

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

The webcast will begin shortly...



Outline

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



Presenter

Mattia Perrone

Research Scientist

Rush University Medical
Center

Host

Kristoffer Iversen

Technical Sales Executive

AnyBody Technology



Control Panel

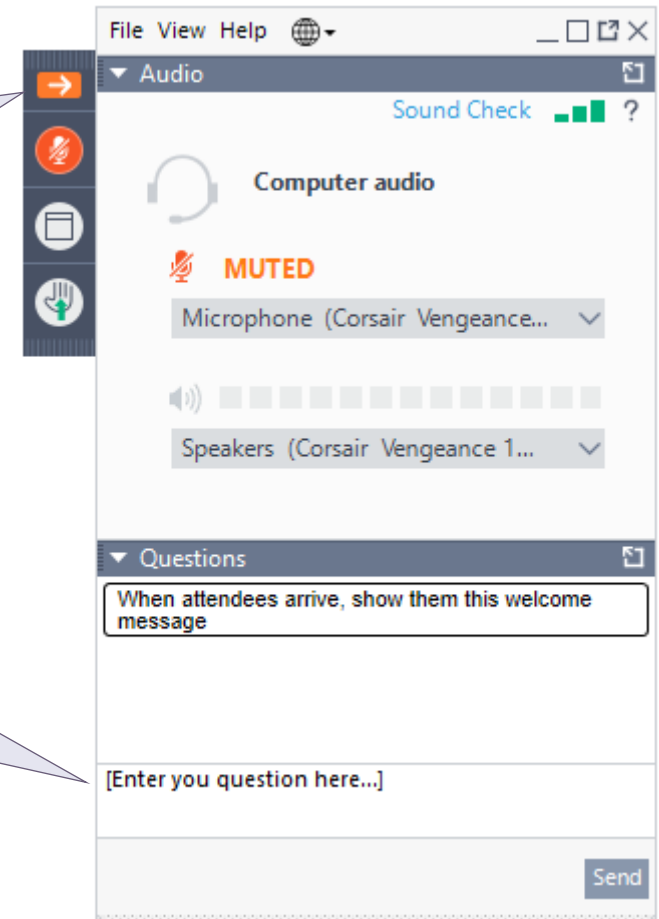
Expand/Collapse the Control Panel

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

Submit questions and comments via the Questions panel.

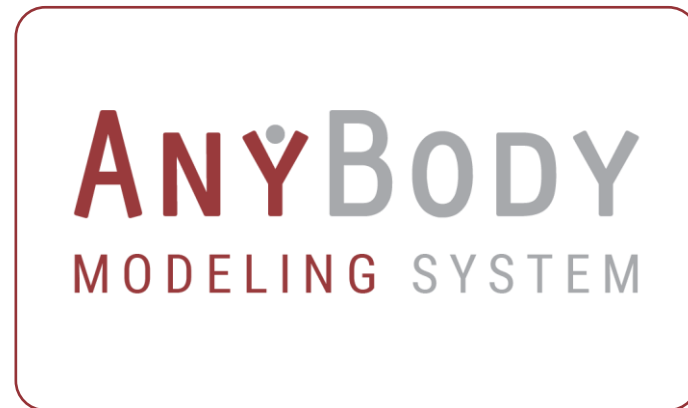
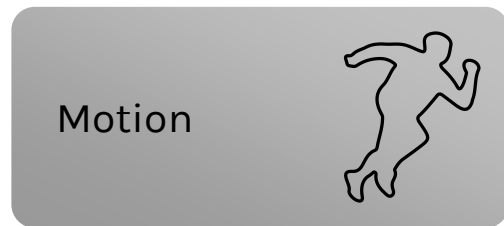
Questions will be addressed at the end of the presentation. If your question is not addressed, we will do so by email.

Ask a question during the presentation



Musculoskeletal simulations

INPUT • Motion data



OUTPUT • Internal Body Loads

Joint reaction forces

Muscle forces

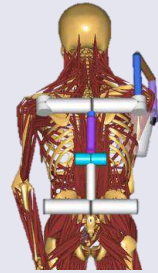
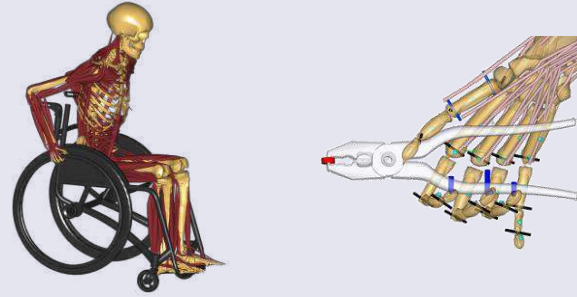
Muscle activity

Metabolic energy



Motion analysis

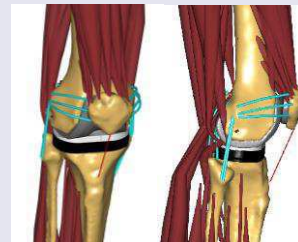
Product design and optimization



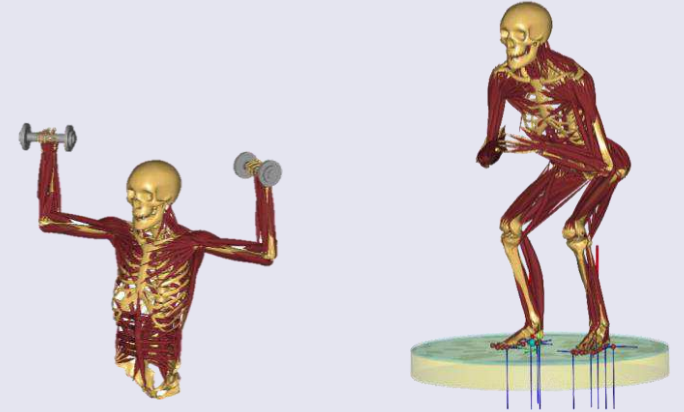
Ergonomics with/without exoskeletons



ANYBODY
MODELING SYSTEM



Orthopedics and Rehabilitation

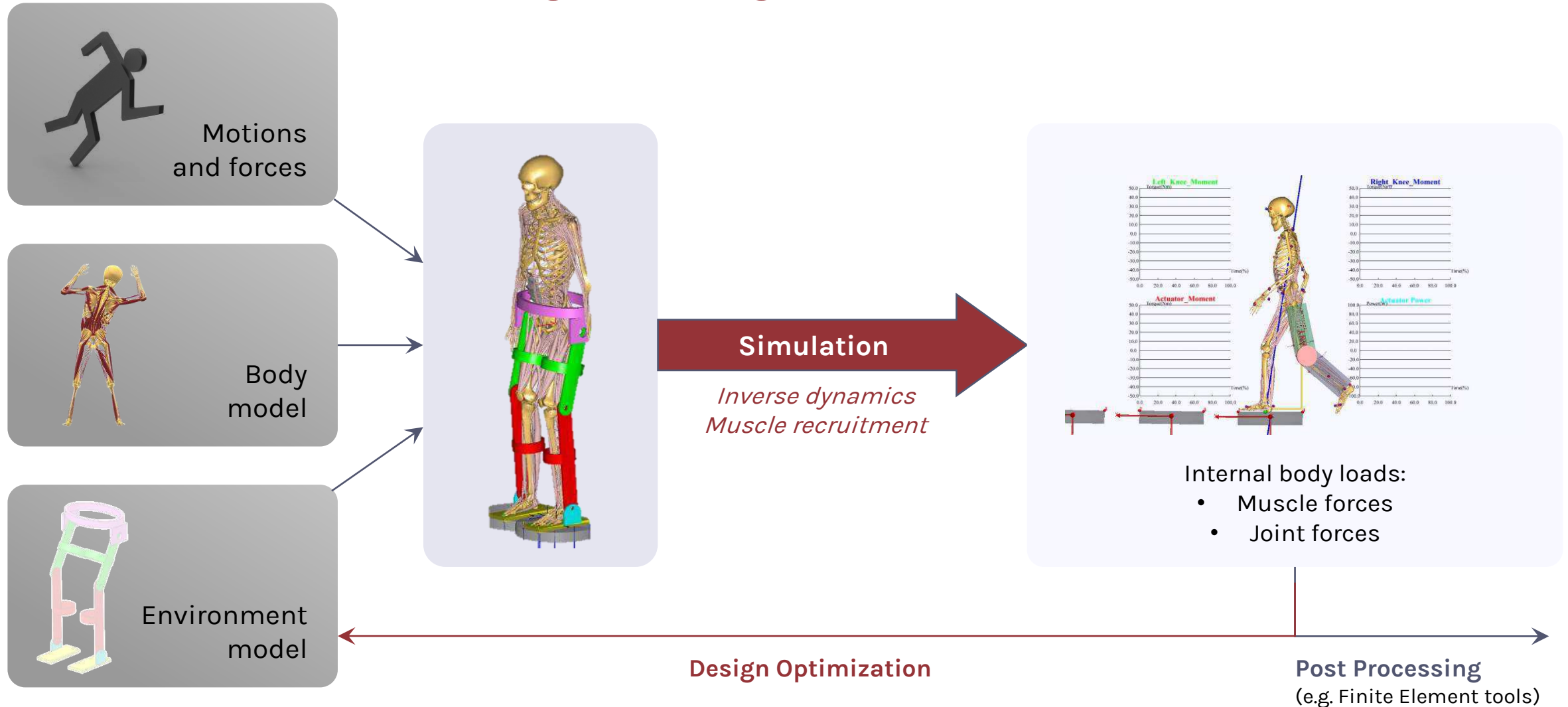


Sports



Automotive

Workflow

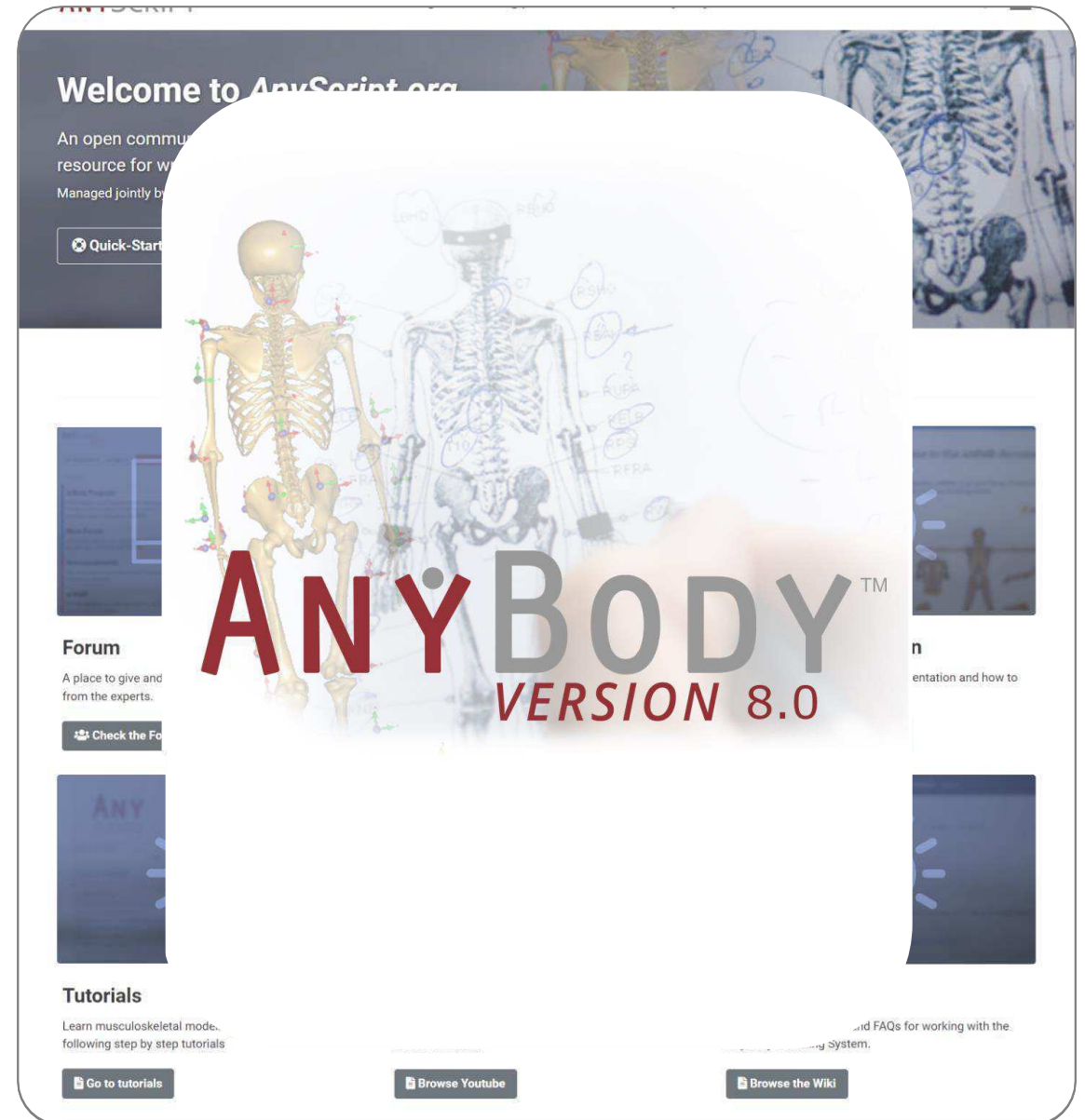


An analysis of hip joint contact forces in people with femoroacetabular impingement syndrome during squat task



Resources

- www.anybodytech.com
 - Events, Webcast library, Publication list, ...
- www.anyscript.org
 - Wiki, Blog, Repositories, Forum
- **Events**
 - **Mar 21:** [Webcast] New features in the AnyBody Modeling System Version 8.0
 - Join us for a tour of the new AnyBody Modeling System 8.0 and the included updated AnyBody Managed Model Repository 3.0.



1000+

publications

filter by:

Industry

Research area

Body part

100+

webcasts

filter by:

Industry

ANYBODY TECHNOLOGY | INDUSTRIES | PRODUCTS | EVENTS | RESOURCES | CONTACT | LOGIN / REGISTER | SEARCH

Publication list

Resources | Publication list

Industry
[sports](#) [exoskeleton](#) [work place ergonomics](#) [orthopedics](#) [defense](#) [aerospace](#) [automotive](#) [consumer products](#) [furniture](#)

Research area
[gait](#) [methods](#) [validation](#) [animal](#) [sensitivity analysis](#) [rehab](#) [seating](#) [fea](#) [occupational health](#) [AnyBody Tech selected](#)

Body part
[knee](#) [lower extremity](#) [foot](#) [spine](#) [upper extremity](#) [hand](#) [shoulder](#) [hip](#) [mandible](#) [wrist](#) [trunk](#) [elbow](#) [ankle](#) [leg](#)

NEW

Year **1029 Publications**

2024 De Pieri E, Egloff C, Mundermann A, Nuesch C, Herger S, Liphardt AM, Chammartin F. (2024). "Load-induced blood marker kinetics in patients with medial knee compartment osteoarthritis are associated with accumulated load and patient reported outcome measures". F1000 Research, vol. 12, pp. 299. [DOI, WWW] **NEW** [orthopedics](#) [knee](#) [leg](#) [lower extremity](#)

2024 Bassani T, Ignasiak D, Cina A, Galbusera F. (2024). "Prediction of trunk muscle activation and spinal forces in adolescent idiopathic scoliosis during simulated trunk motion: A musculoskeletal modelling study". J. Biomech., pp. 111918. [DOI, WWW] **NEW** [orthopedics](#) [spine](#)

2024 Sylvester A, Kramer P. (2024). "Achieving kinematic identity across shape diversity in musculoskeletal modeling". Palaeontol. Electronica. [DOI, WWW] **NEW** [hip](#) [lower extremity](#) [gait](#)

2023 Diao H, Xin H, Jin Z. (2023). "Estimation of Cervical Spinal Loading and Internal Motion at Adjacent Segments after C5-C6 Fusion Using a Musculoskeletal Multi-Body Dynamics Model during the Head Flexion-Extension Movement". Applied Sciences, vol. 14. [DOI, WWW] **NEW** [orthopedics](#) [spine](#)

2023 Rasmussen J, Skeja S, Waagepetersen RP. (2023). "Predicting tissue loads in running from inertial measurement units". Sensors. [DOI, WWW] **NEW** [sports](#) [knee](#) [leg](#) [lower extremity](#)

2023 Ji R, Lee WY, Guan X, Yan B, Yang L, Yang J, Wang L, Tao C, Kralj S, Fan Y. (2023). "Comparison of plugin and redundant marker sets to analyze gait kinematics between different populations". Biomed. Eng. Online, vol. 22, pp. 122. [DOI, WWW] **NEW** [gait](#)

2023 Hosseini N, Arjmand N. (2023). "An artificial neural network for full-body posture prediction in dynamic lifting activities and effects of its prediction errors on model-estimated spinal loads". J. Biomech., pp. 111896. [DOI, WWW] **NEW** [orthopedics](#) [work place ergonomics](#) [spine](#) [methods](#)

2023 Lee D, Lee J, Oh JH, Shin CS. (2023). "Effect of subscapularis repair on joint contact forces based on degree of posterior-superior rotator cuff tear severity in reverse shoulder arthroplasty". Front Bioeng Biotechnol, vol. 11, pp. 1229646. [DOI, WWW] **NEW** [orthopedics](#) [shoulder](#)

2023 Shoulin X, Yafei QU, Jiaxuan REN, Jing Z, Hui Li, Zhenxian C. (2023). "Effect of prosthetic joint line installation height errors on ison wear in unicompartmental knee arthroplasty". Journal of Biomedical Engineering, vol. 40. [DOI] **NEW** [orthopedics](#) [knee](#) [leg](#) [lower extremity](#) [fea](#)

2023 Perrone M, Guidetti M, Galli M, Nho SJ, Wimmer MA, Malloy P. (2023). "Hip Joint Contact Forces are Lower in People with Femoroacetabular Impingement Syndrome During Squat Tasks". J. Orthop. Res., [DOI, WWW] **NEW** [orthopedics](#) [hip](#) [lower extremity](#)

2023 Li H, Huang H, Zhang S, Ren S, Rong Q. (2023). "Muscle dynamics analysis by clustered categories during jogging in patients with anterior cruciate ligament deficiency". BMC Musculoskelet. Disord., vol. 24, pp. 919. [DOI, WWW] **NEW** [orthopedics](#) [sports](#) [knee](#) [leg](#) [lower extremity](#)

Publications list

Webcast library

Resources | Webcast library

All | Aerospace | All use cases | Animal | Assistive devices | Automotive | Consumer | Ergonomics | Exoskeleton | Orthopedics | Product presentations | Sports | Universities | Workplace ergonomics

23. November 2023

In silico approach for personalized gait modification to decelerate knee osteoarthritis progression
 Dr. Amir Estrafilian, Department of Technical Physics, University of Eastern Finland, Kuopio, Finland

13. October 2023

Toward personalized total knee arthroplasty - Pre-planning the patient's optimal joint function in robotic-assisted surgery
 Periklis Tzanetis, Post Doc, University of Twente

15. September 2023

Increased femoral anteversion in children - can musculoskeletal modeling better inform clinical decision-making?
 Dr. Enrico De Pieri - Senior Research Engineer at

27. April 2023

From Vicon motion capture data to musculoskeletal analysis using AnyBody
 Søren Tørholm, Head of Services, AnyBody Technology

Webcasts list

Questions

Meet us

- Send email to sales@anybodytech.com

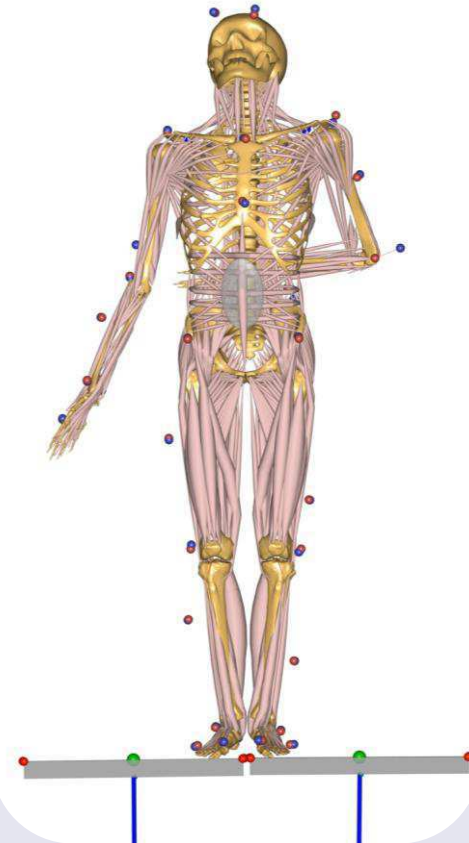
Trial version

- Send email to sales@anybodytech.com

Presentation questions

- Send email to ki@anybodytech.com

Thank you for your attention!





An Analysis of Hip Joint Contact Forces in People with Femoroacetabular Impingement Syndrome during Squat Tasks

Mattia Perrone^{1,2,3,4}, Martina Guidetti¹, Manuela Galli³, Shane J. Nho¹,
Markus Wimmer^{1,2}, Philip Malloy^{1,4}

¹Rush University Medical Center, Chicago, IL, ²University of Illinois at Chicago, Chicago, IL,
³Politecnico di Milano, Milan, Italy, ⁴Arcadia University, Glenside, PA,

Disclosures: S.J.N. (CONMED Linvatec, OSSÜR, Allosource, Arthrex, DJ Orthopaedics, Athletico, Miomed, Smith & Nephew, Stryker), none of the other authors has anything to disclose.

Outline

- 1. Background**
- 2. Methods**
- 3. Results**
- 4. Discussions**
- 5. Conclusions**

Outline

- 1. Background**
- 2. Methods**
- 3. Results**
- 4. Discussions**
- 5. Conclusions**

“Hip joint contact forces are lower in people with femoroacetabular impingement syndrome during squat tasks”



DOI: 10.1002/jor.25744

Affiliations



POLITECNICO
MILANO 1863





Background

Background

Femoroacetabular impingement syndrome (FAI)

- Hip condition: premature contact between the proximal femur and the acetabulum¹
- Incidence of 20% in young athletes and active adults (US population)¹



¹ Griffin DR, Dickenson EJ, O'donnell J, et al. The Warwick agreement on femoroacetabular impingement syndrome (FAI syndrome): an international consensus statement. Br J Sports Med. 2016;50: 1169-1176

Background

In vivo test

Background

In vivo test

In vitro test

Background

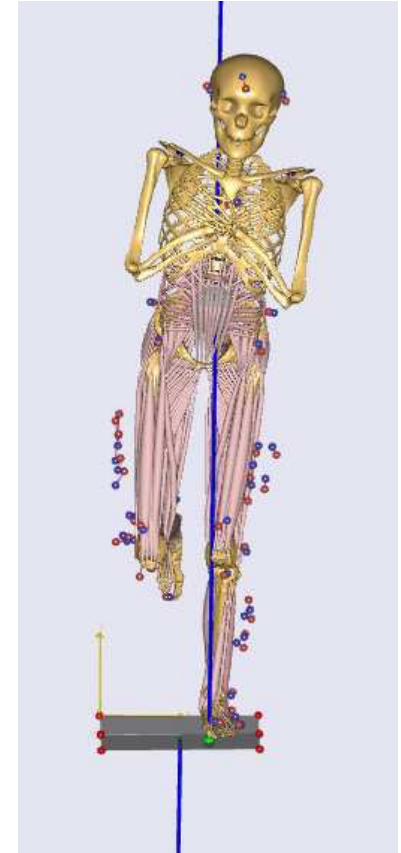
In vivo test

In vitro test

In silico test

Musculoskeletal Models

- Musculoskeletal (MSK) models include representations of bones, joints, ligaments and muscles
- Input data: kinematics and forces
- Output data: joint moments, muscle forces and joint forces



Literature on FAI - MSK models

Gait:

- Motion task most commonly investigated
- End of hip range of motion not involved
- Inconsistent results in the literature

Literature on FAI - MSK models

Gait:

- Motion task most commonly investigated
- End of hip range of motion not involved
- Inconsistent results in the literature

Double Leg Squat:

- Motion task less investigated than gait
- End of hip range of motion is reached
- Low forces at the hip

Literature on FAI - MSK models

Gait:

- Motion task most commonly investigated
- End of hip range of motion not involved
- Inconsistent results in the literature

Double Leg Squat:

- Motion task less investigated than gait
- End of hip range of motion is reached
- Low forces at the hip

Single Leg Squat:

- Motion task scarcely investigated
- End of hip range of motion is reached
- High forces at the hip

Aim of the Study

- Comparison of Hip Joint Forces (HJF) during gait, double leg squat and single leg squat between healthy controls and patients with FAI
- Comparison of HJF between healthy leg and injured leg in patients with FAI
- It can be hypothesized that HJF will be lower in people with FAI



Methods

Motion Capture Pipeline

Acquisition System

Force Plates
(GRF)

14-IR Camera
(Marker Trajectories)

Pre-processing

Motive OptiTrack
(C3D Data)

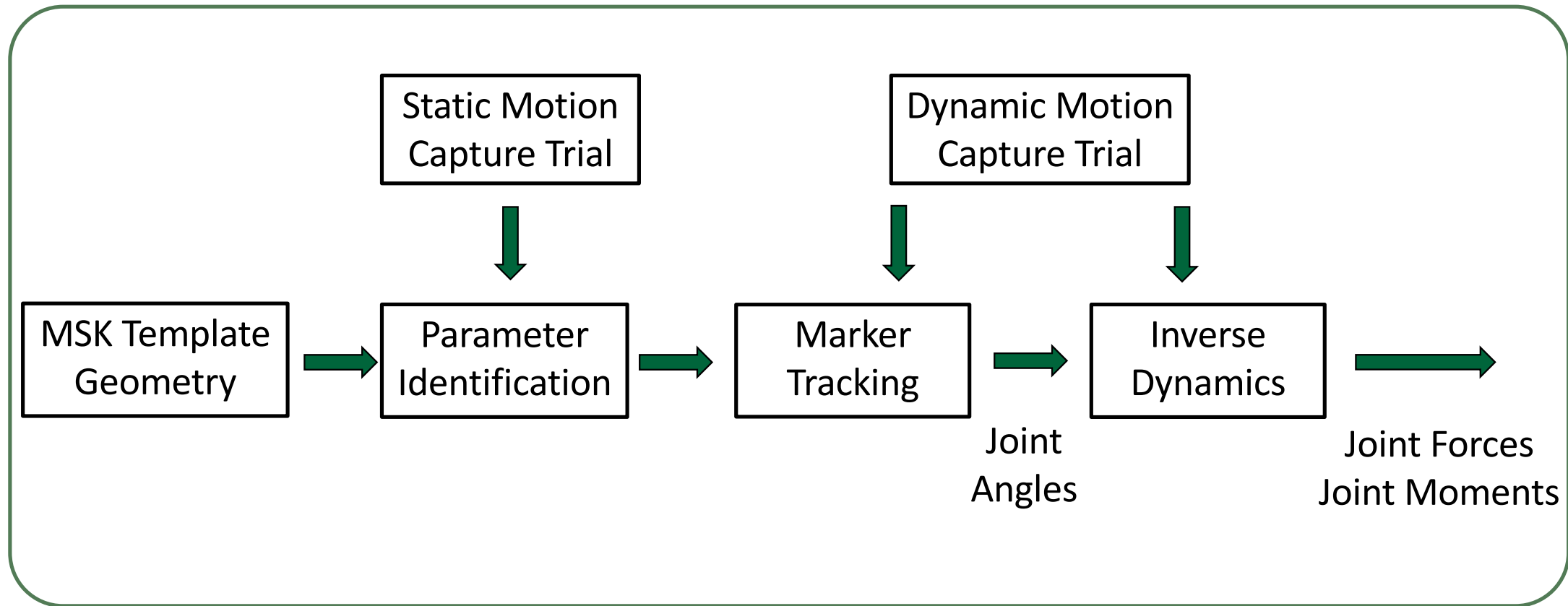
AnyBody
Pipeline

Post-processing

AnyPyTools
(HJF, HJA, HJM)

MatLab
(SnPM)

AnyBody Pipeline



MSK models in AnyBody

Model

Twente Lower Extremity Model
(TLEM-version 2.1)

Model Configuration Files

TrialSpecificData.any

- Selection of the C3D file and its initial/final frames

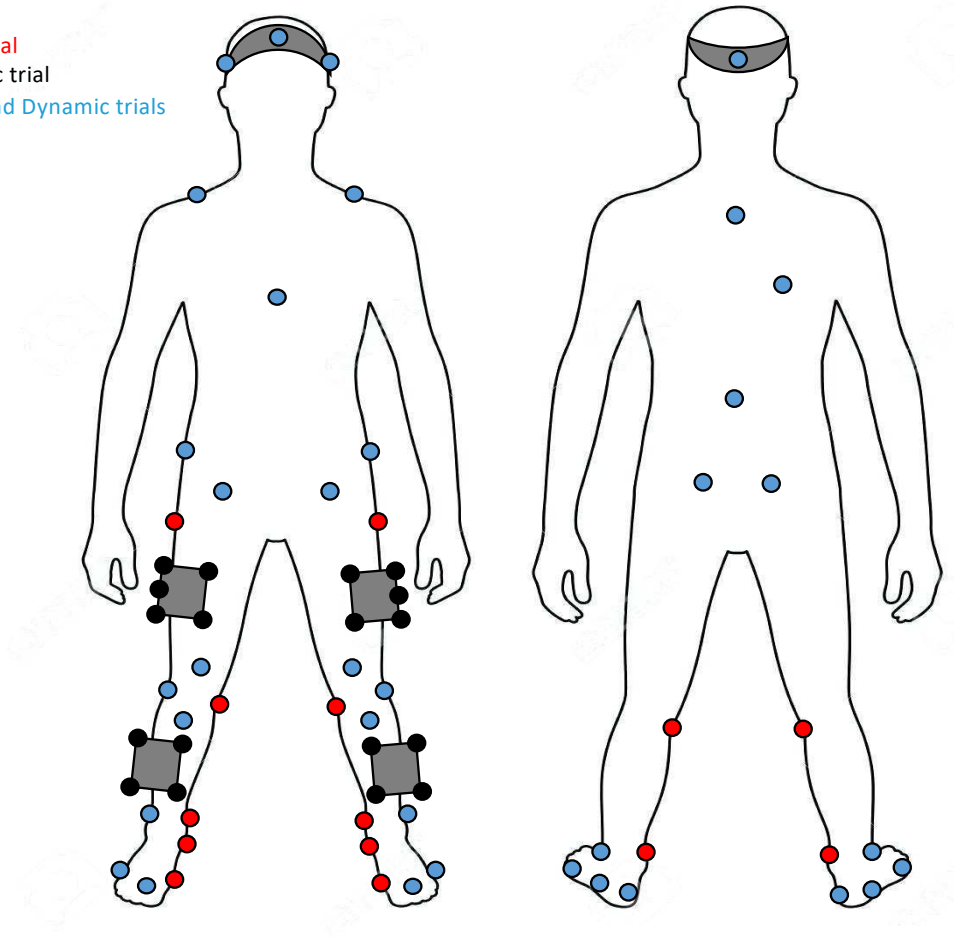
SubjectSpecificData.any

- Anthropometric data given in input

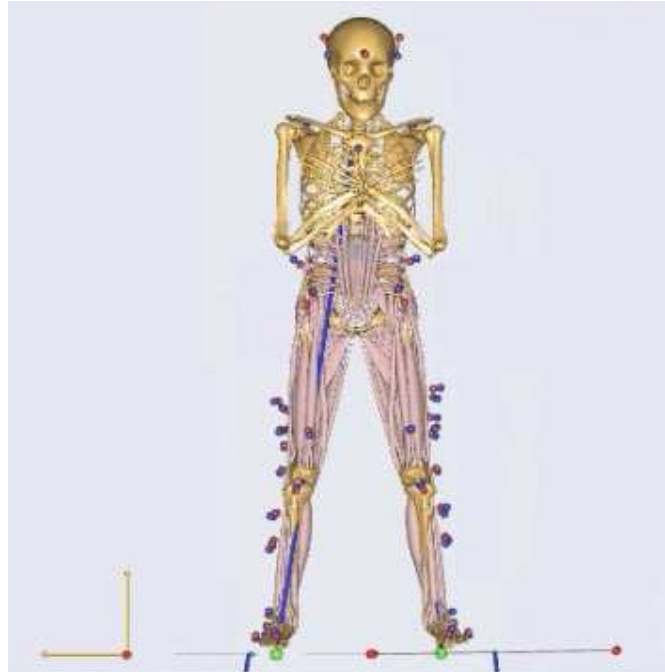
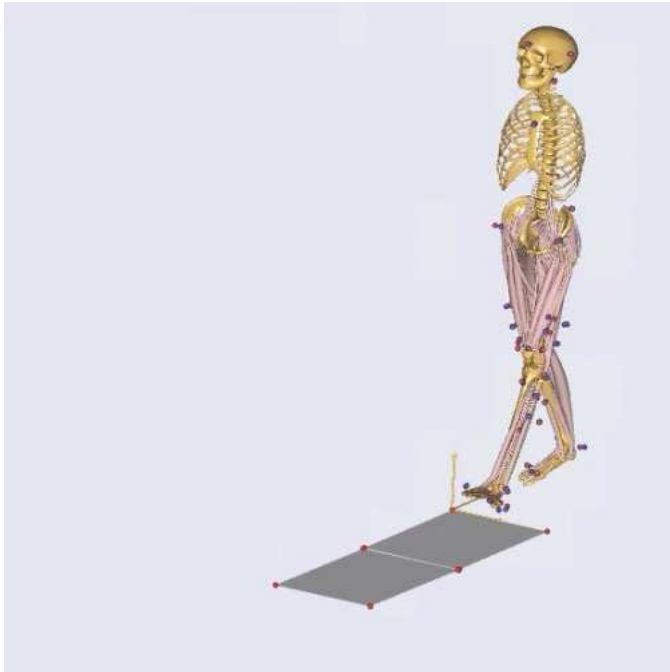
MarkerProtocol.any

- Marker protocol tuning

- Static trial
- Dynamic trial
- Static and Dynamic trials



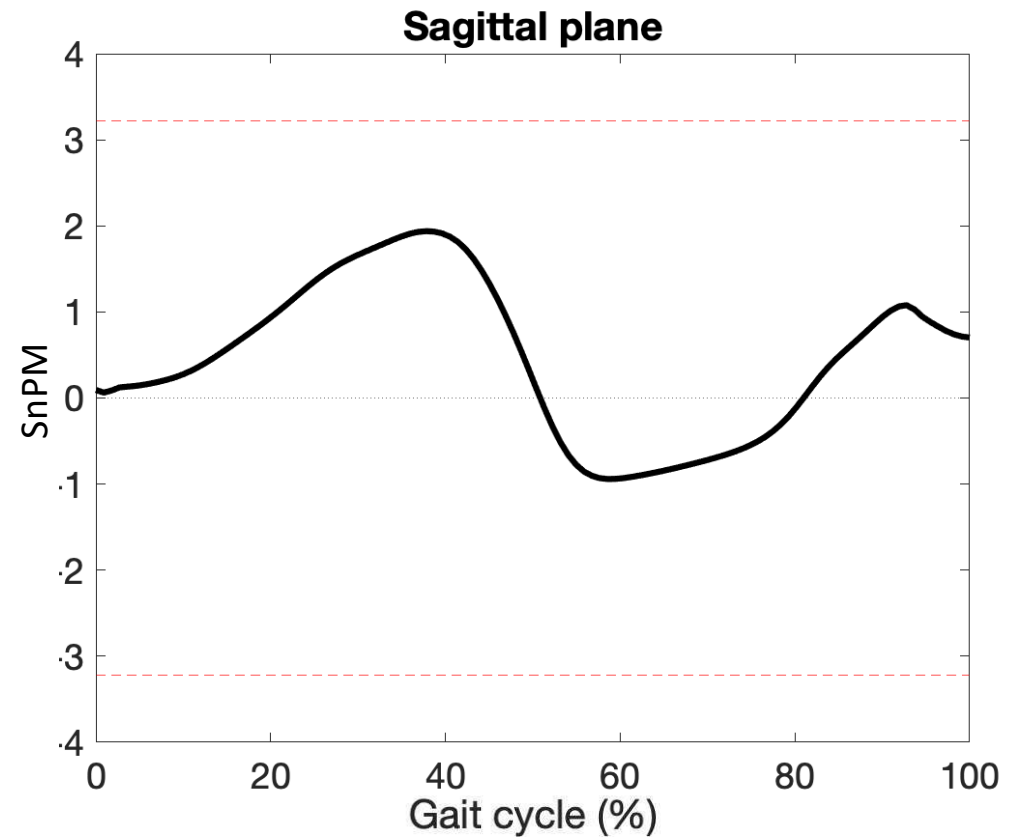
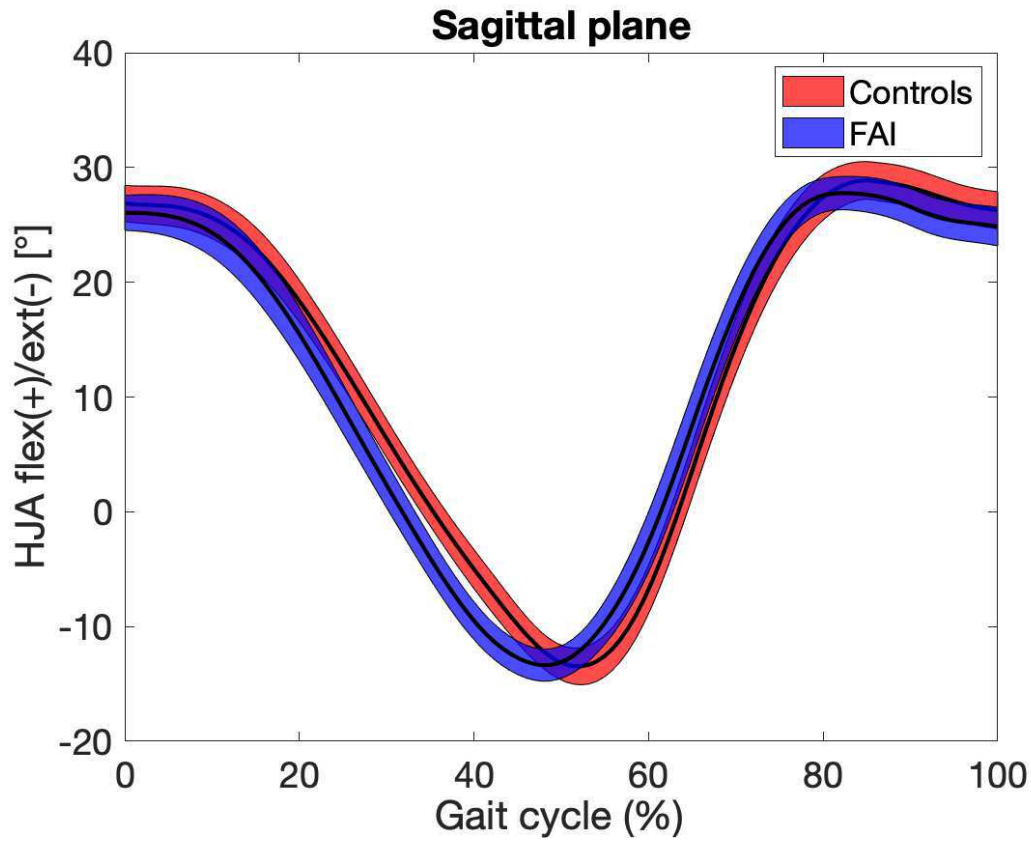
Motion Tasks Analyzed



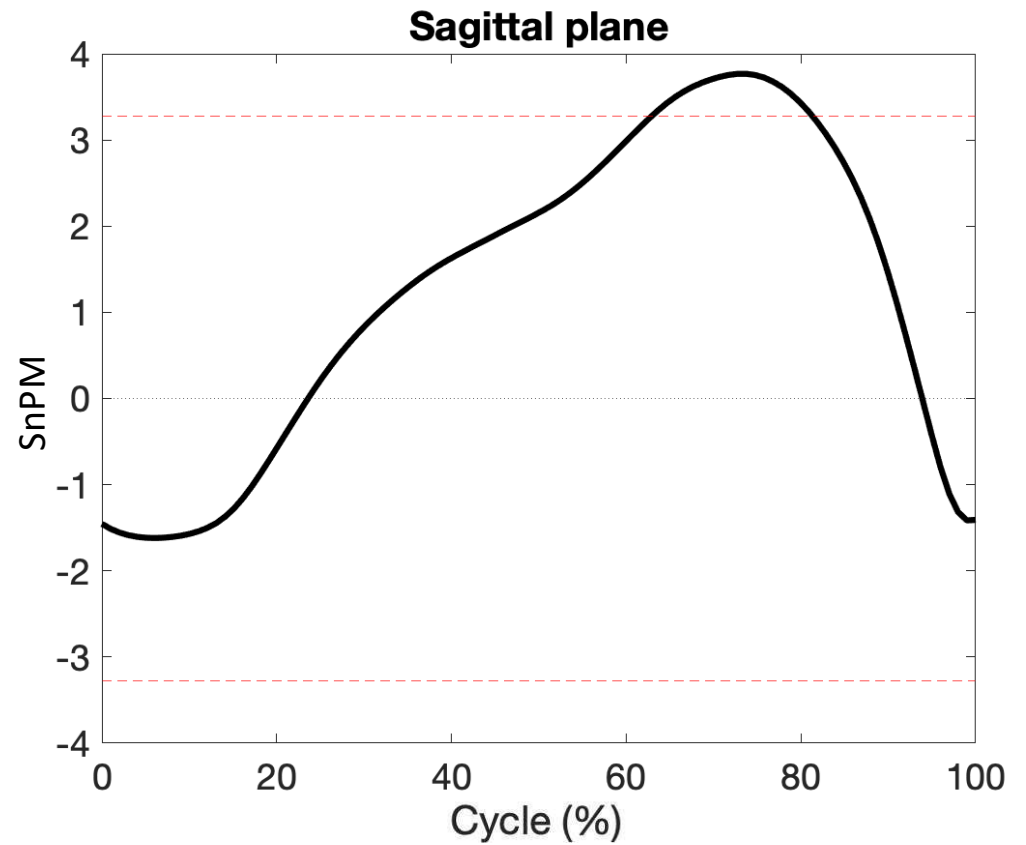
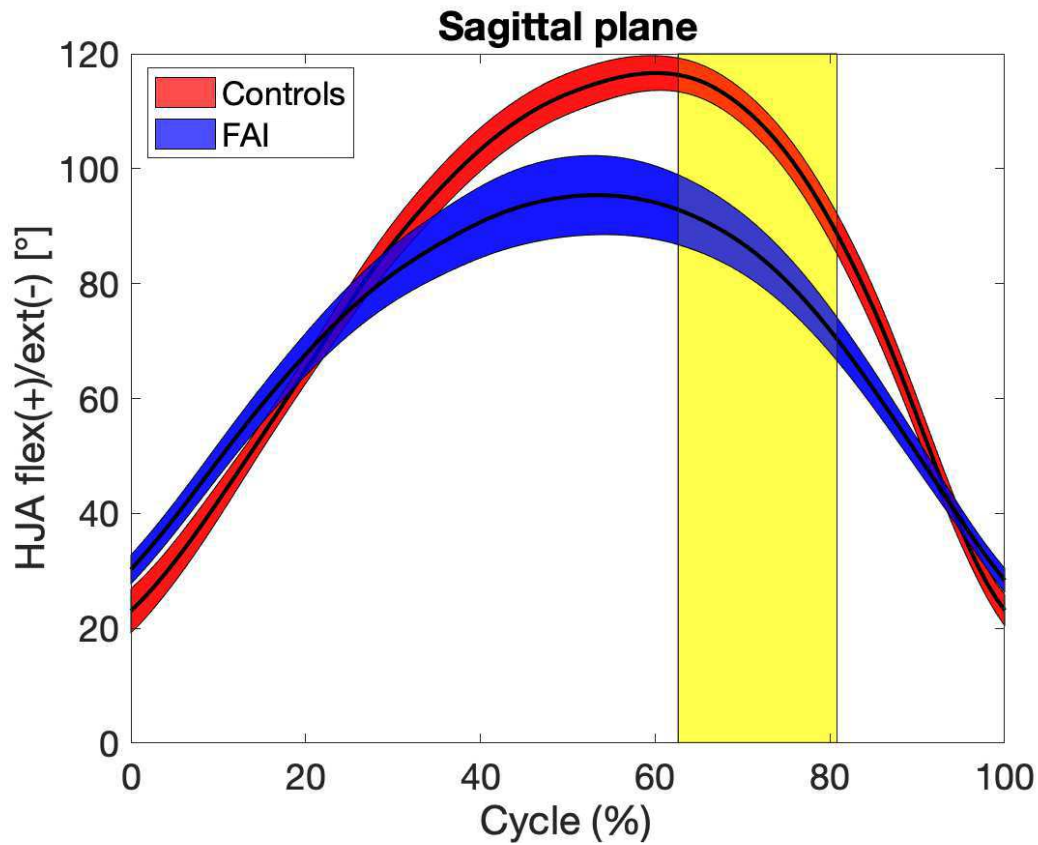
Gait	Double leg squat	Single leg squat
10 controls	10 controls	8 controls
10 patients with FAI	10 patients with FAI	8 patients with FAI

Results

Results

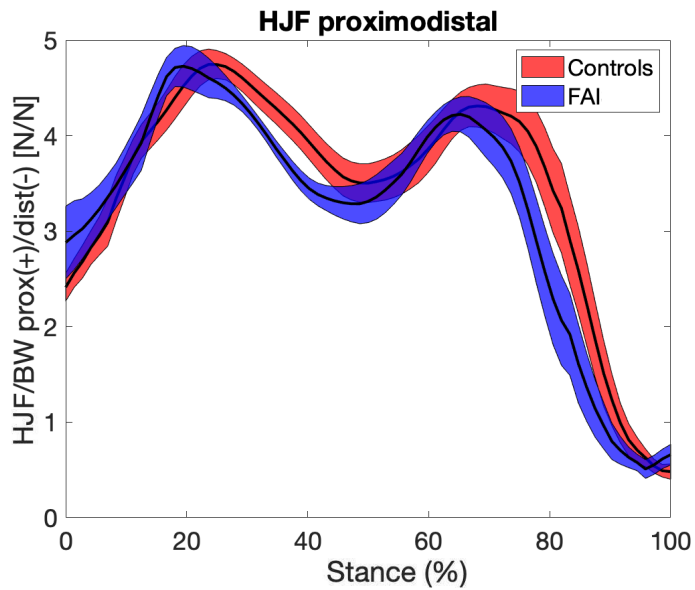


Results

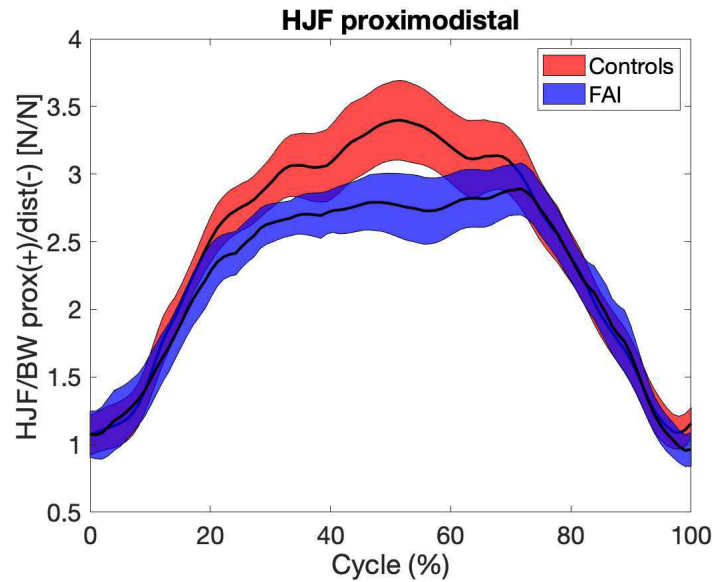


Comparison of HJF during different tasks

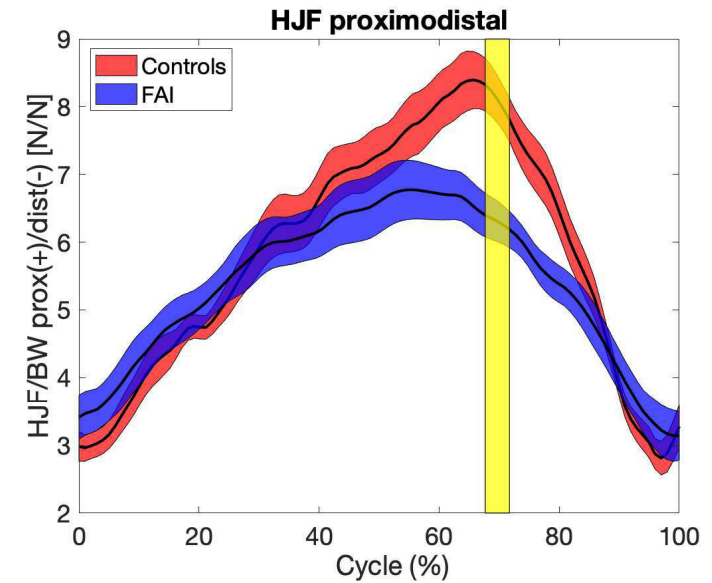
Gait



Double leg squat

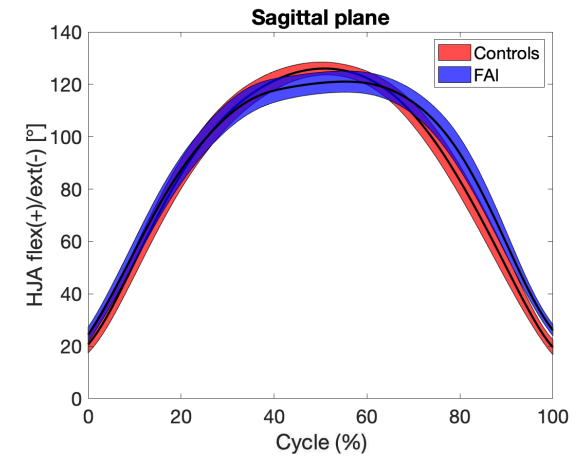
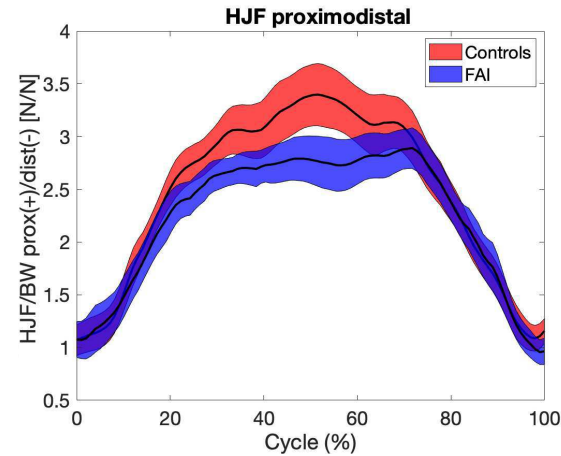


Single leg squat

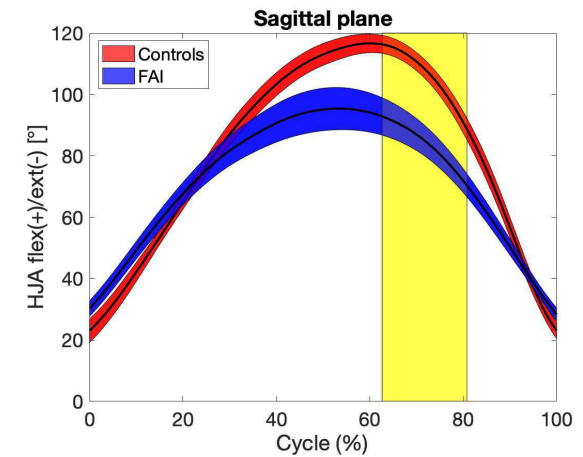
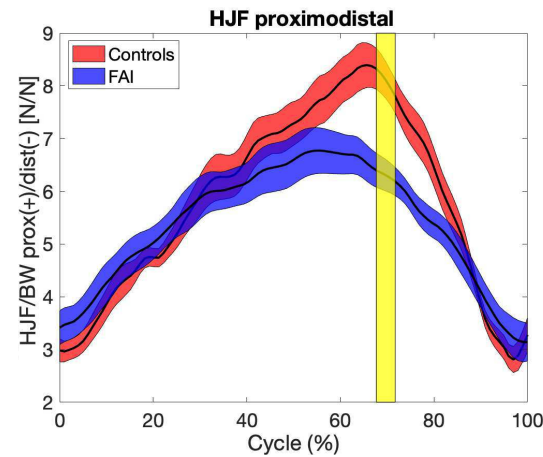


Comparison of HJA and HJF during different tasks

Double leg squat

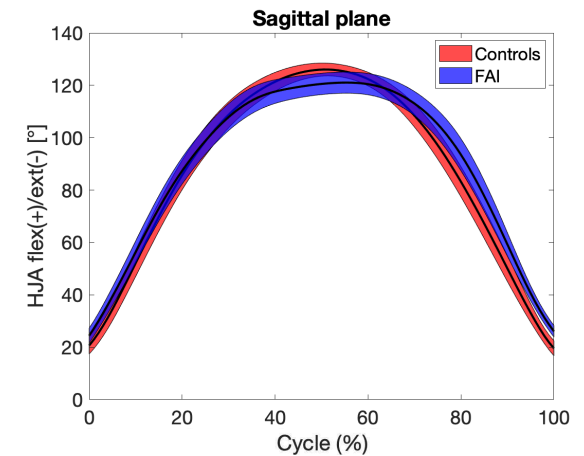
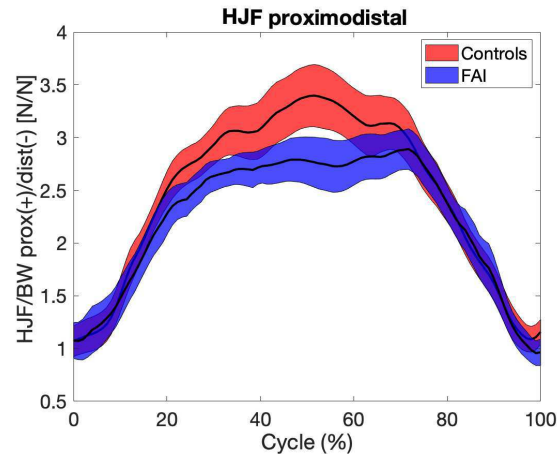


Single leg squat

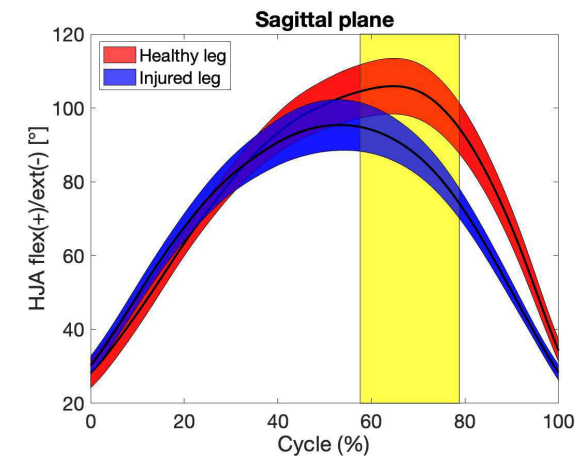
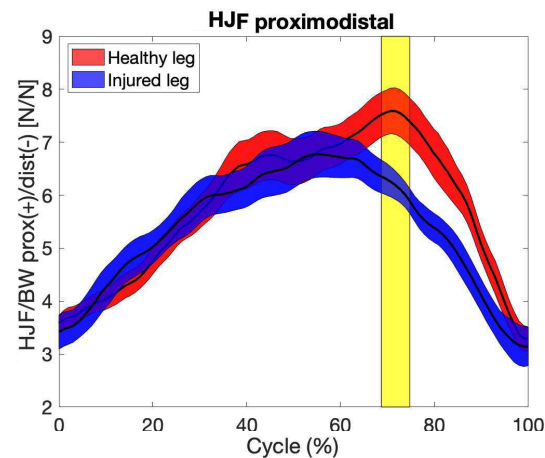


Comparison of HJA and HJF during different tasks

Double leg squat



Single leg squat





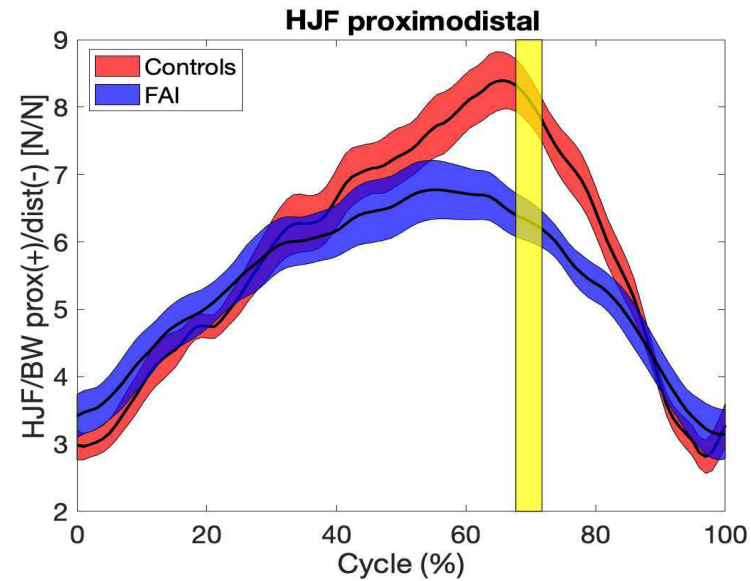
Discussions

Main findings

- **Single leg squat:** Lower proximodistal HJF in patients with respect to controls



Strategy to avoid pain during this high demand task



Main findings

- **Single leg squat:** Lower proximodistal HJF in patients with respect to controls



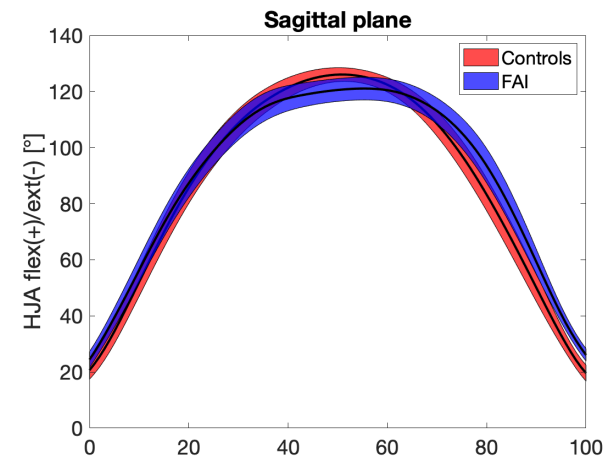
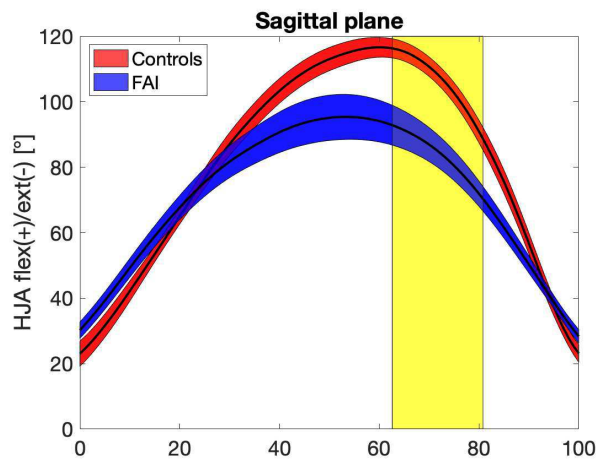
Strategy to avoid pain during this high demand task

- **Single leg squat:** Lower flexion HJA between patients and controls



Focus on proximodistal HJF when dealing with patients with FAI

- **Double leg squat:** No differences in terms of flexion HJA



Main findings

- **Single leg squat:** Lower proximodistal HJF in patients with respect to controls



Strategy to avoid pain during this high demand task

- **Single leg squat:** Lower flexion HJA between patients and controls



Focus on proximodistal HJF when dealing with patients with FAI

- **Double leg squat:** No differences in terms of flexion HJA

- **Gait and double leg squat:** No differences in terms of flexion HJA between patients and controls



Lower proximodistal HJF during these tasks



Conclusions

Conclusions

Background

- Femoroacetabular Impingement Syndrome
- Musculoskeletal models

Conclusions

Background

- Femoroacetabular Impingement Syndrome
- Musculoskeletal models

Methods

- Implementation of MSK models in AnyBody

Conclusions

Background

- Femoroacetabular Impingement Syndrome
- Musculoskeletal models

Methods

- Implementation of MSK models in AnyBody

Results and Discussion

- Lower proximodistal HJF for patients with FAI during single leg squat (high demand task)

Conclusions

Background

- Femoroacetabular Impingement Syndrome
- Musculoskeletal models

Methods

- Implementation of MSK models in AnyBody

Results and Discussion

- Lower proximodistal HJF for patients with FAI during single leg squat (high demand task)

Next steps

More complex MSK models can be implemented:

- Subject specific hip geometry from MRI reconstruction
- Analysis of hip muscles behaviors from EMG data

Thank you

