The webcast will start in a few minutes….

LifeLongJoints

LARGE CLINICAL DATASET FOR ASSESSMENT OF JOINT REPLACEMENTS.

SEVENTH FRAMEWORK PROGRAMME

Grant agreement no. NMP-310477

Outline

- Short introduction to the AnyBody Modeling System.
- Background on LifeLongJoints
- Large data set for functional assessments of total hip replacement patients
- Questions and answers

Professor Richard M. Hall
LifeLongJoints coordinator
School of Mechanical Engineering
Leeds University.

Post.Doc. David Lunn
Leeds NIHR Biomedical Research Centre
Leeds Teaching Hospitals NHS Trust

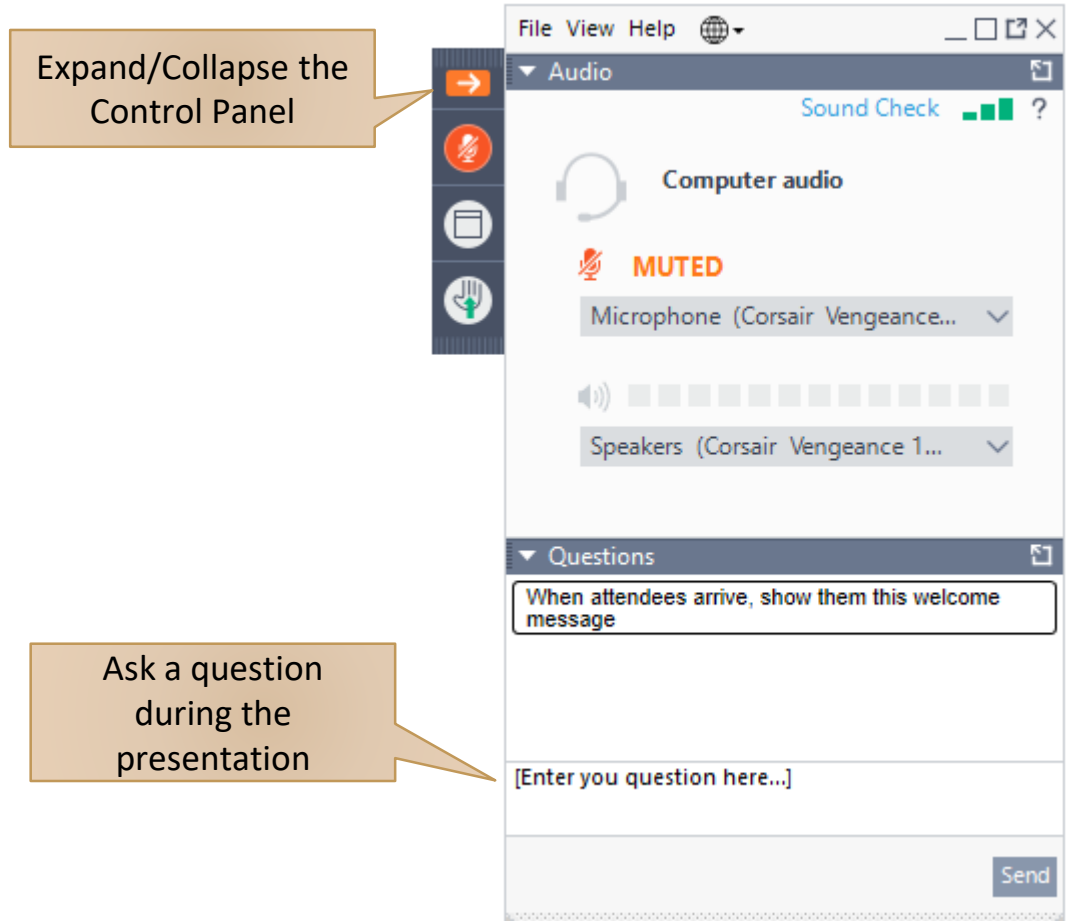
Host:
Morten Enemark Lund
R&D Engineer
AnyBody Technology

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

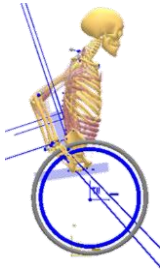
Kinematics + Forces

ANYBODY Modeling System

Body Loads

- Joint moments
- Muscle forces
- Joint reaction forces

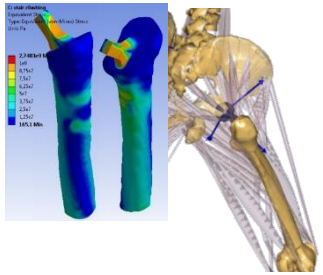
Movement Analysis



Product Design Optimization

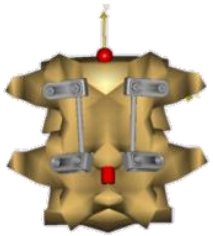
ANYBODY Modeling System

Ergonomic Analysis



Load Cases for Finite Element Analysis

Surgical Planning and Outcome Evaluation

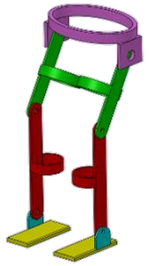


AnyBody Modeling System

Motion and Forces

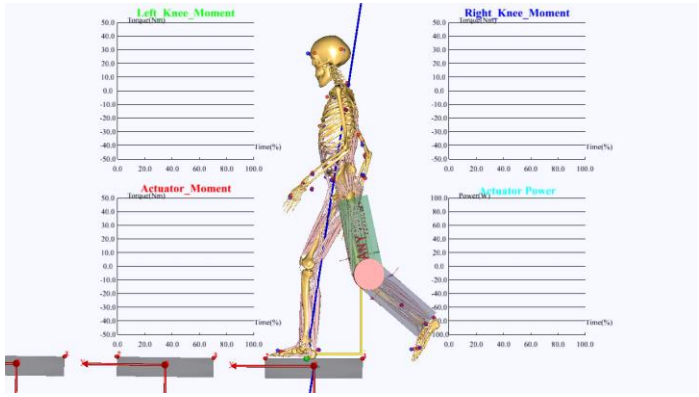
Body model

Environment model



Inverse dynamics
Muscle recruitment

Simulation



Internal body loads

- Muscle forces
- Joint forces

Design Optimization

Post Processing (e.g. FE tools)

Background on LifeLongJoints

Professor Richard M. Hall
LifeLongJoints coordinator
School of Mechanical Engineering
Leeds University.

LIFE LONG JOINTS

Background on LifeLongJoints

- Functional Outcomes of hip arthroplasty
- Implant testing from ADLs
- Public release of the dataset

Post.Doc. David Lunn
Leeds NIHR Biomedical Research Centre
Leeds Teaching Hospitals NHS Trust

Large dataset for functional assessment of total hip replacement patients

Dr David Lunn & Prof Anthony Redmond
Leeds Teaching Hospital NHS Trust

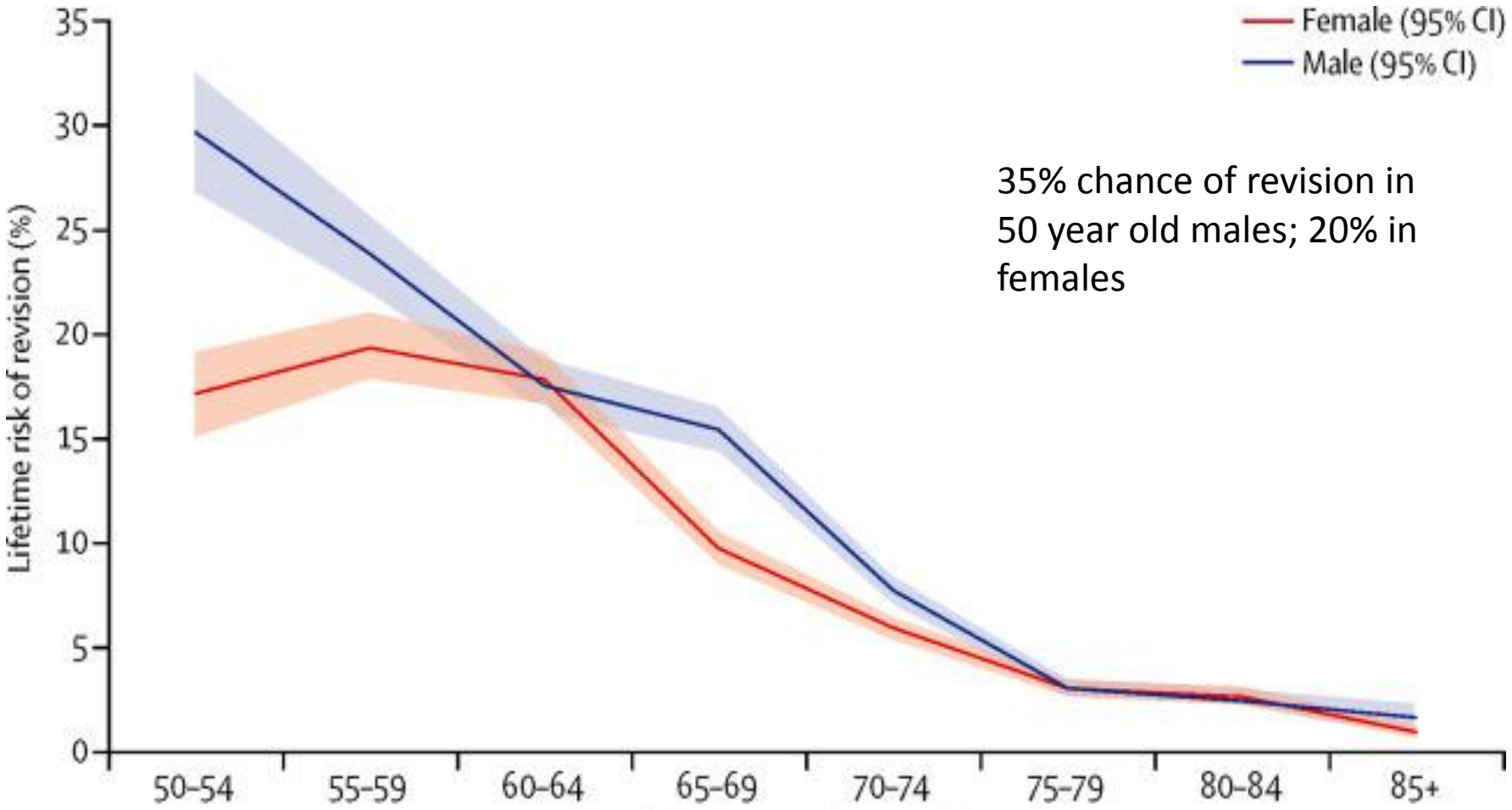
Overview

- Introduction
- Data collection
- Patient stratification results
- Joint contact forces
- Pre clinical testing- waveform development
- Future plans for the data

THR & Revision Rates

- 93,234 primary total hip replacements took place in the UK (National Joint Registry, 2016)
- THR revision rates at 4.4% at 10 years and a 20 year revision rate of 15%
- The majority of failures will be due to the wear
- Revision rates are linked with patient characteristics

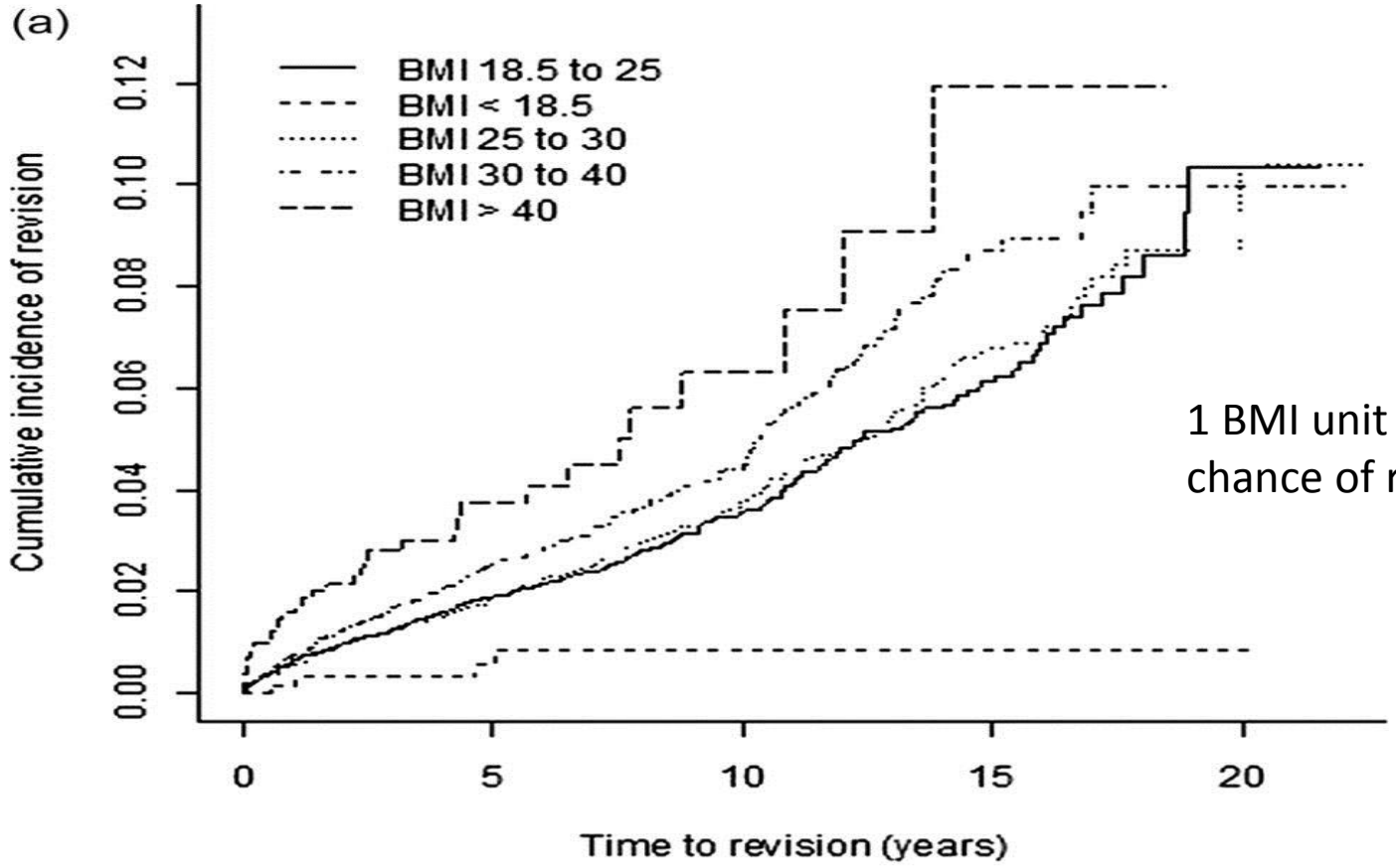
THR & Revision Rates



35% chance of revision in 50 year old males; 20% in females

Bayliss LE, Culliford D, Monk AP, Glyn-Jones S, Prieto-Alhambra D, Judge A, et al. The effect of patient age at intervention on risk of implant revision after total replacement of the hip or knee: a population-based cohort study. The Lancet.389:1424-30.

Revision Rates

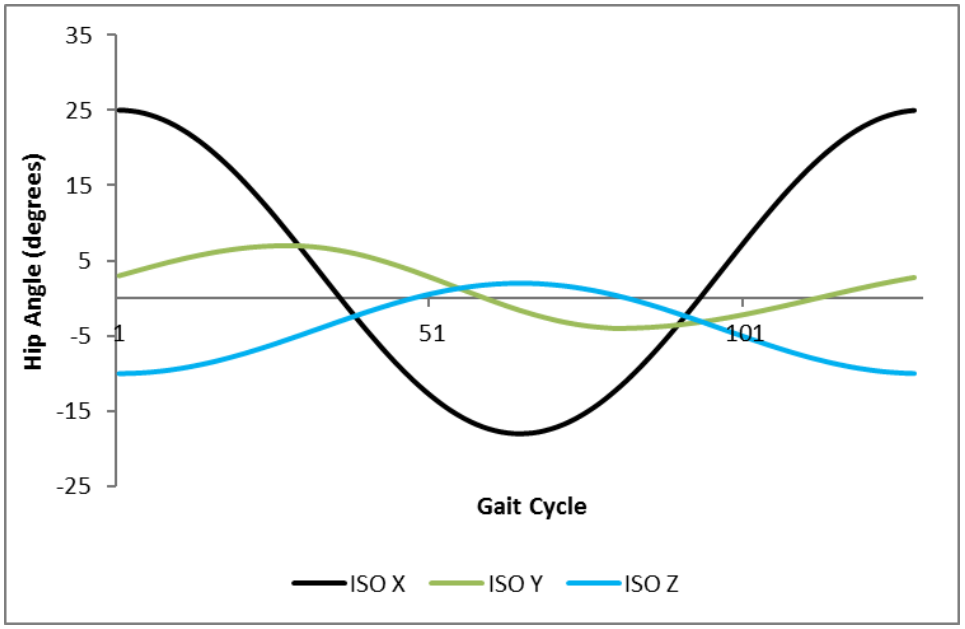


1 BMI unit = 2% increase in chance of revision

Culliford D, Maskell J, Judge A, Arden NK. A population-based survival analysis describing the association of body mass index on time to revision for total hip and knee replacements: results from the UK general practice research database. BMJ Open. 2013;3.

Current Preclinical Testing

ISO 14242



- 3 KN axial force
- Only walking
- 5 million cycles= 45mins walking/ day for 1.5 years
- Not THR patients

PARAMETER	MAXIMUM	MINIMUM	AVERAGE	Average
SUBJECT'S HEIGHT - IN.	72.5	62.5	68.2	5ft 6in
WEIGHT- LB.	180	127	140.7	10st 5lbs
AGE - YR.	36.9	18.5	21.6	21.6 years

Paul (1967)

Improving Preclinical Testing

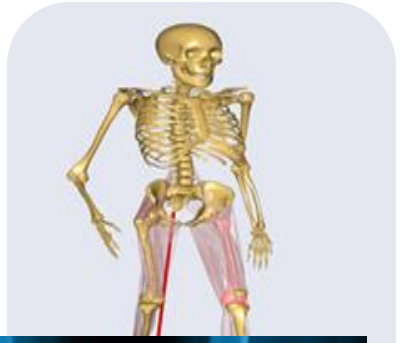
Preclinical testing should be-

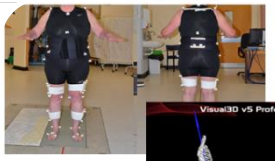
- Patient specific
  - Movement and loads
- Patient relevant
  - Activities of daily living

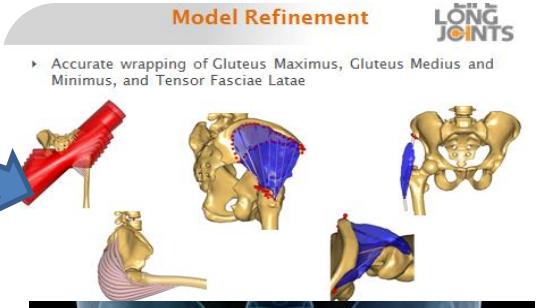
Our Task- Develop new more representative waveforms which could be used for preclinical testing.

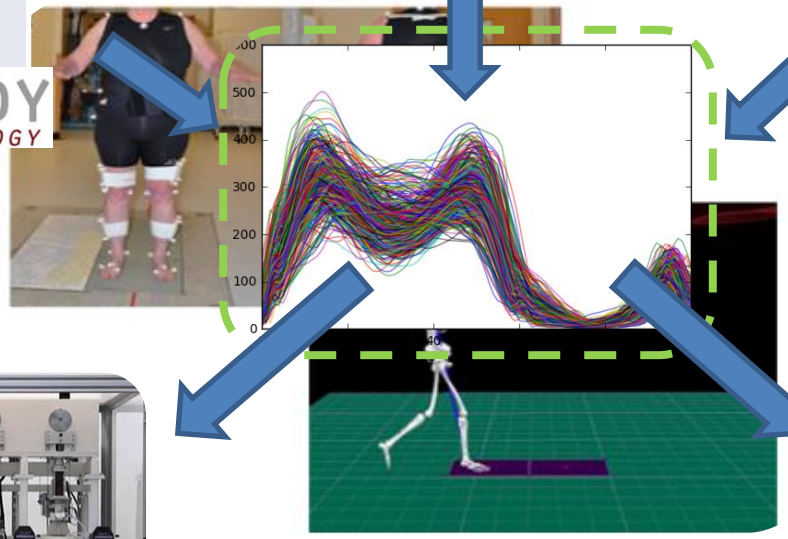
The Leeds Teaching Hospitals NHS
NHS Trust

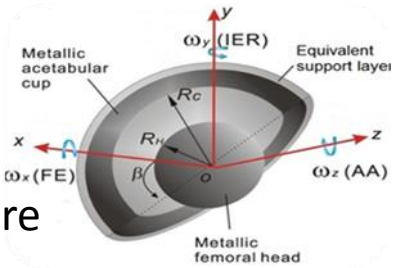
LIFE LONG JOINTS











Leeds NIHR Biomedical Research Centre

UNIVERSITY OF LEEDS

Imperial College London

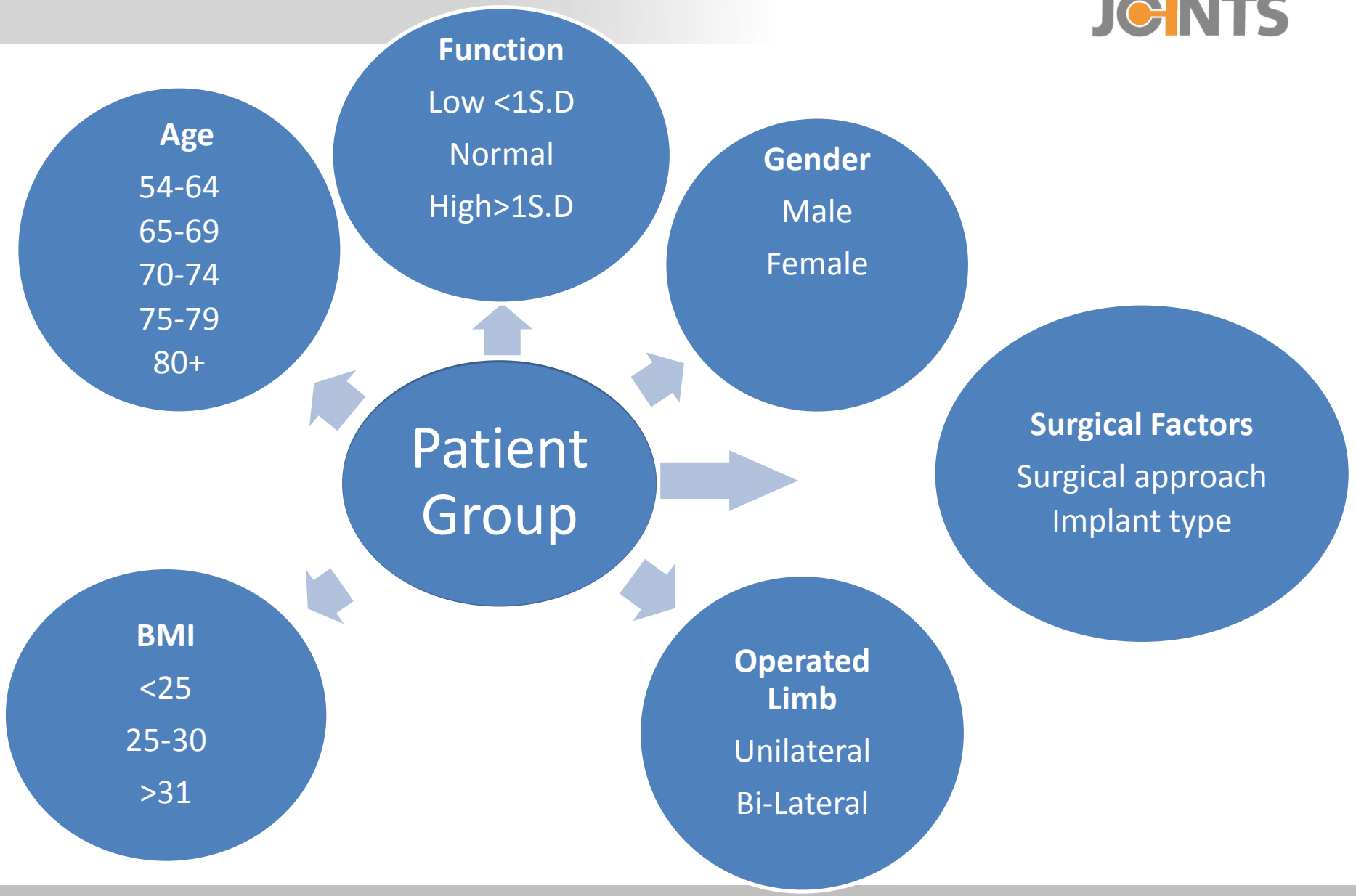
Recruitment- Patient Specific

- Large numbers to explore patient characteristics
  - 1300 patients contacted –Clinical database
  - All THR between 1-5 years
  - No other joint replacements
  - No pain

Patients Recruited

Number	Gender	BMI	Age (years)
137 THR patients	70 (Male) 67(Female)	28.1 (3.9)	71.1 (9.6)

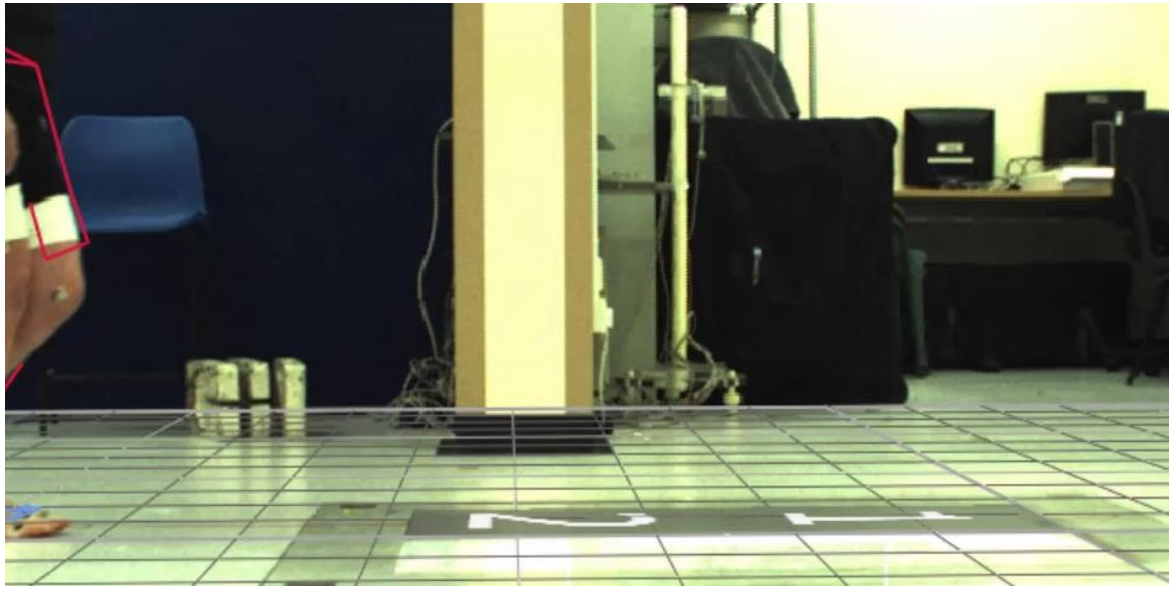
Stratification



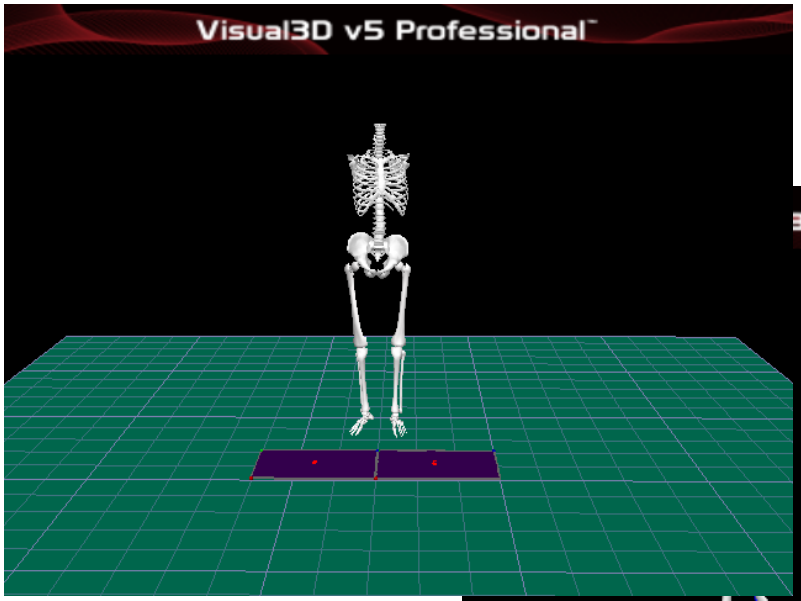
Data Collection

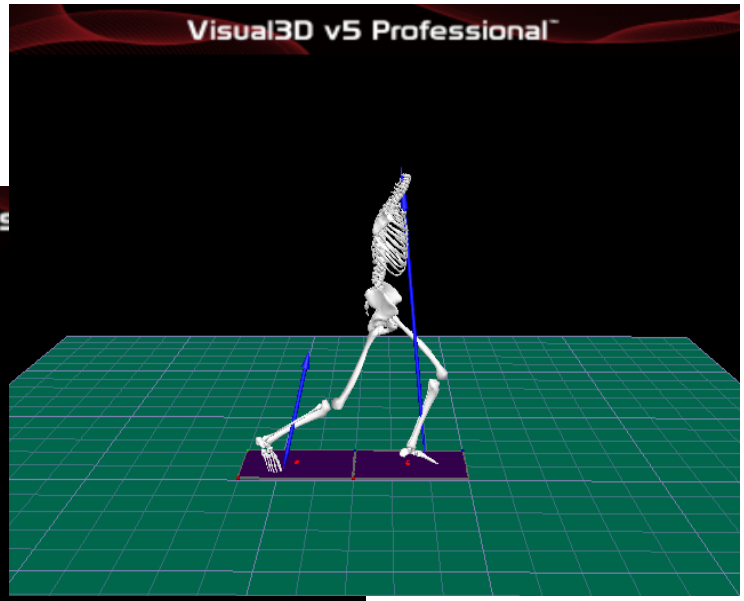
Gait Laboratory

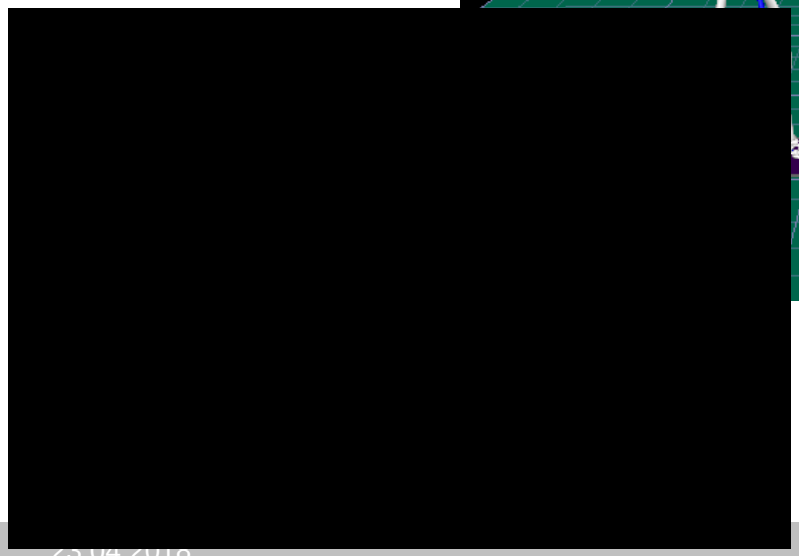
- 10 camera Vicon system
- 2 AMTI force plates
- Force plate mounted stairs
- CAST marker set
- 6 upper body markers

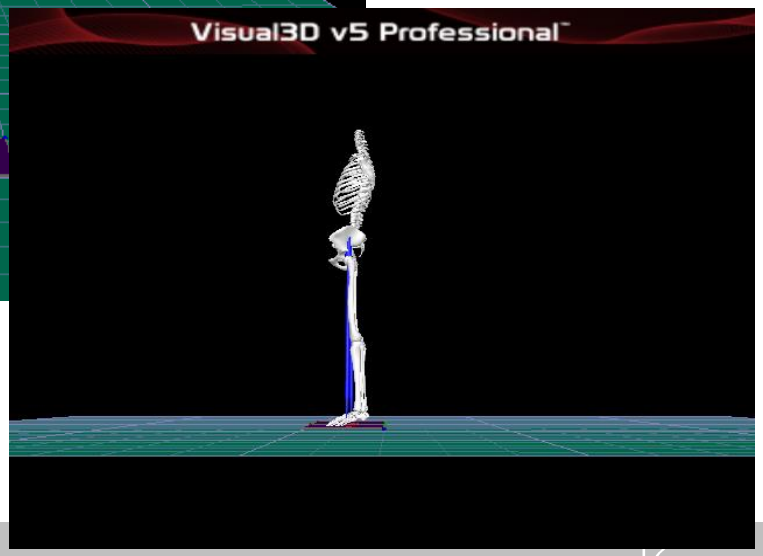


Activities of Daily Living









Collected Data

ADL's	Patients Collected
Walk	137
Fast	120
Sit to Stand	120
Stairs	112
Lunge	45
Squat	41
Foot on Bench	60
Jog	3
Jump	2

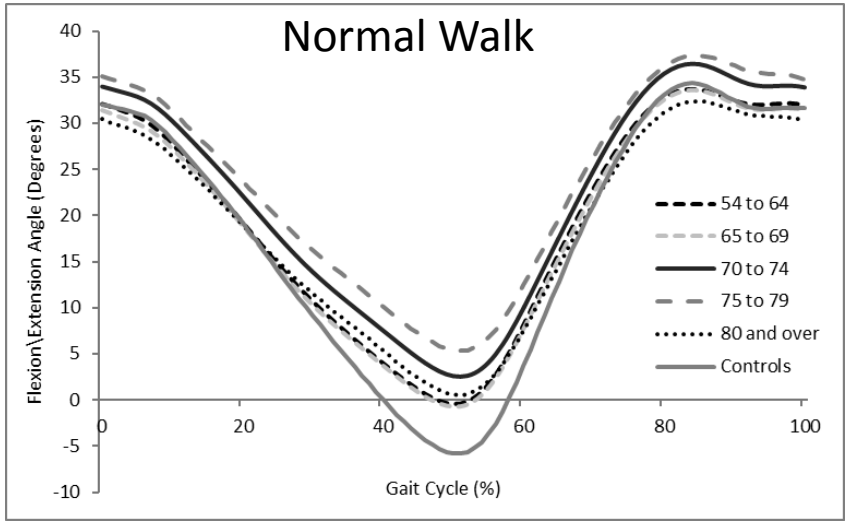
Patient Stratification

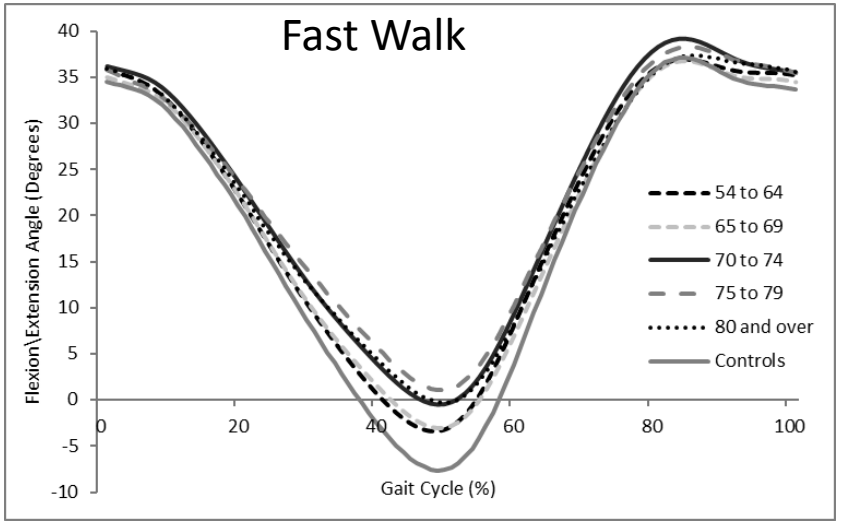
- Age- 54 to 64; 65 to 69; 70 to 74 years; 75 to 79;80 and over

- Function- low function; normal function and high function

Gait compared under normal and fast walking conditions

Age Strata





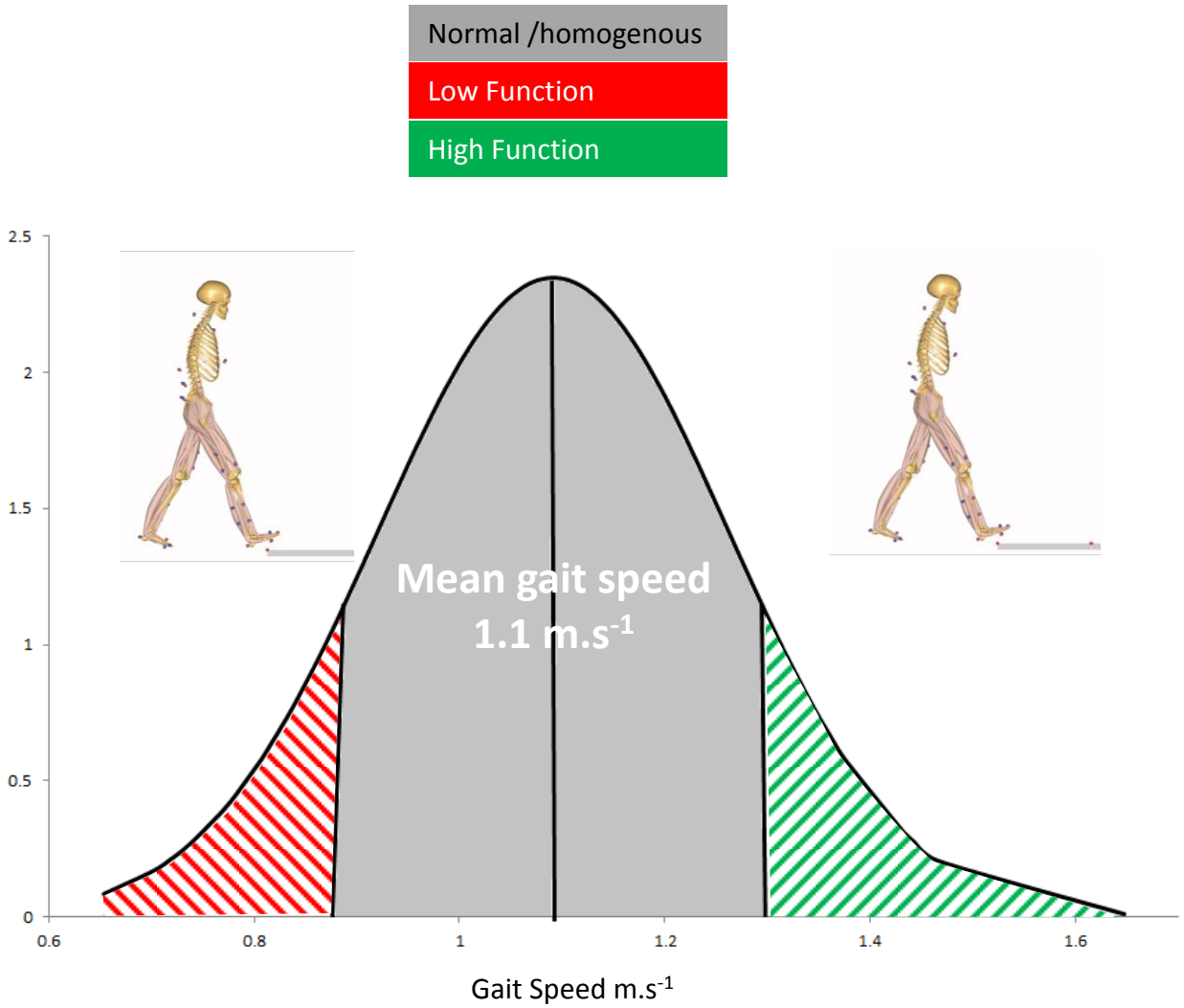
Older patients

- Gait speed,
- Peak abduction moment
- Reduced peak extension

In fast walking differences were less clear

Lunn et al- Submitted to Osteoarthritis & Cartilage

Better indicator of function?



Low Function Group (LF)

- -1SD (≥0.93 $m.s^{-1}$)
- N=19 (6male)
- Age 77.0±5.9 years
- BMI-28.3±4.8

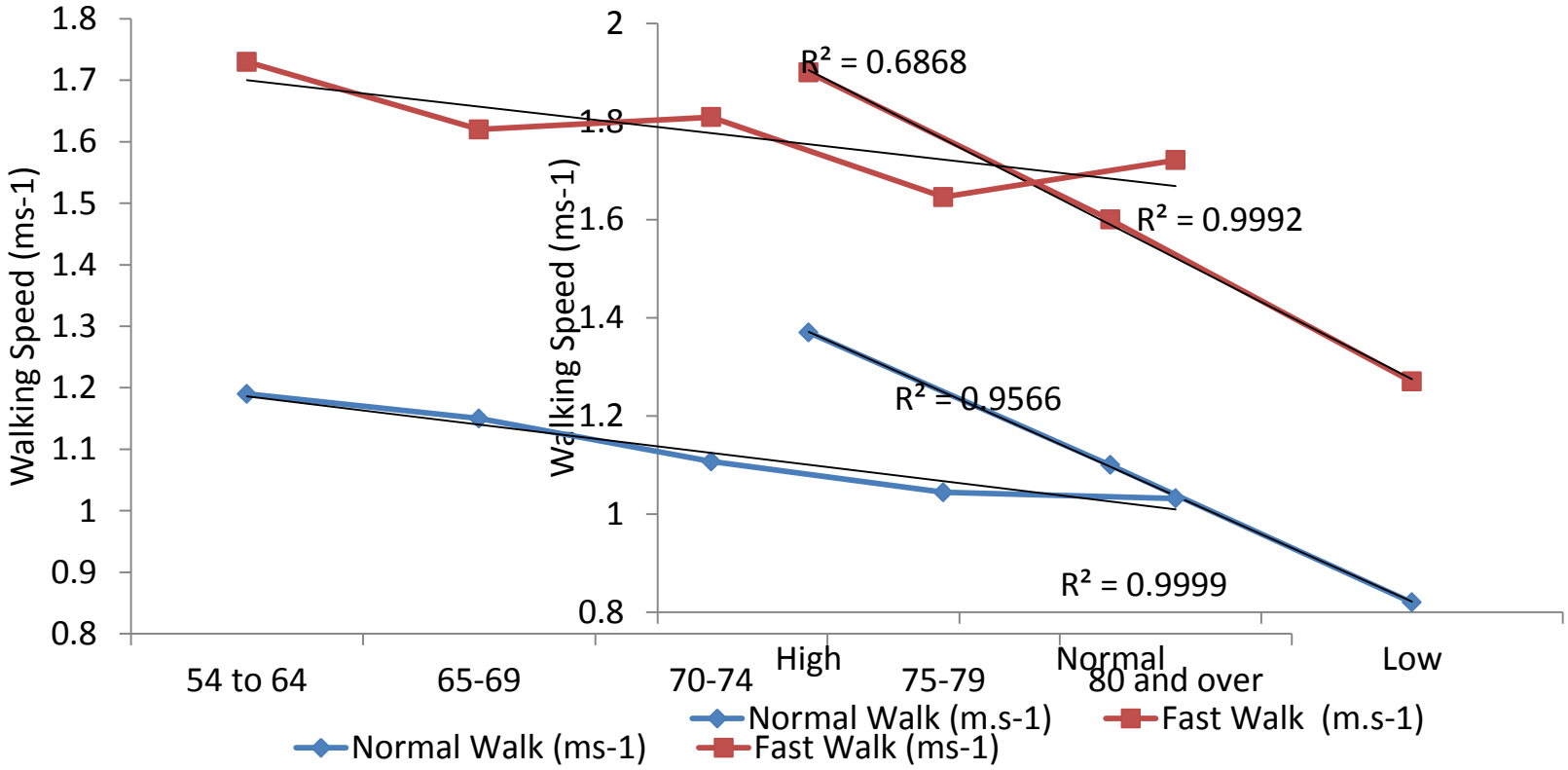
High Function Group (HF)

- +1SD (≥1.26$m.s^{-1}$)
- N=19 (10male)
- Age-68.7±6.7 years,
- BMI-27.3 ±3.0

Healthy Control Group (CG)

- N=27 (5male)
- Age-71.2 ±6.9 years,
- BMI-25.63 ±4.2

Age & Function Results

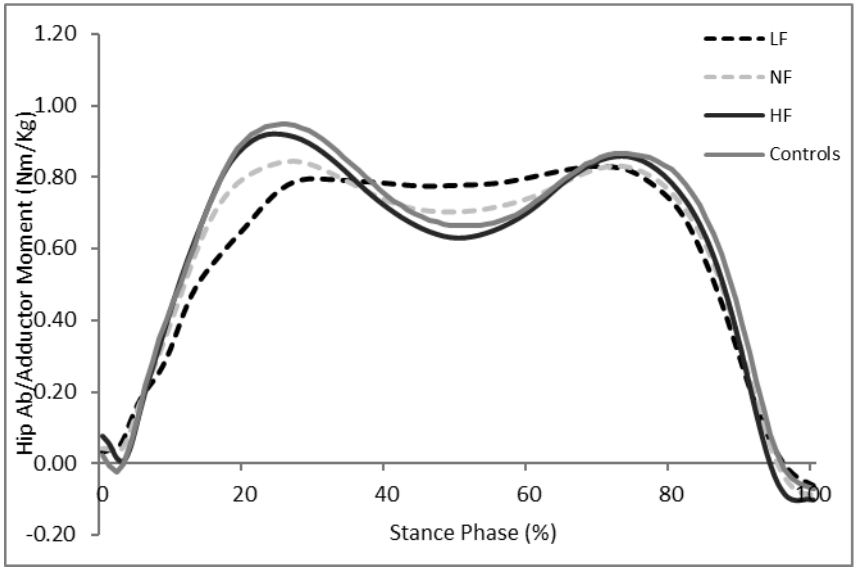


- Walking speed for the HF group was 1.4 ms^{-1} (95% CI 1.34 to 1.42) compared to 0.8ms^{-1} (CI 0.78 to 0.85) in the LF group

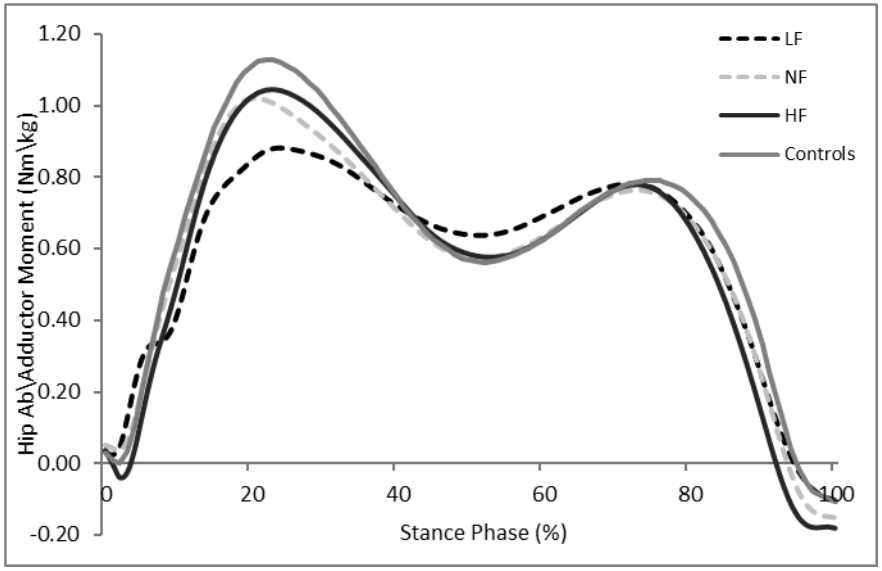
Lunn et al , (ISTA, 2017)

Function Walk and Fast Walk

Normal Walk



Fast Walk



- Low function group lower in most joint kinematic and kinetic variables
- Low functioning patients demonstrated a systematically reduced GRF which were reflected in the hip moments

Age and Function Strata

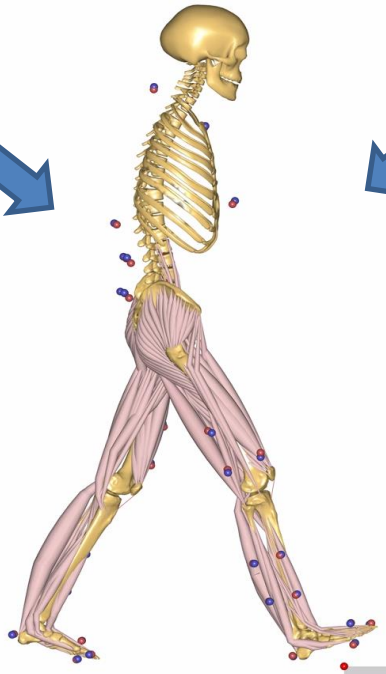
- Age is not a consistent indicator of true function
- Stratifying by gait speed is a better indicator of function
- Stratifying patients is useful to identify heterogeneity within patients.

Joint Contact Force

137 THR Patients

Marker positions

Ground reaction forces

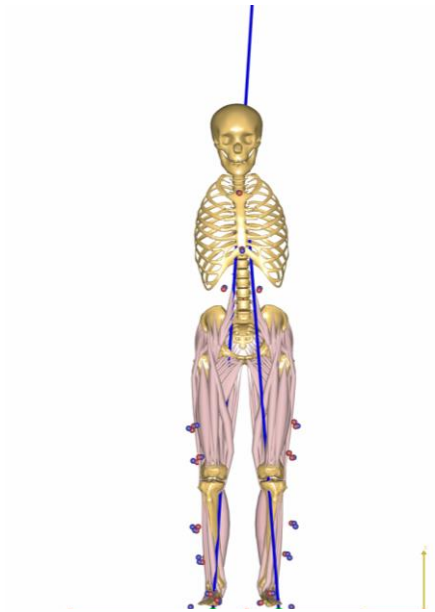


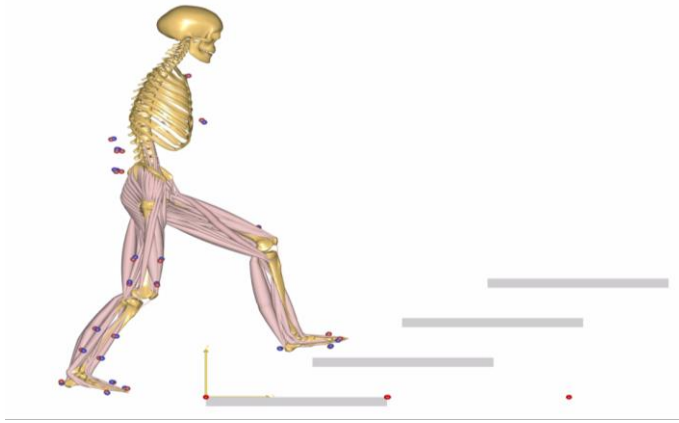
Scaled generic musculoskeletal model
Refinement and validation-
Good agreement with measured HCF
RMSE=0.298*BW (*De Pieri et al*, ISB 2017)

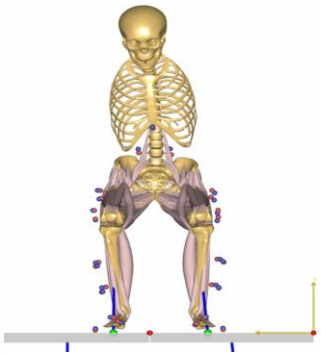
Webcast ETHZ-
Enrico De Pieri &
Stephen Ferguson
(mid May)

Joint kinematics and joint contact forces

Activities of Daily Living







627- Walking Trials

504- Fast walking

406- Sit to stand

406- Stand to sit

243- Stair ascent

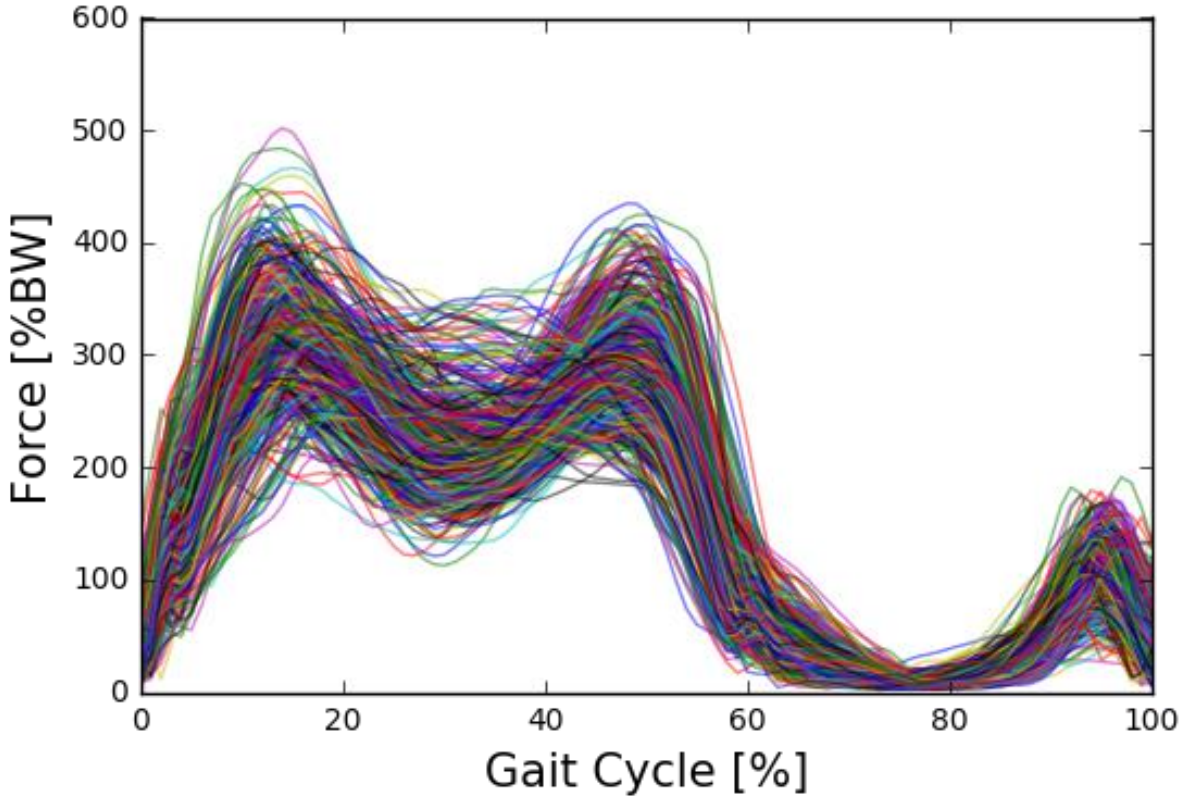
221- Stair descent

206- Squat

121- Lunge

3- Jogs

Joint Contact Force



627- Walking Trials

504- Fast walking

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3- Jogs

simulation solutions

Preclinical Testing

LIFE LONG JOINTS

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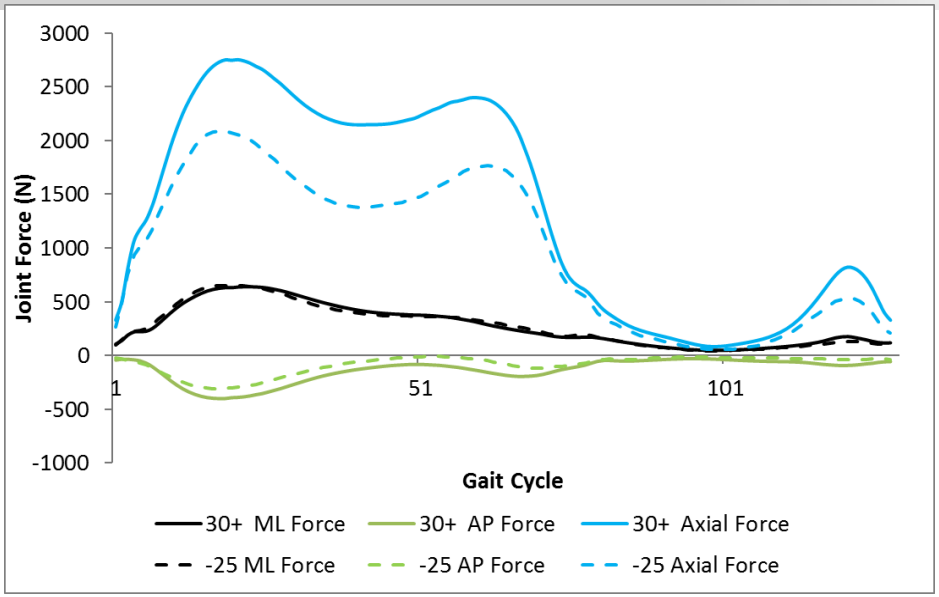
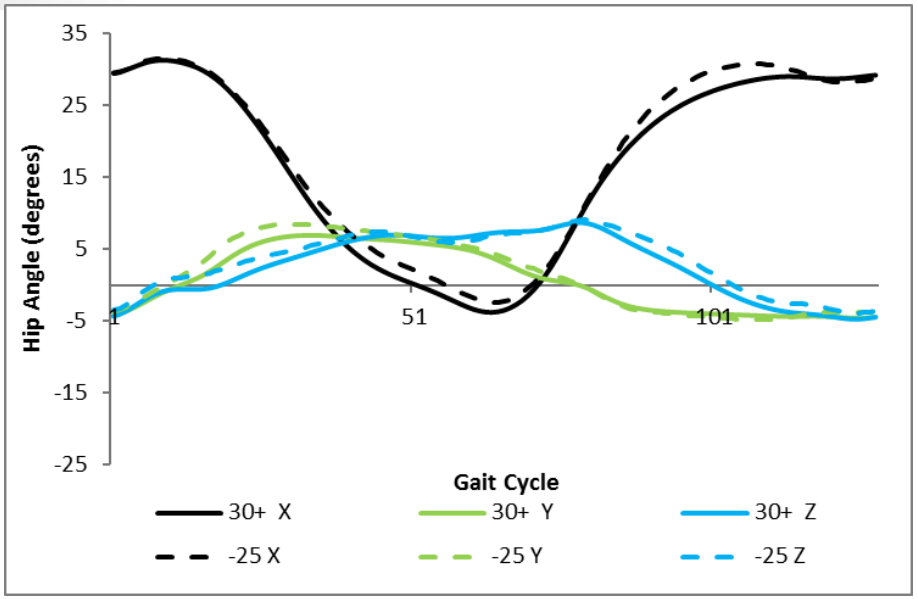
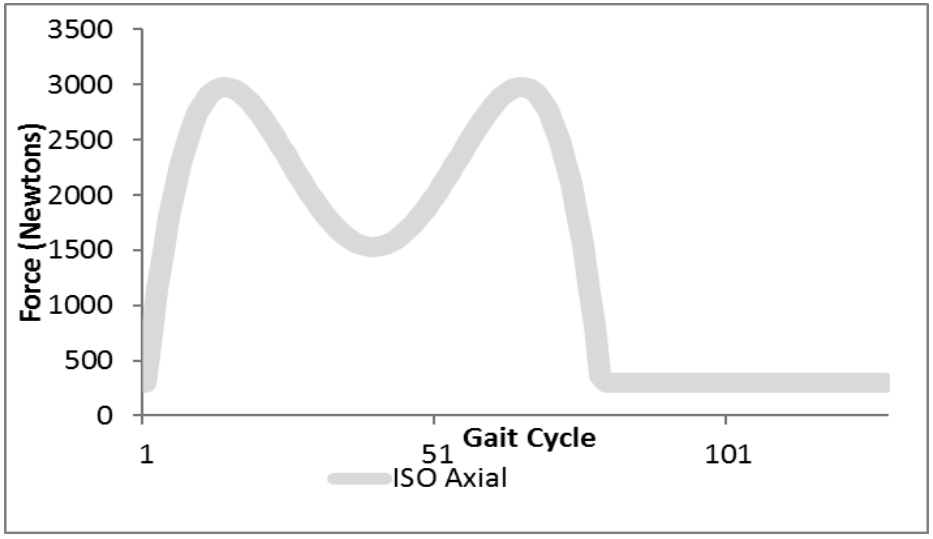
- **BMI**- Low versus high- Healthy(<25) versus Obese (>30)

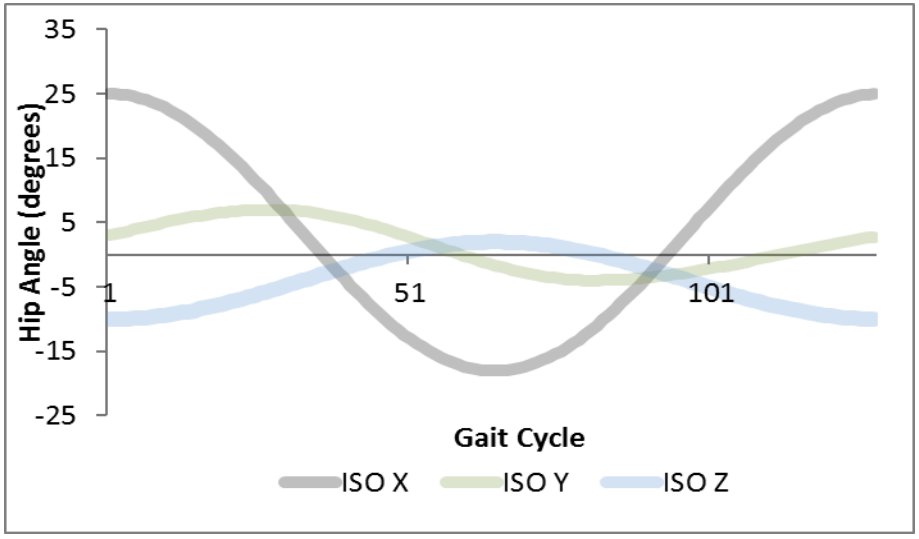
- **Patient Function**- Low versus high functioning

Wear Testing- BMI

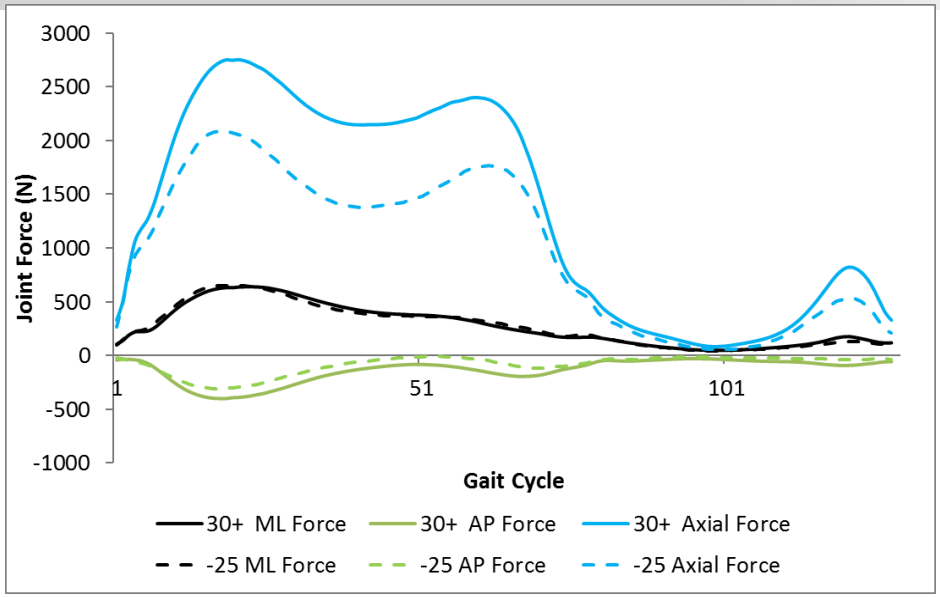


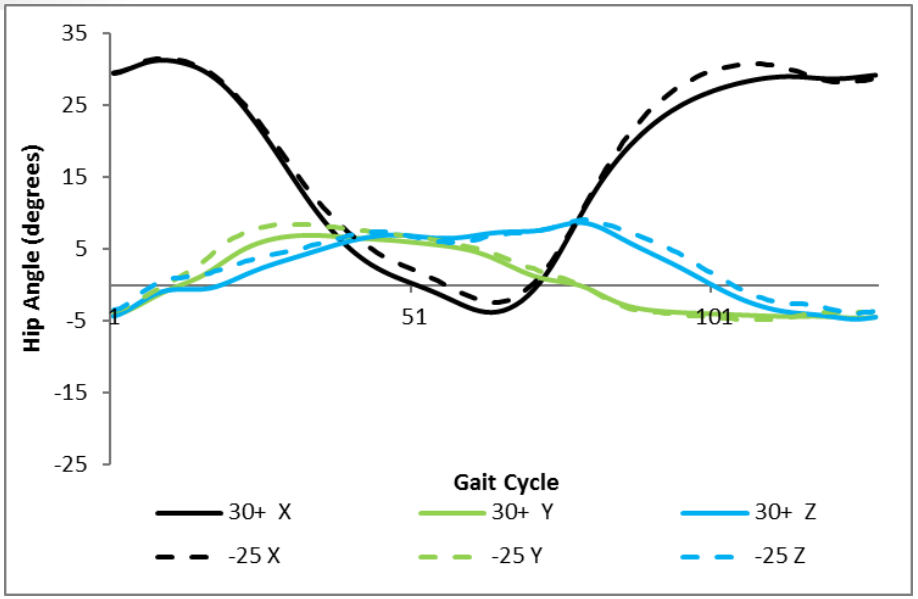




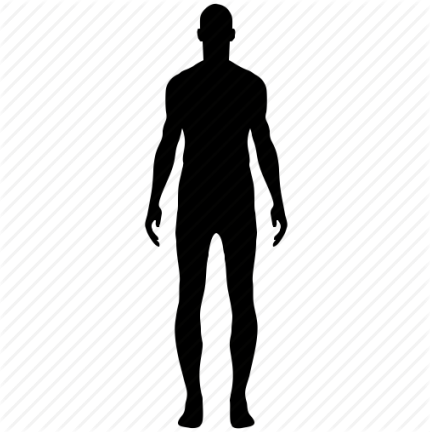


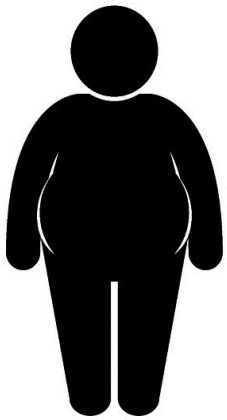
Wear Testing- BMI





International Organization for Standardization ISO 9001





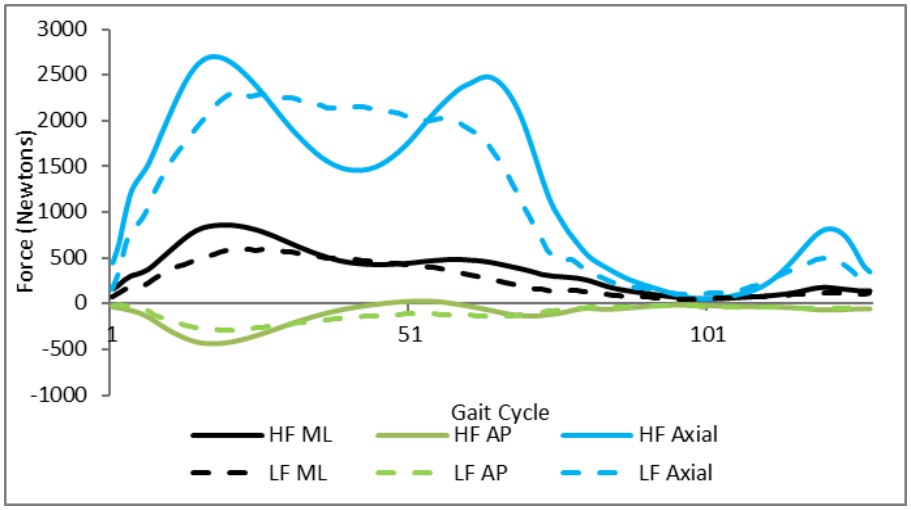
Wear volume 3-5 million cycles

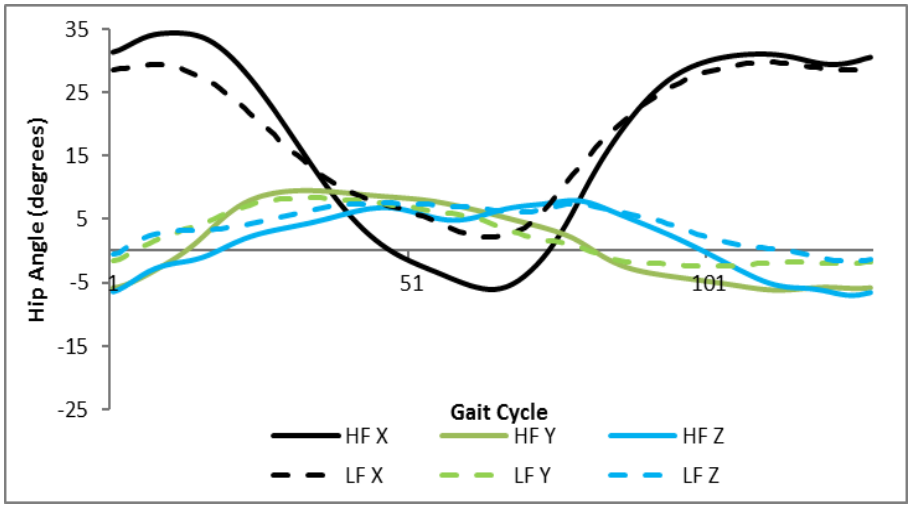
15-22 mm^3

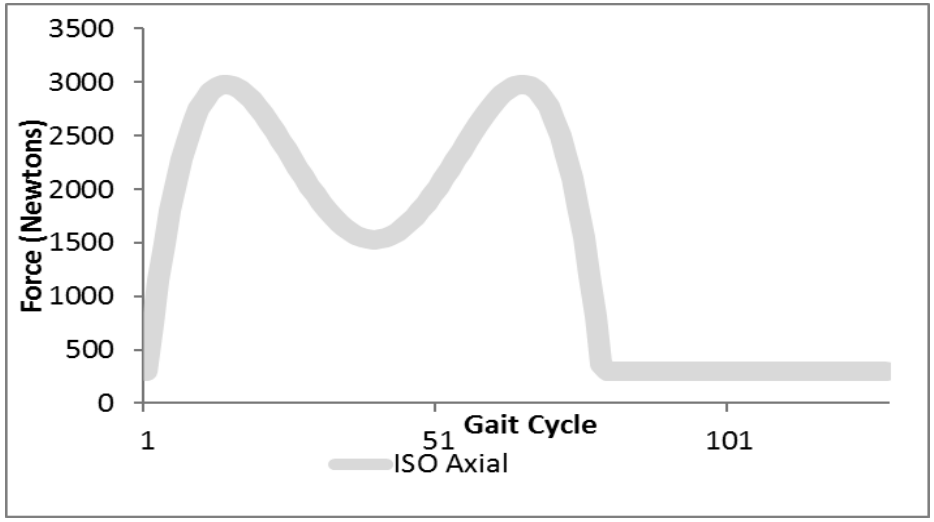
55-66mm^3

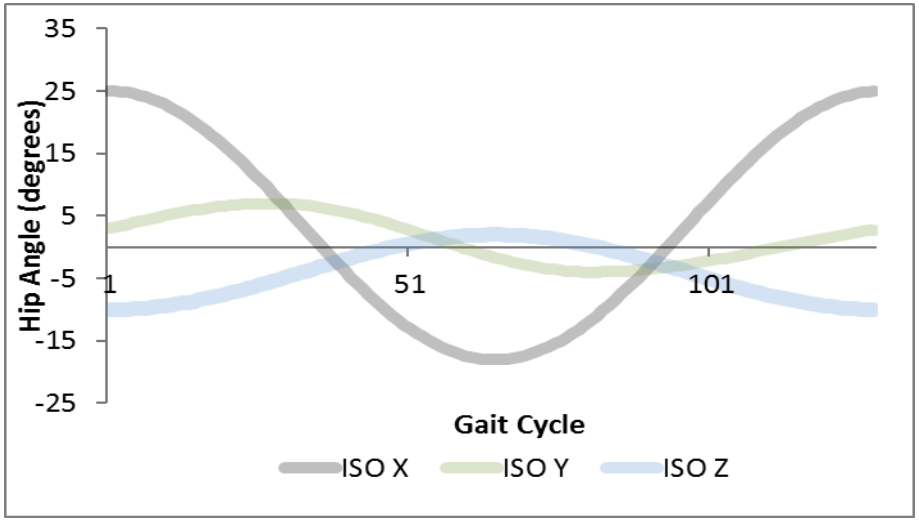
70-80mm^3

Future Wear Testing- Patient Function









Conclusion

- Stratifying patients by demographic **&** biomechanical characteristics reveal differences in patient function
- Start to understand relationship between patient function and revision rate
- Help to avoid the ASR failure through improved preclinical testing

Data Release

- A large amount of data generated through this project(~3000 trials)

- First release-
  - 3 patients; 56 trials (walk, fast, ascent, descent etc)

-Data Access Walkthrough-

https://doi.org/10.5518/345

Data Release

- Future releases

- Data requests- d.lunn@leeds.ac.uk

- Keep updated via twitter

  @davidlunn86

  @ProfTonyRedmond

  @msdresearch

Acknowledgements

LIFE LONG JOINTS

The Leeds Teaching Hospitals NHS Trust

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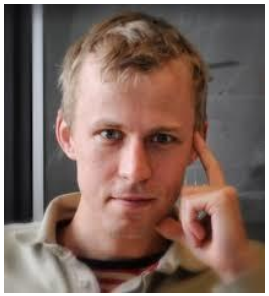
ANYBODY TECHNOLOGY

ETH zürich
Department of Health Sciences and Technology
Institute for Biomechanics



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http://www.lifelongjoints.eu/

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Biomedical Research Centre for supporting this work.

NHS
National Institute for
Health Research

The Leeds Teaching Hospitals NHS
NHS Trust

Thank you for listening

Data access- https://doi.org/10.5518/345

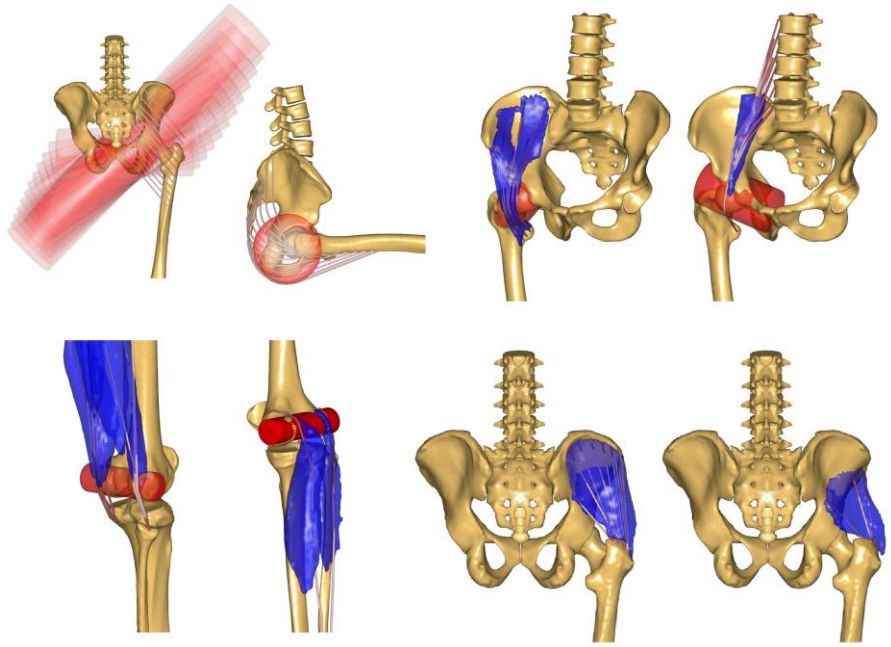
Questions?

Next LifeLongJoints Webcast (mid May)

Musculoskeletal validation and wear simulation.

Prof. Dr Stephen J. Ferguson
Laboratory for Orthopaedic Technology
ETH Zürich

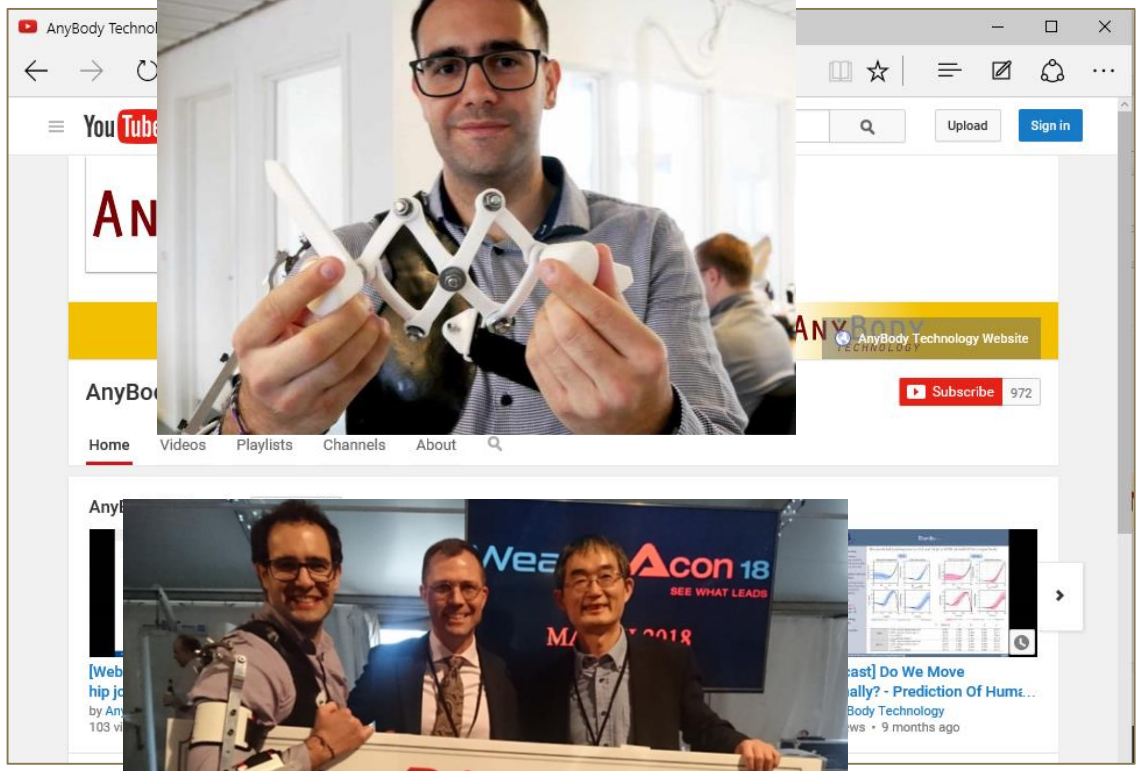
Enrico De Pieri, PhD student
Laboratory for Orthopaedic Technology
ETH Zürich



Upcomming webcast

26 Apr: Model validation using the anatomical reachable 3-D workspace

Miguel Castro, Aalborg University



www.anybodytech.com

- Events, dates, publication list, ...

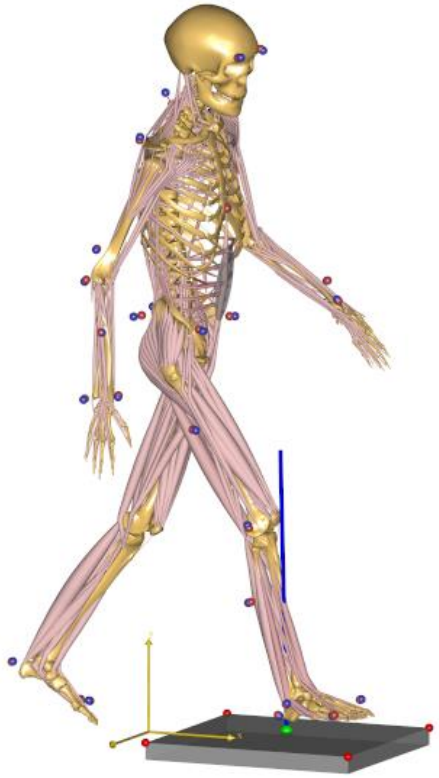
Events:

24 Apr: Workshop**.** Let's meet for the KNEEMO event at OARSI World Congress in Liverpool, UK

7- 9 May: Qualisys User meeting. Gothenburg, Sweden

Meet us? Send email to sales@anybodytech.com

Time for questions:



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