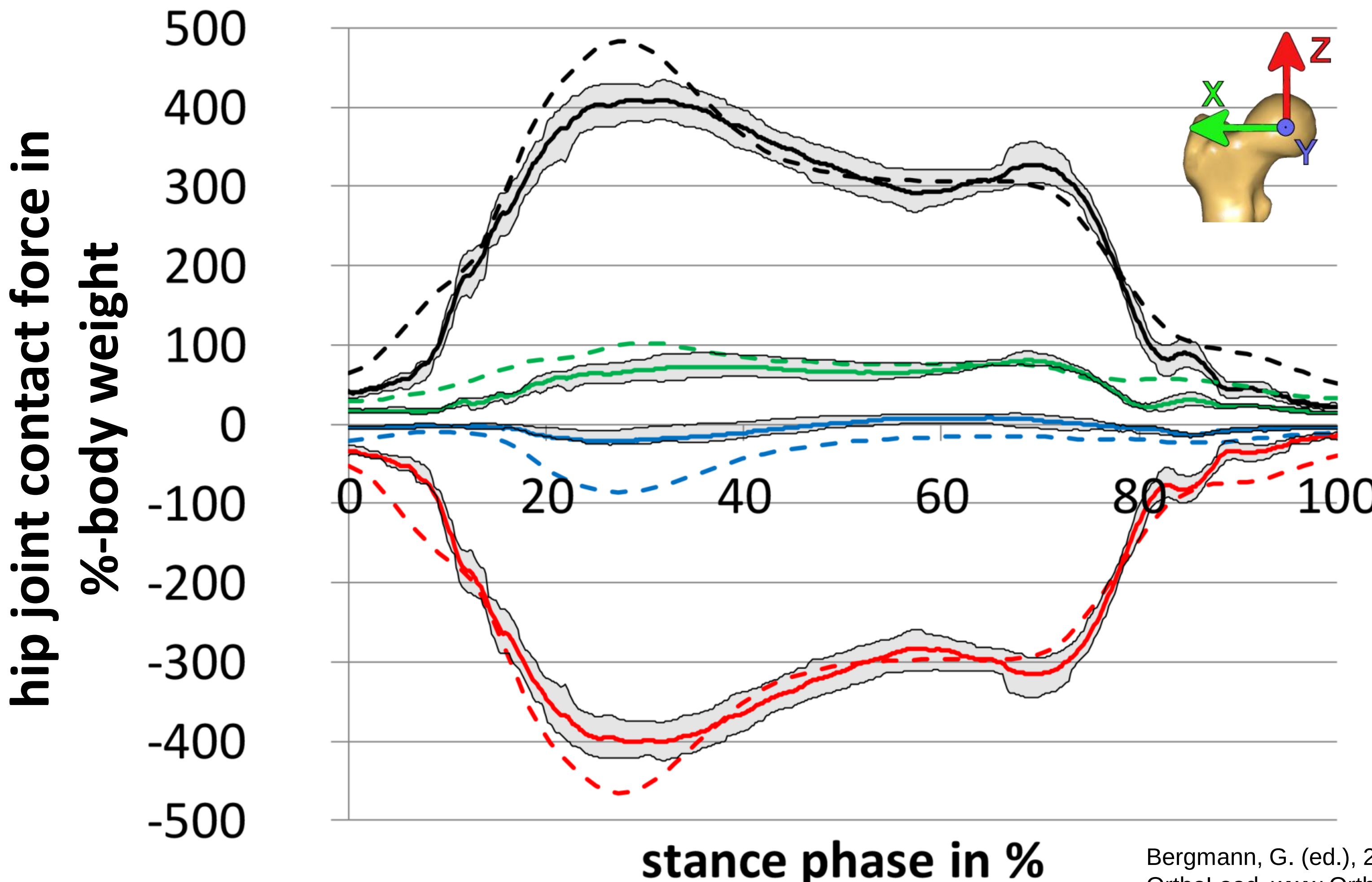
sitting down in AnyBody

Gait



Bergmann, G. (ed.), 2008. OrthoLoad. www.OrthoLoad.com: h2r_151110_1_184

Carrying 25kg



Bergmann, G. (ed.), 2008. OrthoLoad. www.OrthoLoad.com: h2r_100611_1_68

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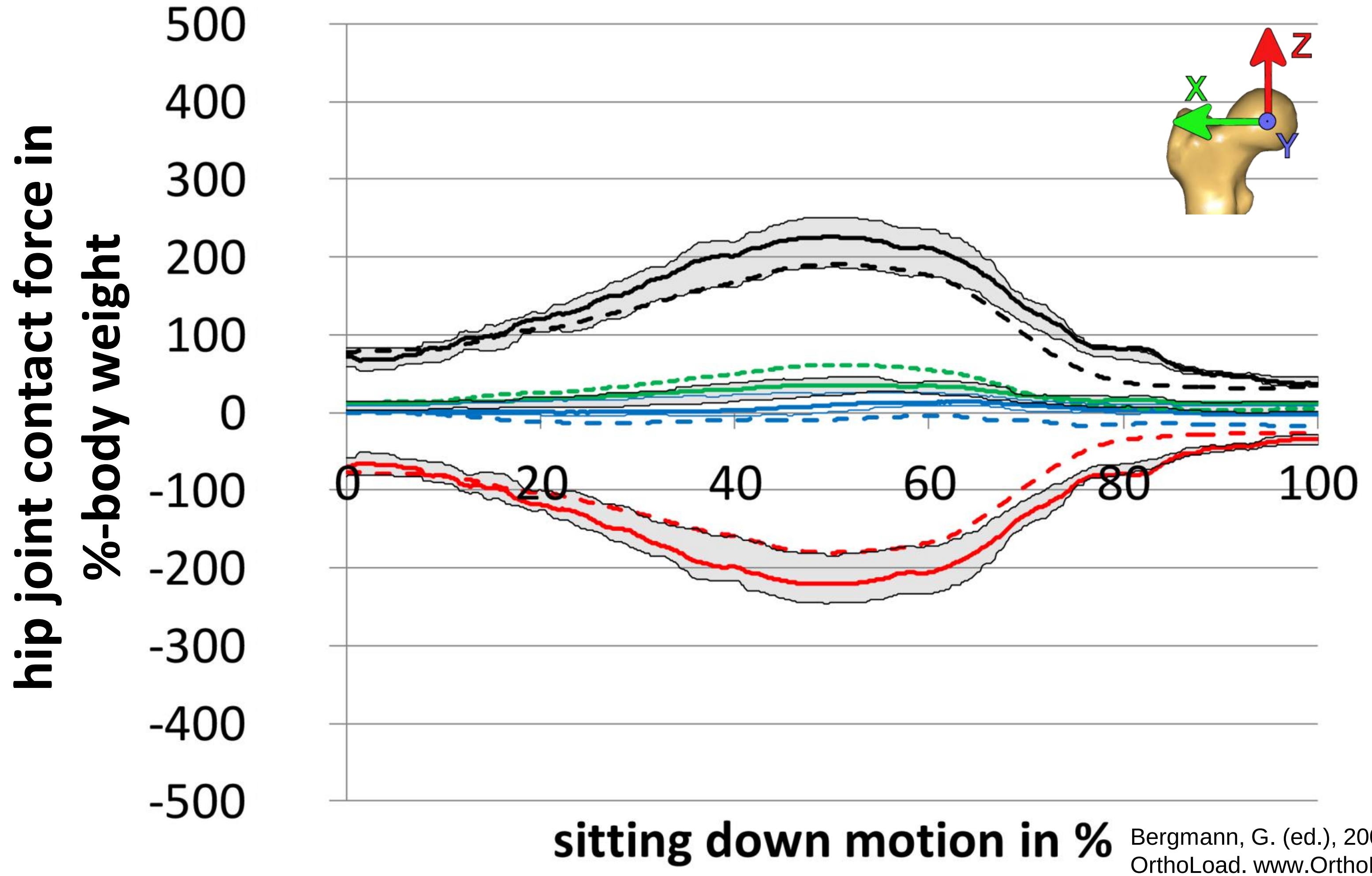
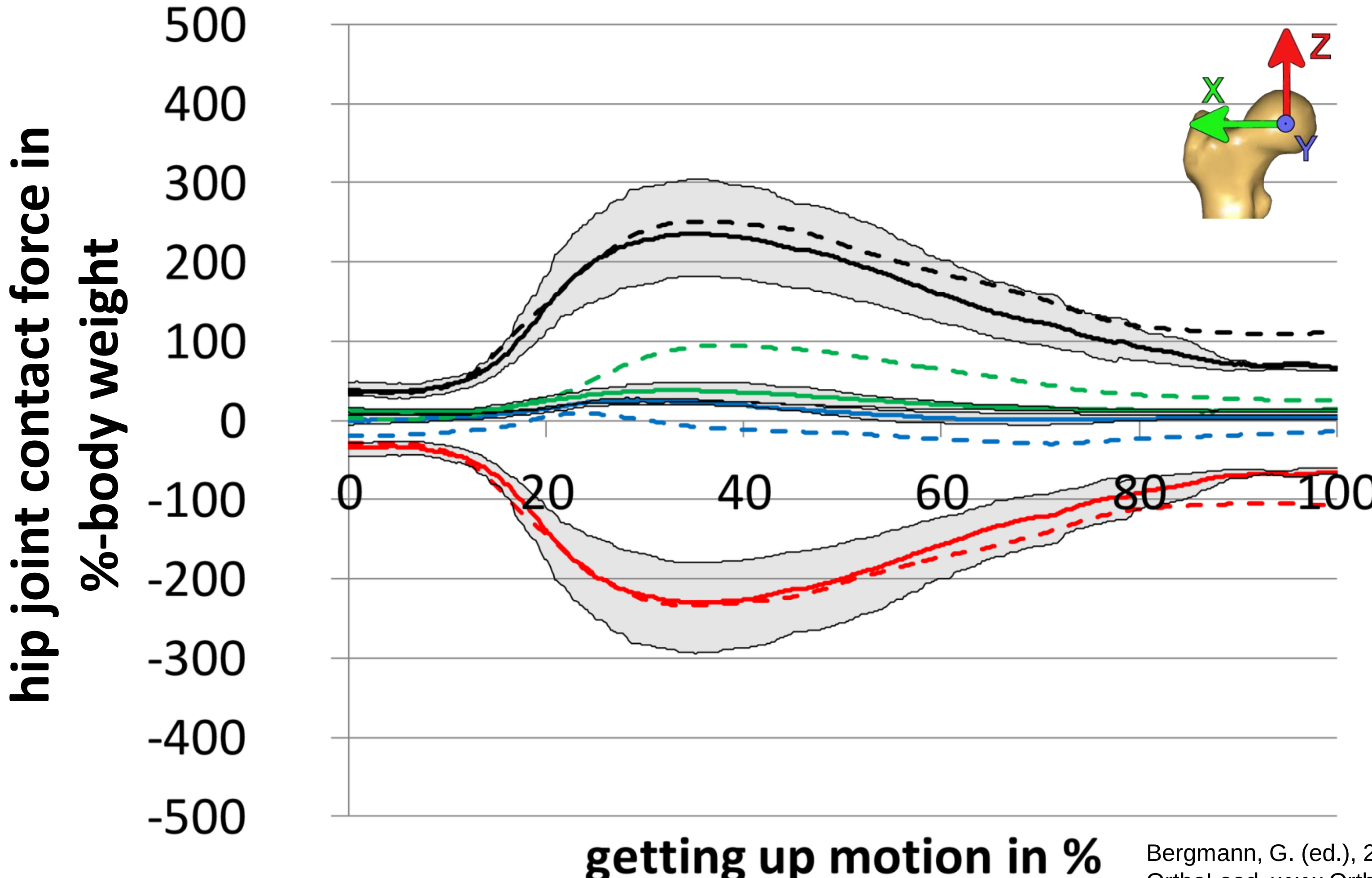
Sitting down



Bergmann, G. (ed.), 2008. OrthoLoad. www.OrthoLoad.com: IBL721A

Getting up



Bergmann, G. (ed.), 2008. OrthoLoad. www.OrthoLoad.com: IBL721A

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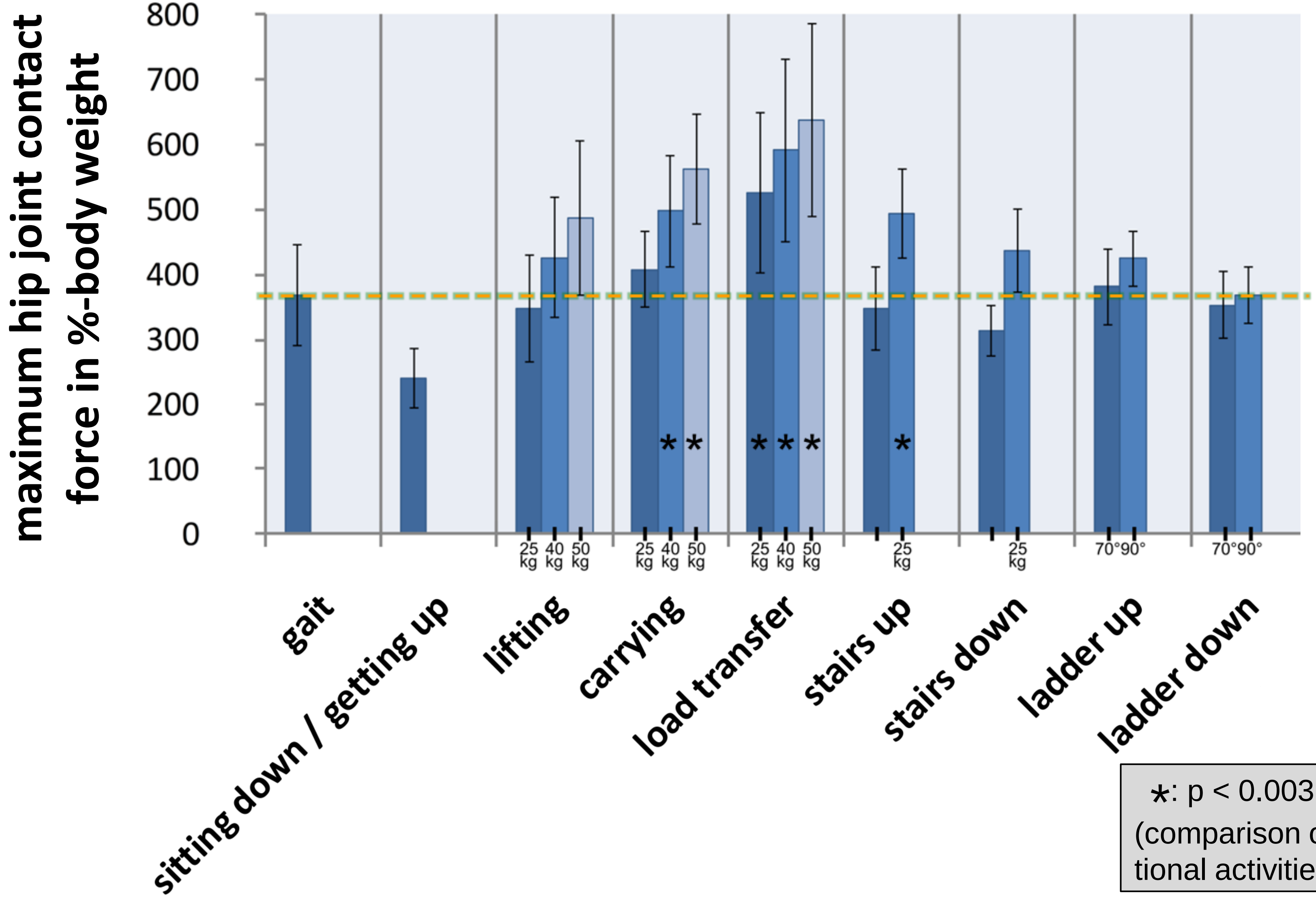
Maximum hip joint contact forces for all activities



*: $p < 0.003$
(comparison of occupational activities to gait)

ELSEVIER
Journal of Biomechanics
Available online 6 July 2015
In Press, Corrected Proof — Note to users

Loads in the hip joint during physically demanding occupational tasks: A motion analysis study

Patrick Aljoscha Varady[a], Ulrich Glitsch[b], Peter Augat[a]

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doi:10.1016/j.jbiomech.2015.06.034

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Abstract

Epidemiolo… …ible connection between … …disease. This study investigated the … …manding occupational tasks (lifting, carrying, … …ass: 25 kg, 40 kg and 50 kg); stair climbing without and with … of 25 kg; ladder climbing) and compared these with everyday activities (level gait, sitting down and getting up). The hip joint contact force was calculated with the human multibody simulation software AnyBody employing motion capture and ground reaction force measurements by force plates and an instrumented staircase and ladder.

Structure

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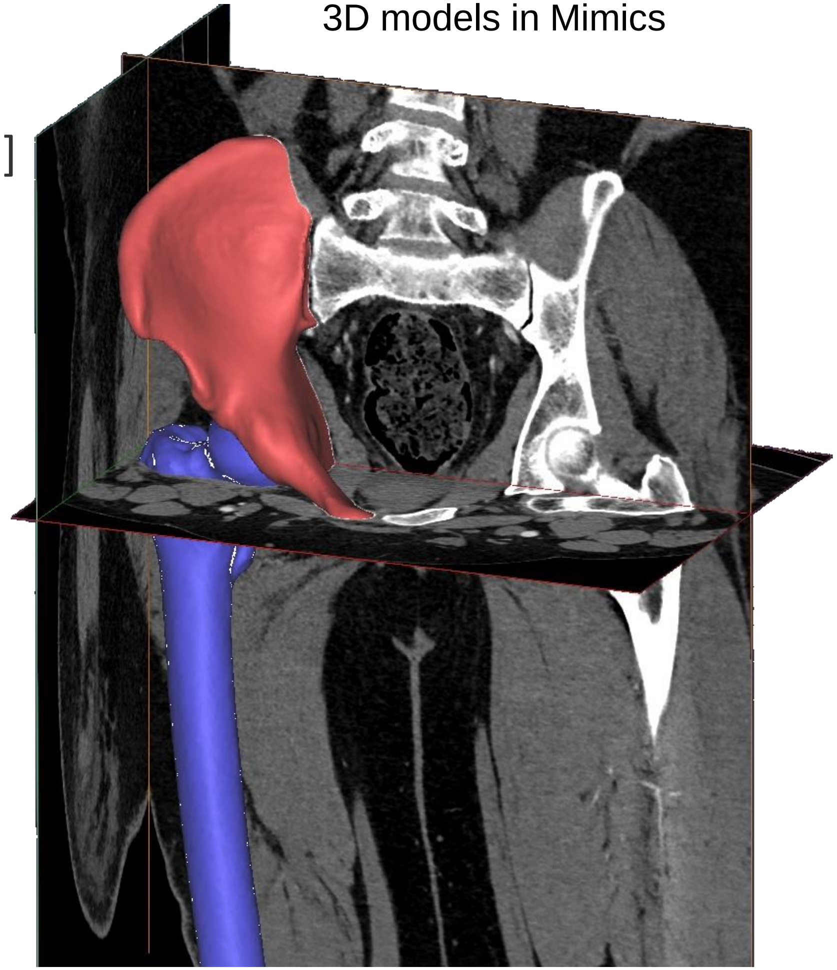
Segmentation of CT data

- Mimics 16.0 (Materialise NV, Leuven, BE)
- CT arthrogram with cartilage[5]
- semi automatic segmentation (> 200 HU)

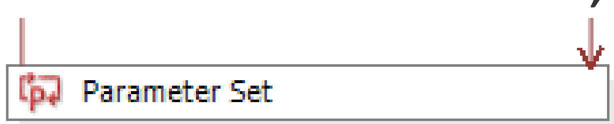
3D models in Mimics



[5] Harris MD, Anderson AE, Henak CR, Ellis BJ, Peters CL, Weiss JA: Finite element prediction of cartilage contact stresses in normal human hips. Journal of Orthopaedic Research, 30(7), 2012.

Model

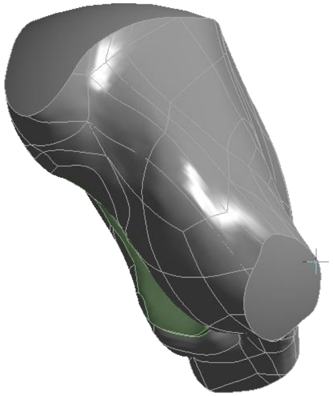
- simulation of AnyBody load cases in ANSYS Workbench 16.1 (ANSYS Inc., Canonsburg, US-PA)
- AnyBody geometries and segmented geometries were superimposed while maintaining the hip joint rotation center
- this allowed the use of the AnyBody results as parameter sets in ANSYS workbench (rotational orientation, hip joint load)



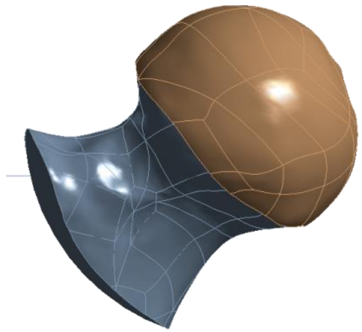
AnyBody femur and segemented femur superimposed in ANSYS Design Modeler

Model

- limit the model to the region of interest
- pelvis with fixed support
- remote load on the cut surface of the femur located as remote point in joint rotation center
- cartilage: hyperelastic (μ=5.52MPa, K=550MPa)[6]
- bone: linear isotropic (E=17GPa, ν=0.3)
- contacts: bonded and frictional (μ=0.04)



trimmed pelvis in ANSYS

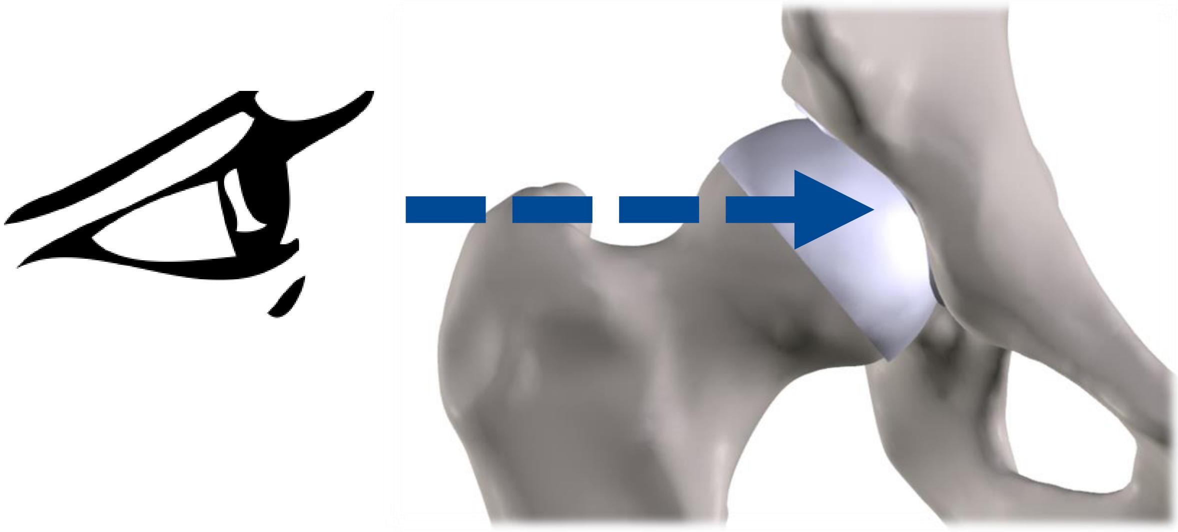


trimmed femur in ANSYS

[6] Henak, C. R., Ateshian, G. A., & Weiss, J. A. (2014). Finite element prediction of transchondral stress and strain in the human hip. *Journal of Biomechanical Engineering*, *136*(2), 021021. http://doi.org/10.1115/1.4026101

FEA: Results

results are displayed as a view of the right acetabulum from lateral



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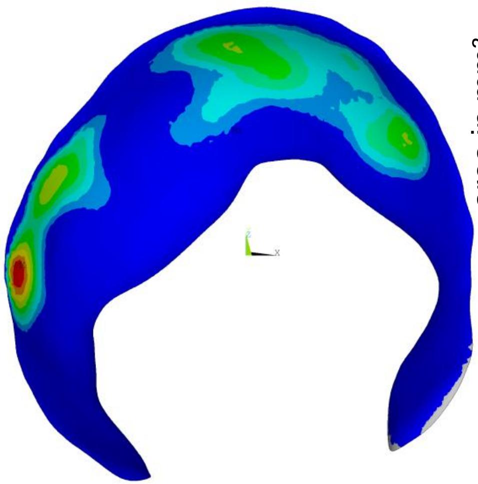
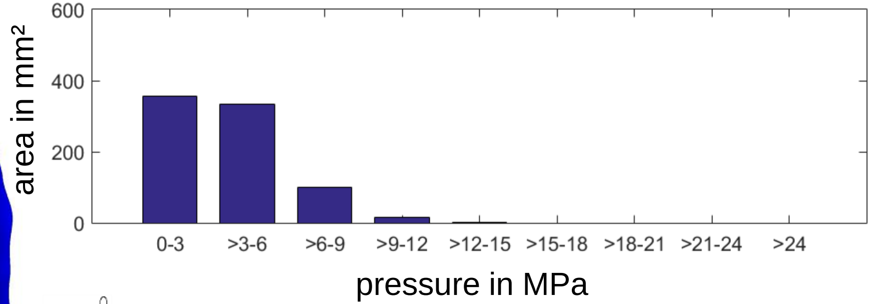
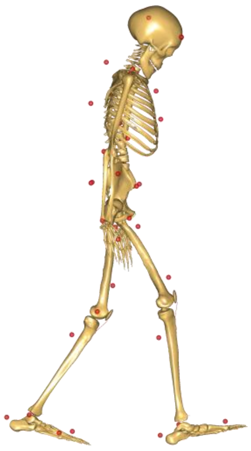
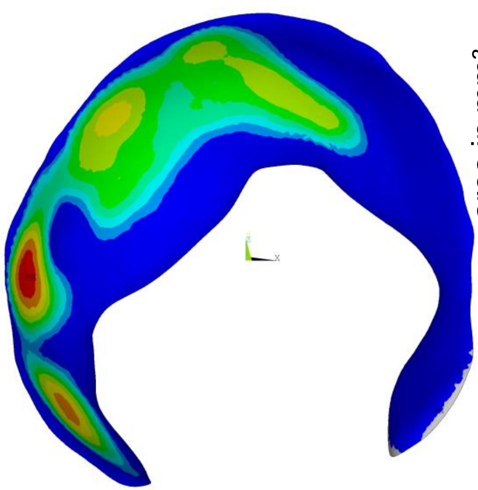
Contact pressures: gait and carrying 50kg

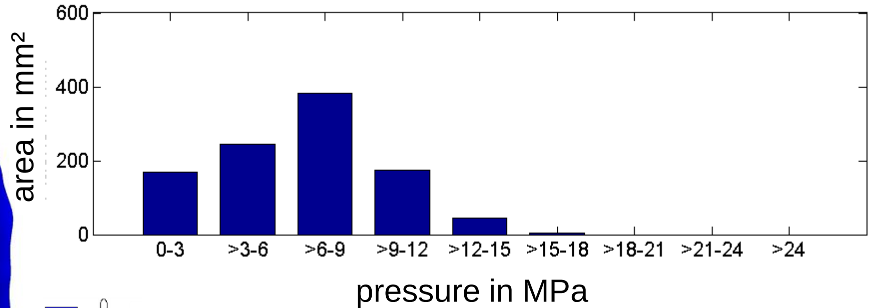


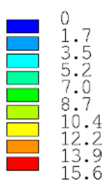


Contact pressure distribution (MPa) in the right acetabulum for gait (first peak). View from lateral.

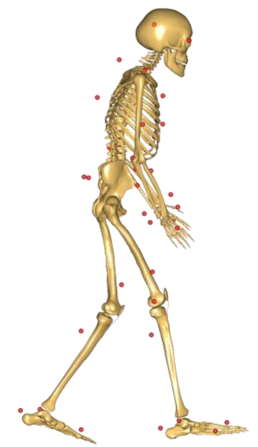








Contact pressure distribution (MPa) in the right acetabulum for carrying 50kg (time of maximum force). View from lateral.



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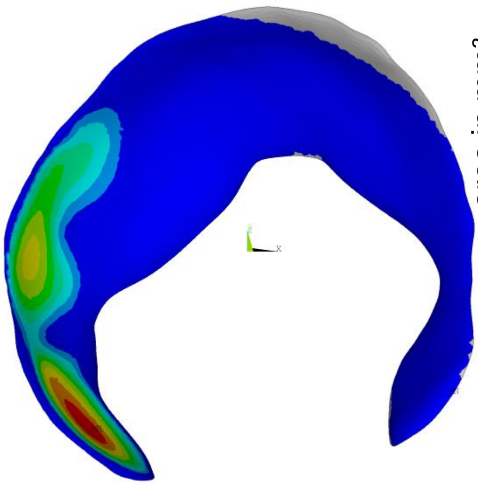
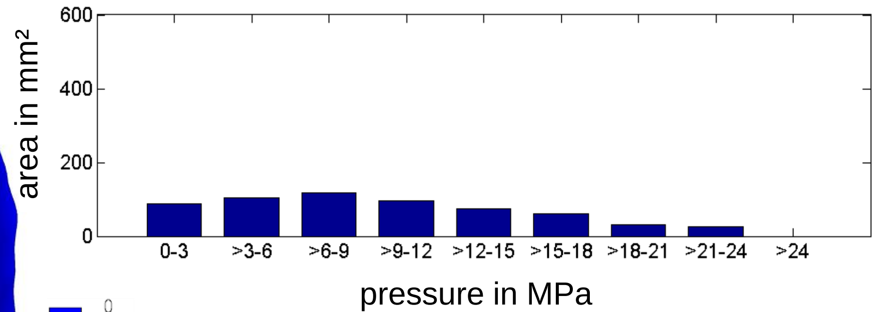
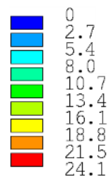
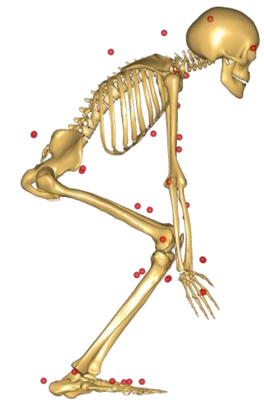
Contact pressures: lifting 50kg, stairs up 25kg

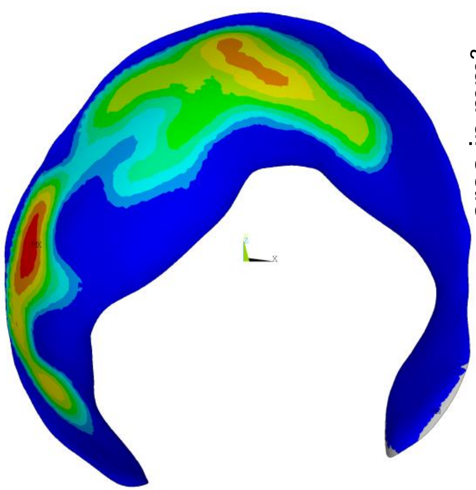


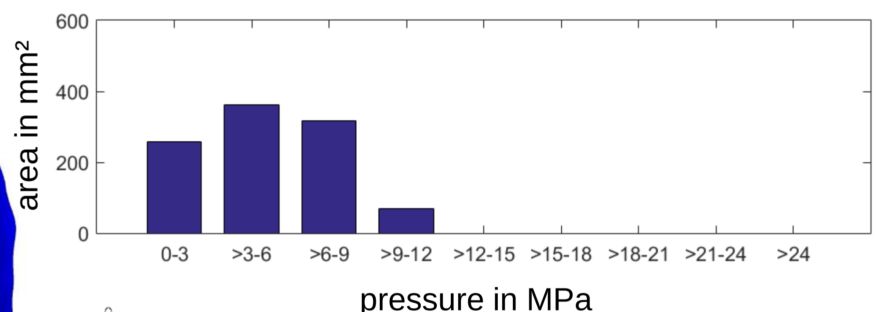


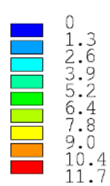


Contact pressure distribution (MPa) in the right acetabulum for lifting 50kg (time of maximum force). View from lateral.









Contact pressure distribution (MPa) in the right acetabulum for climbing stairs with 25kg (time of maximum force). View from lateral.

Structure

Introduction	• Main Question
Motion Capture	• Methods
Multibody Simulation	• Methods • Results
Finite Element Analysis	• Methods • Results
Discussion	• Limitations • Discussion • Conclusion

Limitations

- MBS models did not incorporate the test persons' own bone geometries
- simplified FEA model
- FEA geometry is not test person specific either
- FEA is only validated in comparison to previously published studies

Discussion

- AnyBody data agrees with in-vivo data
- AnyBody results are comparable to previous studies[7,8]
- FEA data agrees with other studies[9]
- no specific detrimental mechanism, no relationship of hip-joint load and osteoarthritis

[7] Kunze, M., Schaller, A., Steinke, H., Scholz, R., Voigt, C., 2012. Combined multi-body and finite element investigation of the effect of the seat height on acetabular implant stability during the activity of getting up. Comput. Methods Progr. Biomed. 105, 175–182.
[8] Weber, T., Al-Munajjed, A.A., Verkerke, G.J., Dendorfer, S., Renkawitz, T., 2014. Influence of minimally invasive total hip replacement on hip reaction forces and their orientations. J. Orthop. Res.: Off. Publ. Orthop. Res. Soc. 32, 1680–1687.
[9] Henak, C. R., Kapron, A. L., Anderson, A. E., Ellis, B. J., Maas, S. A., & Weiss, J. A. (2014). Specimen-specific predictions of contact stress under physiological loading in the human hip: validation and sensitivity studies. Biomechanics and Modeling in Mechanobiology, 13(2), 387–400.

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Conclusion

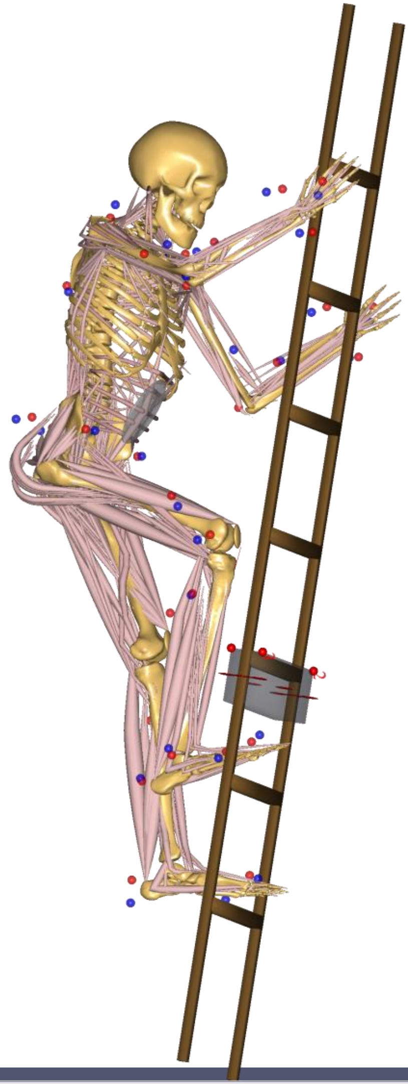
- relation of the loads for the different activities
  - e.g. gait (368 %-BW) vs.
    load transfer of 50kg (637 %-BW) and
    carrying of 50 kg (570 %-BW)
- highest loads have been found for activities involving one legged stance phases and the carrying of the additional weight
- results provide an orientation for epidemiological research

This research project was supported by a grant provided by the German Social Accident Insurance.

Webcast:

Loads analysis of the hip joint for occupational activities

Patrick Varady, Dipl.-Ing.,
Trauma Center Murnau and
Paracelsus Medical University Salzburg



AnyBody events

- 10 Nov - Webcast:
  Loading an aircraft: Validation of the lumbar spine model and analysis of lumbar loads in airport baggage handlers

www.anybodytech.com

- *Events, dates, publication list, ...*

www.anyscript.org

- *Wiki, forum*

www.youtube.com/anybodytech

- *Videos, webcasts, help, demos, tips & tricks*

Upcoming webinar:

Loading an aircraft: Validation of the lumbar spine model and analysis of lumbar loads in airport baggage handlers"

Assistant professor
Henrik Koblauch, Ph.D.
School of Physiotherapy UCC

<ins>Save date: November 10, 2015</ins>

Presentation:

- Validation of the lumbar spine model for estimating lumbar loading in lifting tasks.
- Musculoskeletal modeling of baggage handlers working inside the luggage compartment of a Boeing 737-800.