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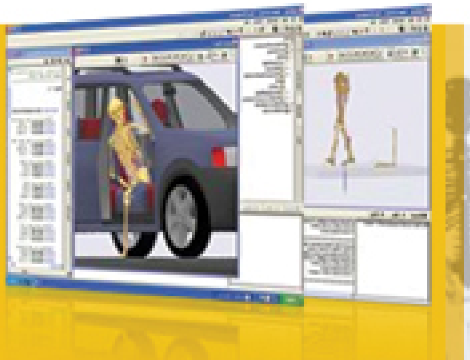
Welcome to a presentation hosted by AnyBody Technology

...Public webcasts on AnyBody-related topics are regularly hosted by AnyBody Technology. The webcasts typically address research projects, related technologies and workflows, or instructions on how to use and benefit from the AnyBody Modeling System™.

This presentation will begin shortly...

We hope you will have a good experience. Please take time to respond to the poll after the presentation - it only takes a few seconds. Thank you!



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Today's webcast presentation: Osteoarthritic knee kinematics and kinetics

Presenter

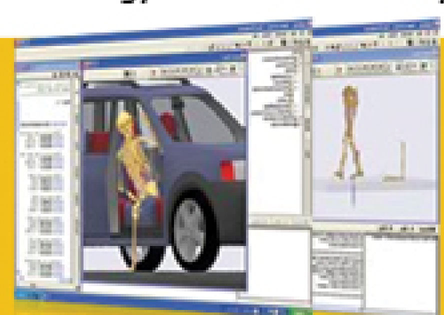
Peter R. Worsley
University of Southampton

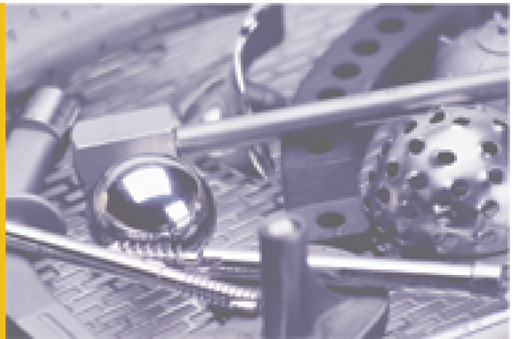
Host

Casper G. Mikkelsen
AnyBody Technology

Panelist

Søren Tørholm, Ph.D
AnyBody Technology





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Using AnyBody to compare Healthy and Osteoarthritic Knee Kinematics and Kinetics

Peter Worsley postgraduate student, BioEngineering
University of Southampton

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A little about me

- I'm a physiotherapist by background
- My PhD is looking into pre- and post-operative knee arthroplasty function.
- Using;
  - Motion analysis (VICON, Force plates, EMG)
  - AnyBody modelling
  - Clinical test (questionnaires, range of motion, ultrasound imaging, postural sway, pain ect).
- Main use of AnyBody is to predict knee kinematics and kinetics
- Present my early findings of pre-operative patients (end stage OA)
- Compare the findings to healthy age matched individuals.

Osteoarthritis

- Degeneration of cartilage
- Often changes mechanical axis of knee
- Pain
- Weakness in muscles
- Patients adapt activities of daily living
- Loss of function

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Osteoarthritis Continued

- The prevalence of osteoarthritis of the knee, hip, and hand increases with age.
  - Although most people with osteoarthritis are past working age, it also affects substantial numbers of working-age people.
- It is estimated that osteoarthritis causes joint pain in 8.5 million people in the UK.
- **Knee Pain:**
  - About 20% of adults 45–64 years of age have osteoarthritic pain in the knee.
  - About 35% of women of 75 years of age or more have osteoarthritic pain in the knee.
- **Disability:**
  - About 25% of adults of 50 years of age or more report disability from severe knee pain.
- In 1999–2000, 36 million working days were lost because of osteoarthritis, costing the economy nearly £3.2 billion in lost production.
- 70,000 knee replacements each year in England and Wales

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Participants

- To assess knee kinematics and kinetics during activities of daily living in healthy and osteoarthritic patients.
  - 20 healthy individuals
  - 20 pre-operative OA patients
  - 2 hrs in the lab

Data Collection

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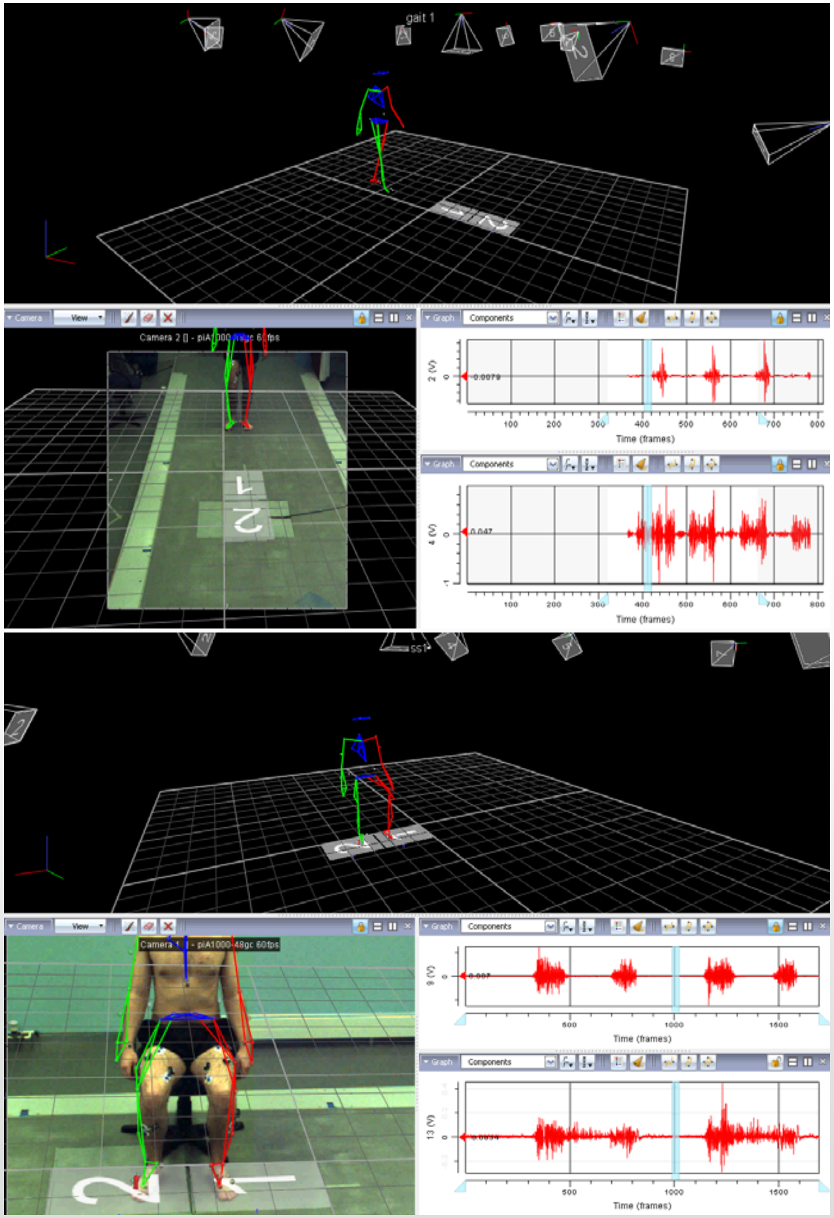
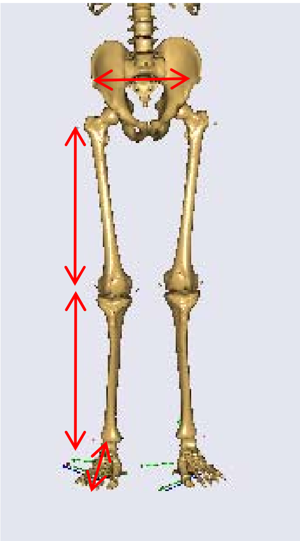
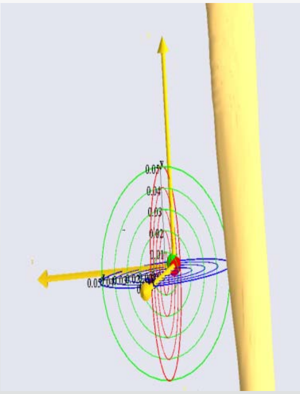
- VICON 12 camera Tx system
- 2 Kistler Force Plates
- 16 channels of ZeroWire EMG
- *2 Basler digital camera’s
- Gait
- Sit-Stand

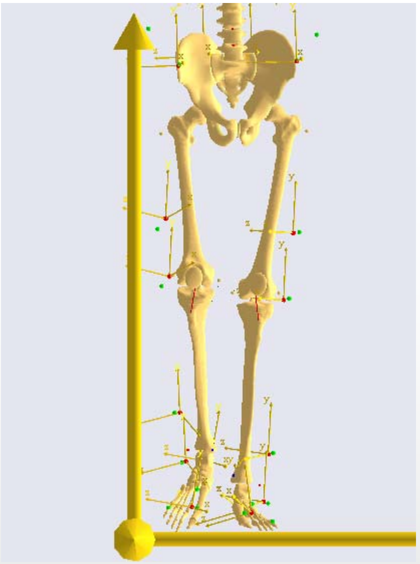
- Noise
- Soft tissue artefact
- Anatomical landmark definition

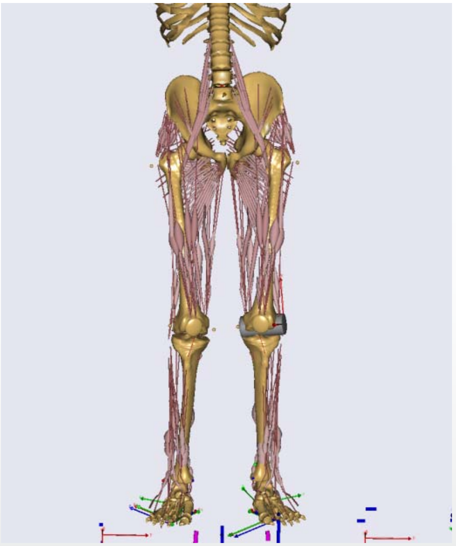


Motion capture to inverse model

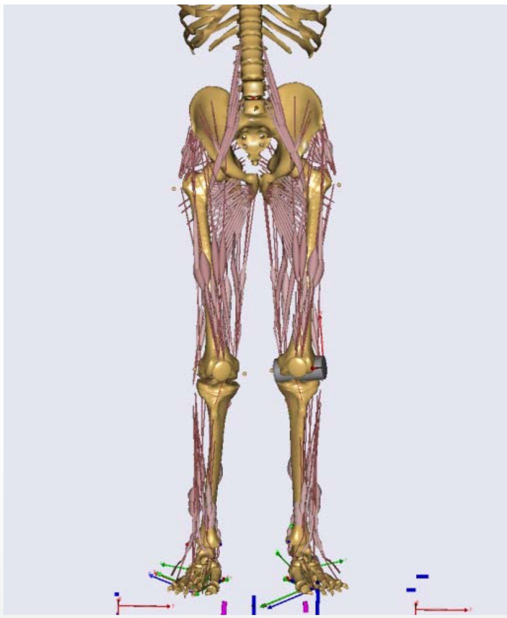


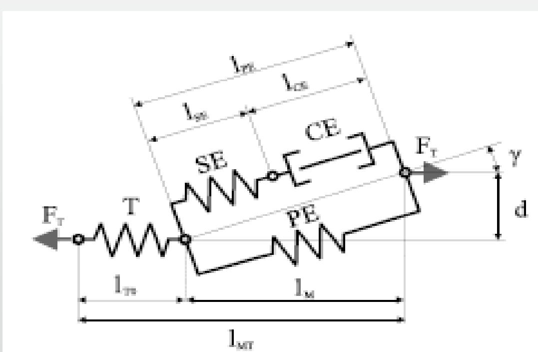






Muscle Modelling





- PCSA
- Tendon length
- Pennation angle
- Origin and insertion
- Max force output

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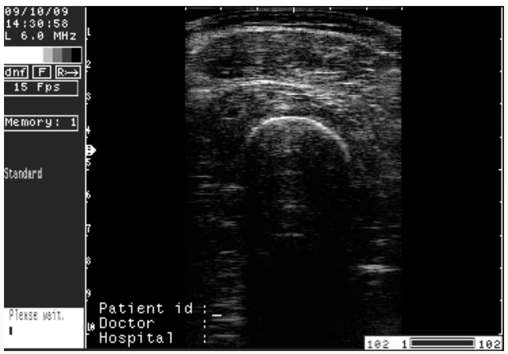
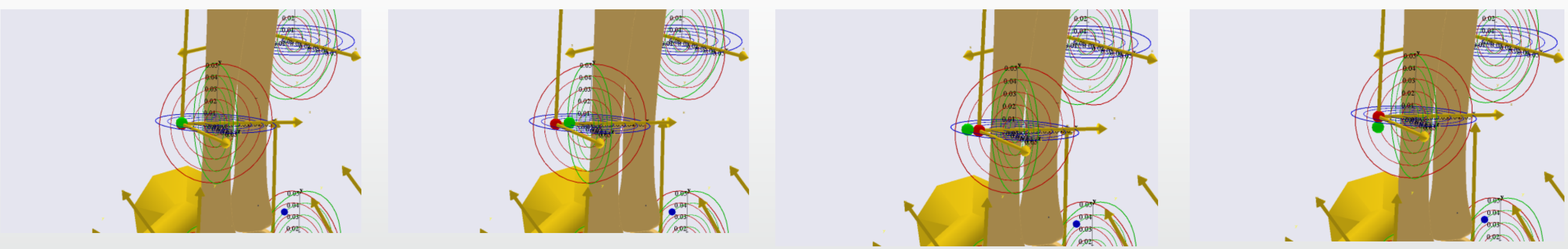
Ultrasound Imaging

Rectus Femoris	Vastus Medialis	Vastus lateralis
		
•-24.8% atrophy in TKR	•-9.1% atrophy in TKR	•-1.82% atrophy in TKR
•-15.5% atrophy in UKR	•-6.3% atrophy in UKR	•-6.3% atrophy in UKR

-5.5% difference in contractibility for both TKR and UKR

Optimisation of Scaling and Kinematics

- Minimise estimated and measured marker trajectories error across the time frames subject to holonomic constraints (16 degrees of freedom).
- Optimise segment lengths to 'best fit'
- Lu and Connor (1999) principles
- Andersen (2009), KOS
- Optimised Kinematics for inverse dynamics.



Lu, T.W. and J.J. O'Connor, *Bone position estimation from skin marker co-ordinates using global optimisation with joint constraints. Journal of Biomechanics*, *1999.* ***32(2): p. 129-134.***
Andersen, M.S., M. Damsgaard, and J. Rasmussen, *Kinematic analysis of over-determinate biomechanical systems. Computer Methods in Biomechanics and Biomedical Engineering, 2009.* ***12(4): p. 371 - 384.***

Marker set-up

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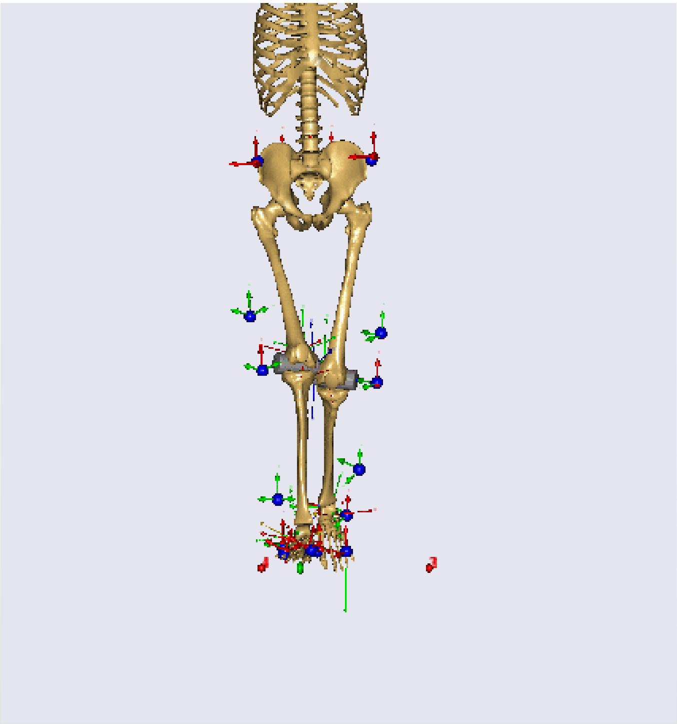
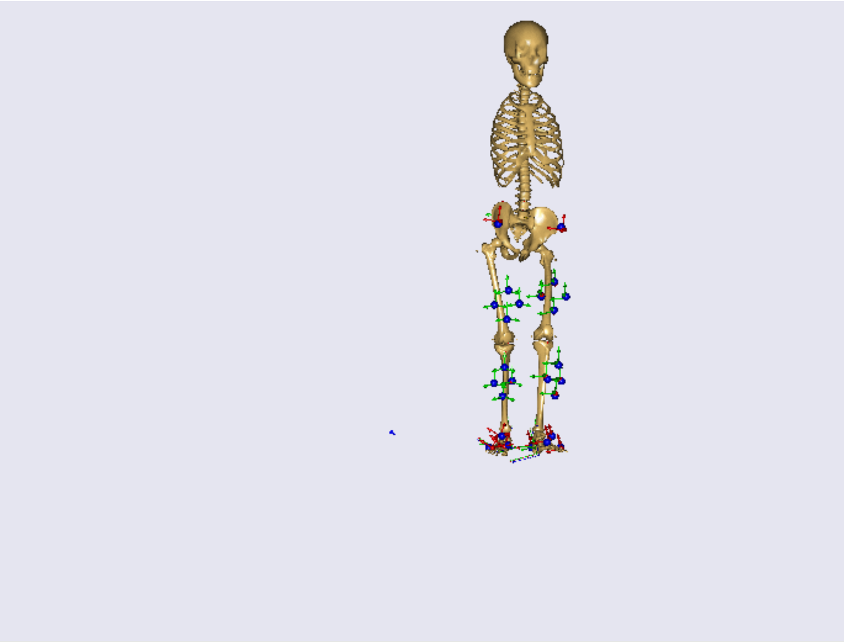
•Optimisation of kinematics (Andersen et al 2009).





Inverse Dynamics

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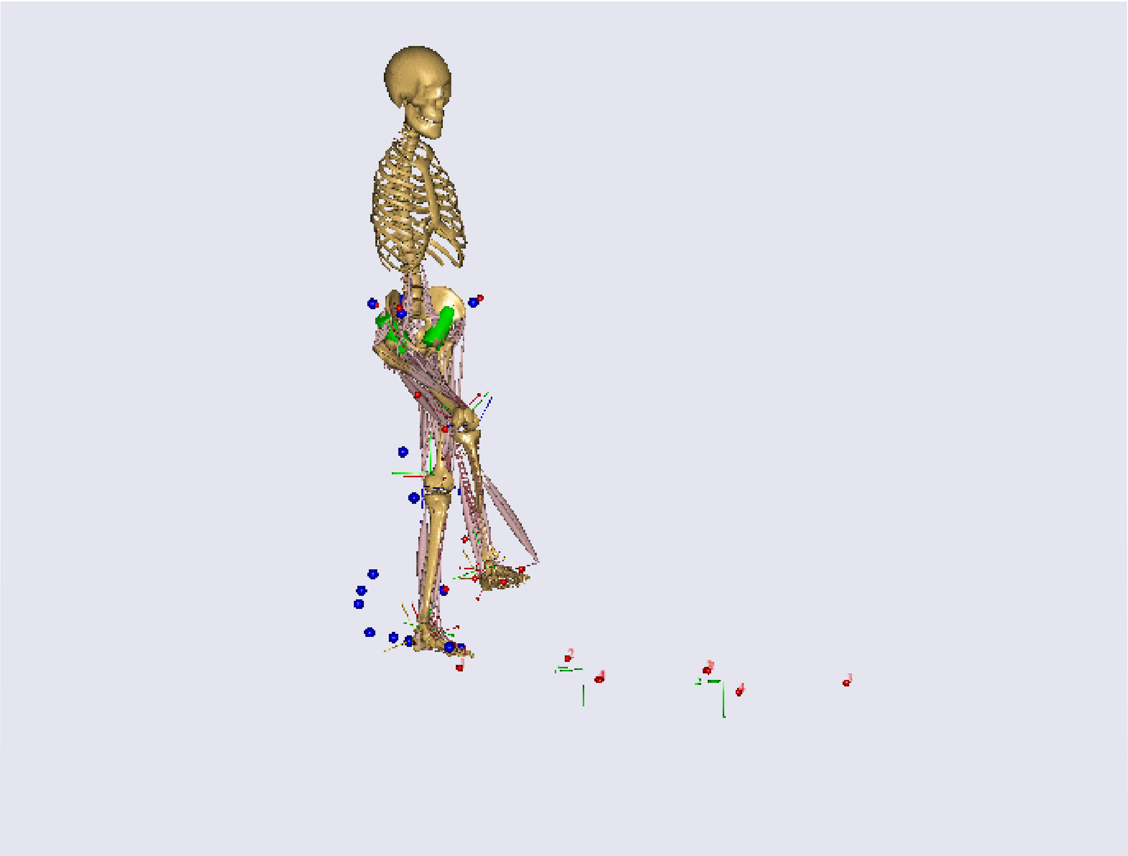
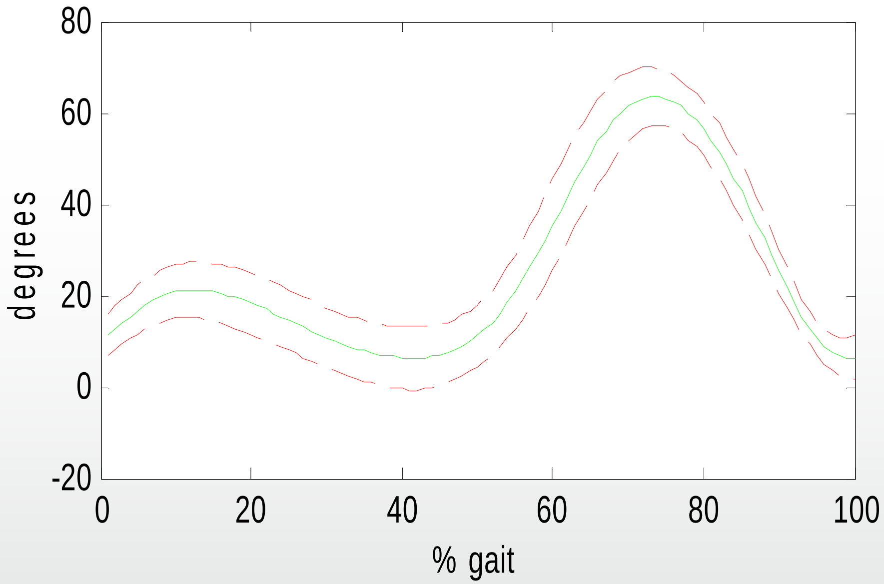
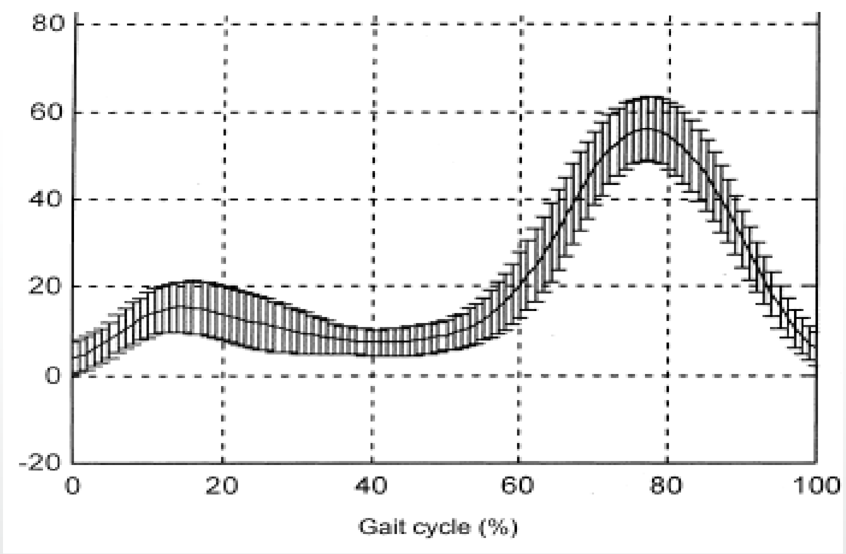
- Input kinematics and joint moments
- Calibration of muscles
- Add force plate data
- 300 Muscles recruited using polynomial solver
- Output to Matlab



Verification

- Kinematics





Marin, F., et al., *On the estimation of knee joint kinematics.* Human Movement Science, 1999. 18(5): p. 613-626.

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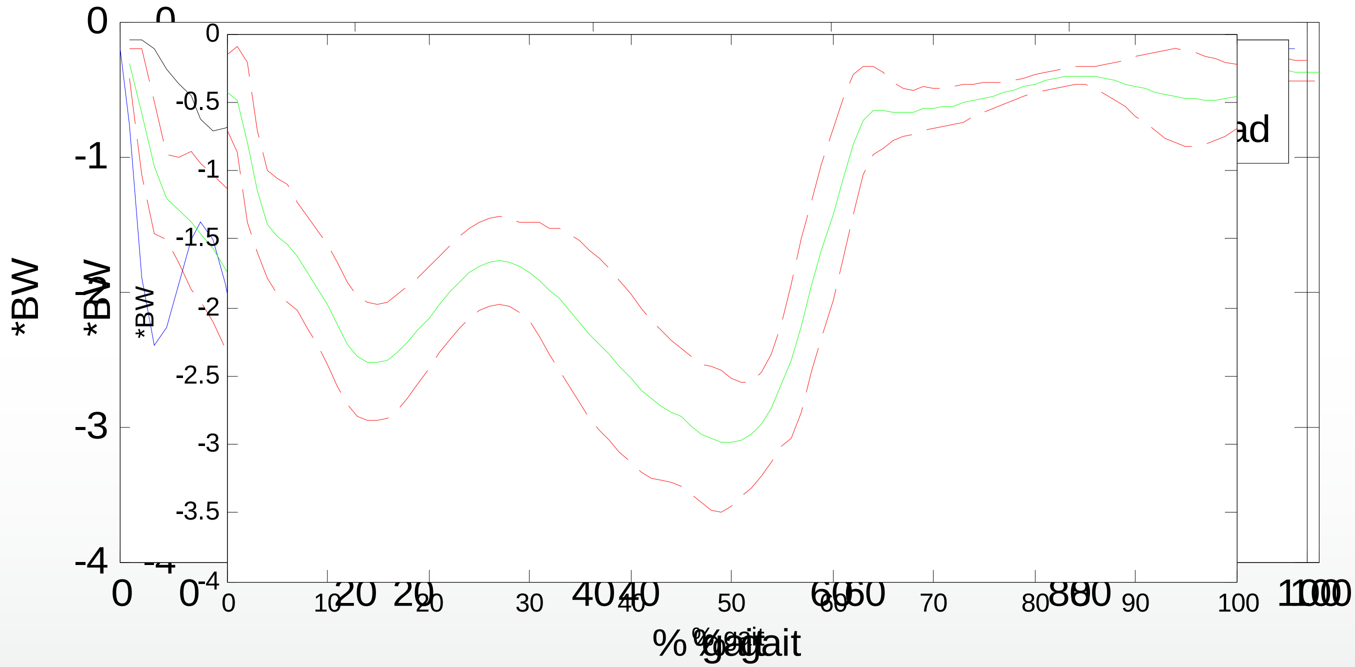
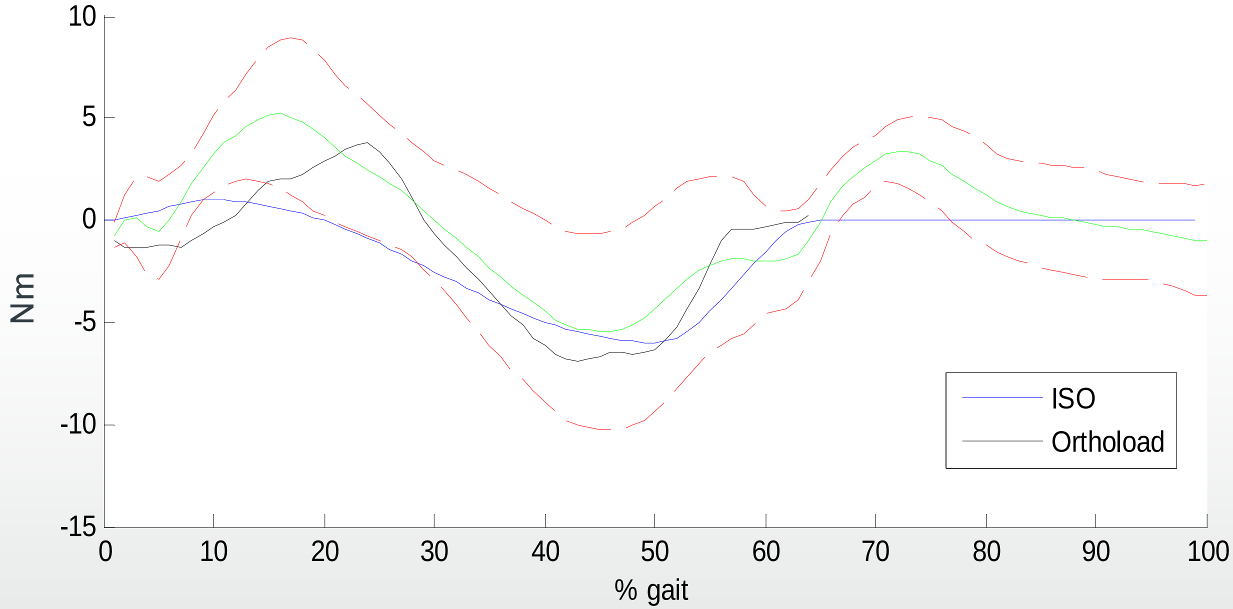
Verification



Heinlein, B., et al., *ESB clinical biomechanics award 2008: Complete data of total knee replacement loading for level walking and stair climbing measured in vivo with a follow-up of 6-10 months. Clinical Biomechanics, 2009.* 24(4): p. 315-326.
14243-1, I., *Implants for surgery. Wear of total knee joint prostheses. Loading and displacement parameters for wear-testing machines with load control and corresponding environmental conditions for test.* 2002, The International Organization for Standardization.

Verification



Heinlein, B., et al., *ESB clinical biomechanics award 2008: Complete data of total knee replacement loading for level walking and stair climbing measured in vivo with a follow-up of 6-10 months. Clinical Biomechanics, 2009.* 24(4): p. 315-326.
14243-1, I., *Implants for surgery. Wear of total knee joint prostheses. Loading and displacement parameters for wear-testing machines with load control and corresponding environmental conditions for test.* 2002, The International Organization for Standardization.

Verification

Inverse Predicted Models				
	Axial *BW	PA *BW	LM *BW	IE torque
Morrison (1969)	3.0			
ISO standard	3.3	0.33		6Nm
Schipplein et al (1991)	3.2			
Kuster et al (1997)	3.9			
Costigan et al (2002)	3.7	0.51	0.15	
Taylor et al (2004)	3.33	0.5		
Worsley (2010)	3.06	0.7	0.14	6.3Nm

Morrison, J., *The Mechanics of the Knee Joint in relation to normal walking. Journal of Biomechanics, 1970.* ***3: p. 51-61.***
14243-1, I., *Implants for surgery. Wear of total knee joint prostheses. Loading and displacement parameters for wear-testing machines with load control and corresponding environmental conditions for test.* 2002, The International Organization for Standardization.
Schipplein, O.D. and T.P. Andriacchi, *Interaction between active and passive knee stabilizers during level walking. Journal of Orthopaedic Research, 1991.* ***9(1): p. 113-119.***
Kuster, M.S., et al., *Joint Load Considerations in Total Knee Replacement. Journal of Bone & Joint Surgery [Br], 1997.* ***79-B(1): p. 109-113.***
Costigan, P.A., K.J. Deluzio, and U.P. Wyss, *Knee and hip kinetics during normal stair climbing. Gait & Posture, 2002.* ***16(1): p. 31-37.***
Taylor, W.R., et al., *Tibio-femoral loading during human gait and stair climbing. Journal of Orthopaedic Research, 2004.* ***22(3): p. 625-632.***

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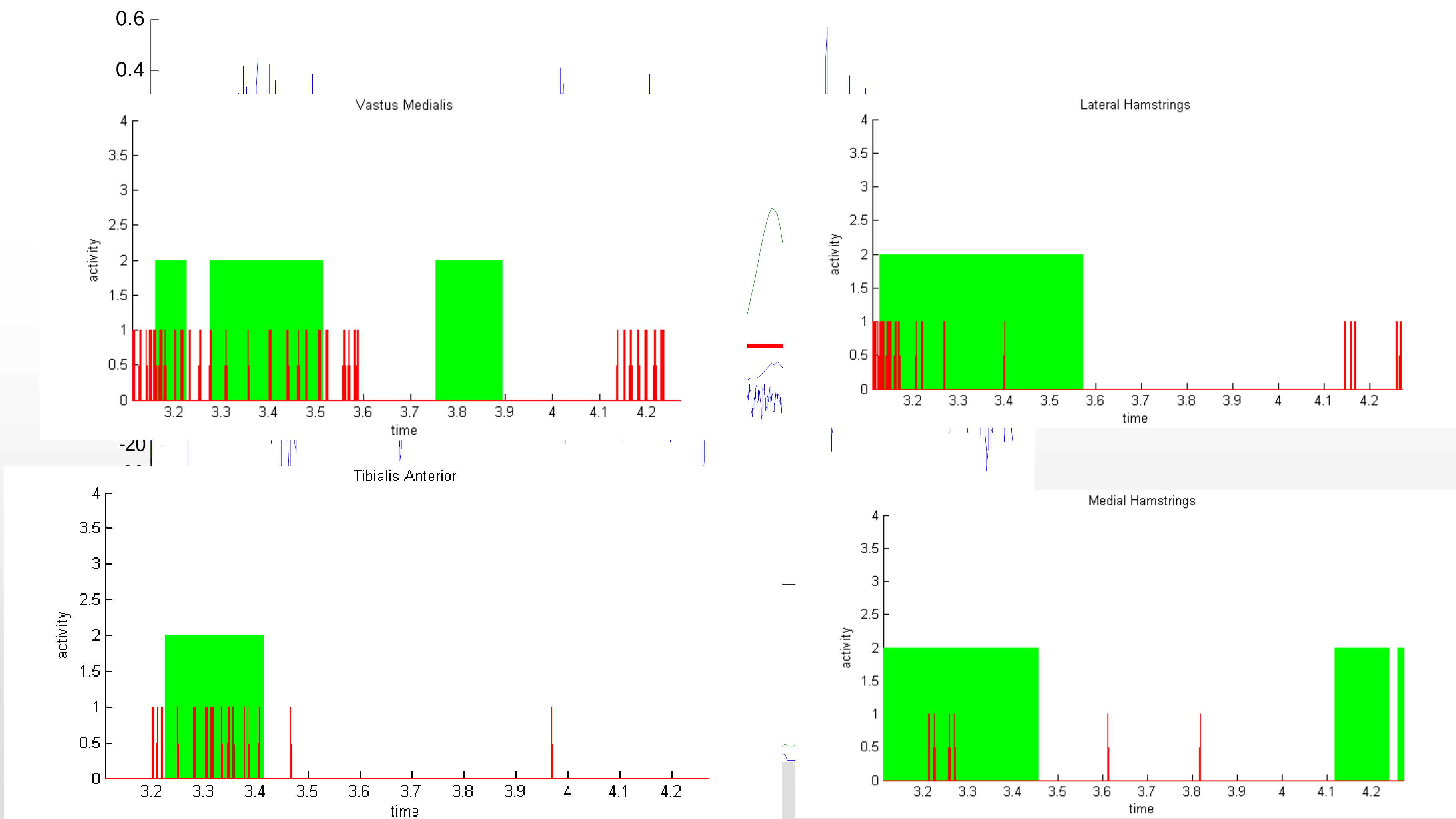
EMG vs Muscle outputs



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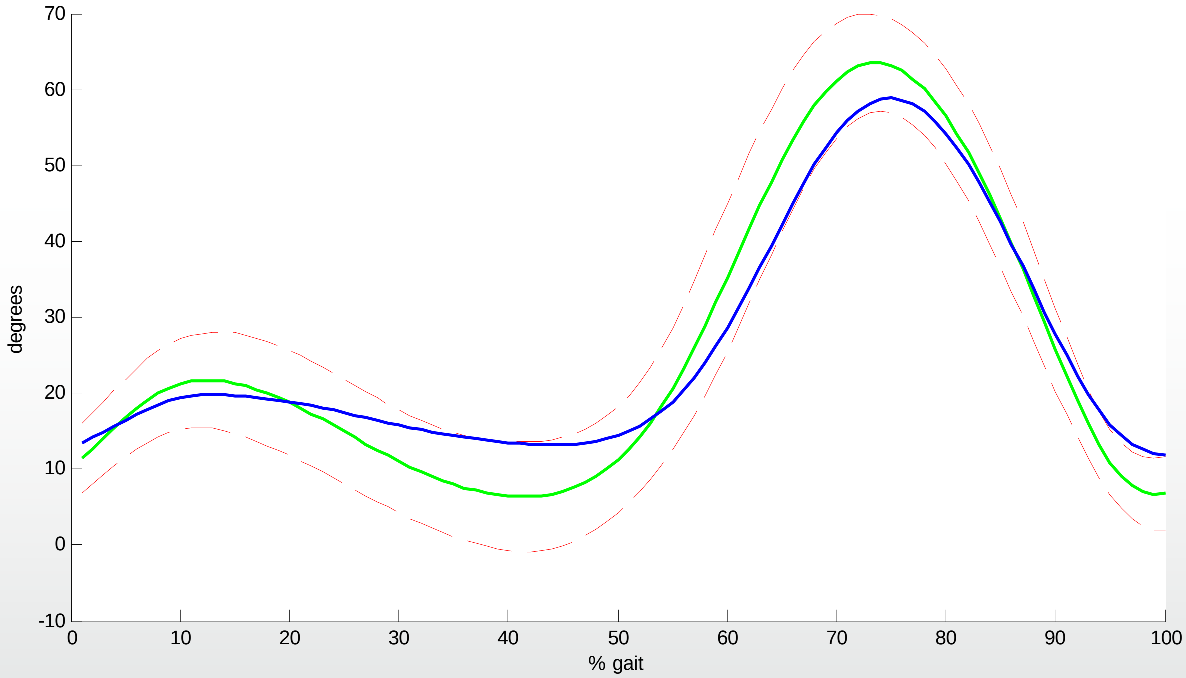
Healthy vs OA kinematics



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Healthy vs OA Kinetics

Peak mean Knee kinetics during 100% of the gait cycle. Kinetics are normalised to % of body weight (BW). Significant differences are highlighted with an asterix. Anterior-posterior reaction (AP), mediolateral reaction (ML), valgus-varus torque (VV), internal-external rotation torque (IE). Standard Deviations in brackets.

KINETICS and KINETICS

	Flexion (deg.)	Extension (deg.)	Axial *BW	AP *BW	ML *BW	VV *BW	IE *BW	Flexion moment *BW
OA affected	60.7 (5)	11.4 (6.9)	3.12 (0.62)	0.58 (0.35)	0.08 (0.11)	0.11 (0.06)	0.02 (0.01)	0.03 (0.03)
OA unaffected	61.9 (3.9)	7.6 (6.3)	3.27 (0.66)	0.55 (0.33)	0.1 (0.11)	0.16 (0.1)	0.04 (0.01)	0.03 (0.02)
Healthy	63.1 (2.1)	6.1 (3.2)	3.06 (0.37)	0.7 (0.17)	0.14 (0.12)	0.06 (0.01)	0.007 (0.004)	0.04 (0.02)

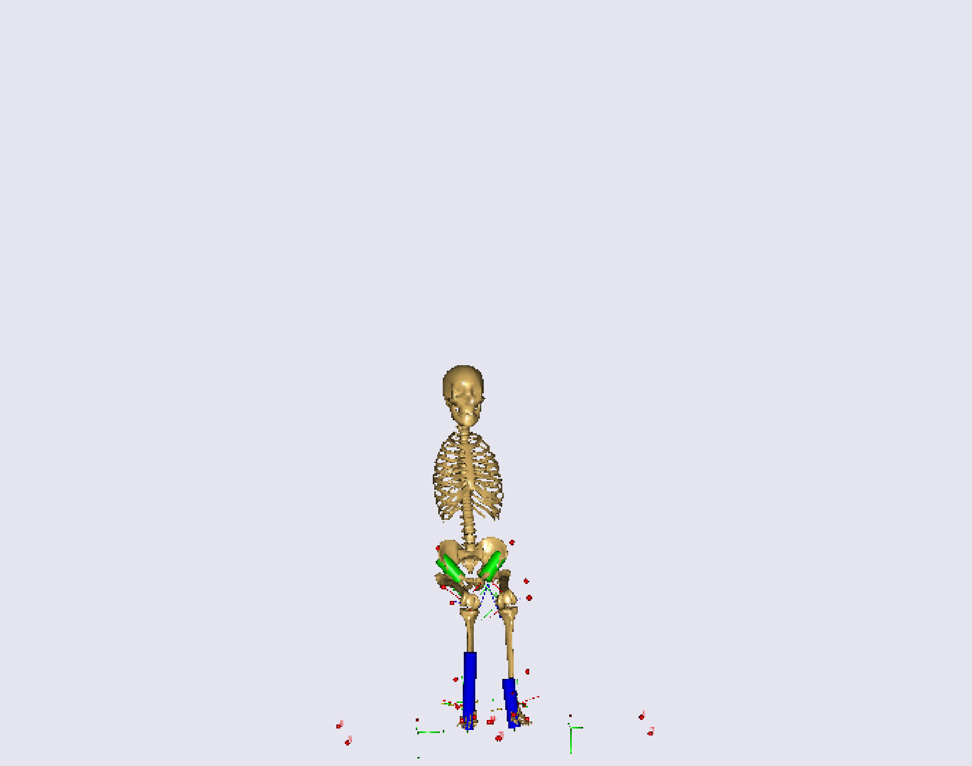
Sit-Stand

- Sit-Stand has higher foot loading asymmetry

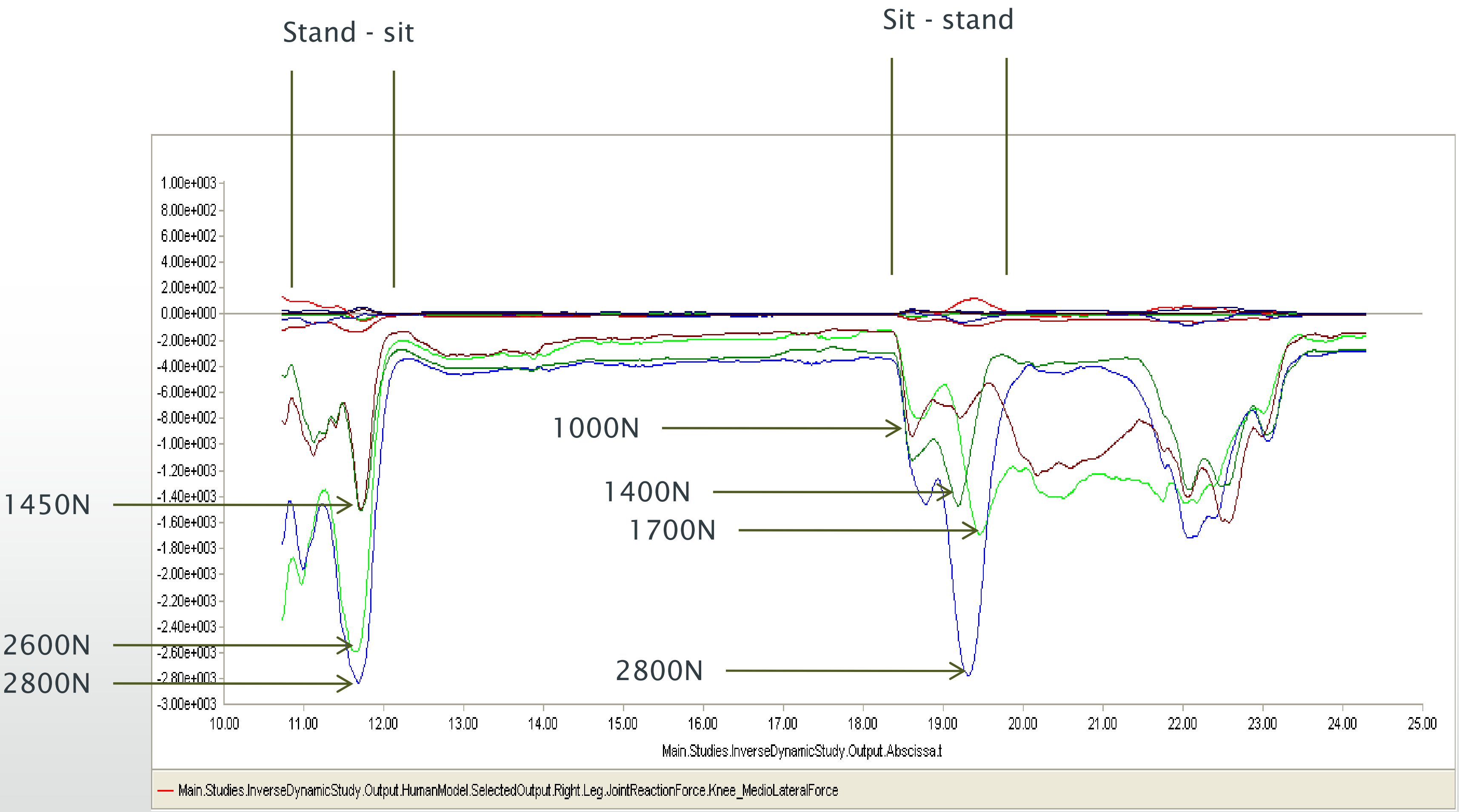
- Large knee forces on contralateral limb

- Potential for early wear of healthy joint

- Subconscious behaviour

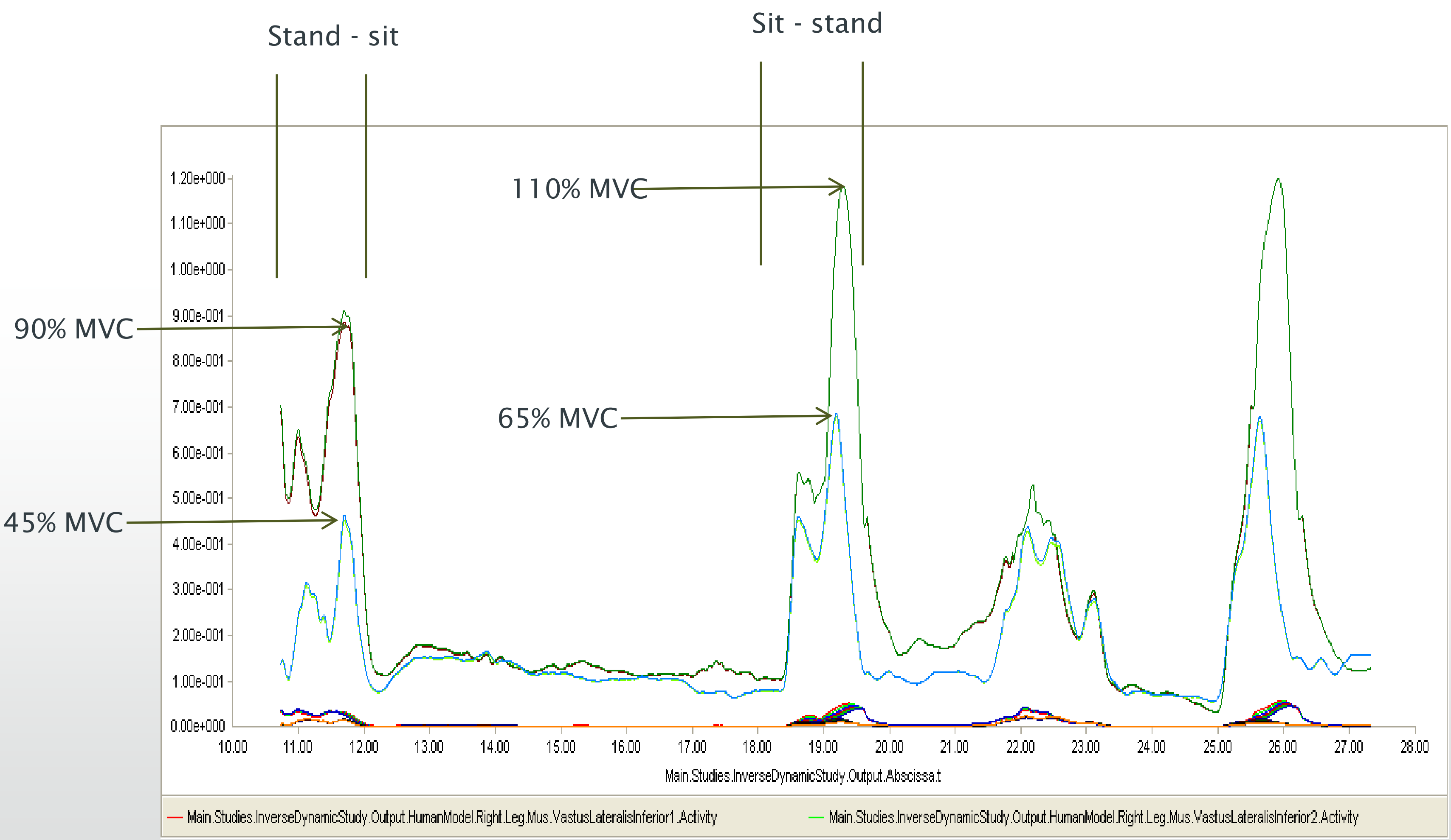


Forces



Stand - sit
Sit - stand
1000N
1400N
1700N
2800N
1450N
2600N
2800N
1.00e+003
8.00e+002
6.00e+002
4.00e+002
2.00e+002
0.00e+000
-2.00e+002
-4.00e+002
-6.00e+002
-8.00e+002
-1.00e+003
-1.20e+003
-1.40e+003
-1.60e+003
-1.80e+003
-2.00e+003
-2.20e+003
-2.40e+003
-2.60e+003
-2.80e+003
-3.00e+003
10.00 11.00 12.00 13.00 14.00 15.00 16.00 17.00 18.00 19.00 20.00 21.00 22.00 23.00 24.00 25.00
Main.Studies.InverseDynamicStudy.Output.Abscissa.t
Main.Studies.InverseDynamicStudy.Output.HumanModel.SelectedOutput.Right.Leg.JointReactionForce.Knee_MedioLateralForce

Muscle Input – Vastus Lateralis



Room for improvement

- Highly dependent on the accurate collection and processing of body segmental kinematics [1]

- Simplification of segments, i.e. foot is represented as a single segment.

- Joints are idealised by adding constraints,

- Scaling of the model is generic and therefore does not represent the varying physical properties.

- Soft tissues structures are ignored.

- Co-contractions

1. Riemer, R., E.T. Hsiao-Wecksler, and X. Zhang, *Uncertainties in inverse dynamics solutions: A comprehensive analysis and an application to gait.* Gait & Posture, 2008. **27**(4): p. 578-588.

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DISCUSSION

- Predicted loading comparable to current literature
- EMG has a good correlation with Pmet from AnyBody
- Altered loading in OA patients
- Variance in loading patterns
- The harder the activity the larger the asymmetry
- Implications

Future Work

- 6 DOF knee modelling
- Valgus Varus modelling
- Brunel 2010 (International Conference on Orthopaedic Surgery, Biomechanics and Clinical Applications)
- European Society of Biomechanics (ESB) 2010

Acknowledgments

Prof Mark Taylor
Prof Maria Stokes
Prof David Barrett

QUESTIONS?

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Q&A Session

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