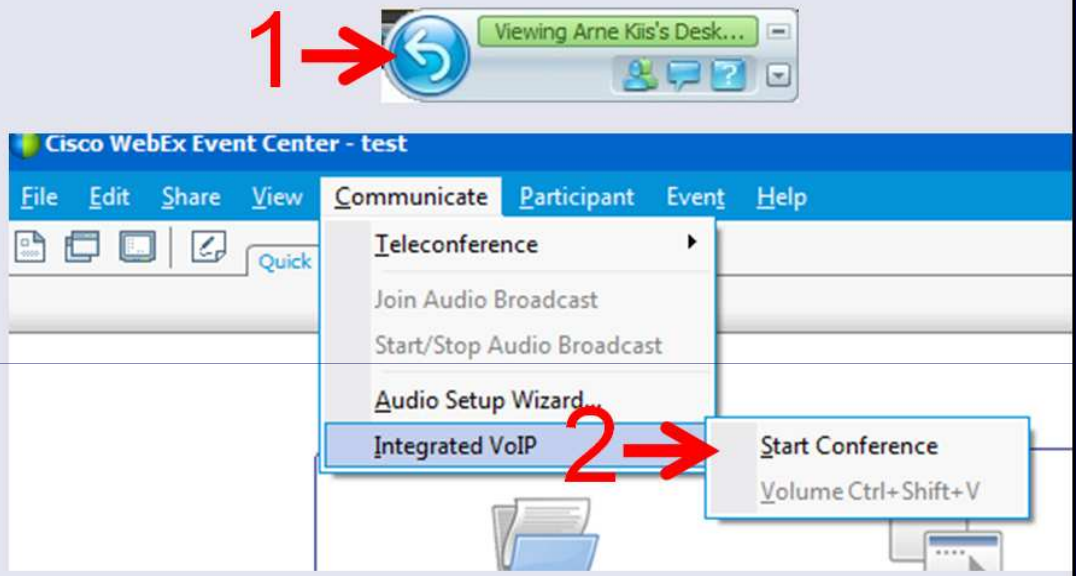
Audio set-up:

During logon

During session

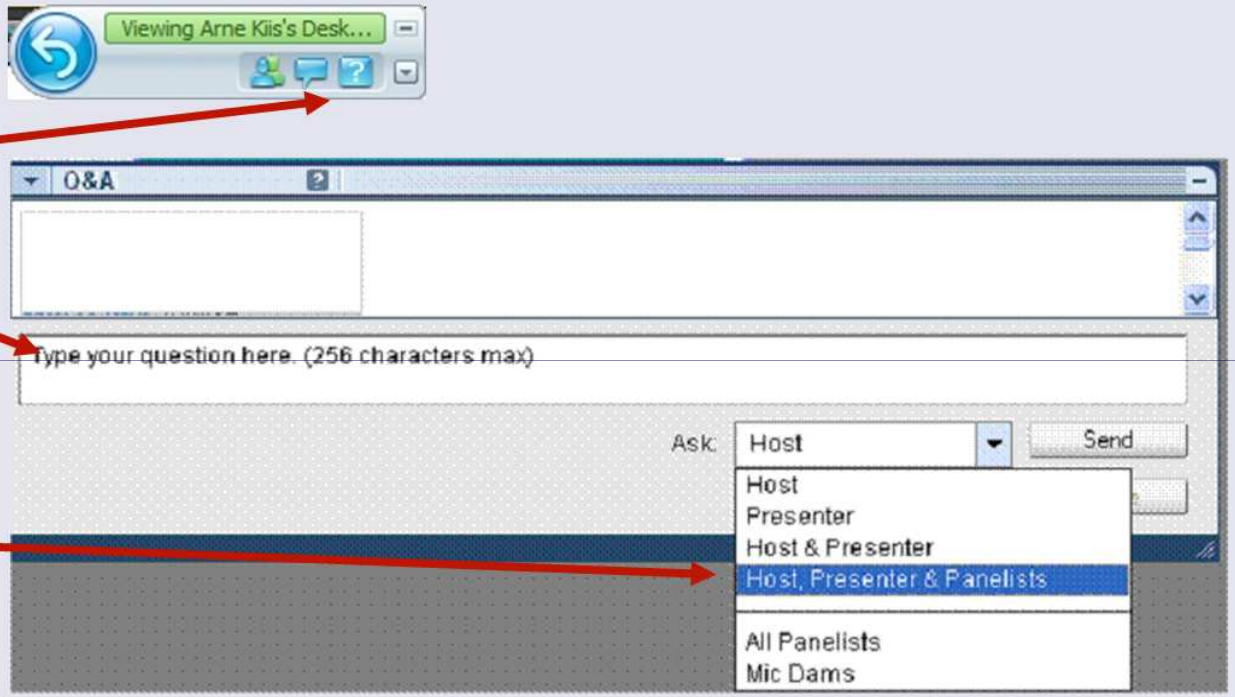


The web cast will start in a few minutes….

ANYBODY TECHNOLOGY

Q&A Panel

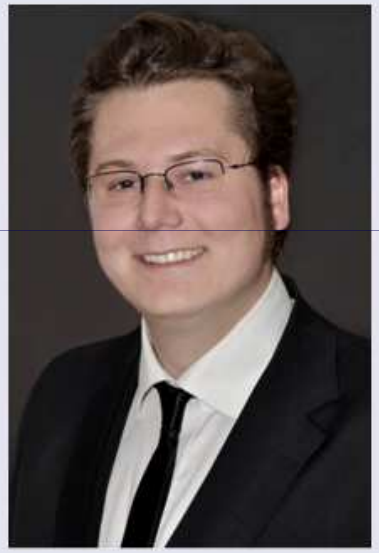
- Launch the Q&A panel from the menu bar.
- Type in your question.
- Send your question to ”Host, Presenter & Panelists”



Notice the answer displays next to the question in the Q&A box. You may have to scroll up to see it.

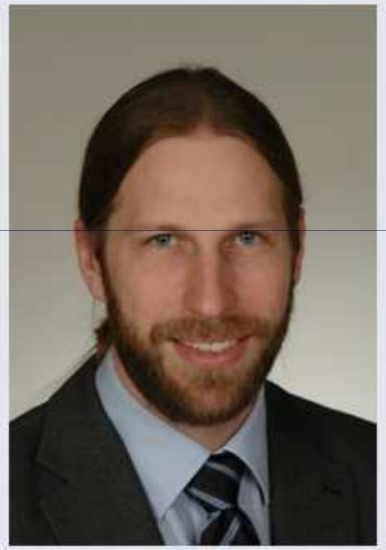
ANYBODY TECHNOLOGY

People



Tim Weber
Presenter

Arne Kiis
Host



Sebastian
Dendorfer
Host

Orthopaedic Clinic for the University Regensburg
at the Asklepios Clinic Bad Abbach

ORTHOPÄDISCHE KLINIK
UNIVERSITÄT REGENSBURG

Functional outcome analyses of navigated minimally invasive total hip endoprosthesis using musculoskeletal modeling

Tim Weber, Dipl. Ing(FH),** (weber.tim@o2online.de)*

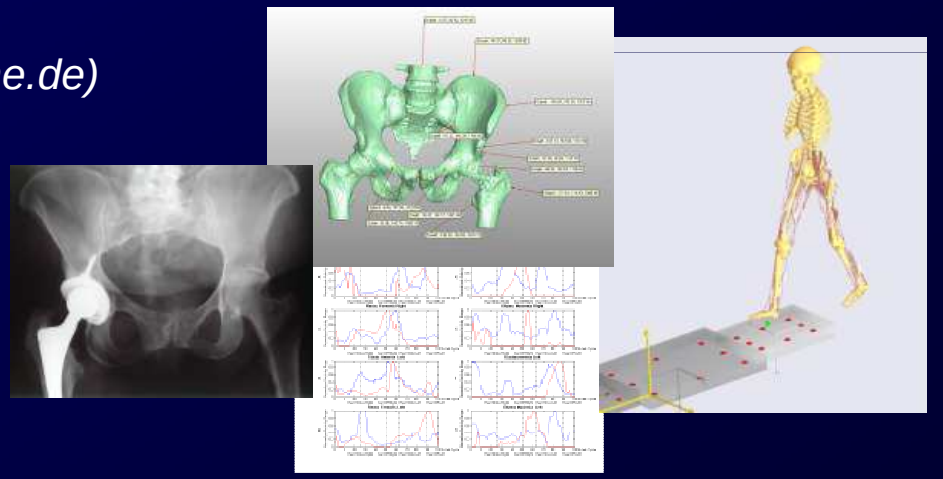
*Tobias Renkawitz, M. D.***

*Sebastian Dendorfer, Dr. Ing.****

*Silvia Dullien, MA***

*Prof. Joachim Grifka, M.D.,Ph.D***

*Prof. Joachim Hammer, Dr. Ing.**



*University of Applied Science Regensburg, Faculty of mechanical engineering, Department for Material Science and Biomechanics

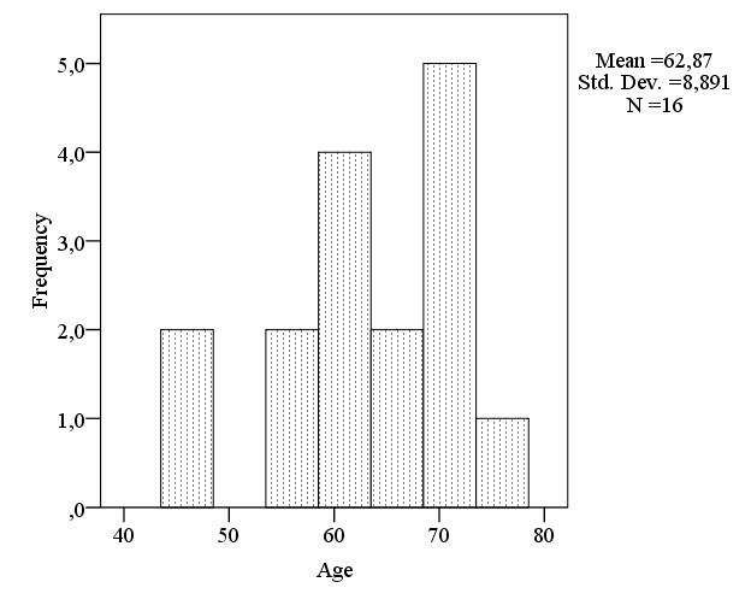
**Orthopaedic Clinic of the University Regensburg

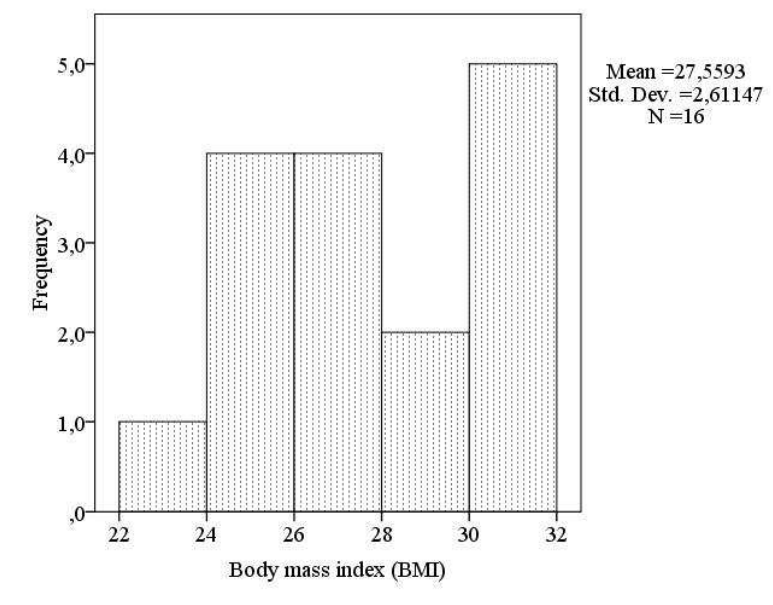
***AnyBody Technology A/S, Denmark

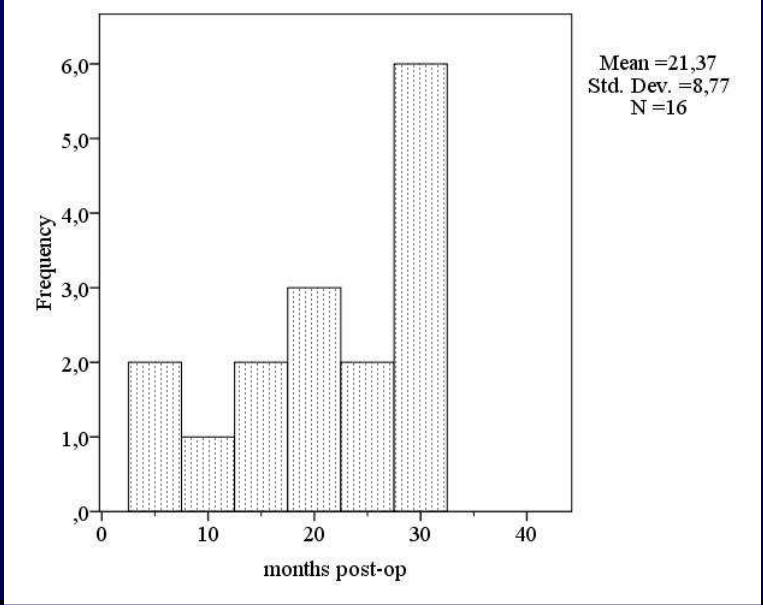
Outline

I) Prospective Study	II) Retrospective Study
Clinical gait analysis combined with musculoskeletal modeling in clinical practise	Evaluation of medical imaging using musculoskeletal modeling
Researching into the biomechanical and clinical outcome for patients after computer-assisted minimally invasive THA using clinical outcome scores combined with gait analysis and musculoskeletal modeling	Focus on the influence of image accuracy (Ct vs. XRay) on the hip biomechanics in order to validate if X-Ray images can be used for proper operational planning or not
Materials and Methods Results Discussion	Materials and Methods Results Discussion

Materials prospective study







N = 16 (11 female, 5 male)

Mean Age = 62.9 years +/- 8.9 years

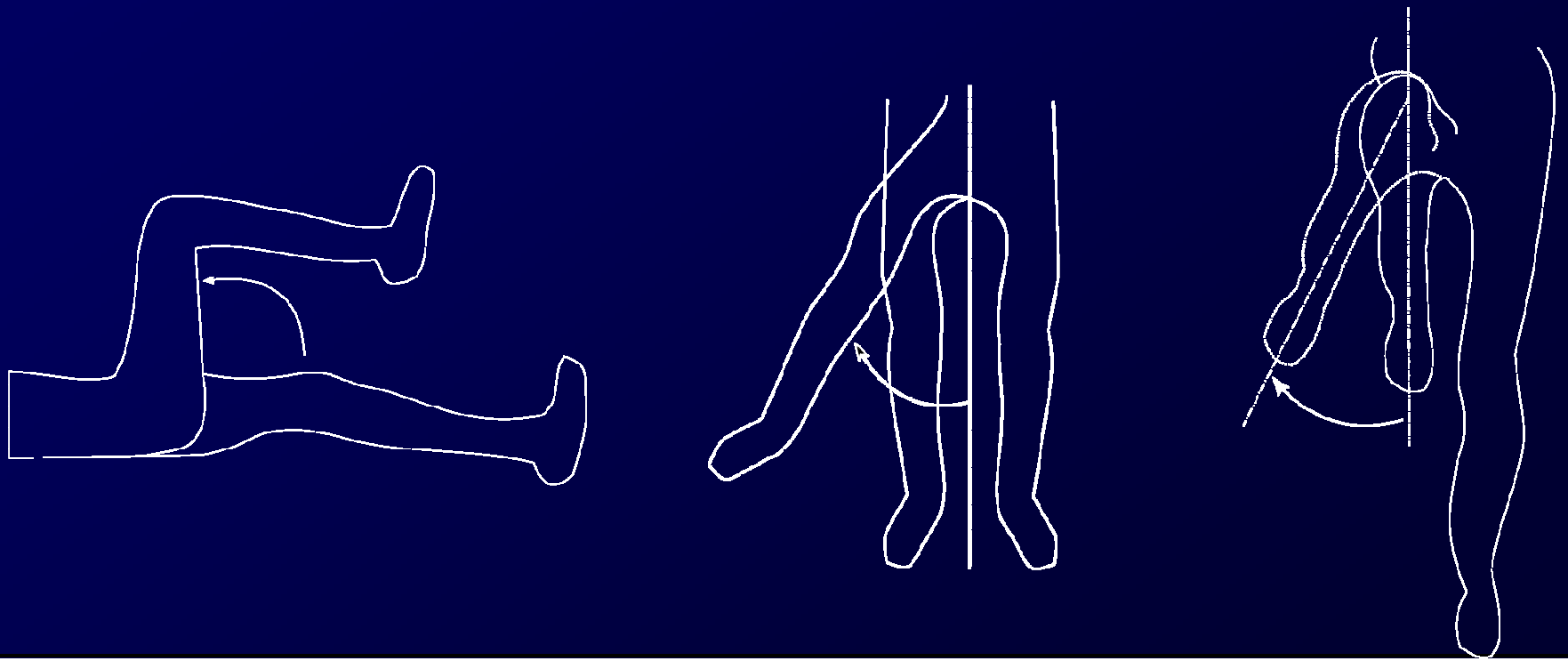
Mean BMI = 27.56 +/- 2.6

Mean post-op = 21.4 +/- 8.7

ORTHOPÄDISCHE KLINIK
UNIVERSITÄT REGENSBURG

Methods prospective study

- Range of motion (ROM)
  - Flexion
  - Abduction
  - External rotation



Methods prospective study

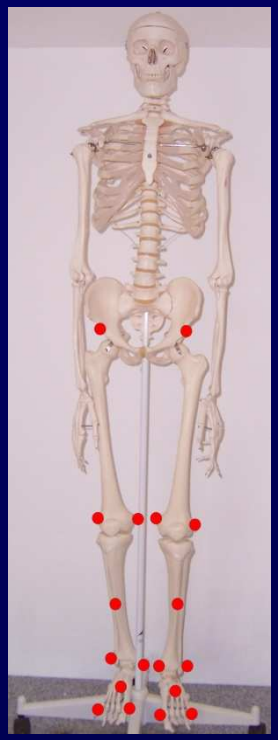
- Hip scores
  - Validated and used in clinical practice:
  - Merlde d‘Aubigne hip score[1]
  - Harris hip score[2]
  - Western Ontario and McMaster Osteoarthritis Index (WOMAC)[3]
  - Hip Disability and Osteoarthritis Outcome Score (HOOS)[3]

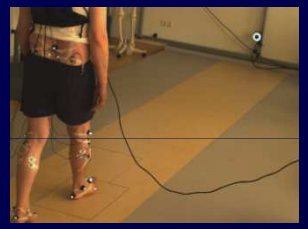
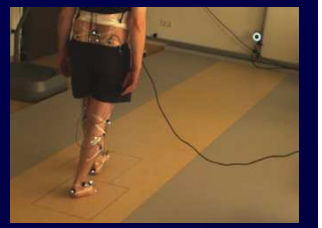
ORTHOPÄDISCHE KLINIK
UNIVERSITÄT REGENSBURG

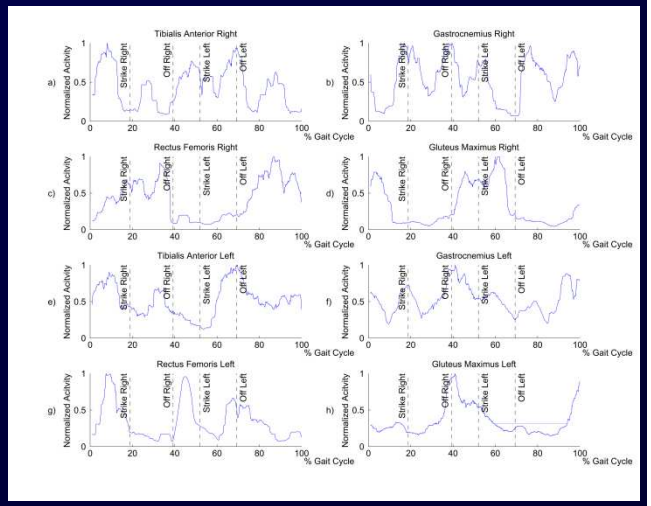
1) d'Aubigne, M., Postel, M., 1954. Functional results of arthroplasty with acrylic prothesis. J Bone Jt Surg 36-A, 451-4755
2) Harris, W. H., Jun 1969. Traumatic arthritis of the hip after dislocation and acetabular fractures: treatment by mold arthroplasty. an end-result study using a new method of result evaluation. J Bone Joint Surg Am 51 (4), 737-755.
3) Klaessbo, M., Larsson, E., Mannevik, E., 2003. Hip disability and osteoarthritis outcome score. an extension of the western ontario and mcmaster universities osteoarthritis index. Scand J Rheumatol 32 (1), 46-51.

Gait analysis

- Gait analysis according to Perry et al.
  - Outcome: marker trajectories, ground reaction forces(GRF), EMG-measurements



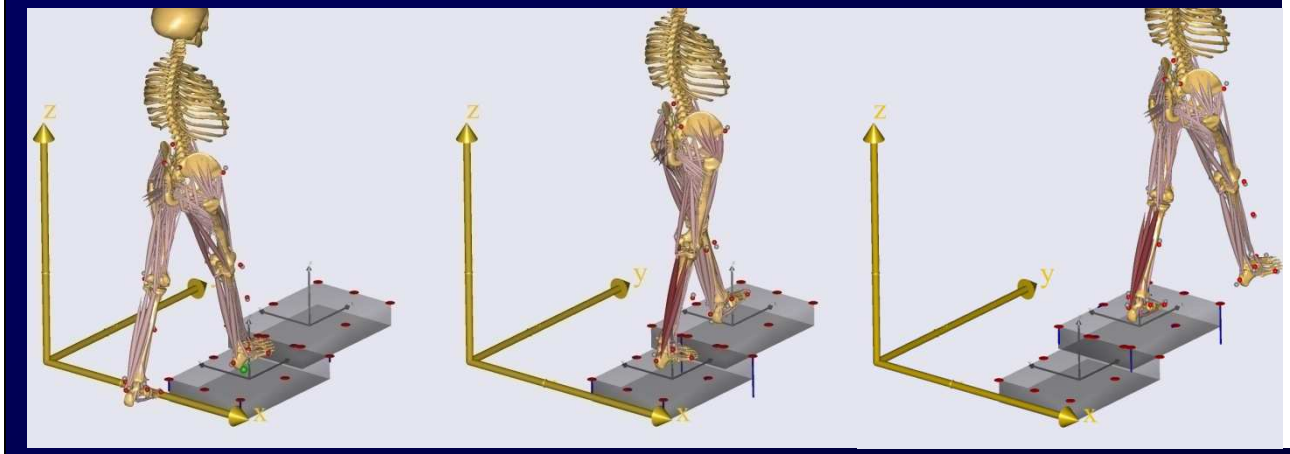


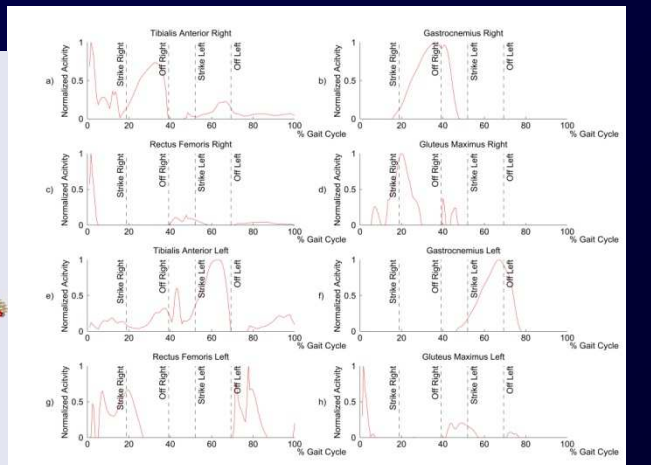
Perry, J., 6 1992. Gait Analysis: Normal and Pathological Function. Slack Inc.

ORTHOPÄDISCHE KLINIK
UNIVERSITÄT REGENSBURG

Musculoskeletal modeling

- Musculoskeletal modeling using the AnyBody modeling system (AMS)
- AMMRV1.2 - GaitLowerExtremity
  - Input: marker trajectories, GRF
  - Outcome: hip reaction forces, hip variation angles, muscle activity





ORTHOPÄDISCHE KLINIK
UNIVERSITÄT REGENSBURG

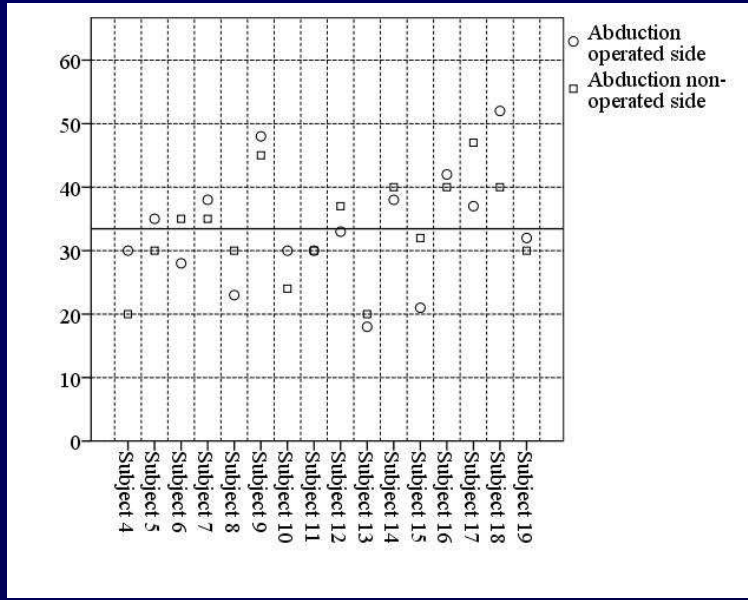
Determination of symmetry

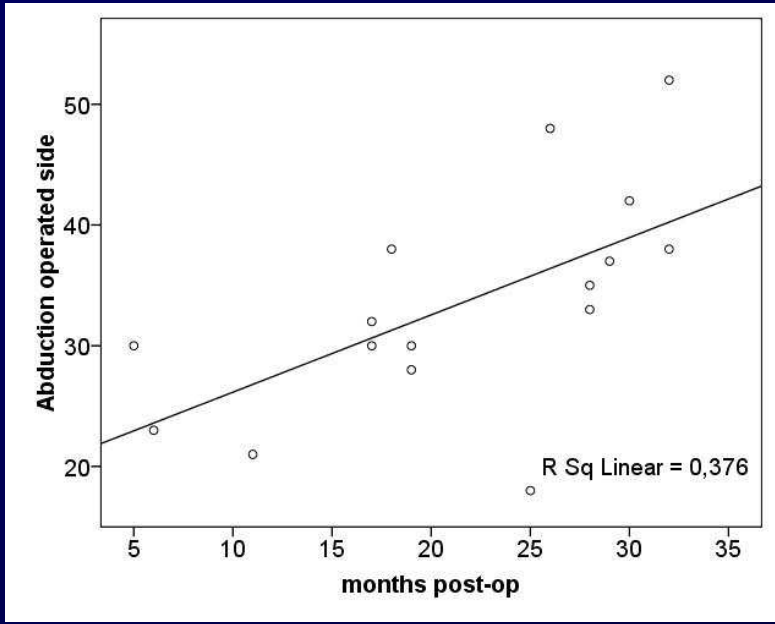
ORTHOPÄDISCHE KLINIK
UNIVERSITÄT REGENSBURG

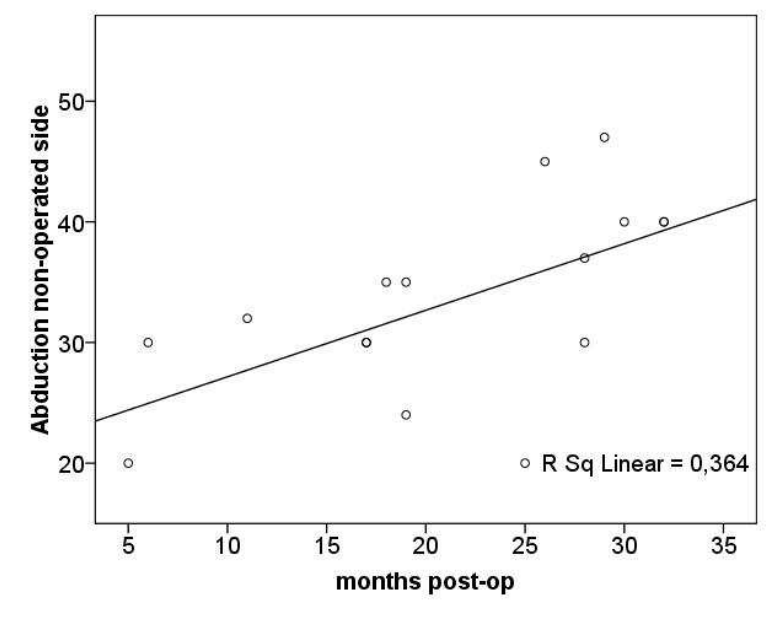
- Up to now geometric parameters have been observed[1]
- Symmetric gait pattern assumed as golden standard
- Calculated due to $R_i = \frac{X_{treated}}{X_{not-treated}}$
- Can describe forces and angles

[1]Cichy et al. 2008, Changes in gait parameters in total hip arthroplasty patients before and after surgery. Med Sci Monit

Results (ROM)





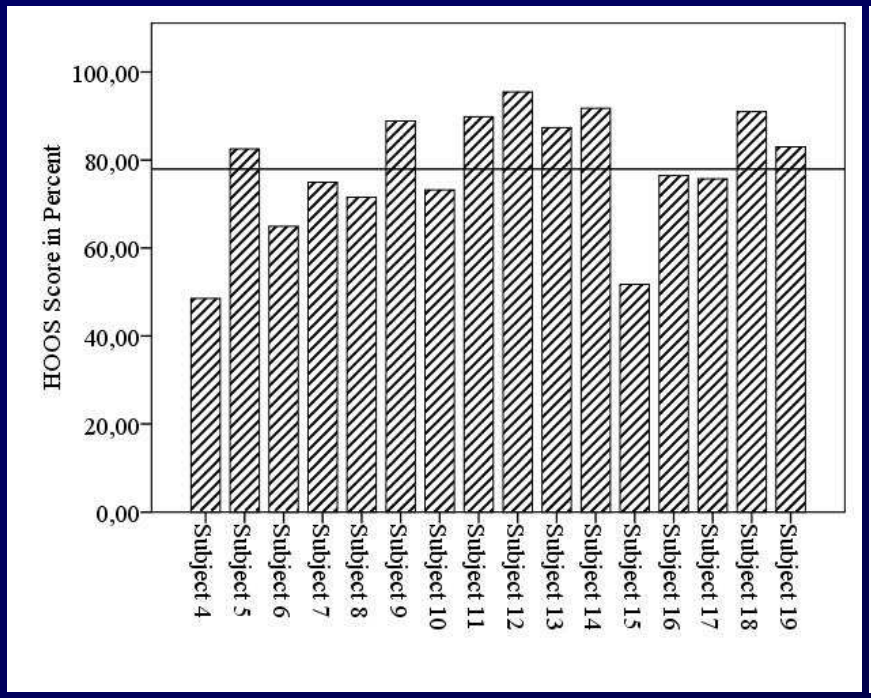


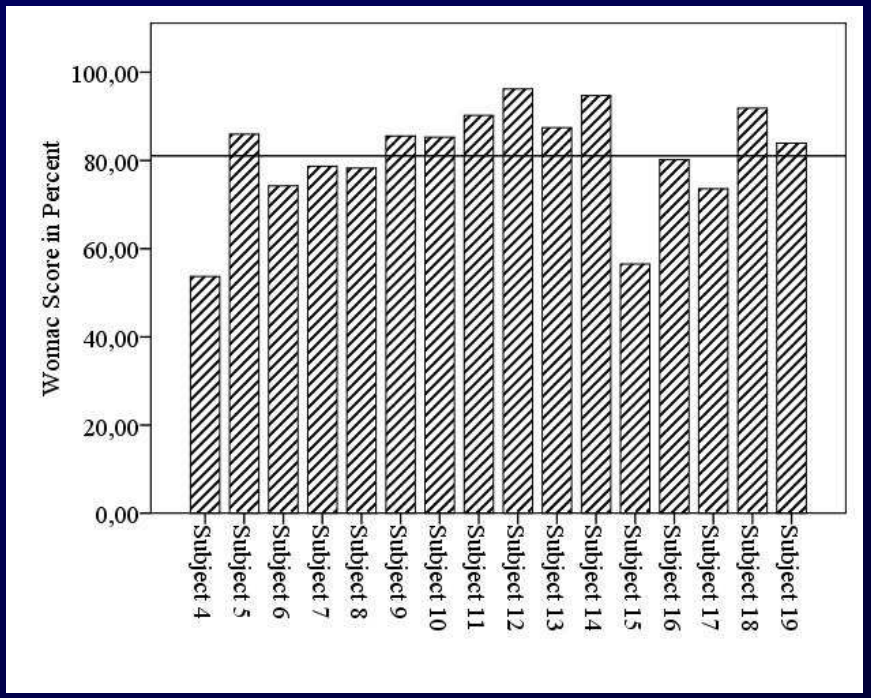
ORTHOPÄDISCHE KLINIK
UNIVERSITÄT REGENSBURG

Discussion (ROM)

- Flexion:
  - Increases on both sides (operated, not-operated)
- Abduction
  - Increases on both sides
- Rotation
  - Decreases on operated side
- Strong scattering (Age, BMI)
- Too little participants
- Feasibility study!!

Results (hip scores)





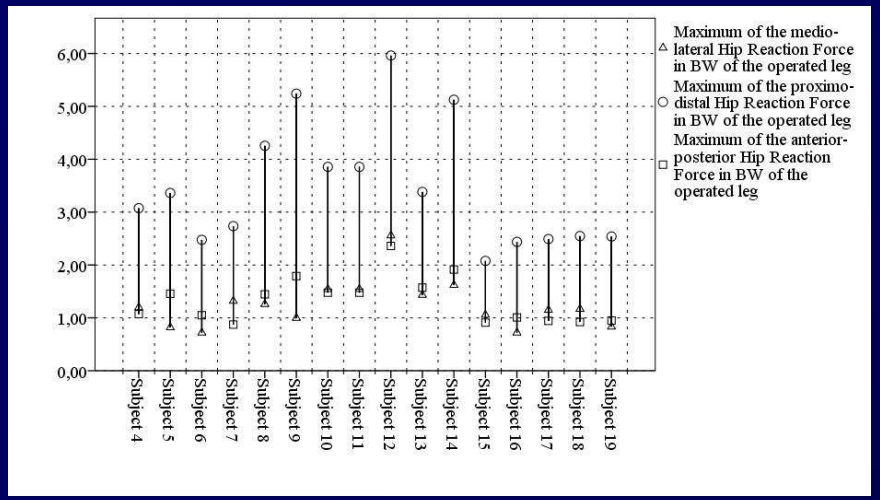
ORTHOPÄDISCHE KLINIK
UNIVERSITÄT REGENSBURG

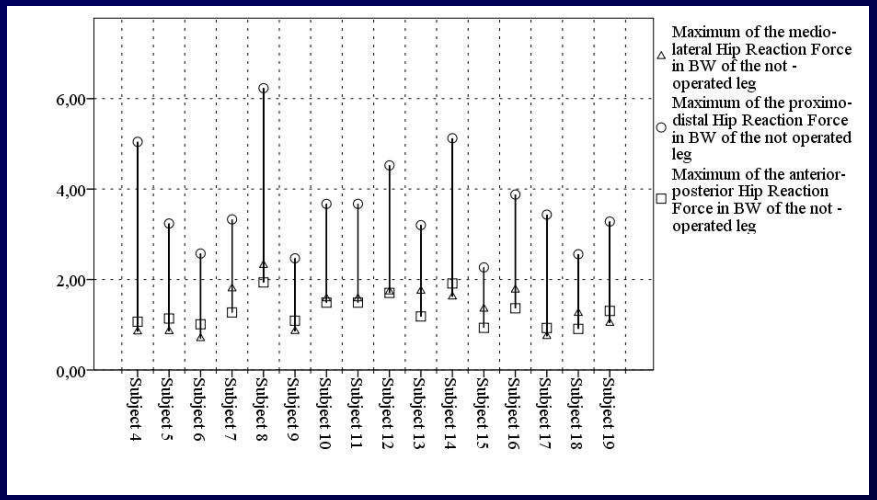
- Subscores of biomechanical interest:
  - Stiffness
  - Function and daily living

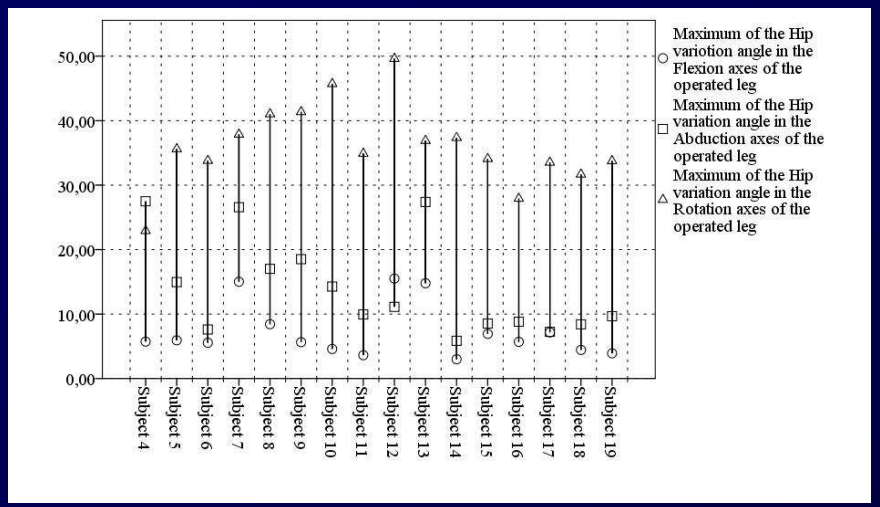
Results (modeling)

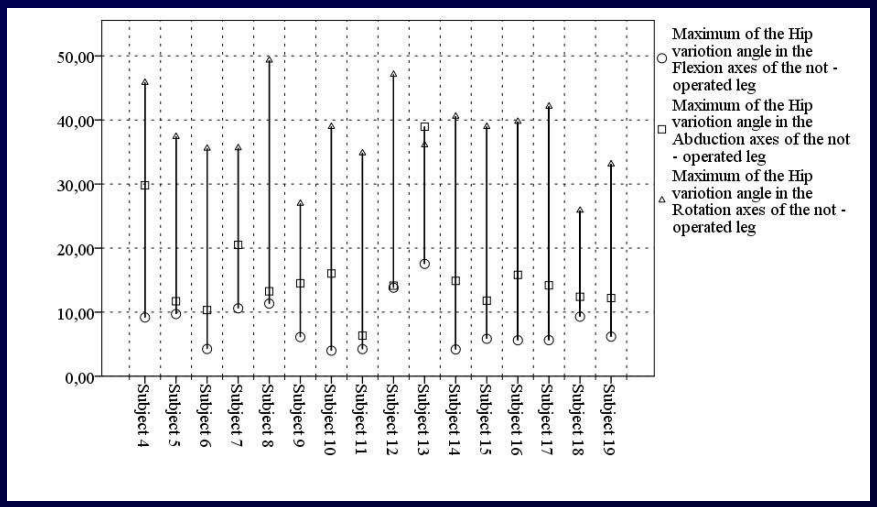
- Hip reaction forces (HRF)
  - Minimum: 0.9 * BodyWeight (BW)
    - medio-lateral / subject 6 / not – operated side
  - Maximum: 6 * BW
    - poximo-distal / subject 12 / operated leg
- Hip variation angles (HVA)
  - Minimum: 2°
    - Flexion axes / subject 11 / operated leg
  - Maximum: 50°
    - Rotation axes / subject 12 / operated leg

Results (modeling)







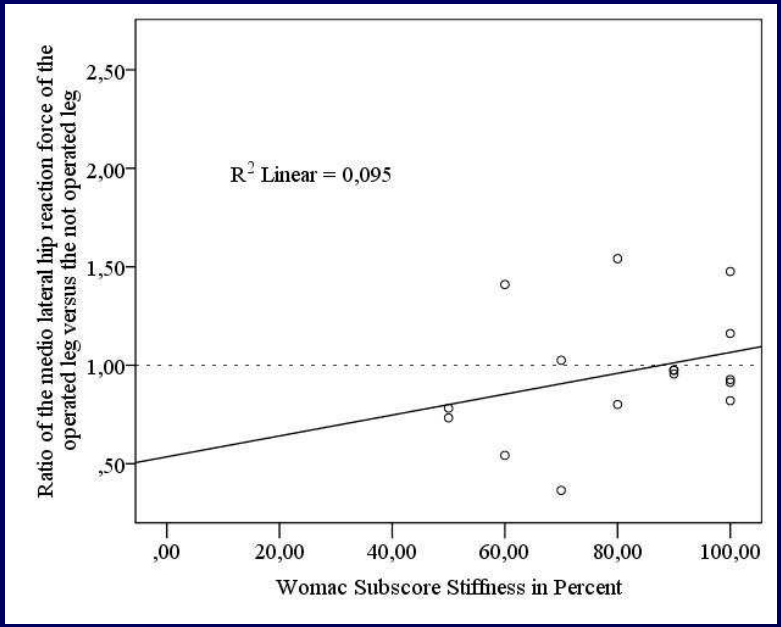


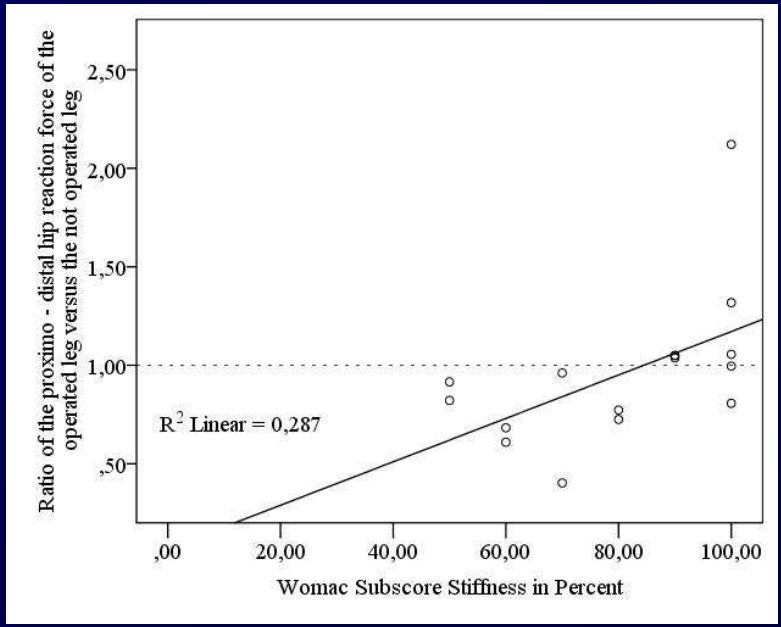
ORTHOPÄDISCHE KLINIK
UNIVERSITÄT REGENSBURG

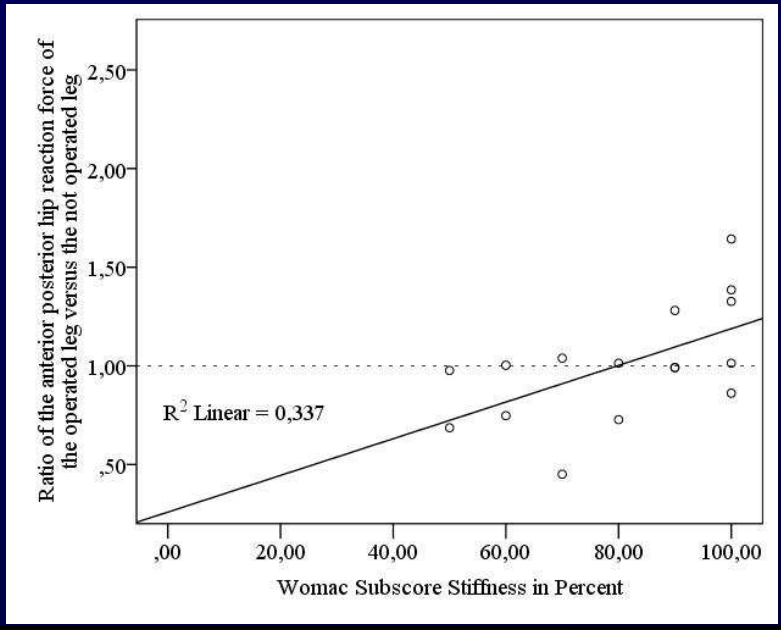
Results (ratios)

- Ratio $R_{HipReactionForces}$
  - Minimum: 0.4 (medio-lateral)
  - Maximum: 2.1 (proximo-distal)
  - Widest range: 1.1 – 2.1 (subject 9)
  - Smallest range: 0.4 – 0.5 (subject 16)
- Ratio $R_{HipVariationAngles}$
  - Minimum: 0.25 (abduction)
  - Maximum: 1.75 (abduction)
  - Widest range: 0.5 – 1.75 (subject 8)
  - Smallest range: 0.5 – 0.9 (subject 4)

Results (ratios and scores)



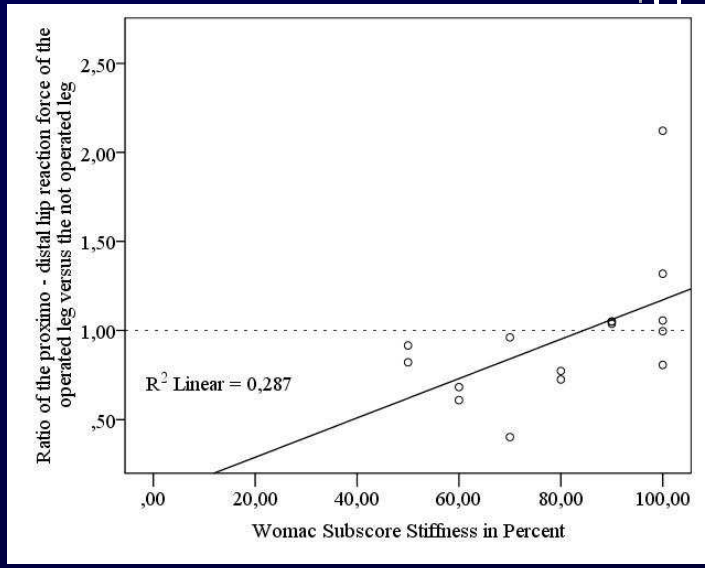




ORTHOPÄDISCHE KLINIK
UNIVERSITÄT REGENSBURG

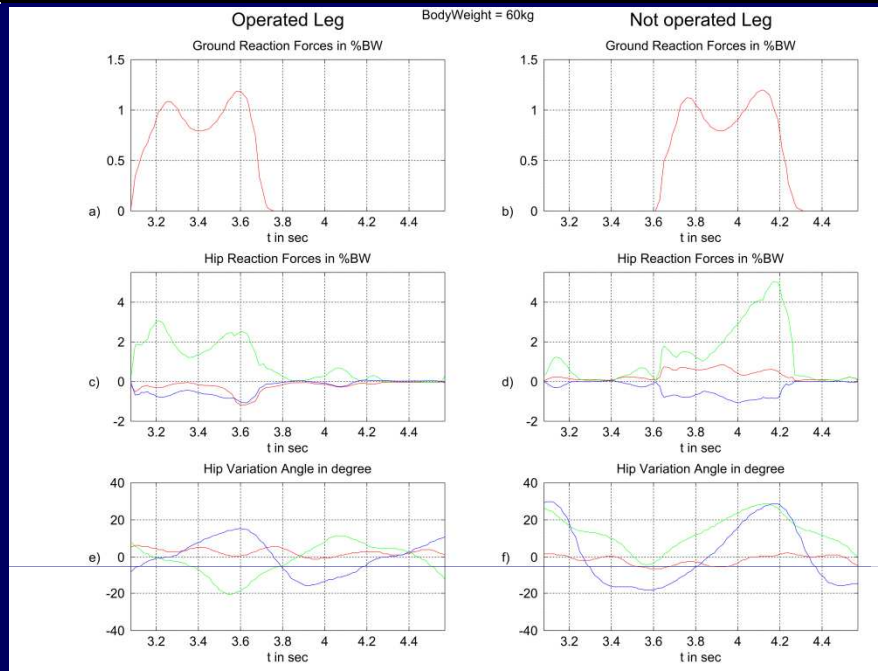
Discussion (ratios and scores)

- Stiffness vs. $Ratio_{HipReactionForces}$
  - High subscore → $R_{HRF} > 1$
- Function and daily living vs. $Ratio_{HipVariationAngles}$
  - High of subscore → $R_{HVA} < 1$

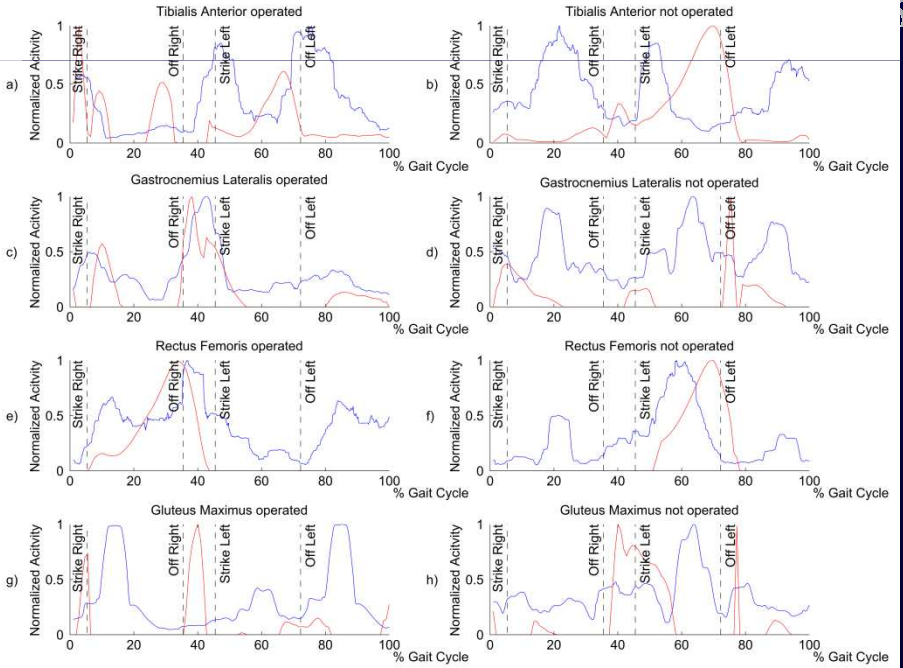


Subjective flexibility increases while the objective measurements stand opposed to that

Results (subject 4)



BodyWeight = 60kg



- 5 months post-op
- 55 years old
- BMI 23.15
- Lowest WOMAC and HOOS Score

Vaughan, C. L., 2 1992. Dynamics of Human Gait. Human Kinetics.

ORTHOPÄDISCHE KLINIK
UNIVERSITÄT REGENSBURG

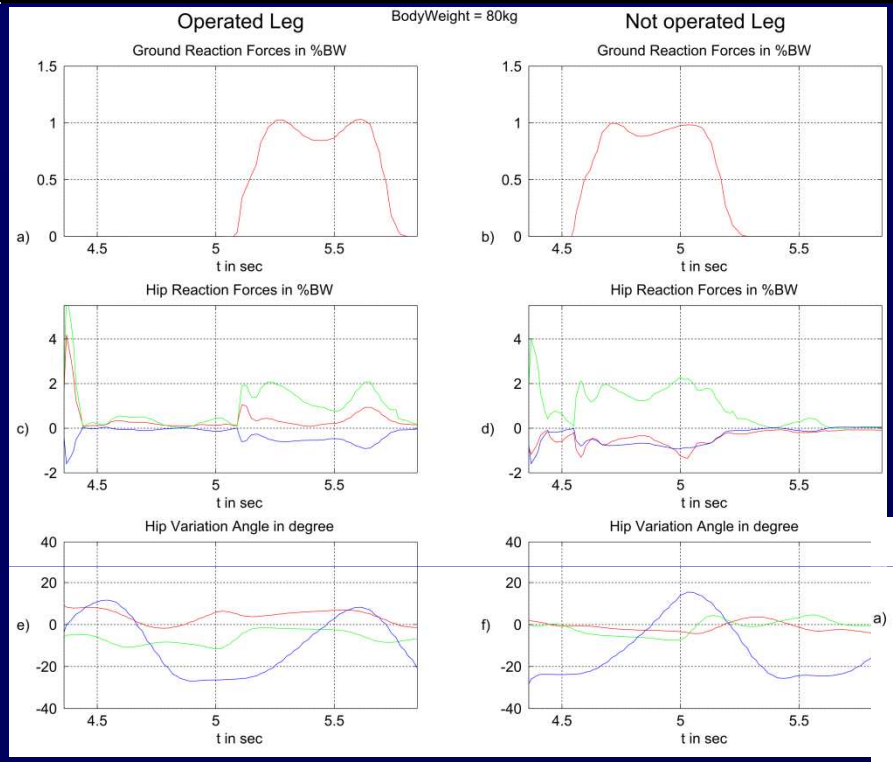
Disscussion (subject 4)

- Lowest hip scores (< 60%)
- Maximum proximo-distal HRF: 5 * BW (not operated side)
- $R_{ProxDist}$ = 0.61
- Why? → subject 4 is in pain (subscores)
- → biomechanical reasons!!

Remarkable loss of confidence in the operated leg → subscores: quality of life, personal statisfaction

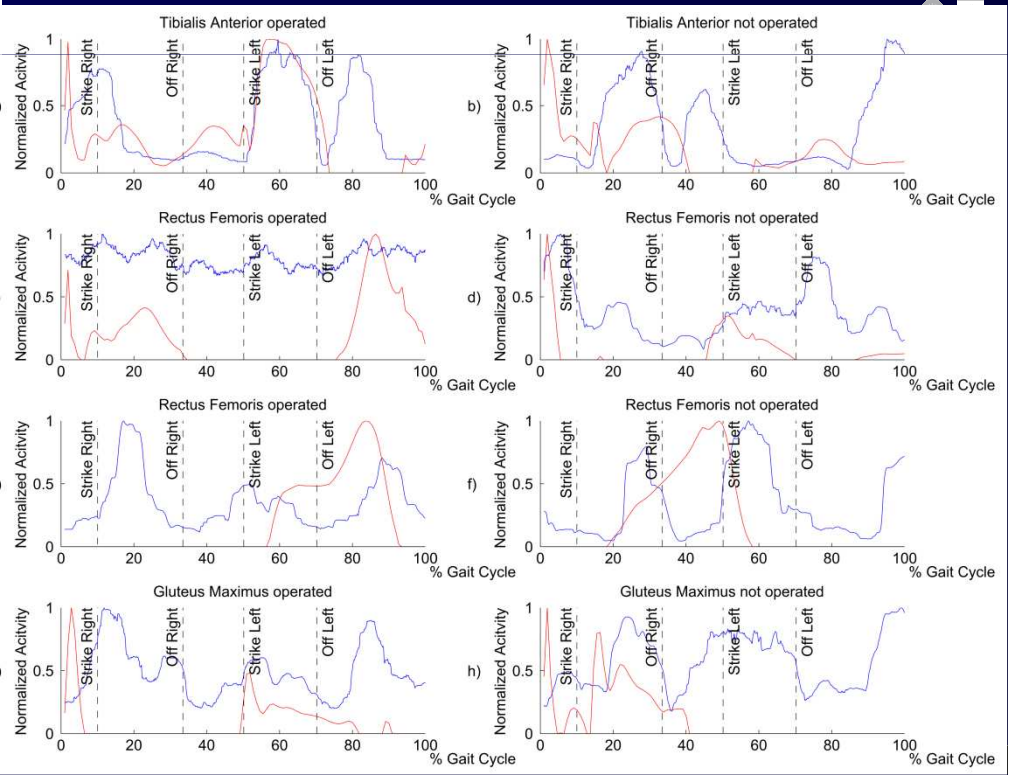
Takes an overcharge of the not-operated leg into account to aid the recovery of the operated leg

Results (subject 15)



BodyWeight = 80kg

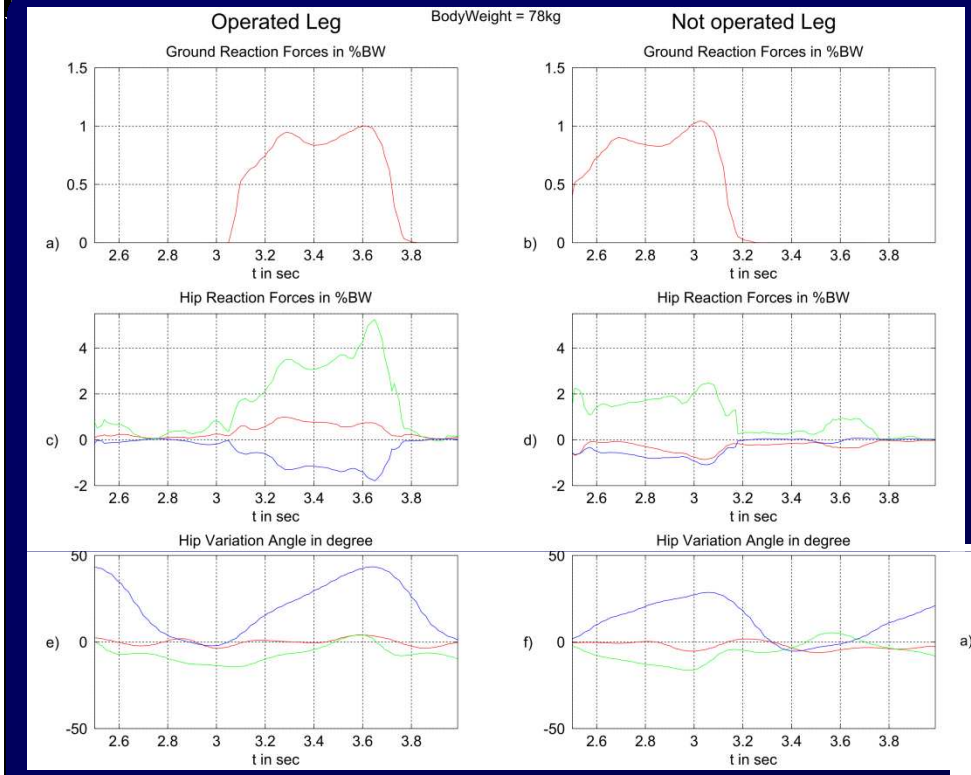
- 11 months post-op
- 68 years old
- BMI 30.5
- Low hip scores



Discussion (subject 15)

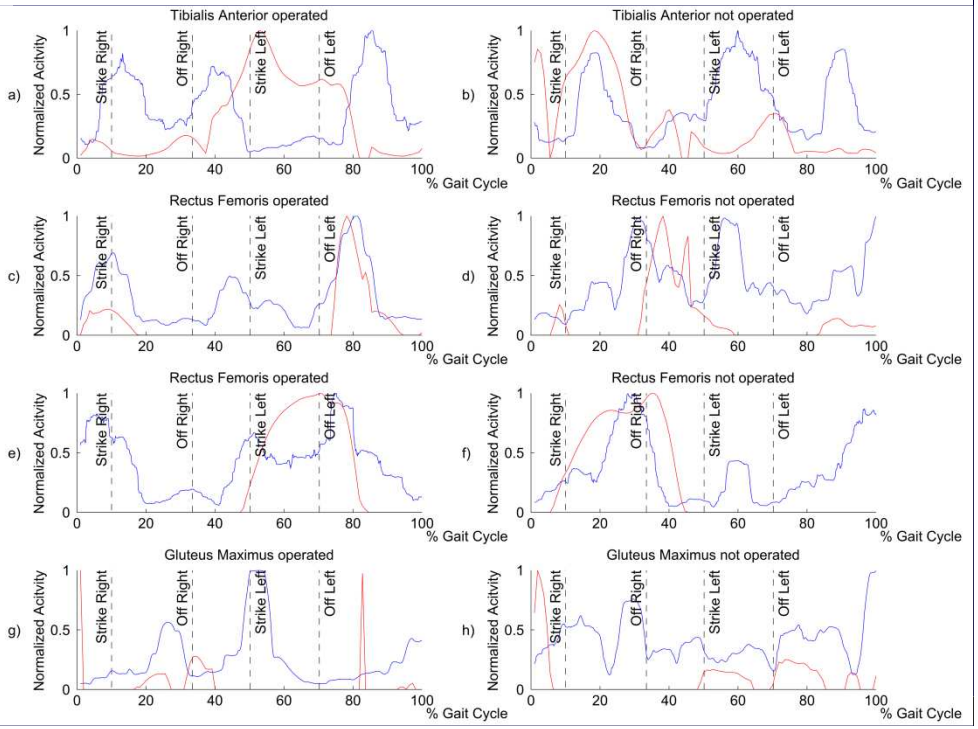
- Similar hip score results as subject 4
- Maximum HRF:
  - proximo-distal force: 2 * BW
- Subscores show: patient is in pain!
- Objective analysis show: not due to biomechanical reasons

Results (subject 9)



BodyWeight = 78kg

- 26 months post-op
- 60 years old
- BMI 26.03
- Widest Range of R_{HRF}



Discussion (subject 9)

- Maximum HRF: 5.66 * BW
- Widest range of $R_{HipReactionForces}$
  - Biggest difference between operated and not-operated side
- Indicator for disturbed gait pattern (Perry et al.):
  - Reduced flexion in the operated leg
    - Loss of muscle control
  - Increased abduction would indicate muscle weakness
- Indicator for natural gait pattern
  - comparison of muscle activity

Patient is able to provide full muscle force but is not able to control it
→ Overcharge of the hip joint → lower durability of the implant

ORTHOPÄDISCHE KLINIK
UNIVERSITÄT REGENSBURG

Conclusion

A certain pattern can be found when combining subjective outome scores with objective measurements!

- Qualitative analysis of objective measurements combined with subjective questionaiers gives deep insight into functional outcome of THR and leads to a better understanding
- Quantitative analysis challenging due to high scattering of patient collective and little number of participants (feasibility study)

ORTHOPÄDISCHE KLINIK
UNIVERSITÄT REGENSBURG

II) Retrospective Study

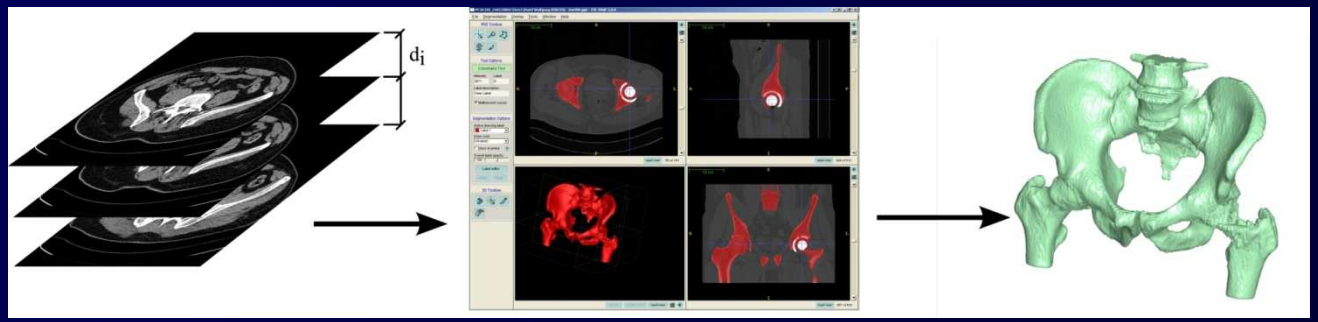
Evaluation of medical imaging using musculoskeletal modeling

Focus on the influence of image accuracy (Ct vs. XRay) on the hip biomechanics in order to validate if X-Ray images can be used for proper operational planning or not

Imaging

- Analog X-Ray imaging, digitized and optimized in terms of sharpness and color depth

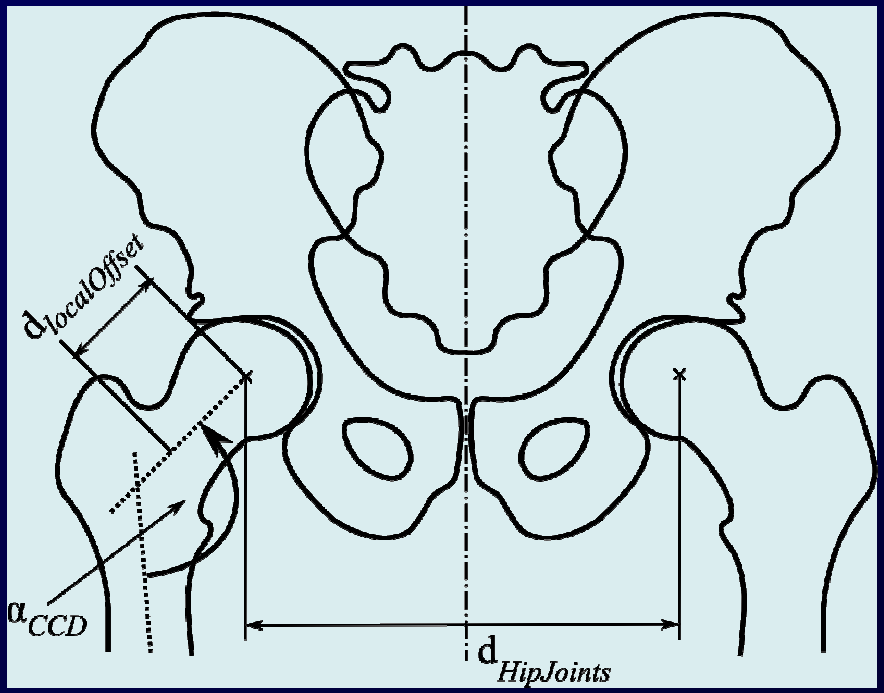
- Transversal Ct-scans segmented to retrieve 3D-Models according to Yushkevich et al.[1] using itksnap 2.0



Yushkevich, P. A., Piven, J., Hazlett, H. C., Smith, R. G., Ho, S., Gee, J. C., Gerig, G., Jul 2006. User-guided 3d active contour segmentation of anatomical structures: signicantly improved eciency and reliability.Neuroimage 31 (3), 1116-1128.

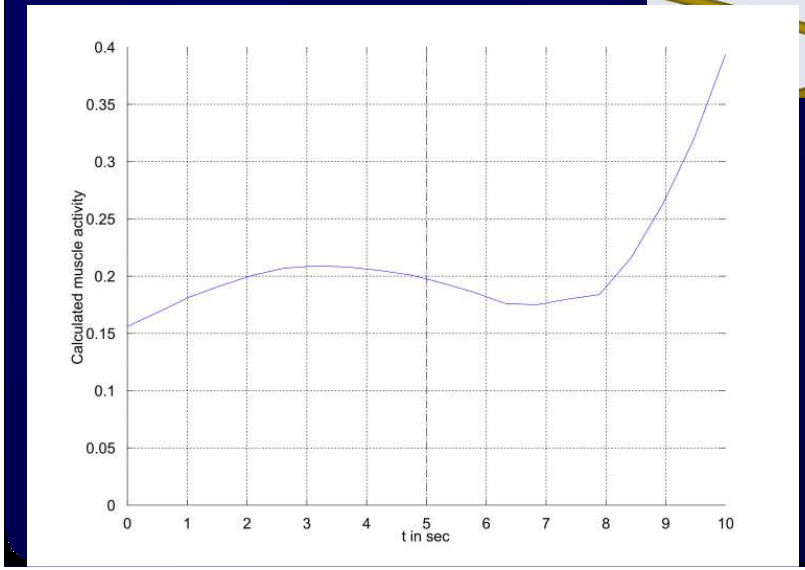
Parameters of interest

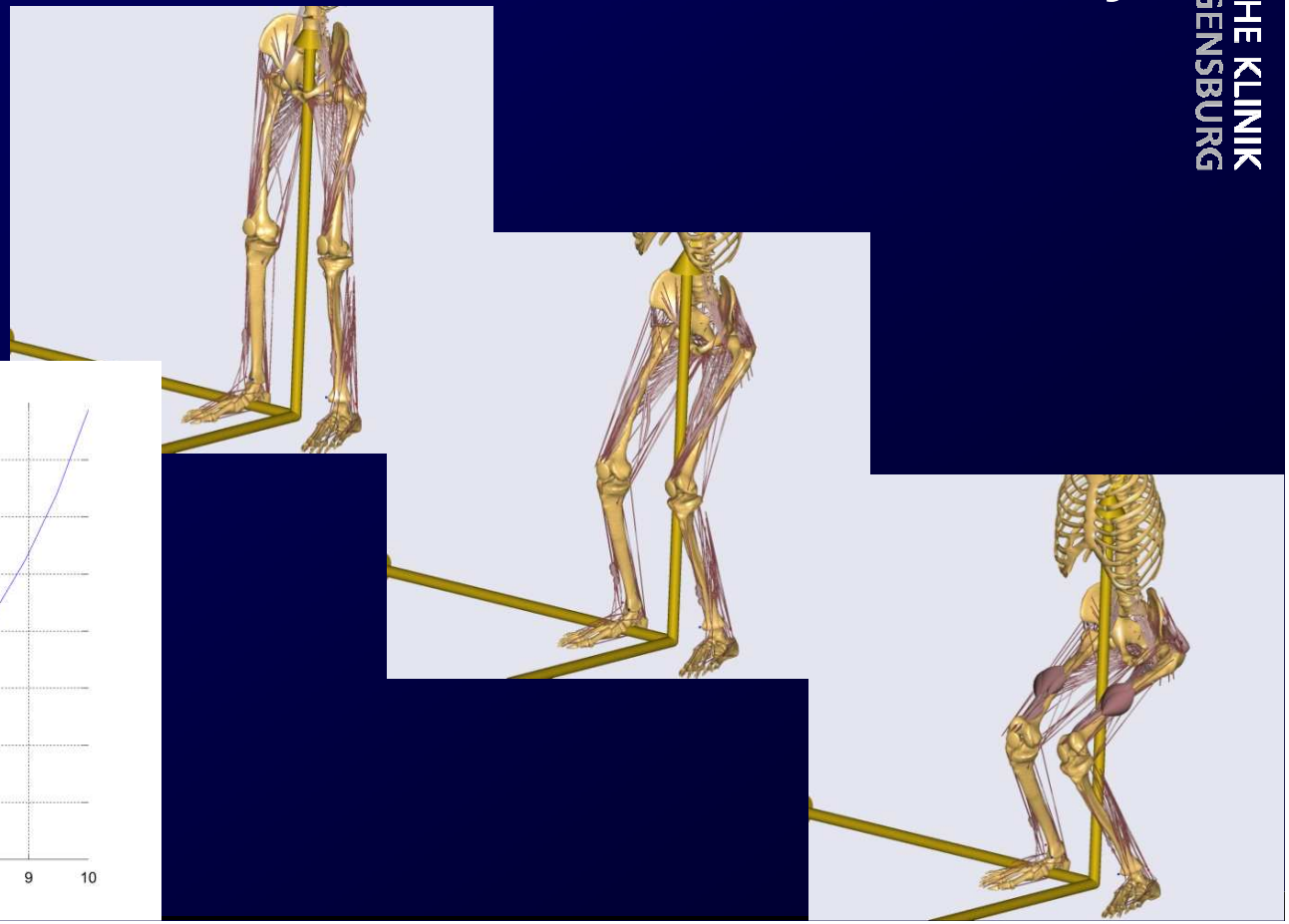
- Pelvis width (distance between hip joints)
- CCD-angle operated / not-operated side
- Local offset operated / not-operated side



Modeling

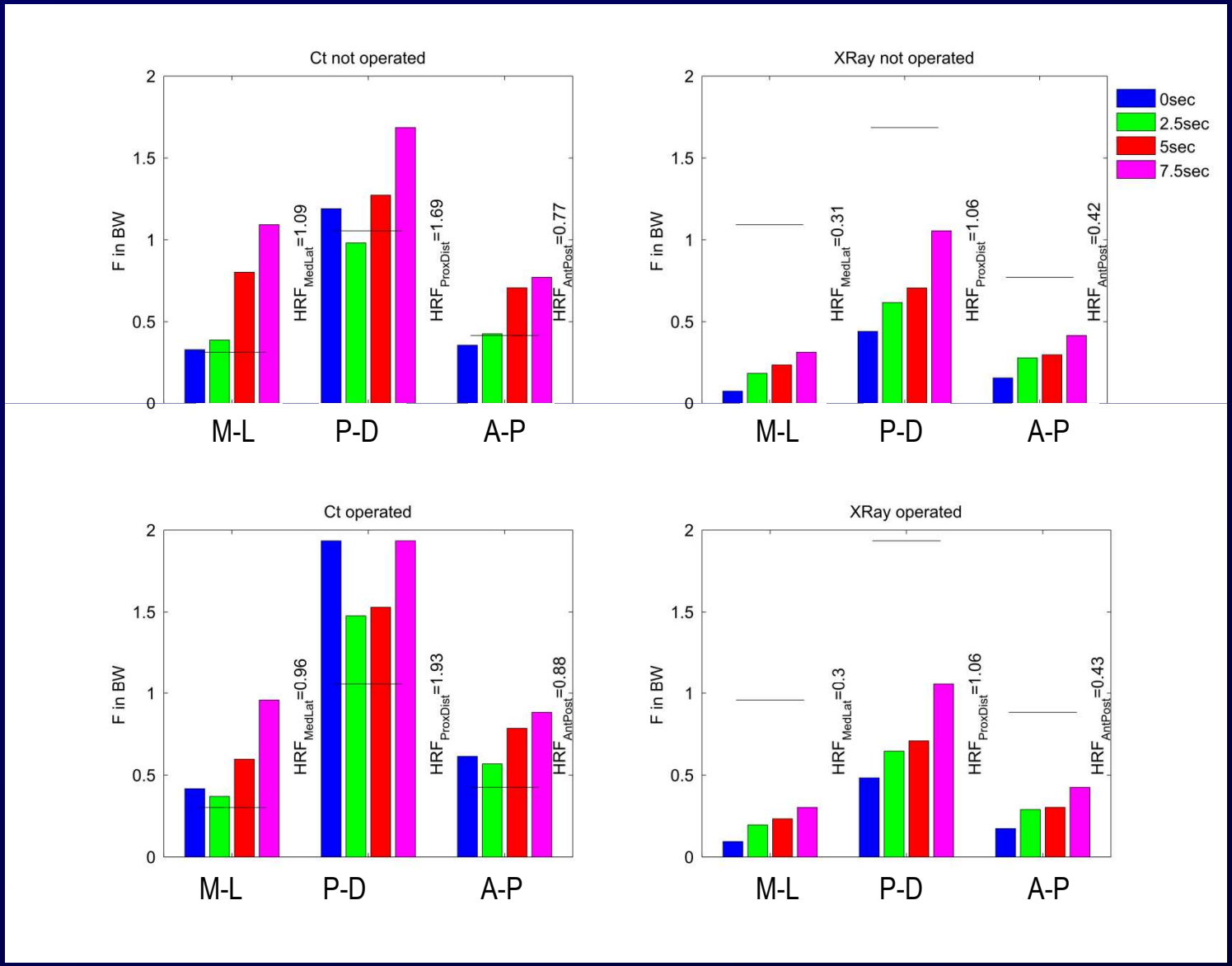
- Knee bend (t = 10sec)
- Input: measured parameters of interest
- Outcome: hip reaction forces, muscle activity





ORTHOPÄDISCHE KLINIK
UNIVERSITÄT REGENSBURG

Results (Hip reaction forces)



ORTHOPÄDISCHE KLINIK
UNIVERSITÄT REGENSBURG

Conclusion

- Inaccuracy of geometric measures for operational planning highly influences the biomechanics of the hip (up to 0.9 * BW)
- Operational planning using radiographs is challenging (Blumentritt et al.[1,2])

!! BUT !!

- Little patient collective (feasibility study!!)
- Only one examiner
- Accuracy can be improved using digitized XRay - imaging

ORTHOPÄDISCHE KLINIK
UNIVERSITÄT REGENSBURG

Blumentritt, S., 1988. [Biomechanical construction principles of the human hip joint in frontal plane]. Gegenbaurs Morphol Jahrb 134 (2), 221-240.
Blumentritt, S., 1990. [The relationship between the gait of humans and the hip joint structure in the frontal plane]. Gegenbaurs Morphol Jahrb 136 (6), 677-693.

Question and Answer

- Feel free to ask
- Contact: weber.tim@o2online.de

ORTHOPÄDISCHE KLINIK
UNIVERSITÄT REGENSBURG