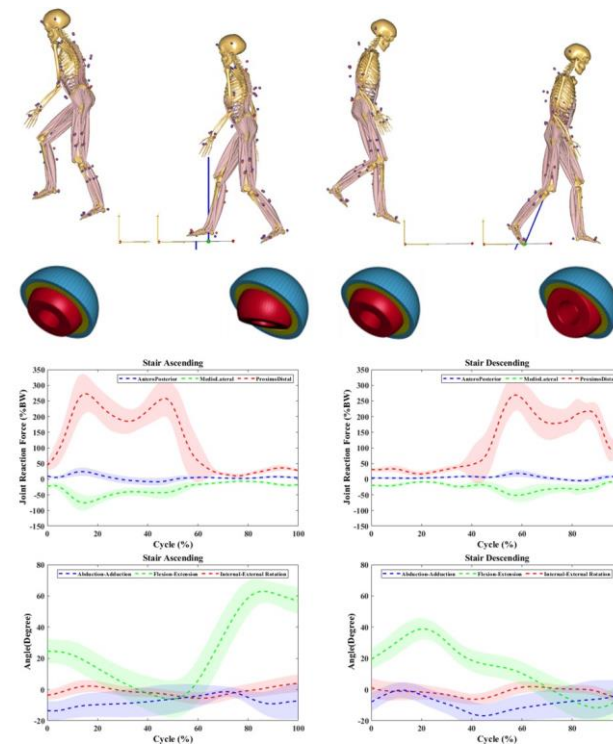


Investigation of stair ascending and descending activities on the lifespan of hip implants



The webcast will begin shortly...

Outline

- Introduction to the AnyBody Modeling System
- Presentation
- Upcoming AnyBody events
- Question and answer session

Presenters

Associate Professor Dr Senay Mihcin

Alican Tuncay Alpkaya, PhD student

Mehmet Yilmaz, PhD student

Ahmet Mert Sahin, PhD student

Izmir Institute of Technology,
Izmir, Turkey



Host

Kristoffer Iversen

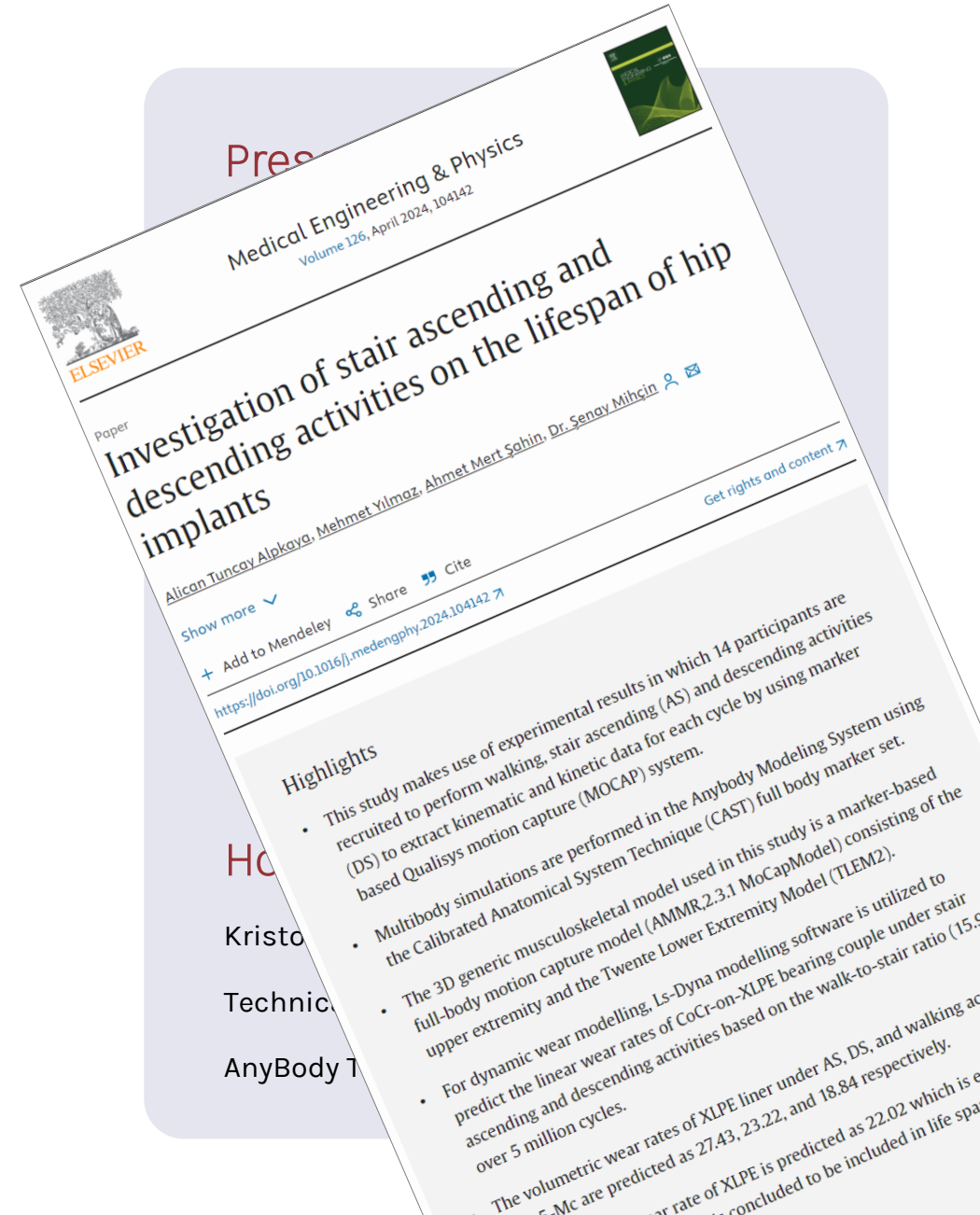
Technical Sales Executive

AnyBody Technology



Outline

- Introduction to the AnyBody Modeling System
- Presentation
- Upcoming AnyBody events
- Question and answer session



Control Panel

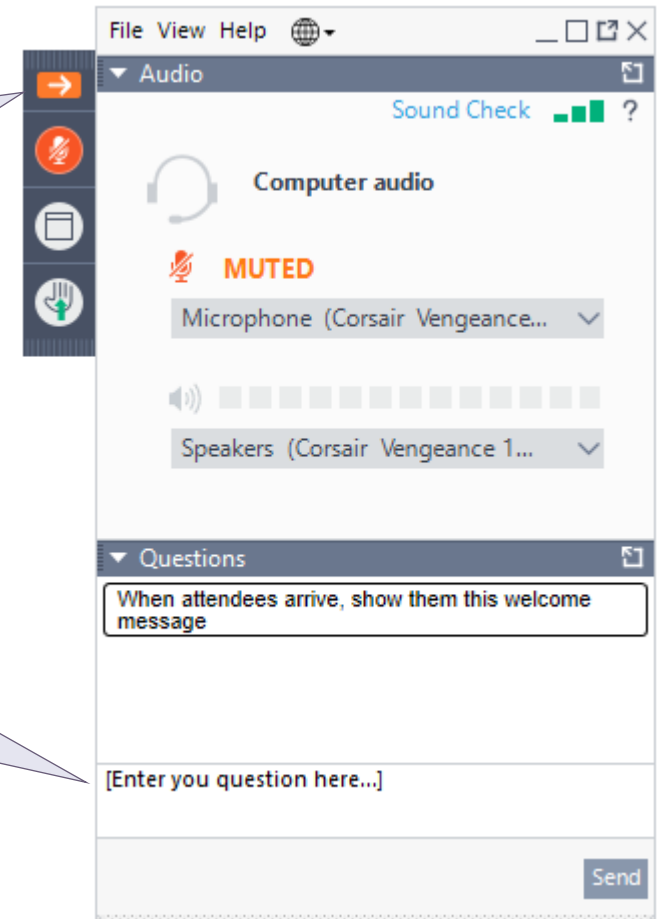
Expand/Collapse
the Control Panel

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

Submit questions and comments via the Questions panel.

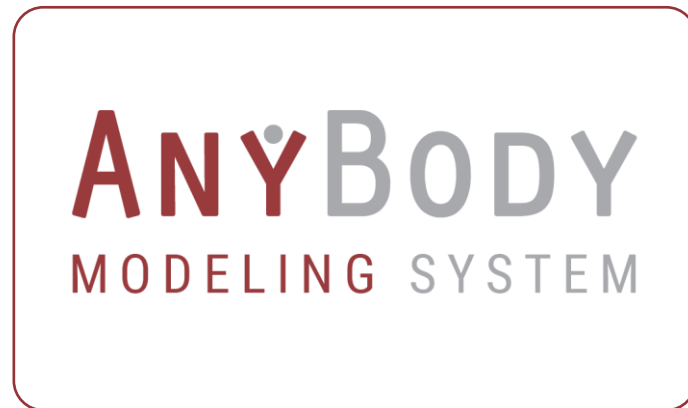
Questions will be addressed at the end of the presentation. If your question is not addressed, we will do so by email.

Ask a question
during the
presentation



Musculoskeletal simulations

INPUT • Motion data



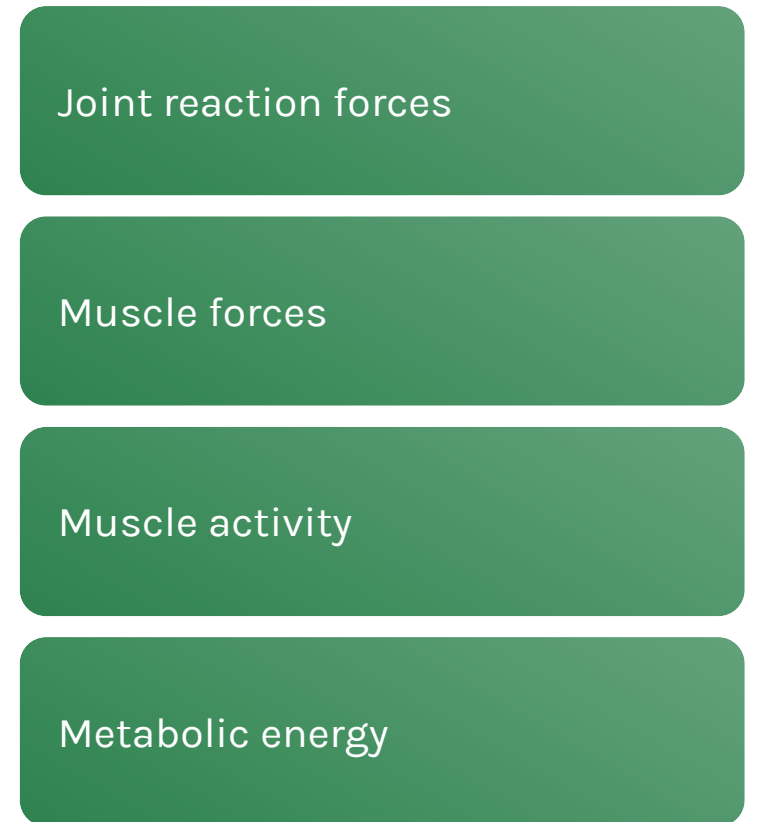
OUTPUT • Internal Body Loads

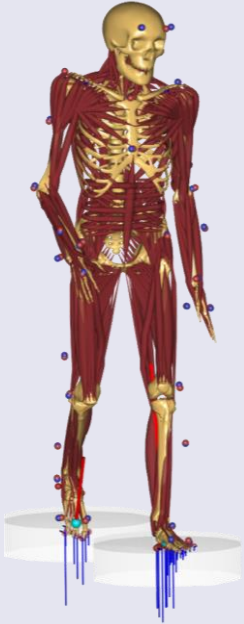
Joint reaction forces

Muscle forces

Muscle activity

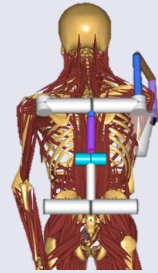
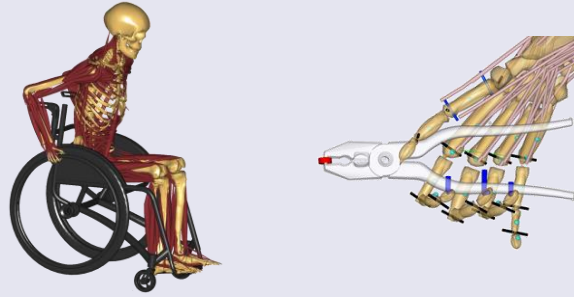
Metabolic energy





Motion analysis

Product design and optimization

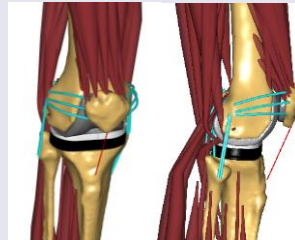


Ergonomics with/without exoskeletons

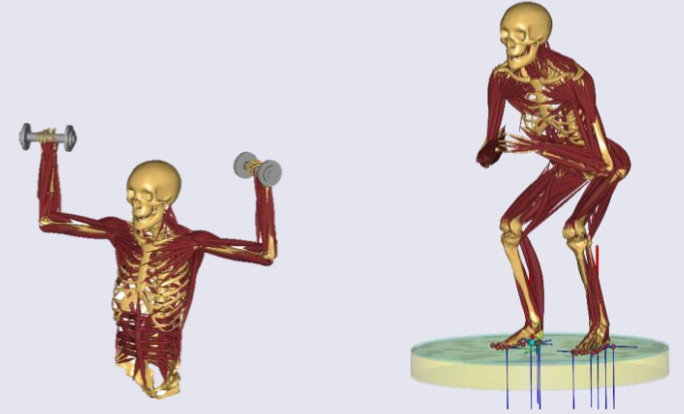


ANYBODY

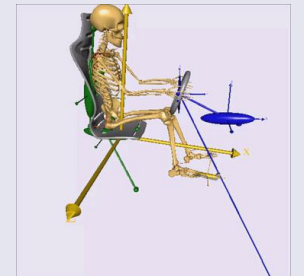
MODELING SYSTEM



Orthopedics and Rehabilitation

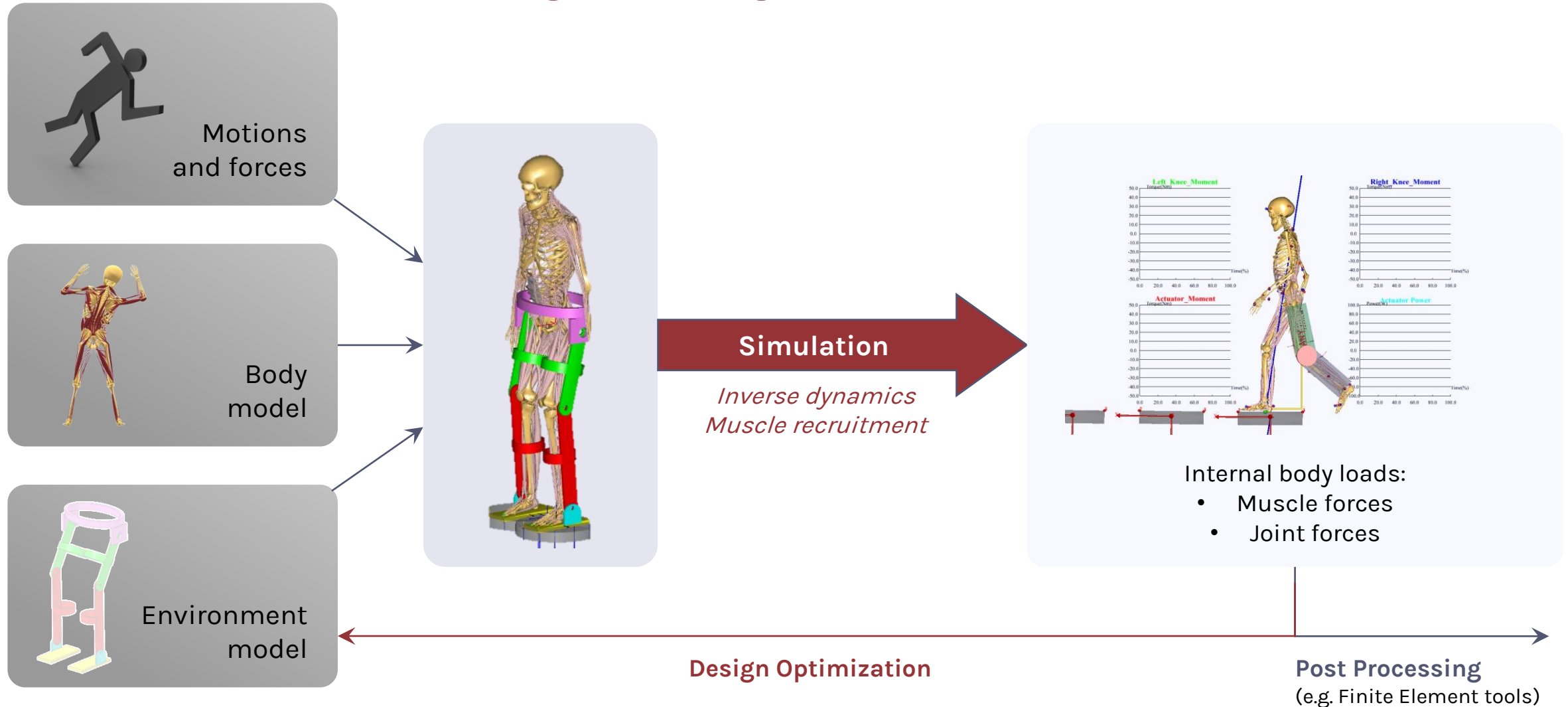


Sports

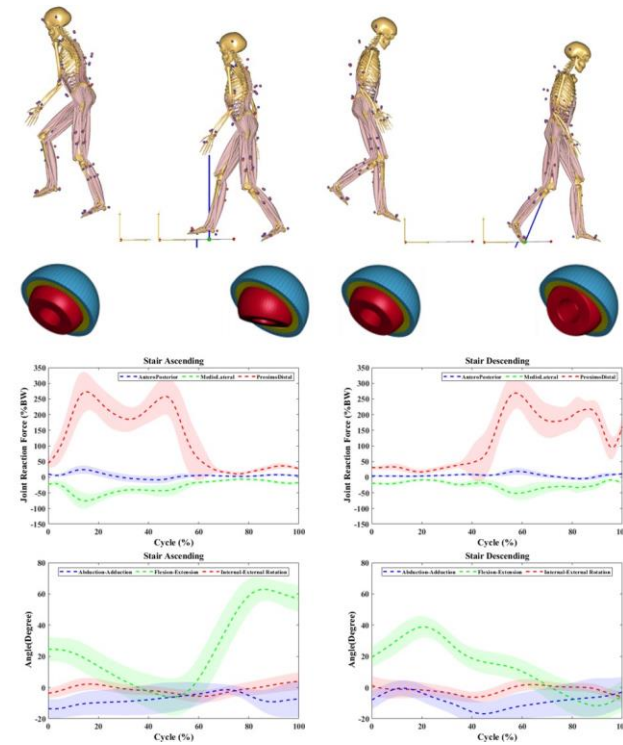


Automotive

Workflow



Investigation of stair ascending and descending activities on the lifespan of hip implants



Investigation of stair ascending and descending activities on the lifespan of hip implants

Authors and Presenters

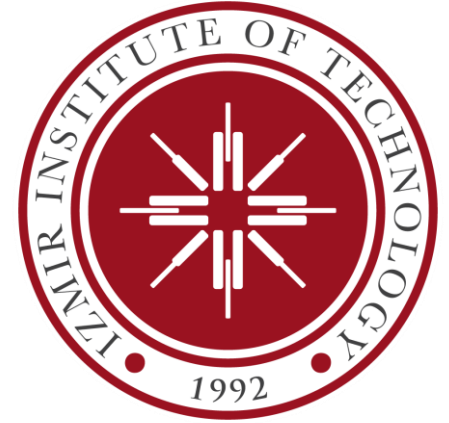
S. Mihcin , A. M Sahin , M. Yılmaz ,A. T. Alpkaya,

IZMIR INSTITUTE OF TECHNOLOGY (IZTECH)

İZMİR INSTITUTE OF TECHNOLOGY

WON FIRST PLACE

in the General Satisfaction Ranking in the
Türkiye University Satisfaction Survey (TÜMA) 2023, conducted by ÜniAr



IZTECH

Ranks **4th** in Turkey

1st in the Aegean Region

Among State Universities in Research Universities Ranking



Awards
Asia 2024

IZTECH RECEIVED HIGHER EDUCATION
LEADERSHIP AWARD



IZTECH Biomechanics and Motion Capture Laboratory



About Biomechanics and Motion Capture Laboratory

Biomechanics and Motion Capture Systems Laboratory was established in October 2020 within the scope of the TÜBİTAK BİDEB 2232 project within the Mechanical Engineering Department of the Izmir Institute of Technology. The primary purpose of the Biomechanics and Motion Capture Systems Laboratory is to create a comprehensive population data and to conduct research in line with these data.

In the 60 m2 laboratory, 1 motion capture system with optical markers (Qualisys, Göteborg, Sweden), 1 force platform (Bertec, Ohio, USA), 1 electromyography sensor set (EMG) (Delsys, Massachusetts, USA) and 1 wearable motion capture system (Rococo, Copenhagen, Denmark).

| Name | Label | Number |
|--|---|--------|
| Motion capture system with optical markers | Qualisys, Göteborg, Sweden | 1 |
| Miquis 3 Cameras | Qualisys, Göteborg, Sweden | 9 |
| Qualisys Track Manager | Qualisys, Göteborg, Sweden | 1 |
| 14 mm reflective markes | Qualisys, Göteborg, Sweden | 100 |
| Force platform | Bertec, Ohio, USA | 1 |
| Electromyography sensor set (EMG) | Delsys, Massachusetts, USA | 1 |
| Wearable motion capture system | Rococo, Copenhagen, Denmark | 1 |
| Hip simulator | IZTECH Biomechanics and Motion Capture Laboratory, Izmir,Turkey | 1 |
| 3D medical PEEK printer | Xi'an Jiaotong University, Shaanxi, China | 1 |
| Anybody Modeling System | AnyBody Technology, Aalborg, Denmark | 2 |
| WorkStation (Intel Xeon W-2245) | 4 | 4 |

Website: <https://biomechlab.iyte.edu.tr/en/homepage/>

Contact mail: senaymihcin@iyte.edu.tr

| People | Assoc Prof Dr. Şenay Mihçin | MSc. Alican Tuncay ALPKAYA | Mehmet Yılmaz | Ahmet Mert Şahin |
|------------|-----------------------------|----------------------------------|--------------------|-------------------------------|
| Role | Team Leader | Researcher Assistant | Researcher | Researcher |
| Degree | Ph.D. | MSc. | BSc | BSc |
| University | Loughborough University | Middle East Technical University | Erciyes University | Izmir Institute of Technology |
| Year | 2008 | 2018 | 2021 | 2021 |

Journal Publications

- [1] S. Mihcin *et al.*, “Database covering the prayer movements which were not available previously,” *Scientific Data*, vol. 10, no. 1, p. 276, 2023, doi: 10.1038/s41597-023-02196-x.
- [2] A. T. Alpkaya and Ş. Mihçin, “The Computational Approach to Predicting Wear: Comparison of Wear Performance of CFR-PEEK and XLPE Liners in Total Hip Replacement,” *Tribology Transactions*, vol. 66, no. 1, pp. 59–72, 2023, doi: 10.1080/10402004.2022.2140727.
- [3] A. T. Alpkaya and S. Mihcin, “Dynamic computational wear model of PEEK-on-XLPE bearing couple in total hip replacements,” *Medical Engineering & Physics*, p. 104006, 2023, doi: <https://doi.org/10.1016/j.medengphy.2023.104006>.
- [4] A. T. Alpkaya, M. Yılmaz, A. M Sahin, and S Mihcin, “Investigation of stair ascending and descending activities on the lifespan of hip implants,” vol. 126, 2024, doi: 10.1016/j.medengphy.2024.104142.
- [5] S.Mihcin, Simultaneous validation of wearable motion capture system for lower body applications: over single plane range of motion (ROM) and gait activities, *BIOMEDICAL ENGINEERING-BIOMEDIZINISCHE TECHNIK*, 2022, 0013-5585, 67, 3, 185-199.
- [6] Torabnia, S., Mihcin, S. & Lazoglu, I. Design and manufacturing of a hip joint motion simulator with a novel modular design approach. *Int J Interact Des Manuf* (2023). <https://doi.org/10.1007/s12008-023-01506-2>



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Paper

Investigation of stair ascending and descending activities on the lifespan of hip implants

Alican Tuncay Alpkaya, Mehmet Yılmaz, Ahmet Mert Şahin, Dr. Şenay Mihçin*

Mechanical Engineering Department, Izmir Institute of Technology, Turkey



ARTICLE INFO

Keywords:

Dynamic wear predict model
Finite element model
Stair ascending and descending
Total hip replacement

ABSTRACT

Total hip arthroplasty (THA) surgeries among young patients are on the increase, so it is crucial to predict the lifespan of hip implants correctly and produce solutions to improve longevity. Current implants are designed and tested against walking conditions to predict the wear rates. However, it would be reasonable to include the additional effects of other daily life activities on wear rates to predict convergent results to clinical outputs. In this study, 14 participants are recruited to perform stair ascending (AS), descending (DS), and walking activities to obtain kinematic and kinetic data for each cycle using marker based Qualisys motion capture (MOCAP) system. AnyBody Modeling System using the Calibrated Anatomical System Technique (CAST) full body marker set are performed Multibody simulations. The 3D generic musculoskeletal model used in this study is a marker-based full-body motion capture model (AMMR,2.3.1 MoCapModel) consisting of the upper extremity and the Twente Lower Extremity Model (TLEM2). The dynamic wear prediction model detailing the intermittent and overall wear rates for CoCr-on-XLPE bearing couple is developed to investigate the wear mechanism under 3D loading for AS, DS, and walking activities over 5 million cycles (Mc) by using finite element modelling technique. The volumetric wear rates of XLPE liner under AS, DS, and walking activities over 5-Mc are predicted as 27.43, 23.22, and 18.84 mm^3/Mc respectively. Additionally, the wear rate was predicted by combining stair activities and gait cycles based on the walk-to-stair ratio. By adding the effect of stair activities, the volumetric wear rate of XLPE is predicted as 22.02 mm^3/Mc which is equivalent to 19.41% of walking. In conclusion, in this study, the effect of including other daily life activities is demonstrated and evidence is provided by matching them to the clinical data as opposed to simulator test results of implants under ISO 14242 boundary conditions.

Aims and Scope

Medical Engineering & Physics provides a forum for the publication of the latest developments in biomedical engineering, and reflects the essential multidisciplinary nature of the subject.

← Journal information

MEDICAL ENGINEERING & PHYSICS

Publisher name: ELSEVIER SCI LTD

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2022

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Five Year

| JCR Category | Category Rank | Category Quartile |
|---|---------------|-------------------|
| ENGINEERING, BIOMEDICAL <i>in SCIE edition</i> | 71/96 | Q3 |

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2021

| JCI Category | Category Rank | Category Quartile |
|---|---------------|-------------------|
| ENGINEERING, BIOMEDICAL <i>in SCIE edition</i> | 75/117 | Q3 |

HIGHLIGHTS



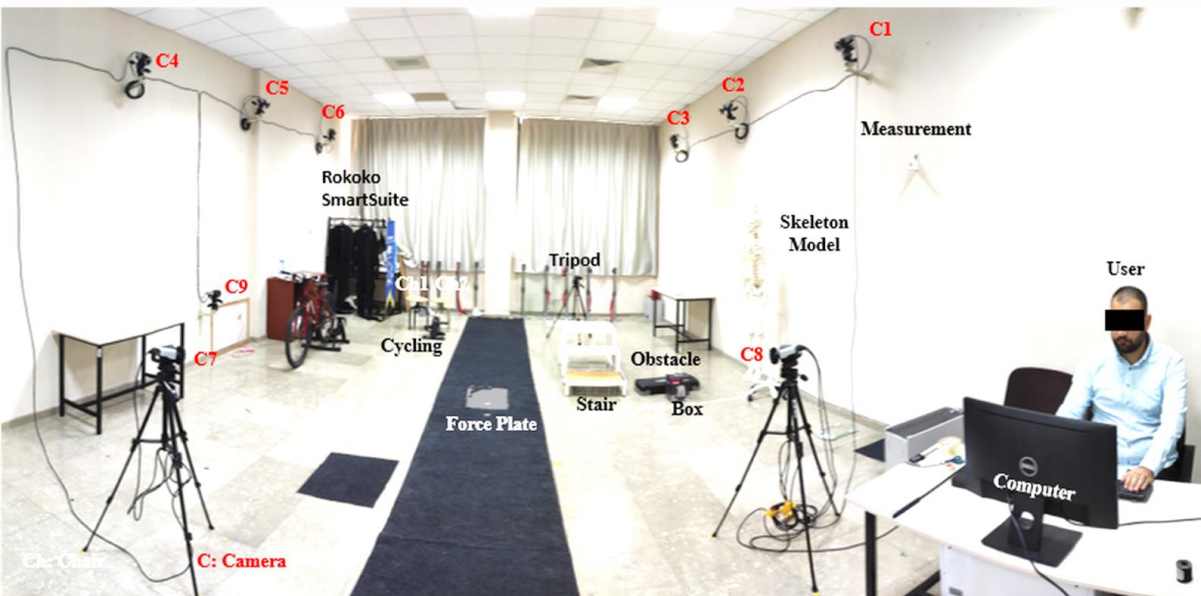
- This study makes use of experimental results in which 14 participants are recruited to perform walking, stair ascending (AS) and descending activities (DS) to extract kinematic and kinetic data for each cycle by using marker based Qualisys motion capture (MOCAP) system.
- Multibody simulations are performed in the Anybody Modeling System using the Calibrated Anatomical System Technique (CAST) full body marker set.
- The 3D generic musculoskeletal model used in this study is a marker-based full-body motion capture model (AMMR,2.3.1 MoCapModel) consisting of the upper extremity and the Twente Lower Extremity Model (TLEM2).
- For dynamic wear modelling, Ls-Dyna modelling software is utilized to predict the linear wear rates of CoCr-on-XLPE bearing couple under stair ascending and descending activities based on the walk-to-stair ratio (15.9:1) over 5 million cycles.
- The volumetric wear rates of XLPE liner under AS, DS, and walking activities over 5-Mc are predicted as 27.43, 23.22, and 18.84 respectively.
- The volumetric wear rate of XLPE is predicted as 22.02 which is equivalent to 19.41% of walking, which is concluded to be included in life span estimations of implants for realistic outcomes.

OUTLINE



- Introduction
- Methodology
 - Participants
 - Construction of the Experiment
 - Data Acquisition
 - Musculoskeletal Modelling
 - Finite Element Method
- Results
- Conclusion

Lab Facilities



Laboratory Environment

| Name | Label | Number |
|--|----------------------------|--------|
| Motion capture system with optical markers | Qualisys, Göteborg, Sweden | 1 |
| Miqus 3 Cameras | Qualisys, Göteborg, Sweden | 9 |
| Qualisys Track Manager | Qualisys, Göteborg, Sweden | 1 |
| 14 mm reflective markes | Qualisys, Göteborg, Sweden | 100 |
| Force platform | Bertec, Ohio, USA | 1 |
| Electromyography sensor set (EMG) | Delsys, Massachusetts, USA | 1 |

Construction of the Experiment



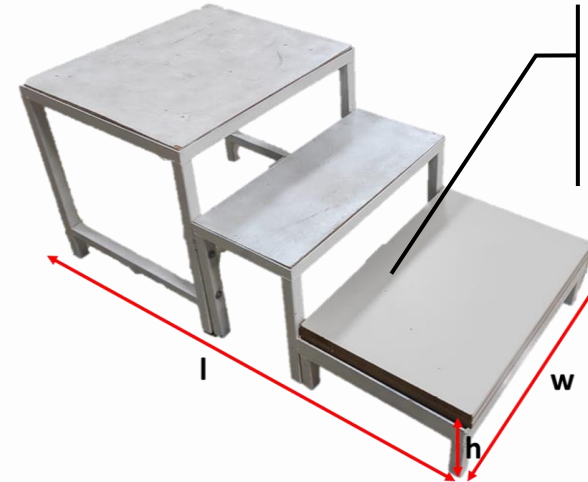
Qualysis Miquis Camera

Capture rate:100
fps
Exposure & Flash
Time[μ s]:70
Marker
Threshold[%]:20
Standard
Deviation: Under
1mm



Marker

14 mm

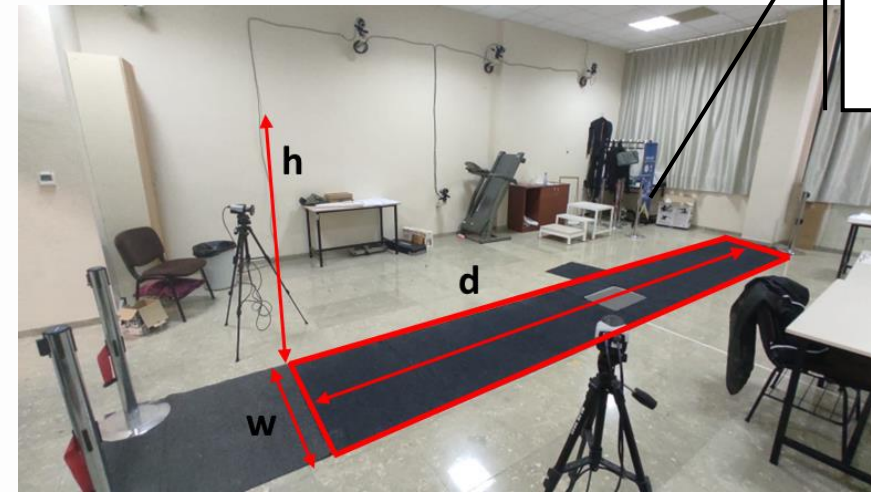


w: 61.8 cm
l: 119.2 cm
h: 16.4 cm



Bertec Force Plate

Capture rate:100 Hertz
Dimensions:
400x600mm
Channel Number: 6



d: 5 meter
w: 1 meter
h: 2 meter

Working volume

Data Acquisition

Data Acquisition (Participation and Measurement)



Participation Conditions

- not having any physical illness, injuries, disability and deformity (Flatfoot, kyphosis, etc.)
- Being over age of 18
- the body mass index must be below 30 BMI.

Participants

| | |
|-------------------------|-----------|
| Participants Number | 14(7F/7M) |
| Age | 30±7 |
| Weight(kg)(Average ±SD) | 64±12 |
| Height(cm)(Average ±SD) | 170±11 |

Anthropometric Measurements

Pelvis Medial Malleolus

Pelvis Width

Shank Length

Thigh Length

Foot Length

Metatarsal Width

Ankle Width

Knee Width

Trunk Height

Shoulder Width

Elbow Width

Hand Width

Wrist Width

Wrist Thickness

Upper Arm Length

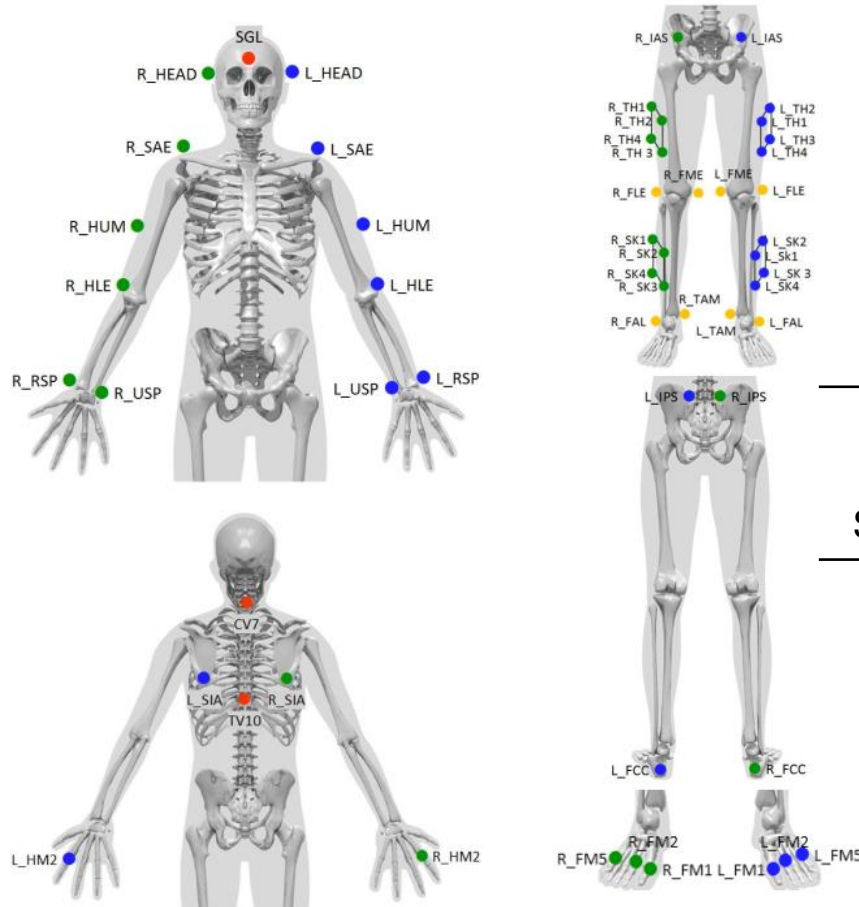
Lower Arm Length

Arm length

Hand Length

Head Length

Data Acquisition (Marker Set)



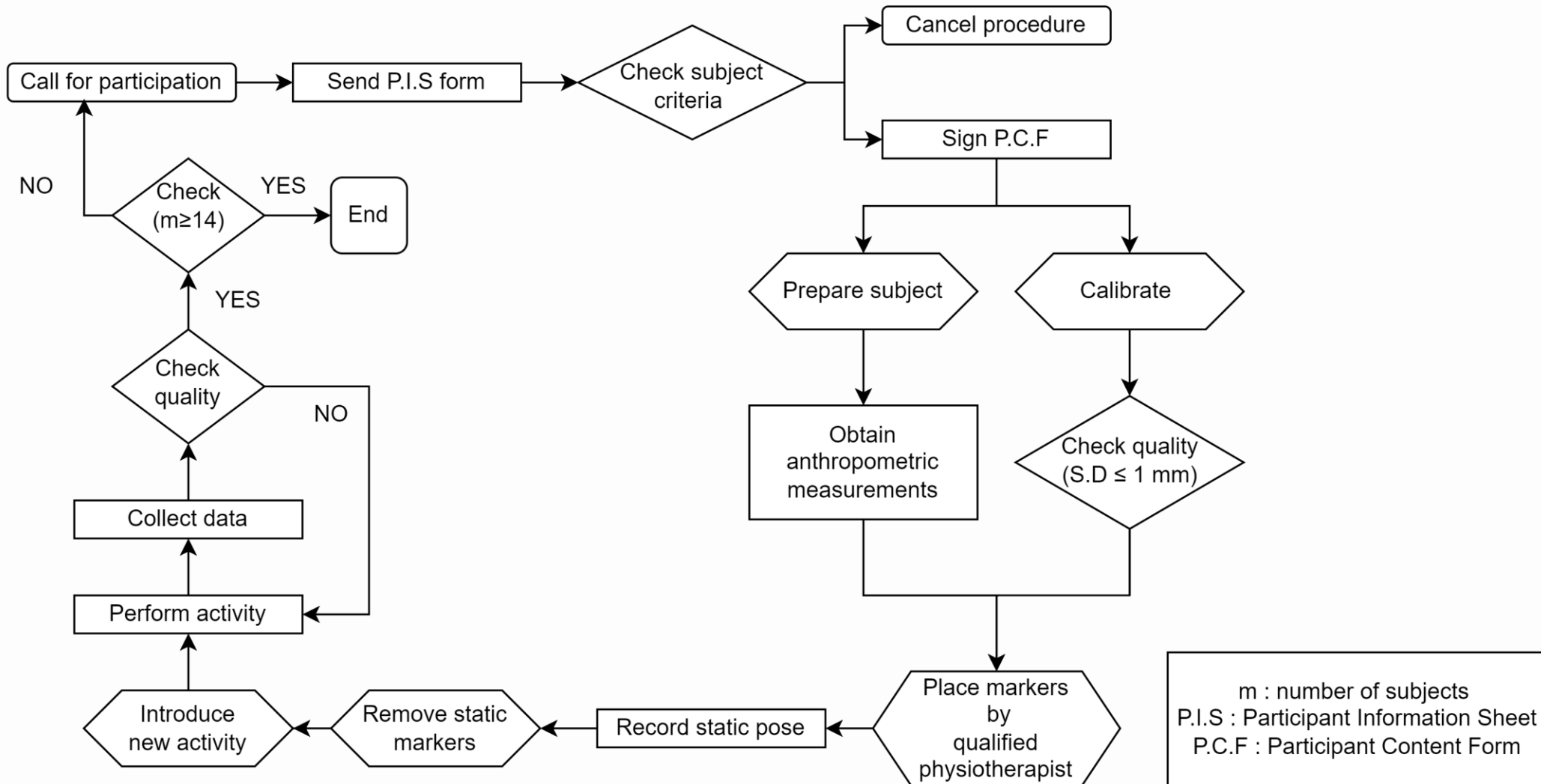
Cast Full Body Marker Set

| | |
|-----------------------------------|---------------------------|
| Marker Set | Cast Full Body Marker Set |
| Number of Marker for Static Pose | 55 |
| Number of Marker for Dynamic Pose | 47 |

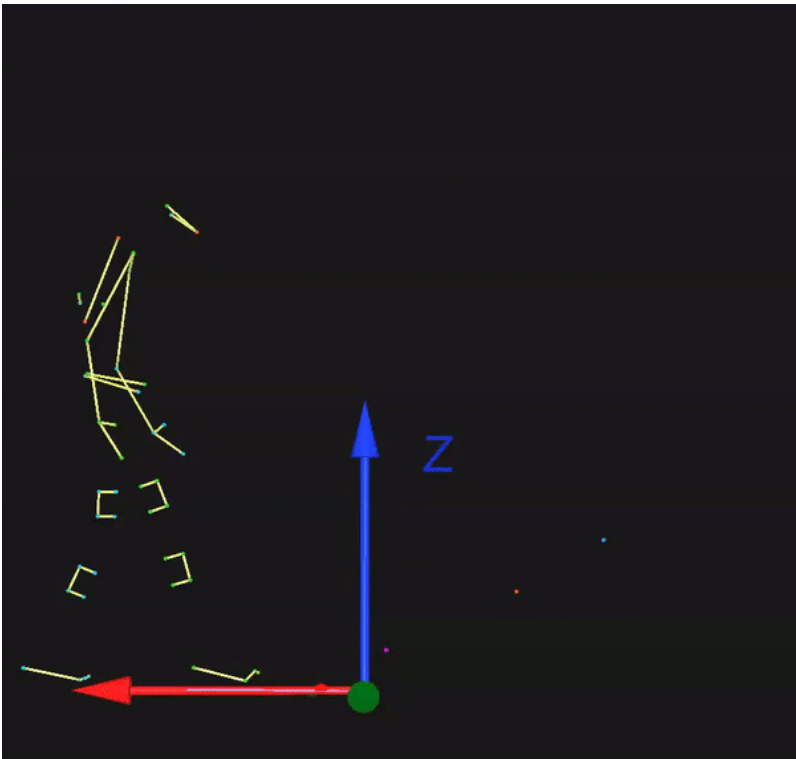


Participant

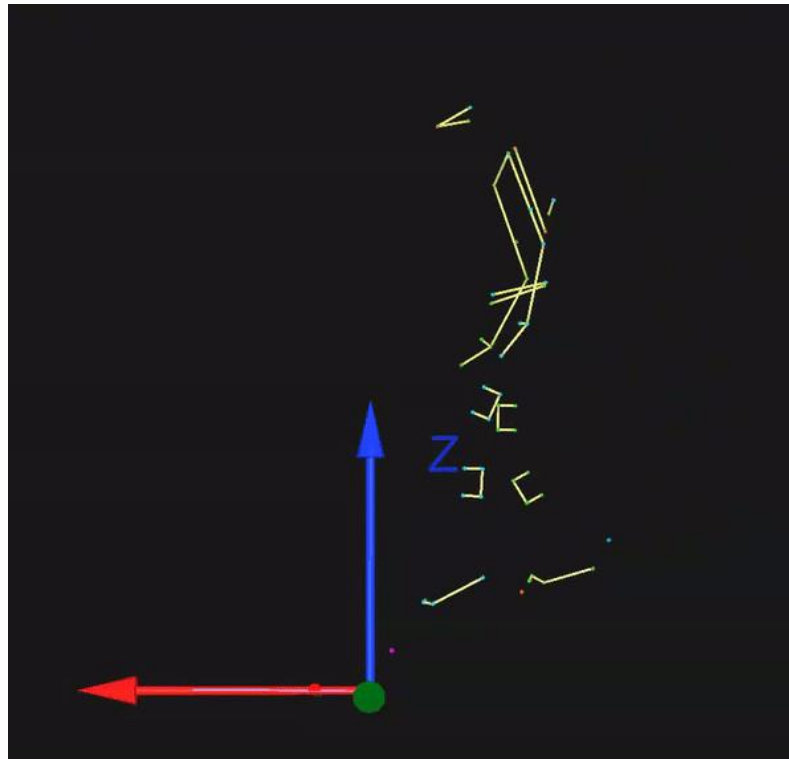
Data Acquisition Flow Chart



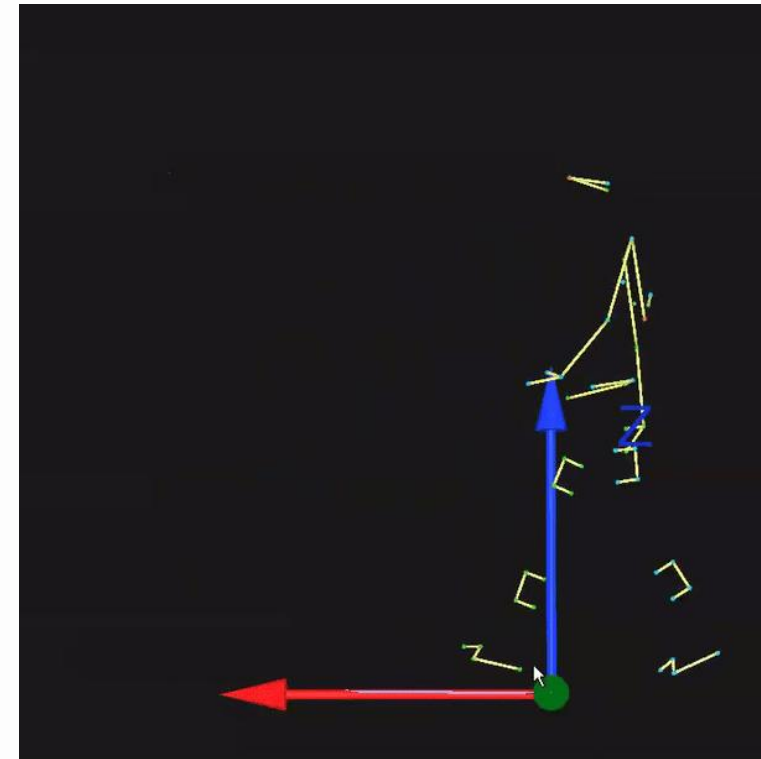
Activities



Stair
Ascending



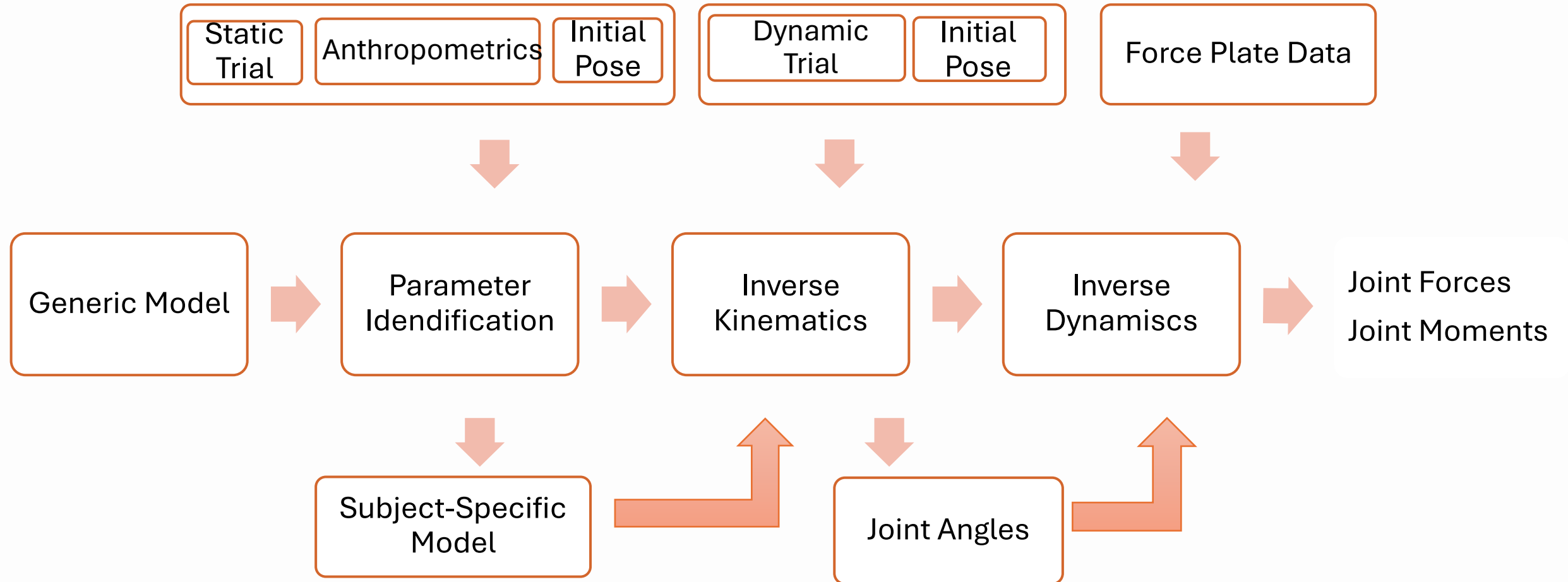
Stair
Descending



Gait

Multibody Musculoskeletal Model Simulations

Work Flow the Multibody Simulations in AnyBody



Full-Body MoCapModel Configurable Variables

- **Model**

- Twente Lower Extremity Model (TLEM2)



- **Scaling**

- Scale taking mass and fat into account; scale segments along X, Y, Z axes; input is scale factors along X, Y, Z axes.



- **Marker Protocol**

- CAST Full Body Marker Set (Static&Dynamic)



- **Force Plate Type**

- BERTEC force platform Type 4



- **Muscle Recruitment Optimization algorithms**

- Third order, polynomial muscle recruitment criterion



- **Anthropometrics**

- Set anthropometrics for each subject (mass, height, etc.)



- **Initial Position of Segments**

- This sets load time limbs positions (Static&Dynamic)



Main.ModelSetup.LabSpecificData

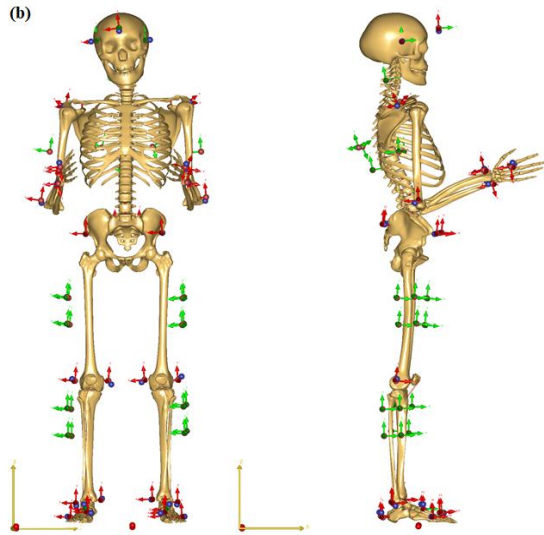
Main.Studies.InverseDynamicStudy

Main.ModelSetup.SubjectSpecificData

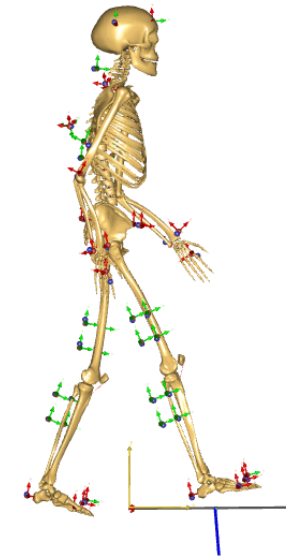
Main.ModelSetup.TrialSpecificData

Static and Dynamic Simulations

Static



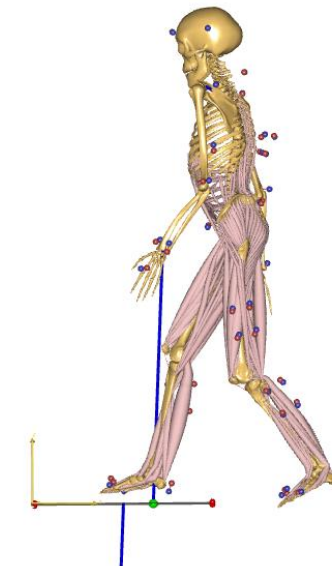
Gait



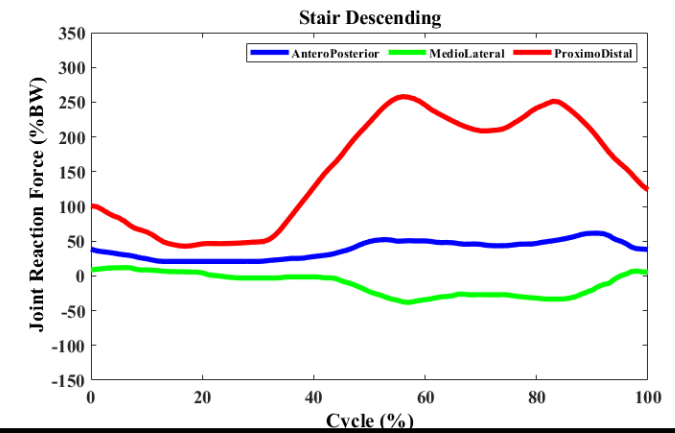
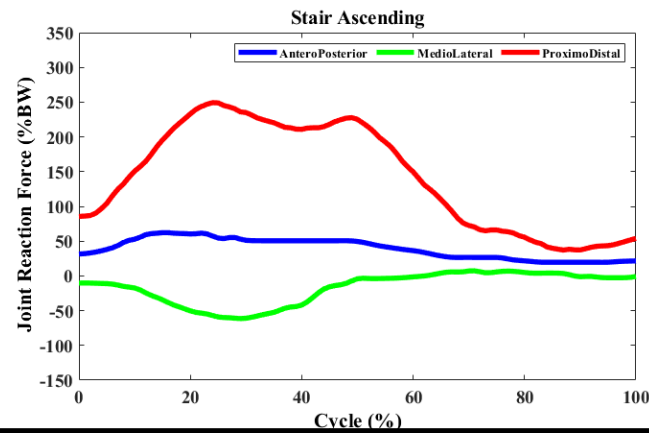
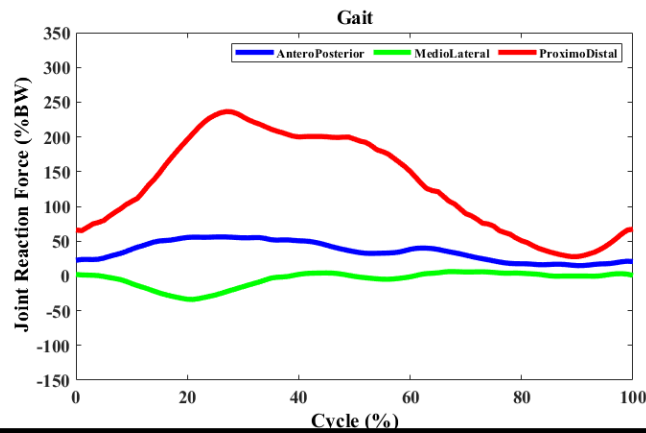
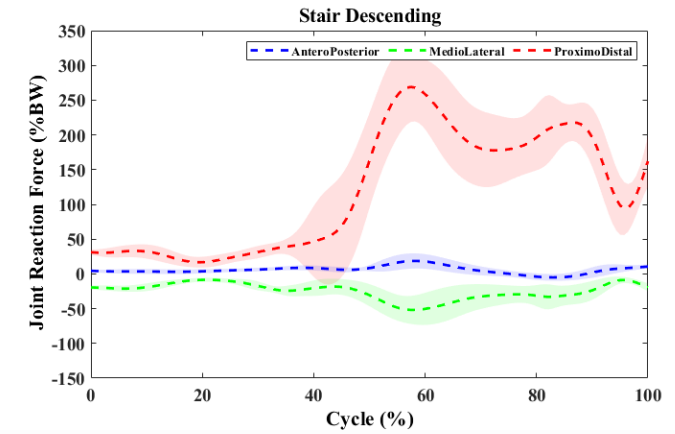
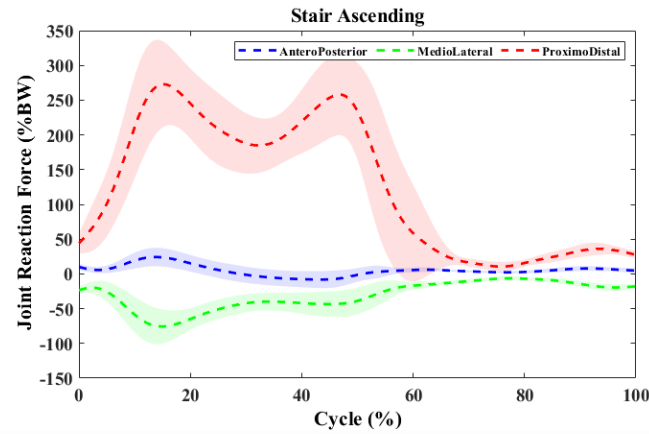
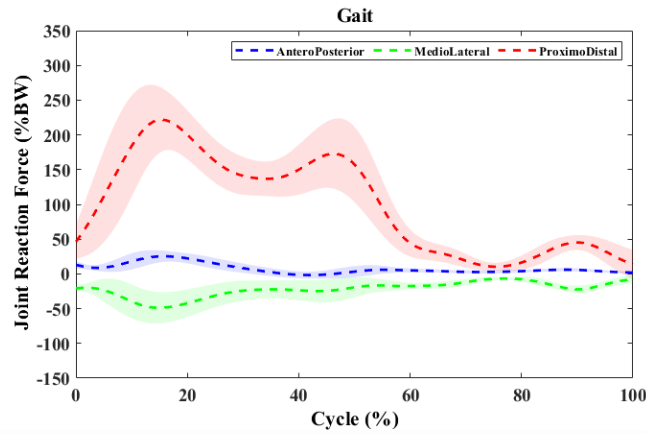
**Stair
Descending**



**Stair
Ascending**

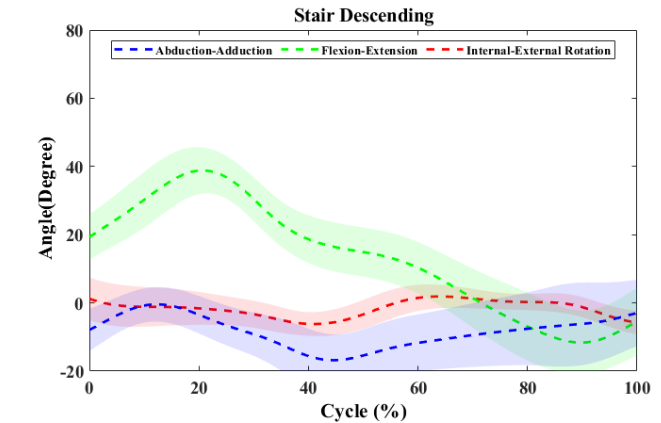
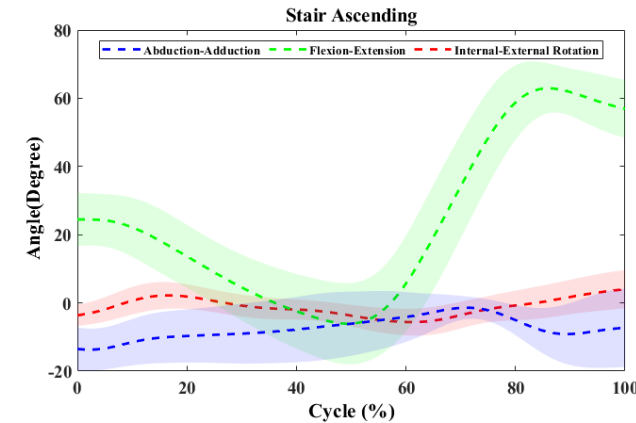
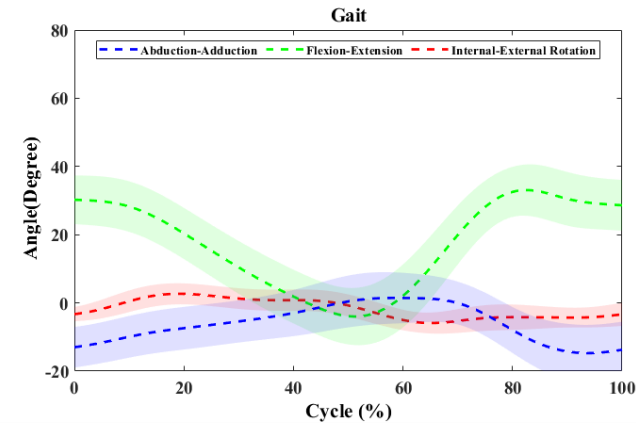
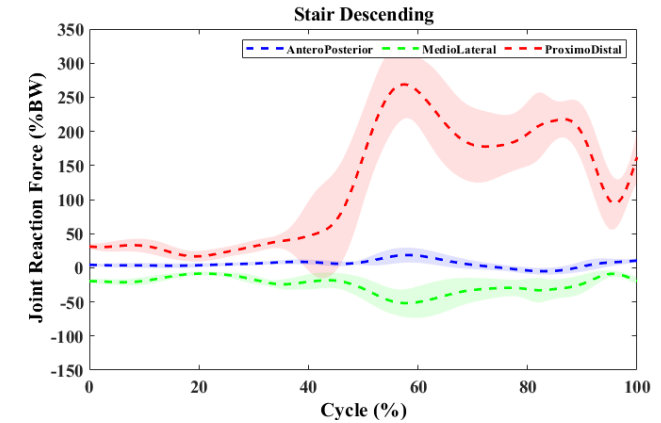
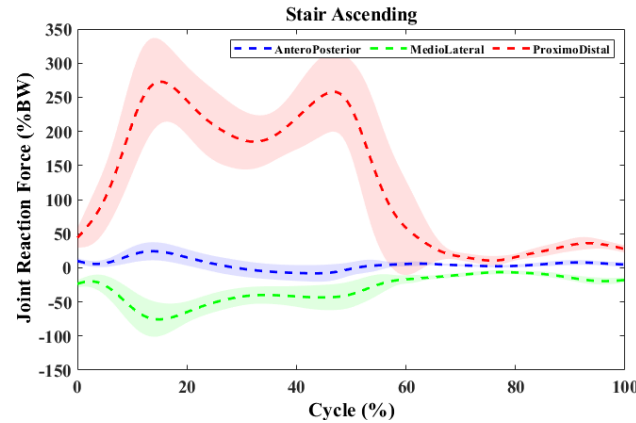
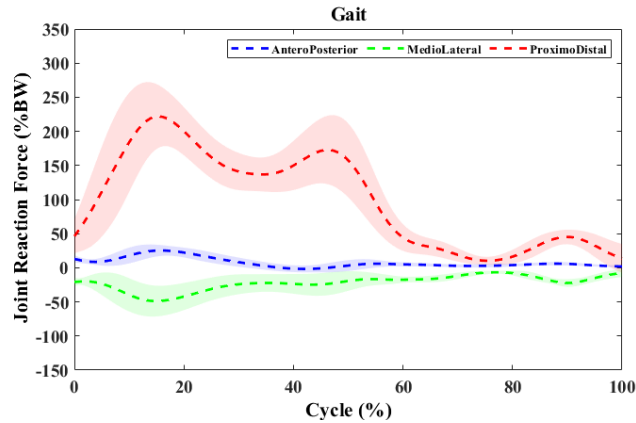


Validation



| Activity | Calculated (%BW) Peak Hip Contact Force | Measured(%BW) Peak Hip Contact Force | (%) |
|------------------|---|--------------------------------------|------------|
| Gait | 221 | 238 | %8 lower |
| Stair Ascending | 272 | 251 | %8 greater |
| Stair Descending | 268 | 260 | %3 greater |

Results

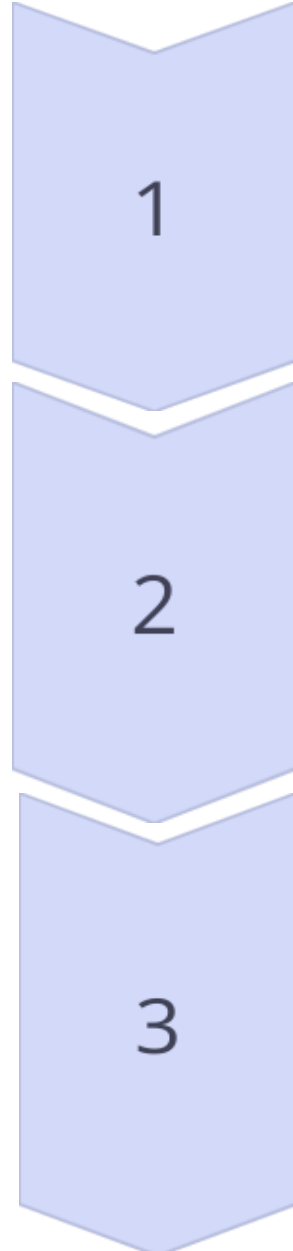
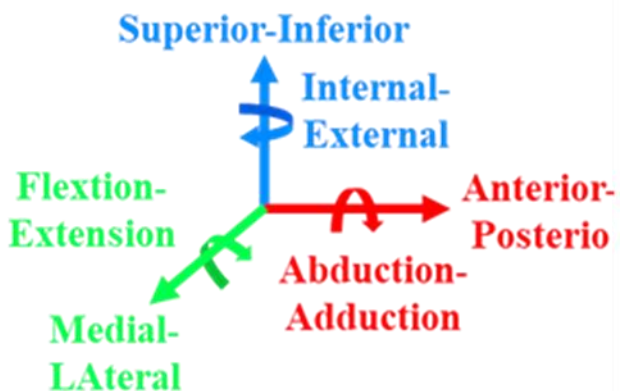
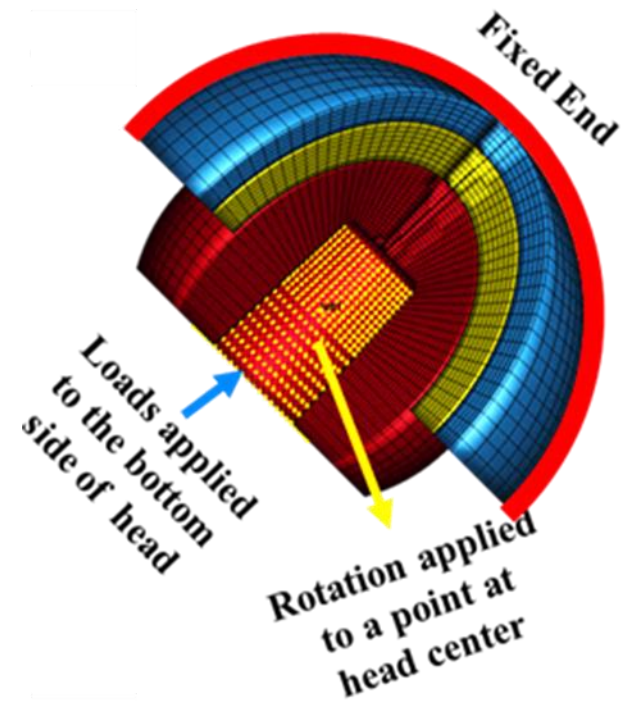


| Activity | ABD(°)Min/Max | FE(°)Min/Max | IE(°)Min/Max | AP(%BW)Min/Max | ML(%BW)Min/Max | PD(%BW)Min/Max |
|------------------|---------------|---------------|--------------|----------------|----------------|----------------|
| Gait | -6/3 | -3/33 | -14/2 | -2/25 | -48/-6 | 10/221 |
| Stair Ascending | -5/4 | -6/63 | -13/-1 | -8/24 | -75/-6 | 10/272 |
| Stair Descending | -6/2 | -11/38 | -16/-1 | -5/18 | -51/-8 | 17/268 |

Finite Element Modelling for Wear Analysis



The hypothesis



Literature Data

- ✓ The lifespan of hip implant under walking cycles in FEM could be predicted as 25.7 years ¹¹
- ✓ J.T. Evans et al studied at the lifespan of 228888 hip implants in 16 different countries ⁶³. The average lifespan of hip implants last 20 years ⁶³

The hypothesis

The daily frequency of stair ascending/descending per day is calculated as

- ✓ 172 cycles which is equivalent to 62780 cycles for stair ascending/descending
- ✓ 3040 steps per day which is equivalent to 1 Mc per year
- ✓ Predicted the walk-to-stair ratio of 15.9:1

Wear Prediction Model

- ✓ We investigate the wear performance and longevity of hip implants adding stair ascending and stair descending wear rates on walking cycles according to the walk-to-stair ratio provided to converge our results with literature data

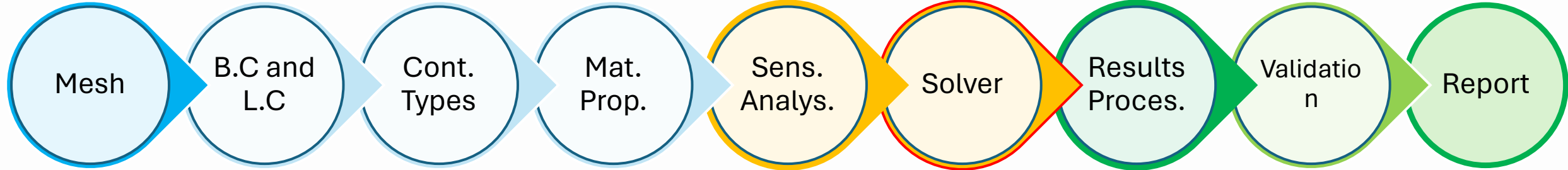
Model Quality



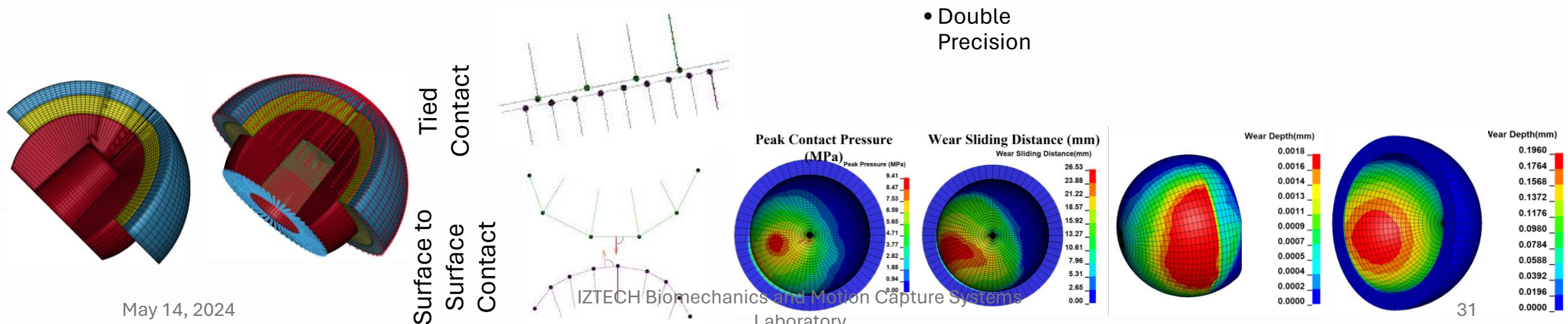
Pre-analysis

Analysis

Post-analysis



- Mesh**
 - Type
 - Order
 - Section
- B.C and L.C**
 - Constrain
 - Load
 - Motion
- Cont. Types**
 - Tied
 - Surface to Surface
- Mat. Prop.**
 - Mat-001
 - Cof
 - Archard W.
- Sens. Analys.**
 - Mesh Size
 - Scaling Factor
- Solver**
 - Ls-Dyna
 - Shared parallel memory (SMP)
 - Double Precision
- Results Proces.**
 - Wear rate
 - Sliding D.
 - Contact P.
 - Contact A.
- Validatio n**
 - Hip simulator
 - Clinical Retrieval
 - Fem Results



Material and Methods

- ✓ An explicit FE analysis tool (Ls-Dyna R.12.0) over 5 million cycles.
- ✓ The liner inserted at 45° on the FE axis.
- ✓ The shell is fixed, while the femoral head is free.
- ✓ The loading is applied, while the rotations are defined.

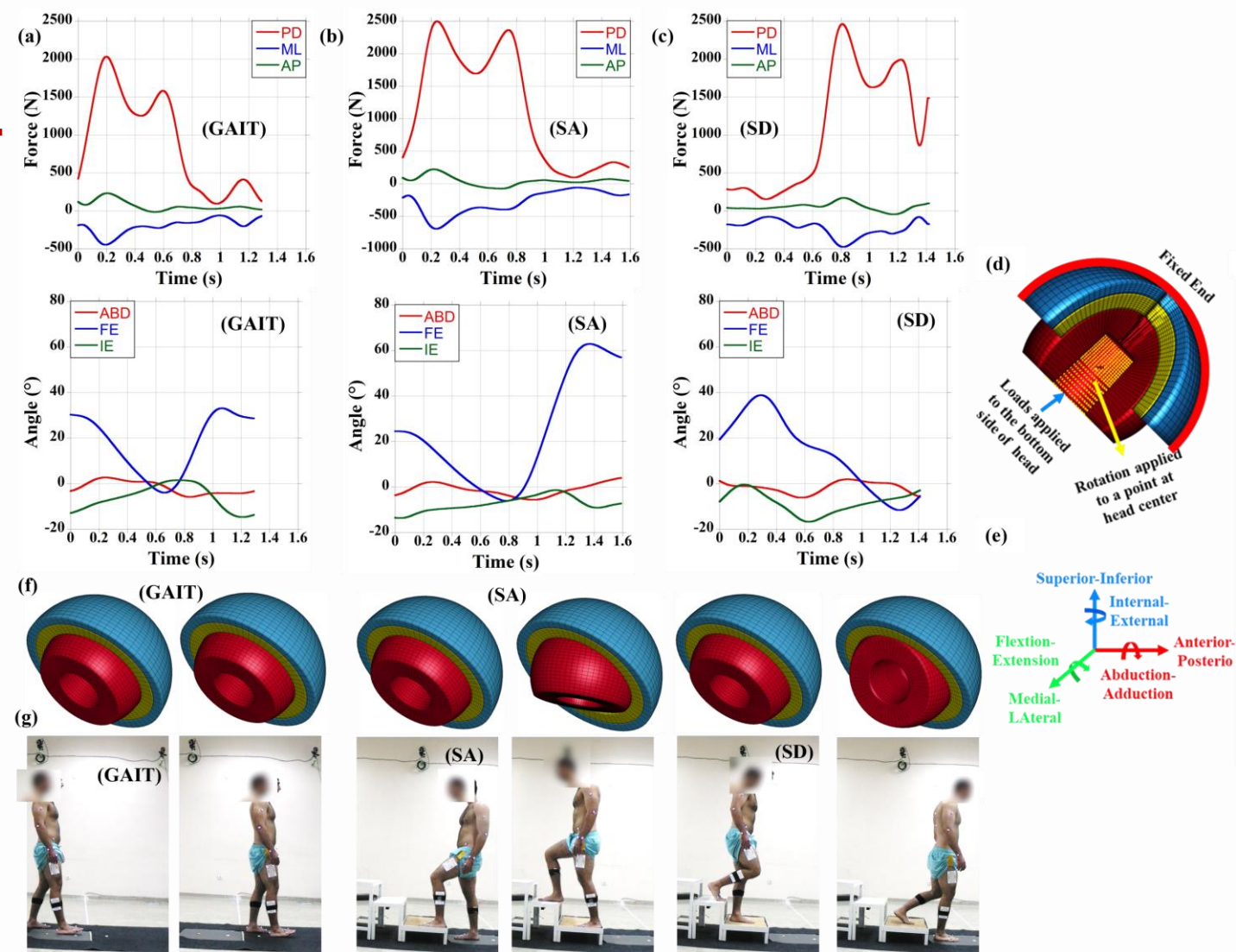


Figure 1 The loading and rotation data for (a) gait, (b) SA, (c) SD, d) applied loading and boundary conditions in FEM, (e) loading and rotation in anatomical axes, and (f) initial and final position in FEM, and (g) initial and middle position of each activity.

Mesh Sensivity Analysis

- ✓ Mesh convergence test is a vital process.
- ✓ Variations in the outputs are less than 1%, the optimum mesh size is determined.
- ✓ Seven CoCr-on-XLPE prototypes were modelled.
- ✓ The optimum mesh will be selected as 1mm

Figure 2 a) Mesh sensitivity analysis of CoCr-on-XLPE bearing couple and b) Peak contact pressure and wear sliding distance results of the prototypes with 1- and 1.6-mm element size

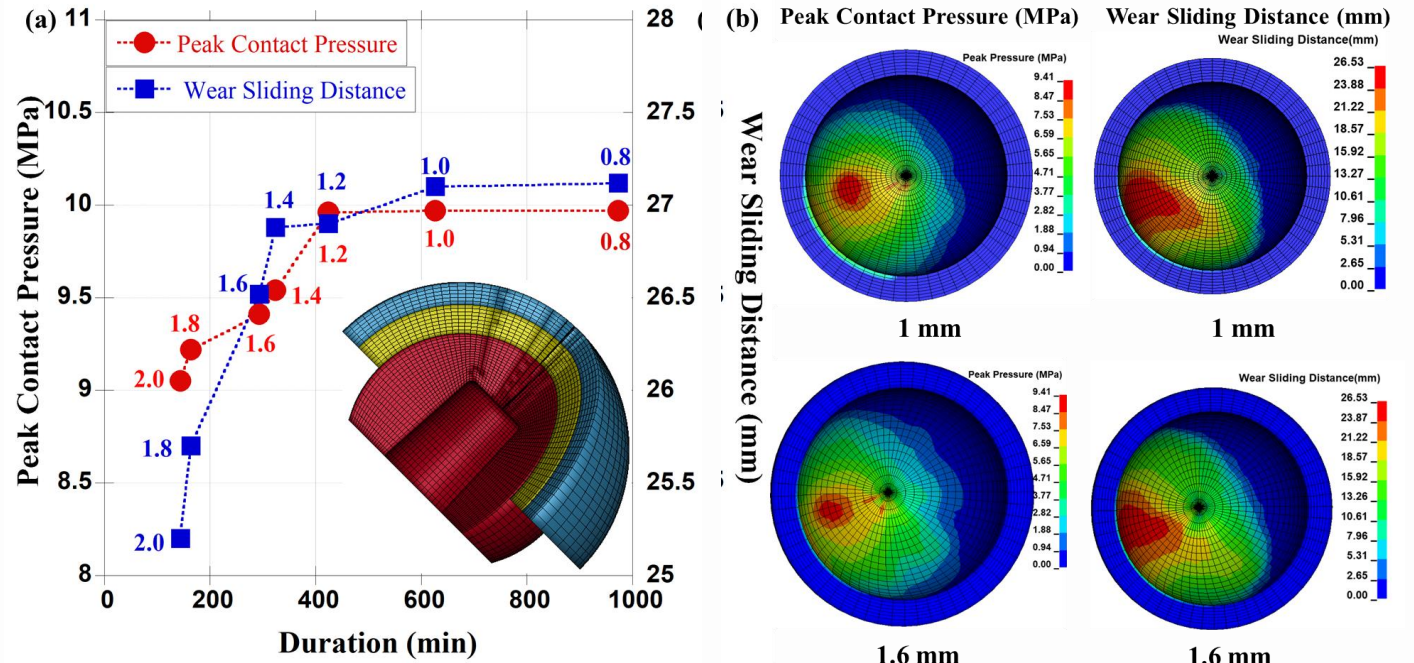


Table 2 Effect of element size on contact pressure, sliding distance and wear depth

| El. Size (mm) | Run (min) | C. P. (MPa) | C.P (%) | W. D. (10^{-8} mm) | W.D. (%) | S.D. (mm) | S.D. (%) | Liner Element |
|---------------|------------|-------------|-------------|-----------------------|-------------|--------------|-------------|---------------|
| 2.00 | 144 | 9.05 | 1.90 | 4.43 | 6.54 | 25.20 | 1.95 | 7200 |
| 1.80 | 164 | 9.22 | 2.05 | 4.74 | 3.46 | 25.70 | 3.09 | 8160 |
| 1.60 | 293 | 9.41 | 1.31 | 4.91 | 0.81 | 26.52 | 1.34 | 9120 |
| 1.40 | 324 | 9.54 | 4.27 | 4.95 | 0.80 | 26.88 | 0.07 | 10560 |
| 1.20 | 424 | 9.96 | 0.04 | 4.99 | 3.48 | 26.90 | 0.74 | 12480 |
| 1.00 | 627 | 9.97 | 0.03 | 5.17 | 0.19 | 27.10 | 0.57 | 14880 |
| 0.80 | 973 | 9.97 | - | 5.18 | - | 27.25 | - | 18720 |

Scaling Factor Sensitivity Analysis

- ✓ The scaling factor (β) has a major impact.
- ✓ Ranged from 0.1 to 1 million cycles
- ✓ The run time of the model with 0.25 million cycles is approximately 2.5 times higher than the model with 0.1 million cycles.
- ✓ The optimum scaling factor is selected as 0.25 million cycles (Figure 3a).

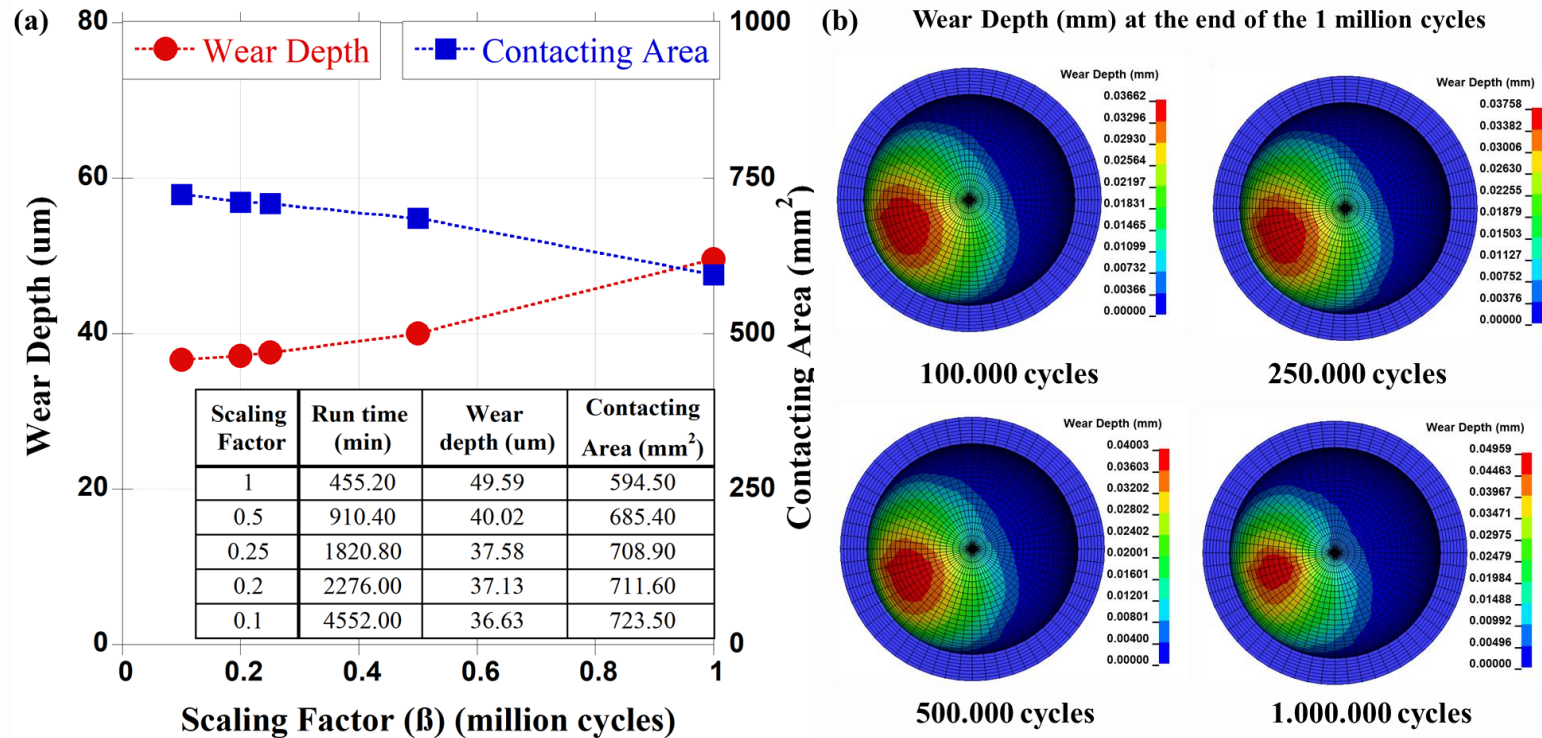


Figure 3(a) The effect of scaling factor on wear depth and contacting area, and (b) wear depth at the end of the 1 million cycles

Results and Conclusion

Contact Pressure

The peak contact pressure values have obtained

- 6.33 MPa for gait at 0.21 s.
- 7.58 MPa for SD at 0.78 s.
- 8.33 MPa for SA at 0.23 s.

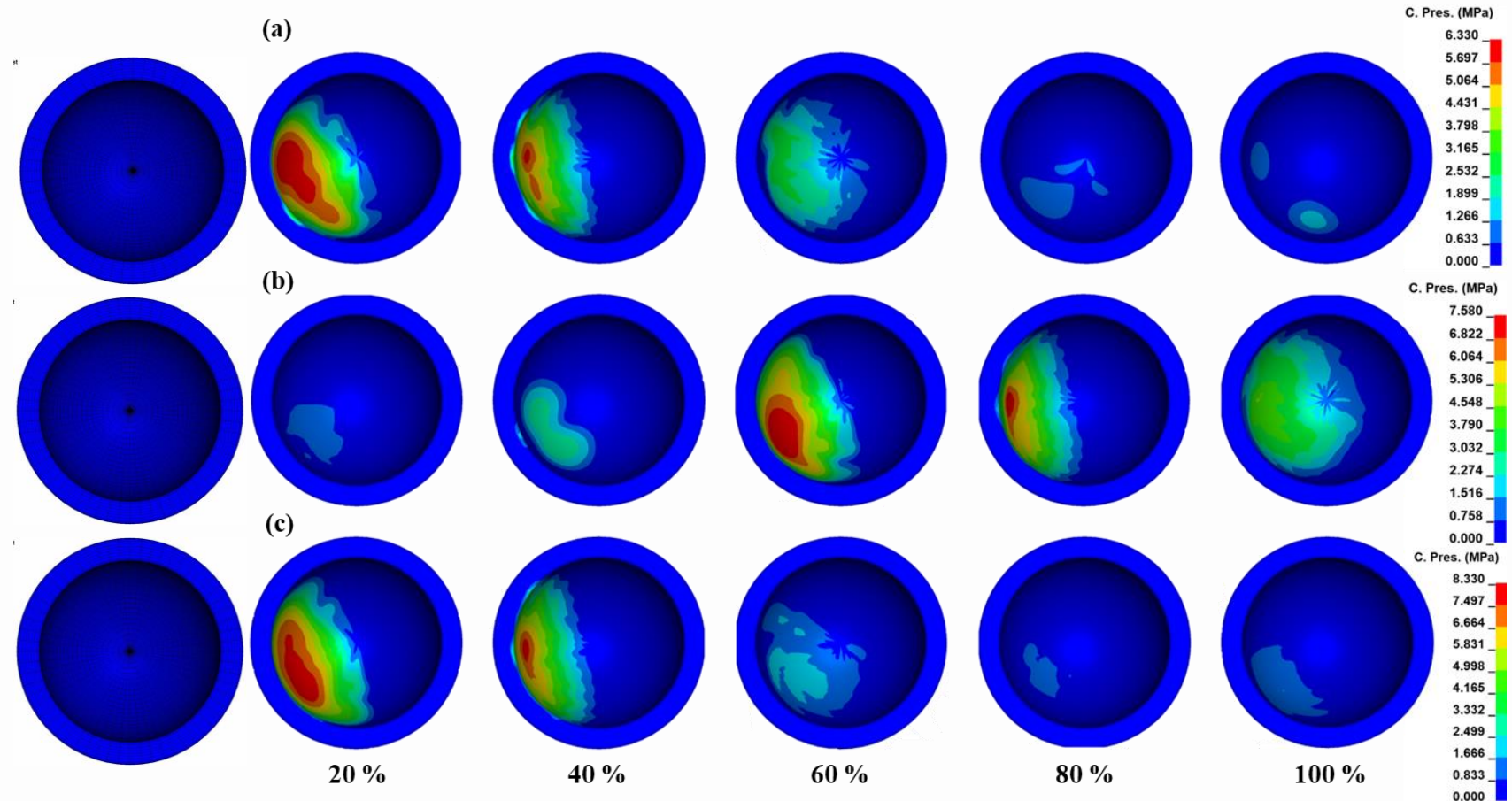


Figure 4 The contact pressure distribution over percentage of (a) gait, (b) SD, and (c) SA activities cycles at the end of the 250.000 cycles

Linear Wear Depth And Volumetric Wear Loss



The percentage increases in mean volumetric wear rates of XLPE liner and CoCr head for gait (by adding SA and SD) activity compared to normal walking are predicted at

- 6.88% for XLPE liner
- 12.02% for CoCr head

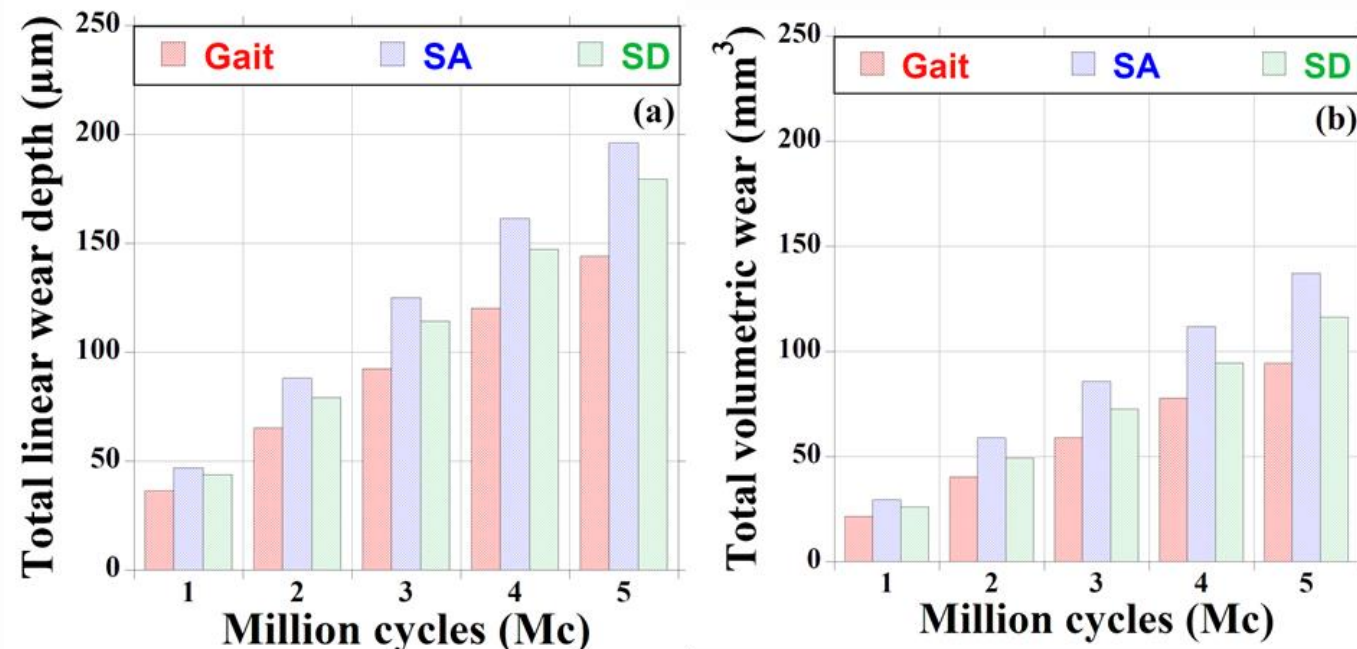


Figure 6 (a) Total linear wear depth and (b) total volumetric wear of XLPE bearing linear under gait, stair ascending and stair descending boundary conditions over five million cycles.

| Part | Mean volumetric wear rate (mm^3/Mc) | | | |
|-------------------|---|--------|--------|-------------------------|
| | SA | SD | Gait | Gait (adding SA and SD) |
| XLPE liner | 27.429 | 23.220 | 18.839 | 22.020 |
| CoCr head | 0.337 | 0.307 | 0.336 | 0.376 |

- ✓ The volumetric wear rates of XLPE under walking increased by 16.9 % by including the effects of stair ascending/ descending activities.
- ✓ The linear wear rates of XLPE for walking increased up to 3.27% by adding stair ascending/descending activities.
- ✓ The lifespan of hip implant under walking cycles could be predicted as 25.7 years¹¹ in FEM and 20 years in clinical retrieval⁶³.
- ✓ In the current study, it could be predicted as 26.9 years for walking compared to 23 years with walking adding stair ascending and descending activities.
- ✓ While estimating the lifetime of the implants, the researchers should consider the cumulative effect of each daily life activity rather than focusing on only gait cycles for more accurate prediction of lifespan of hip implant.

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Resources

- www.anybodytech.com
 - Events, Webcast library, Publication list, ...
- www.anyscript.org
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- **Events**
 - **June 4:** Webcast: New AnyBody Thoracic Spine, Ribcage and Abdominal Model
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Welcome to AnyScript.org
An open community for users of the AnyBody Modeling System and a resource for writing AnyScript code.
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NEW

Year 1057 Publications


| | | |
|------|--|--|
| 2024 | He Z, Liu G, Zhang B, Ye B, Zhu H, (2024). "Impact of specialized fatigue and backhand smash on the ankle biomechanics of female badminton players". Sci. Rep., vol. 14, pp. 10282. [DOI, WWW] | NEW sports ankle lower extremity |
| 2024 | Rieger F, Rothenfluh DA, Ferguson SJ, Ignasiak D, (2024). "Comprehensive assessment of global spinal sagittal alignment and related normal spinal loads in a healthy population". J. Biomech., pp. 112127. [DOI, WWW] | NEW orthopedics spine |
| 2024 | Akiho S, Hashida R, Tagawa Y, Maeyama A, Kinoshita K, Kanazawa K, Matsuse H, Hara M, Yamamoto T, (2024). "Bone morphology and physical characteristics of the pro-cyclist hip joint". Int. Orthop., [DOI, WWW] | NEW sports hip |
| 2024 | Menze J, Rojas JT, Ferguson SJ, De Pieri E, Gerber K, Zumstein MA, (2024). "Lower Trapezius and Latissimus Dorsi Transfer relieve Teres Minor Activity into the Physiological Range in Collin D Irreparable Posterosuperior Massive Rotator Cuff Tears: A Biomechanical Analysis". J. Shoulder Elbow Surg., [DOI, WWW] | NEW orthopedics shoulder |
| 2024 | Takeshita Y, Kawada M, Miyazaki T, Araki S, Matsuzawa Y, Higashi N, Hayashi H, Yamaguchi Y, Nakatsuji S, Nakai Y, Kiyama R, (2024). "Estimation of joint and muscle forces during exercise in various postures". J. Bodyw. Mov. Ther., [DOI, WWW] | NEW sports hip leg lower extremity spine rehab |
| 2024 | Tzanetis P, de Souza K, Robertson S, Fluit R, Koopman B, Verdonschot N, (2024). "Numerical study of osteophyte effects on preoperative knee functionality in patients undergoing total knee arthroplasty". J. Orthop. Res., [DOI, WWW] | NEW orthopedics knee leg lower extremity |
| 2024 | Antognini C, Knowlton C, Wimmer MA, (2024). "APPLICABILITY OF MARKERLESS CAPTURED JOINT KINEMATICS AND KINETICS TO MUSCULOSKELETAL MODELLING OF THE KNEE". Osteoarthritis Cartilage, vol. 32, pp. S175-S176. [DOI, WWW] | NEW knee leg lower extremity |
| 2024 | Song M, Li Z, Jjiang J, Chen W, Guo S, Zheng H, Niu L, (2024). "Design, Simulation and Kinematic Validation of a Hip Prosthetic Mechanism with a Multimotor Function". J. Bionic Eng., [DOI] | NEW exoskeleton hip leg lower extremity |
| 2024 | Höll M, Tröster M, Rack R, Daub U, Schneider U, Bauernhansl T, Müller G, (2024). "Digitale Arbeitsmodelle und Methoden/Digital work models and methods - Transparency for the use of occupational exoskeletons as an ergonomic measure". wt Werkstattstechnik online, vol. 114, pp. 59-65. [DOI, WWW] | NEW exoskeleton work place ergonomics methods |
| 2024 | Wong C, Shayestehpour H, Koutras C, Dahl B, Otaduy MA, Rasmussen J, Bencke J, (2024). "Using Electric Stimulation of the Spinal Muscles and Electromyography during Motor Tasks for Evaluation of the Role in Development and Progression of Adolescent Idiopathic Scoliosis". J. Clin. Med., [DOI, WWW] | NEW spine |

Publications list

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15. April 2024

From Qualisys motion capture to AnyBody musculoskeletal analysis

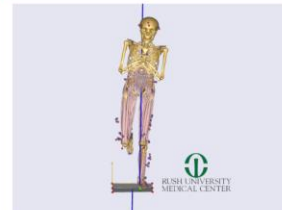
Nils Betzler, Product Manager - Life Sciences at Qualisys & Søren Tørholm Head of Services, AnyBody Technology



22. March 2024

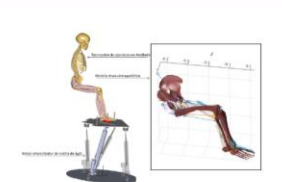
New features in the AnyBody Modeling System Version 8.0

Morten Enemark Lund & Kristoffer Iversen, AnyBody Technology



13. March 2024

An analysis of hip joint contact forces in people with femoroacetabular impingement syndrome during squat tasks



26. January 2024

Validación con AnyBody de un modelo musculoesquelético en tiempo real

Pau Zamora Ortiz Investigador en Ingeniería Biomédica, Universidad Politécnica de Valencia

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