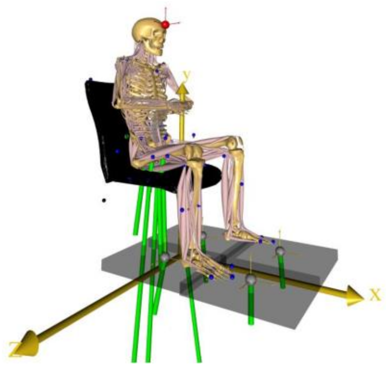


The webcast will start in a few minutes….

Webcast

INVESTIGATION OF MUSCLE ACTIVATION DURING ACTIVE SEATING

Outline

- Introduction by the Host
- Investigation of Muscle Activation During Active Seating
  - *By Kilian Wagner*
- Final words from the host
- Questions and answers

Kilian Wagner
Research Master Student
(Presenter)

Sebastian Dendorfer
Professor
(Panelist)

Laboratory of Biomechanics
Regensburg Center of Biomedical Engineering
OTH Regensburg and University of Regensburg, Germany

Morten Enemark Lund
AnyBody Technology
(Host)

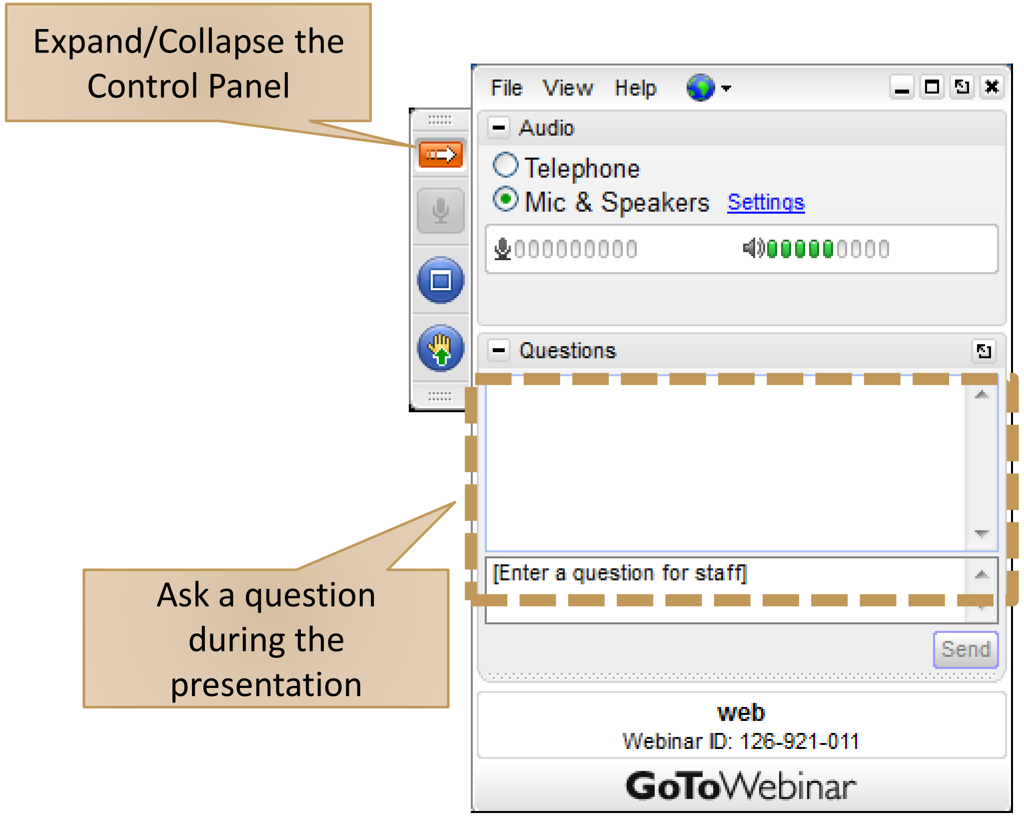
Arne Kiss
AnyBody Technology
(Panelist)

Control Panel

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

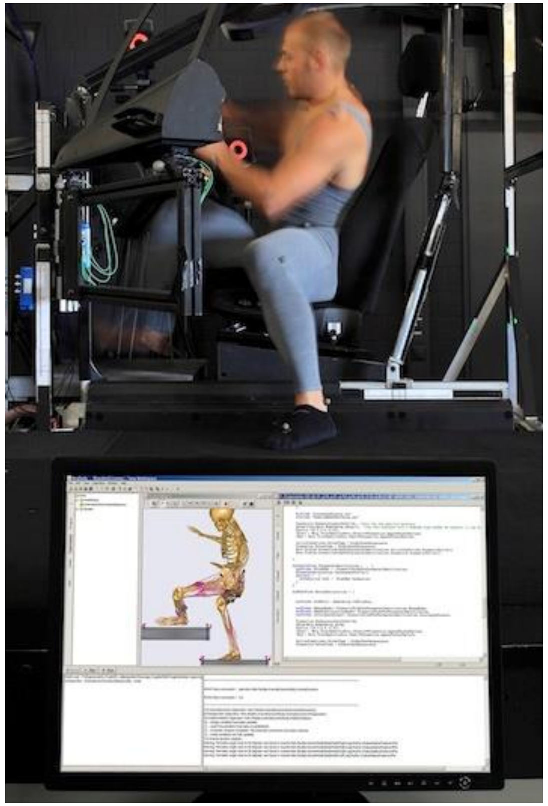
Submit questions and comments via the Questions panel.

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

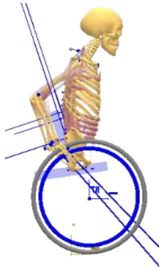


AnyBody Modeling System

- Software for simulations of musculoskeletal systems
- AnyBody Managed Model Repository
- Wide range of simulation options
  - Motion capture
  - Ground reaction force prediction
  - Imaging → Patient-specific anatomy
  - Man-machine simulations



Rasmussen et. al. (2011), ORS Annual Meeting

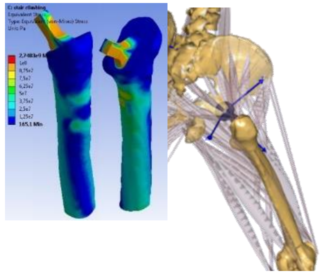


Product Design Optimization

Movement Analysis

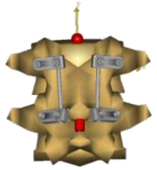
ANYBODY Modeling System

Ergonomic Analysis



Load Cases for Finite Element Analysis

Surgical Planning and Outcome Evaluation

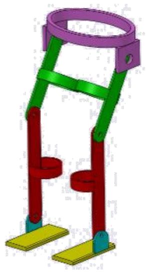


AnyBody Modeling System

Motion and Forces

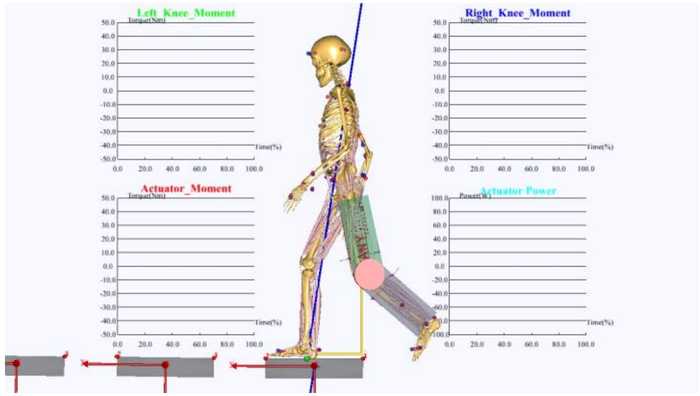
Body model

Environment model



Inverse dynamics
Muscle recruitment

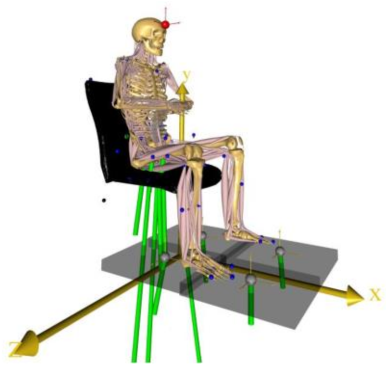
Simulation



Internal body loads
- Muscle forces
- Joint forces

Design Optimization

Post Processing (e.g. FE tools)



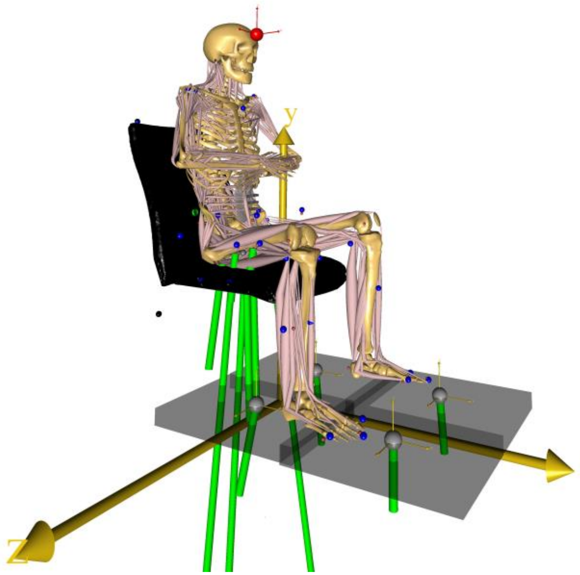
Investigation of Muscle Activation During Active Seating

KILIAN WAGNER

OTH OSTBAYERISCHE TECHNISCHE HOCHSCHULE REGENSBURG

LBM LABORATORY FOR BIOMECHANICS

Investigation of Muscle Activation During Active Seating



<u>Kilian Wagner</u>, Maximilian Aurbach, Sebastian Dendorfer

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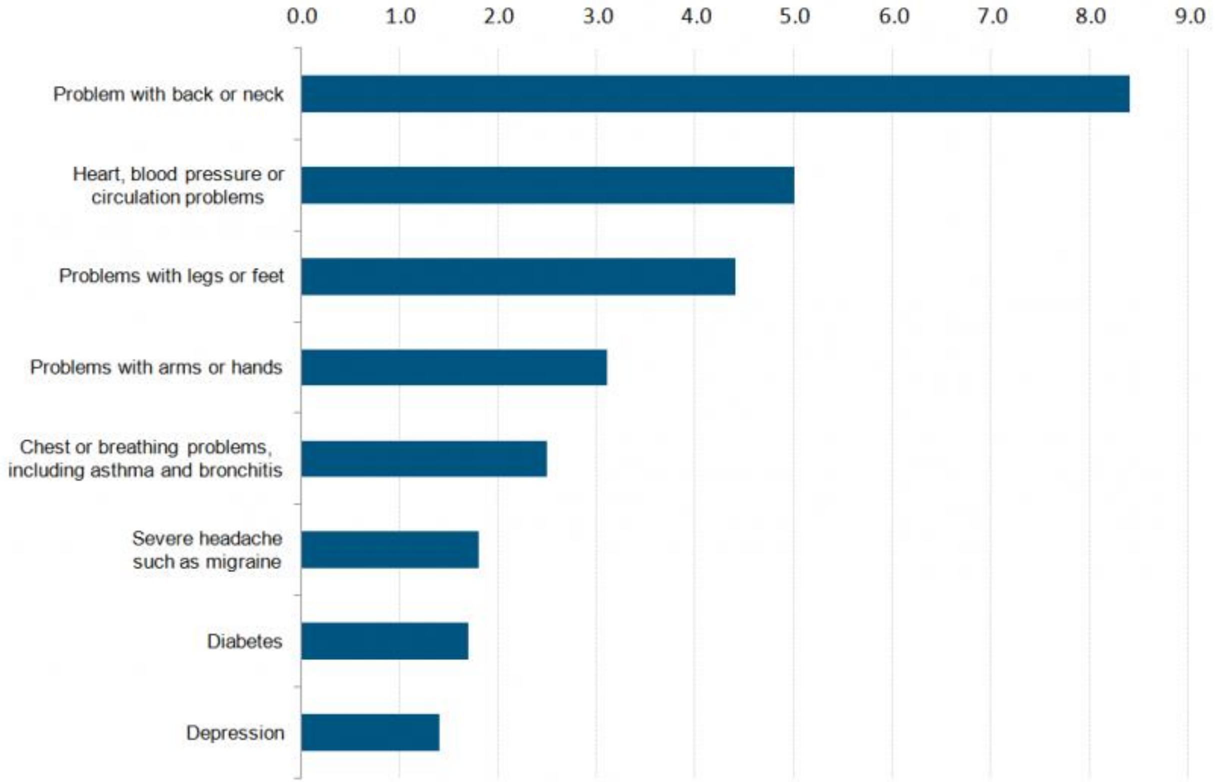
Contents

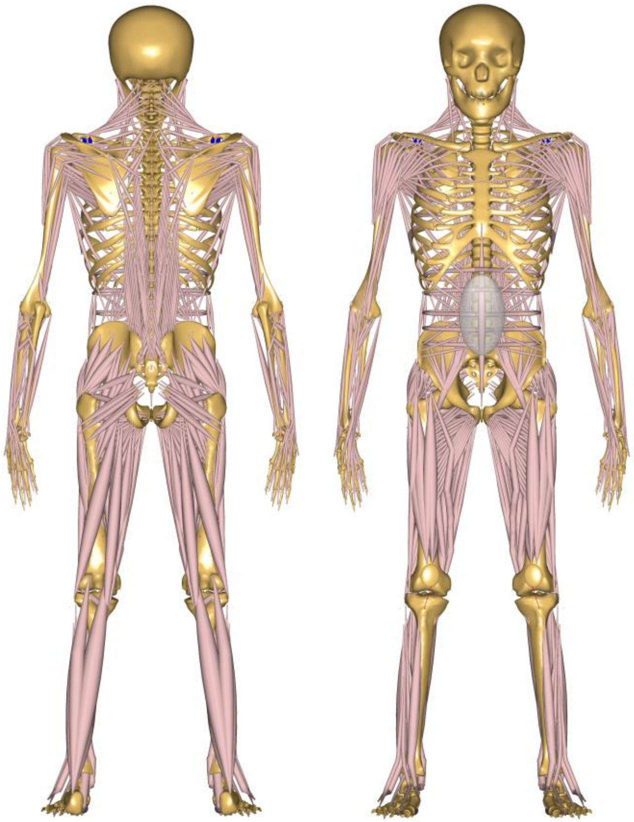
- Sitting as the most frequent working and leisure posture
- Discomfort or health disorders due to wrong way of sitting



- Development of seats based mainly on:
  - Subjective evaluations
  - Prototyping
  - Experimental testing
- Quantification of ergonomic questions by making use of computer aided engineering
- **Investigation of muscle activation during sitting on a specific ergonomic office chair**

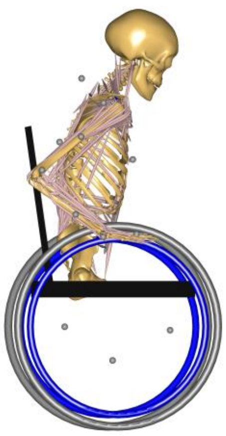
2. AnyBody™
2.1. The AnyBody™ Modeling System

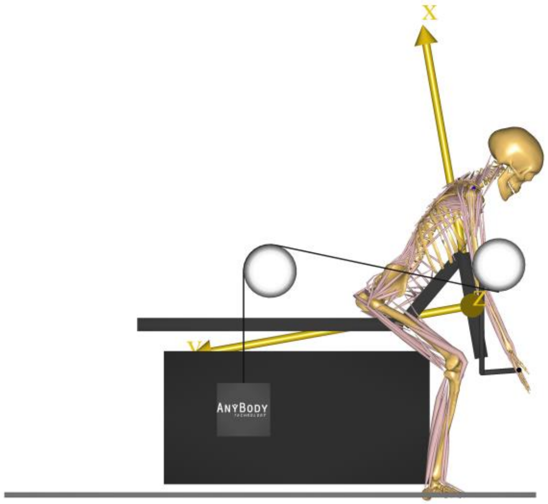
- Musculoskeletal analysis based on Multibody Simulation
- Principle of inverse dynamics
  - Input: posture or motion
  - Output: muscle forces/ joint forces
- Application fields:
  - Orthopedics
  - Consumer Products
  - Research
  - …



2.2. AnyBody Managed Model Repository™

- Containing body - and application models
- Models developed by research projects at academic institutions or by AnyBody™ Technology
- Maintained by AnyBody™ Technology



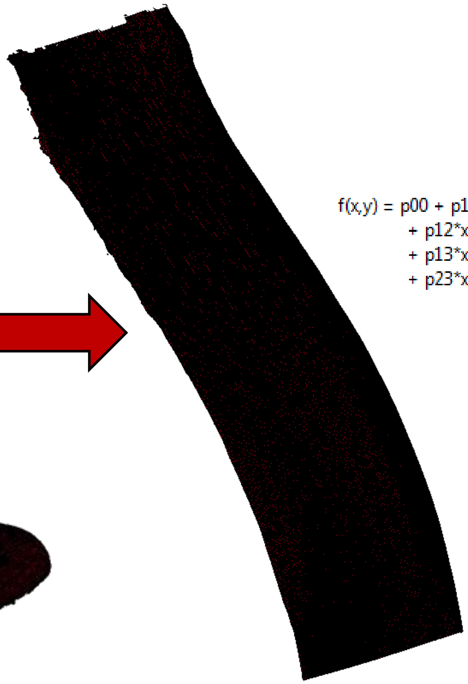


3. Material and Methods
3.1. Experimental Setup

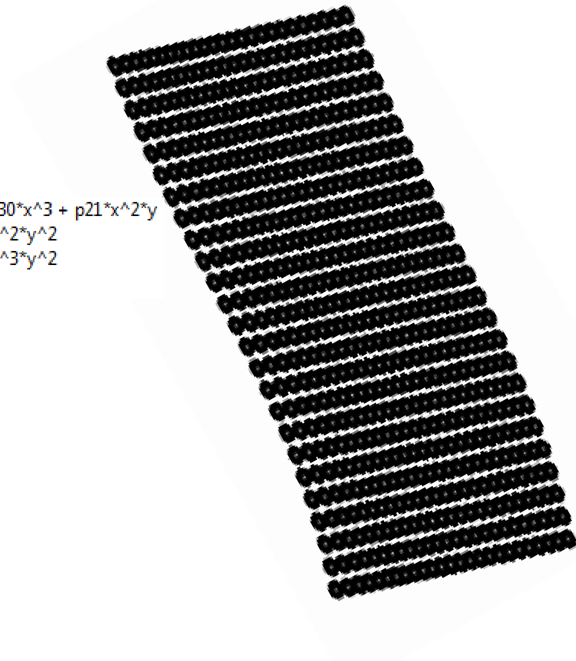
- 5 male subjects (23 to 26; mean body height: 180.8 cm; mean body weight: 76.3 kg)
- Ergonomic office chair with swing element leading to translation in a horizontal plane
- Trials:
  - 2 active (circle, cross)
  - 1 static
- Measurement devices:
  - Inertial Measurement Units (Delsys)
  - Motion Capture (Vicon)
  - Pressure Indicating Film (Tactilus)
  - Four Three Dimensional Force Measure Plates

3.2. Implementation of specific chair and pressure indicating film in the AMS

- Utilization of 3D scanner for obtaining surface of chair
- Mathematical description of chair parts by generating polynomial surface function of order 5
- Incorporation of cells of pressure indicating film as equidistant node cloud

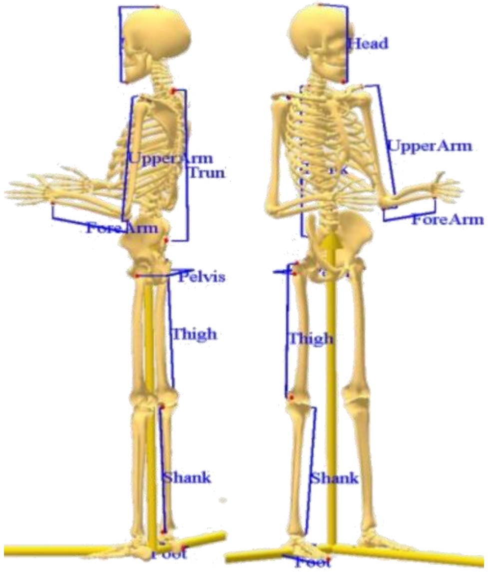


$$f(x,y) = p00 + p10*x + p01*y + p20*x^2 + p11*x*y + p02*y^2 + p30*x^3 + p21*x^2*y + p12*x*y^2 + p03*y^3 + p40*x^4 + p31*x^3*y + p22*x^2*y^2 + p13*x*y^3 + p04*y^4 + p50*x^5 + p41*x^4*y + p32*x^3*y^2 + p23*x^2*y^3 + p14*x*y^4 + p05*y^5$$

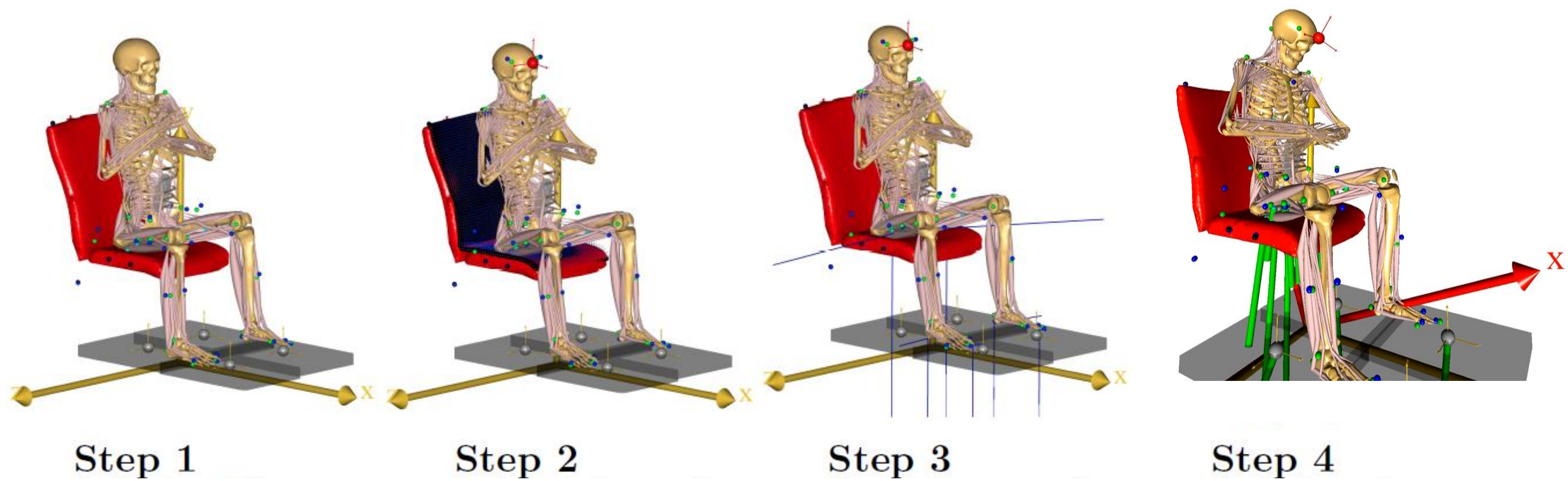


3.3. Model Setup in the AMS

- Work based on the standing model of the AnyBody™ Managed Model Repository (AMMR)
- Utilization of detailed neck model for consideration of neck rotation in three direction → Simple muscle model
- Scaling of human model via scaling-law based on external measurements
- Total of more than 1000 muscles

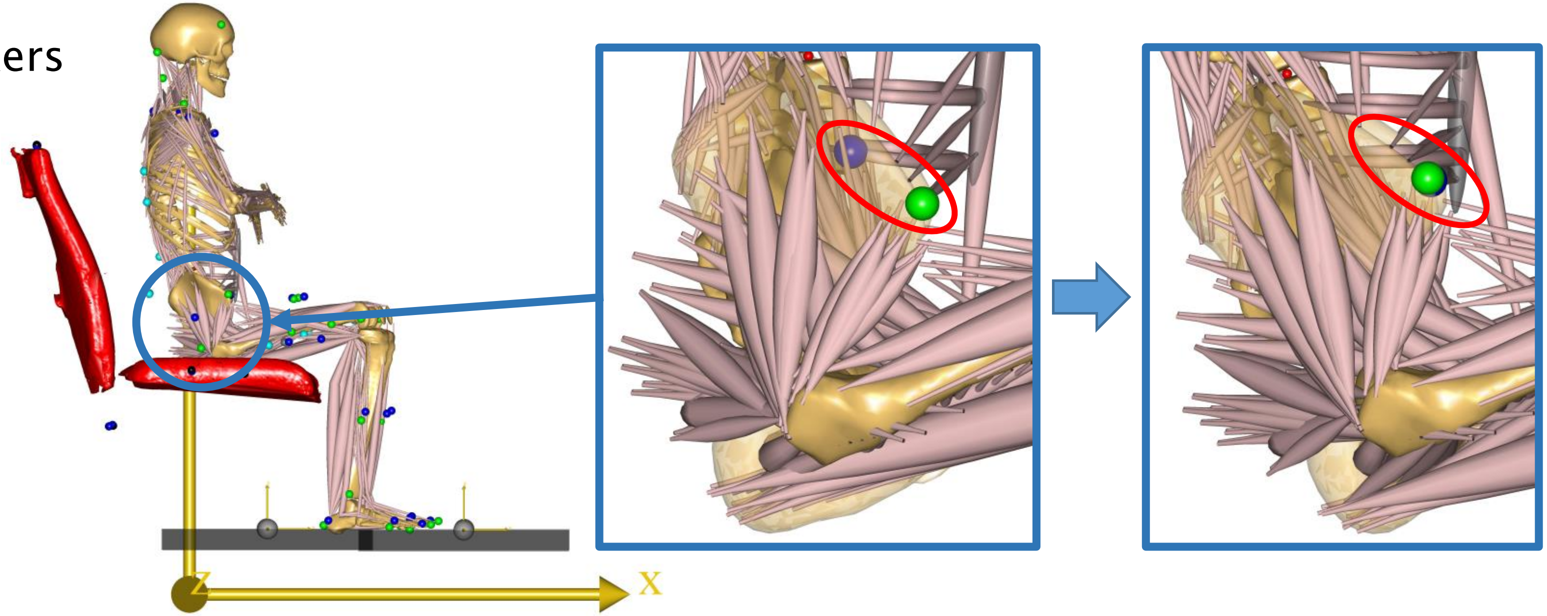


3.4. Simulation Setup



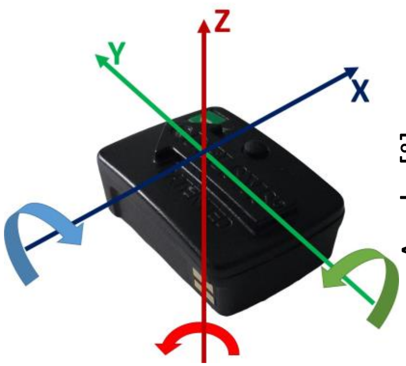
Step 1: Initial Sitting Position

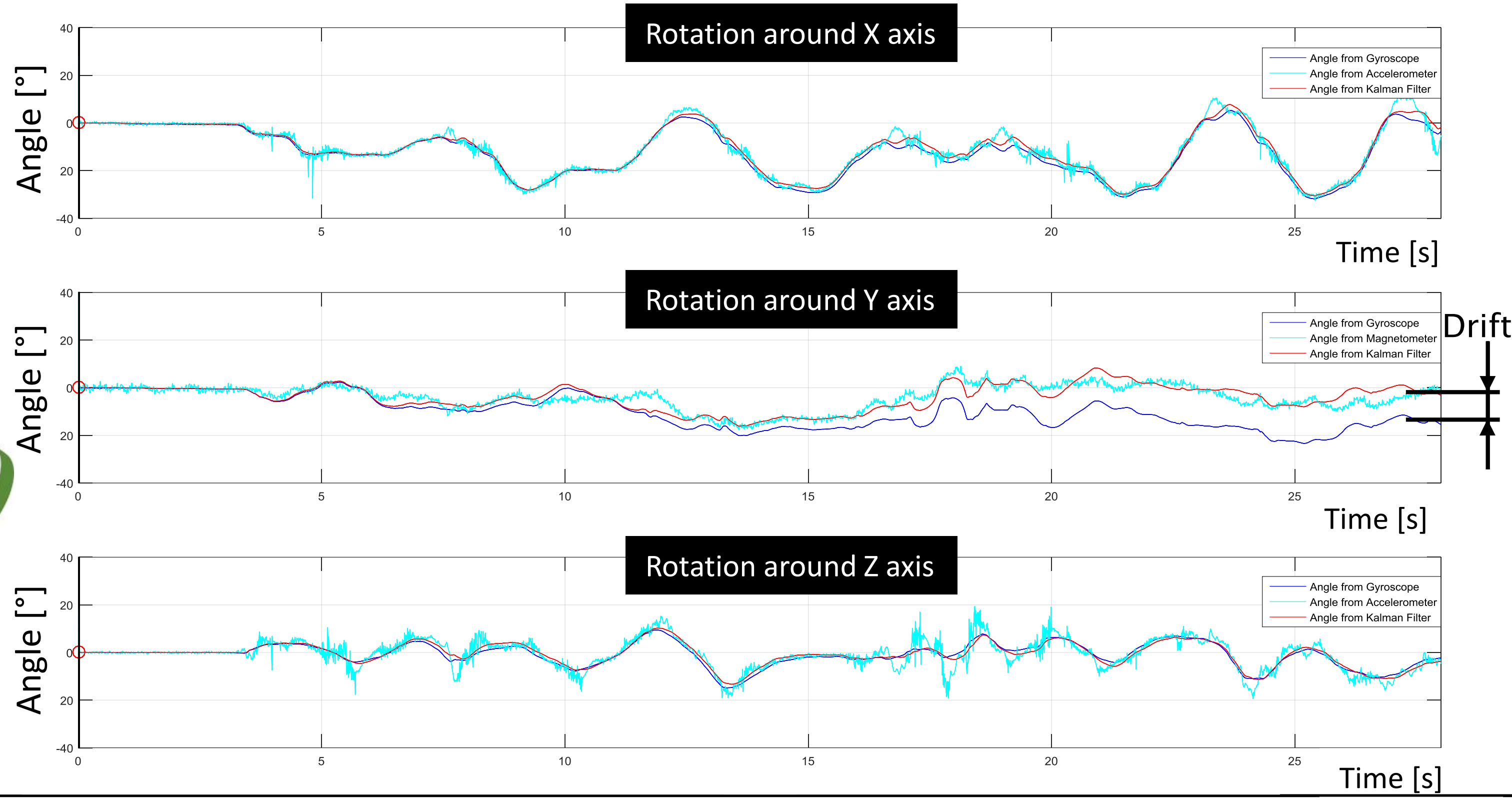
- Positioning of the model by utilizing 26 markers on human, 4 ground markers and 8 chair markers
- Four different weight functions
- Adoption of thorax extension until defined nodes match with measured LASI and RASI markers



3.4. Simulation Setup

- Reference of rotations from the IMUs to local housing coordinate system
- Obtaining angles using projected angles (→ atan2) <u>updated approach</u>: Quaternions
- Utilization of Kalman Filter to compensate drift





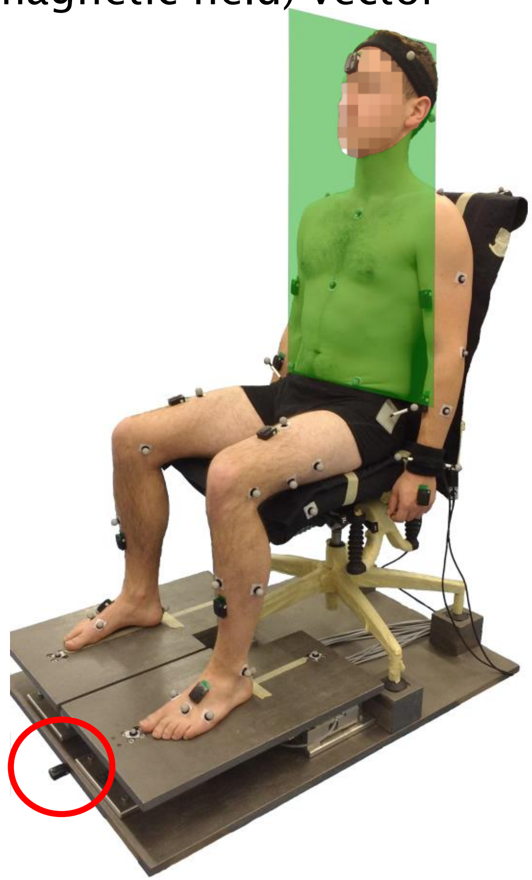
3.4. Simulation Setup

- Processing IMU data for Implementation into AnyBody:
  - Adjusting all IMUs according to $\vec{g}$ (acceleration) and $\vec{b}$ (magnetic field) vector
  - One axis of reference sensor on ground equivalent to coronal plane

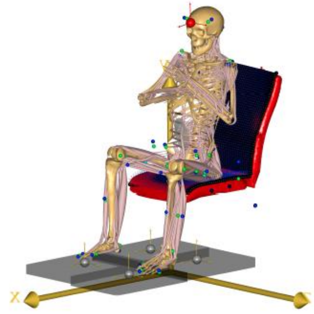
$$\begin{bmatrix} \alpha^{\#S}_{Rotated} \\ \beta^{\#S}_{Rotated} \\ \gamma^{\#S}_{Rotated} \end{bmatrix} = R^{\#S}_{\Theta,\Upsilon} * R^{\#S}_{\Psi} * \begin{bmatrix} \alpha^{\#S}_{Initial} \\ \beta^{\#S}_{Initial} \\ \gamma^{\#S}_{Initial} \end{bmatrix}$$

Angular difference of $\vec{b}$ to reference sensor

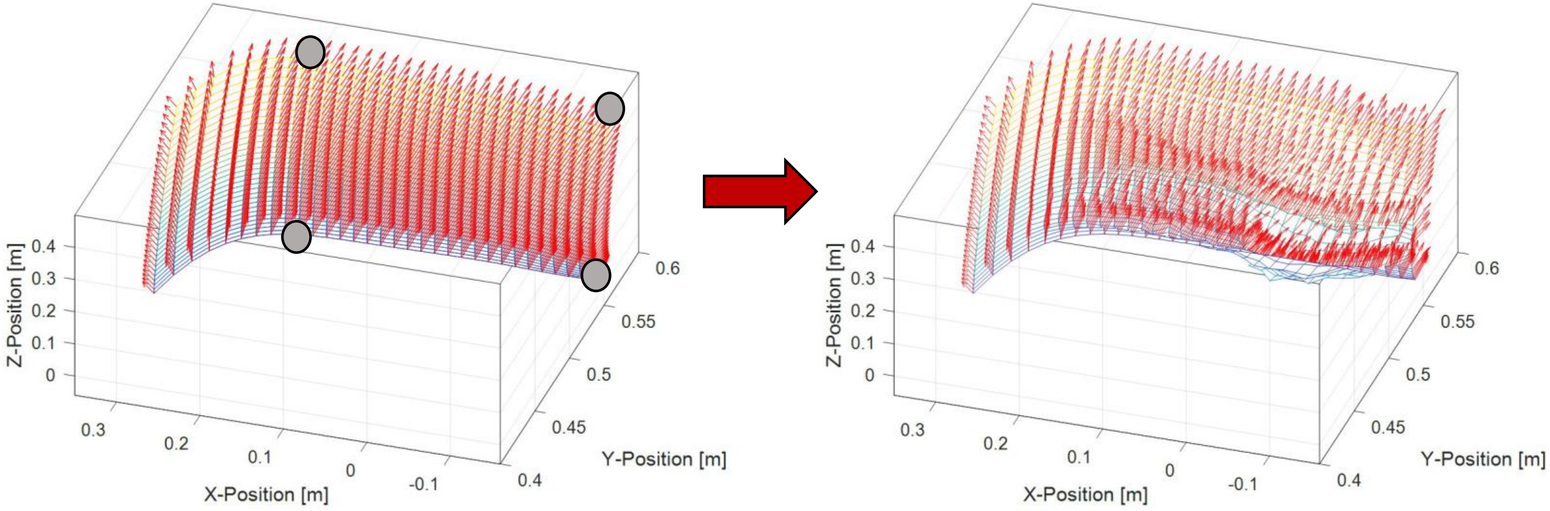
Alignment of $\vec{g}$ with the local Y axis



Step 2: Implementation of pressure indicating film

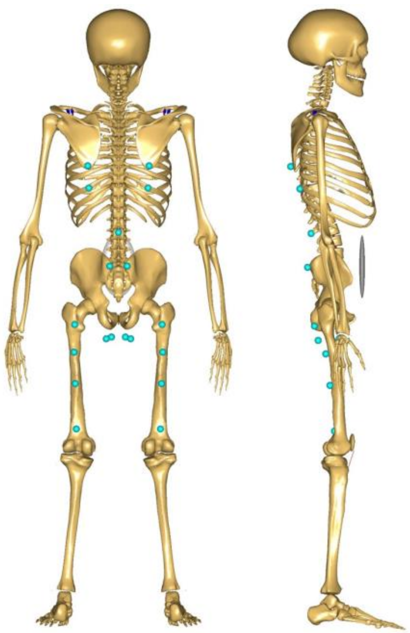


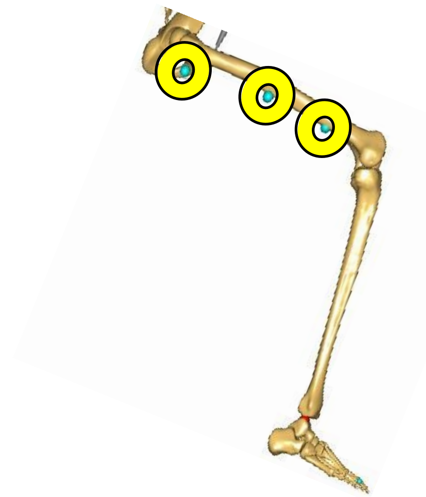
- Implementation of prepared IMU data
- Including pressure indicating film as equidistant node cloud
- Consideration of seat pan deformation at each time step by generating a MATLAB® algorithm

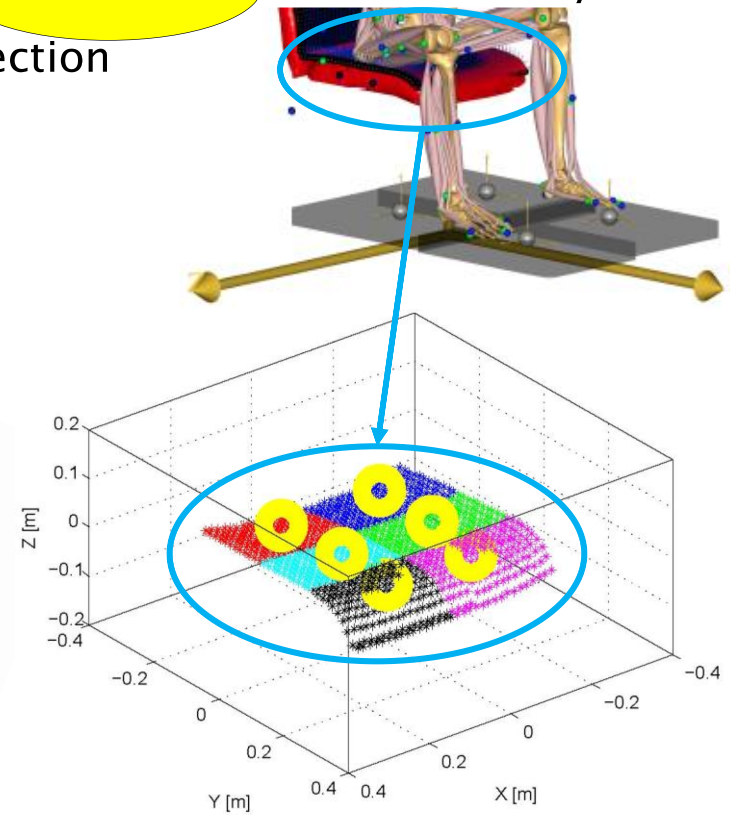


3.4. Simulation Setup

- Measured pressure as weight-matrix for distributing mass of segments from skull to thighs
- Accumulation of scaled forces and moments at defined nodes on human body in seat pan and backrest according to normal direction

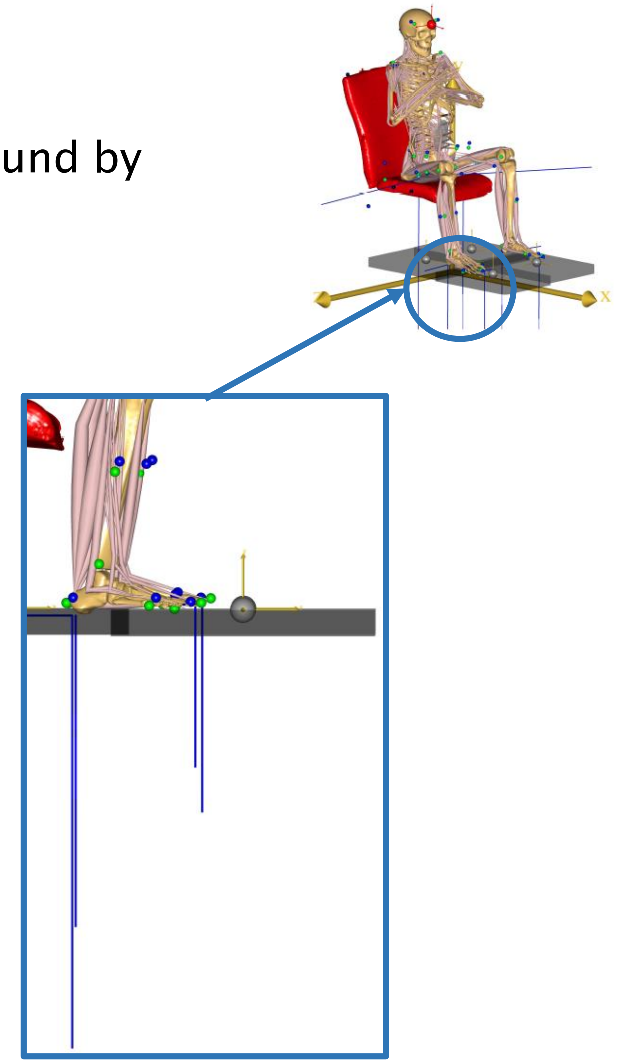






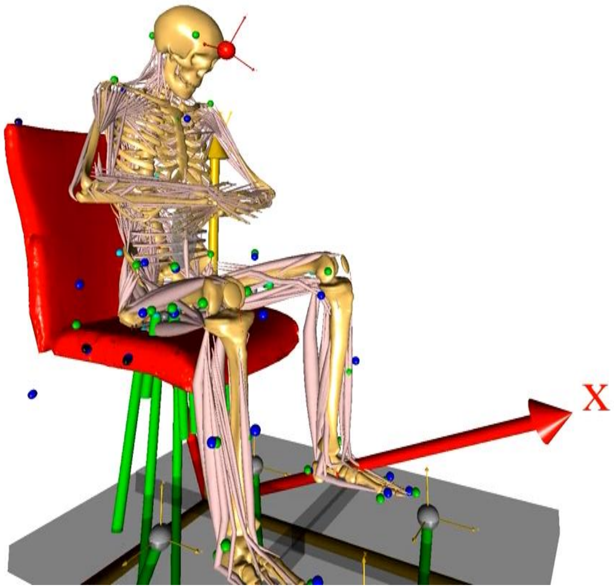
Step 3: Computation of Ground Force

- Computation of initial normal and frictional forces in ground by making use of muscles
- Contact of heel and toe

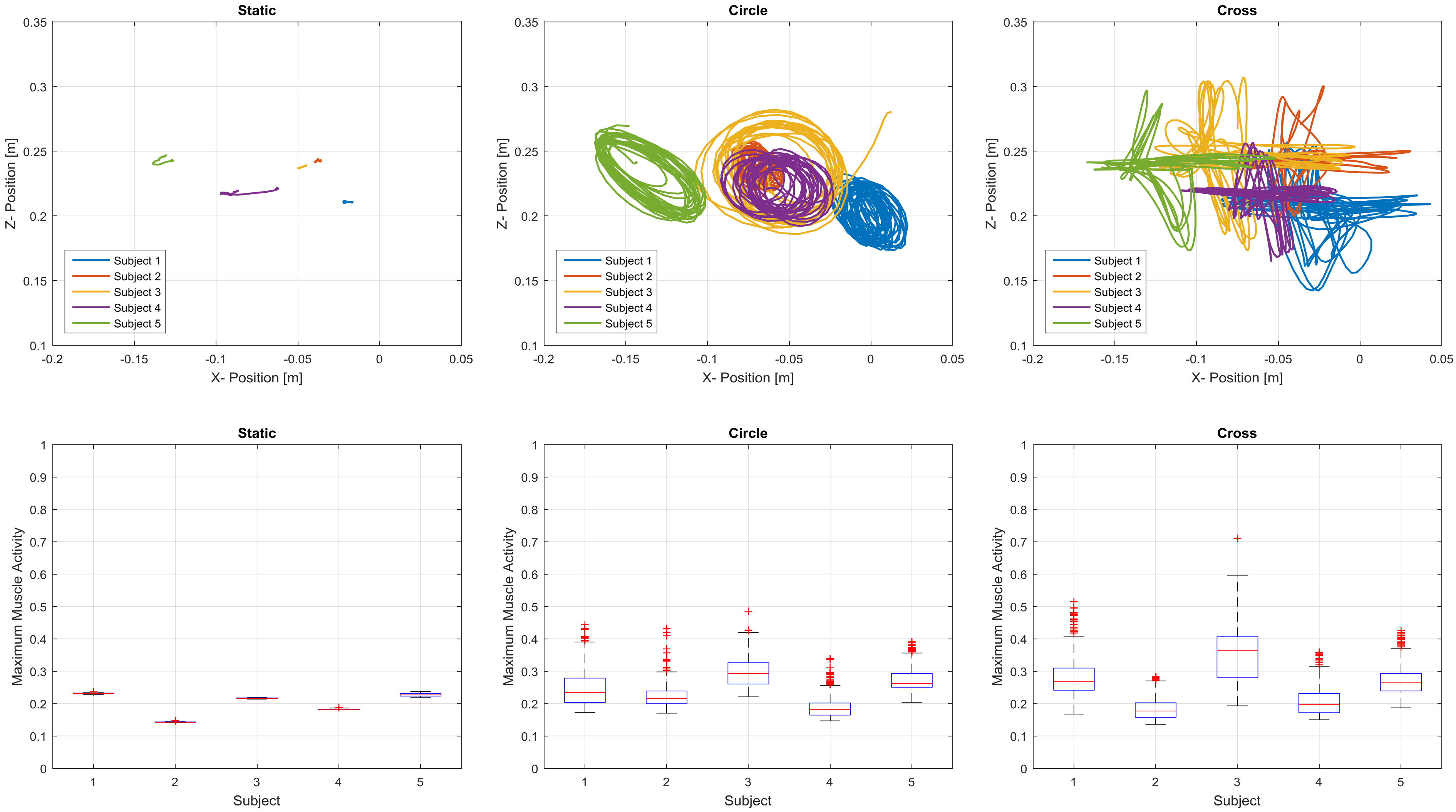


Step 4: Computation of Muscle Forces

- Coupling node in pelvis to global reference system for considering residual forces evoked by motion
- Conducting inverse dynamics analysis



4. Results
4.1. Pelvis Position and Maximum Muscle Activity



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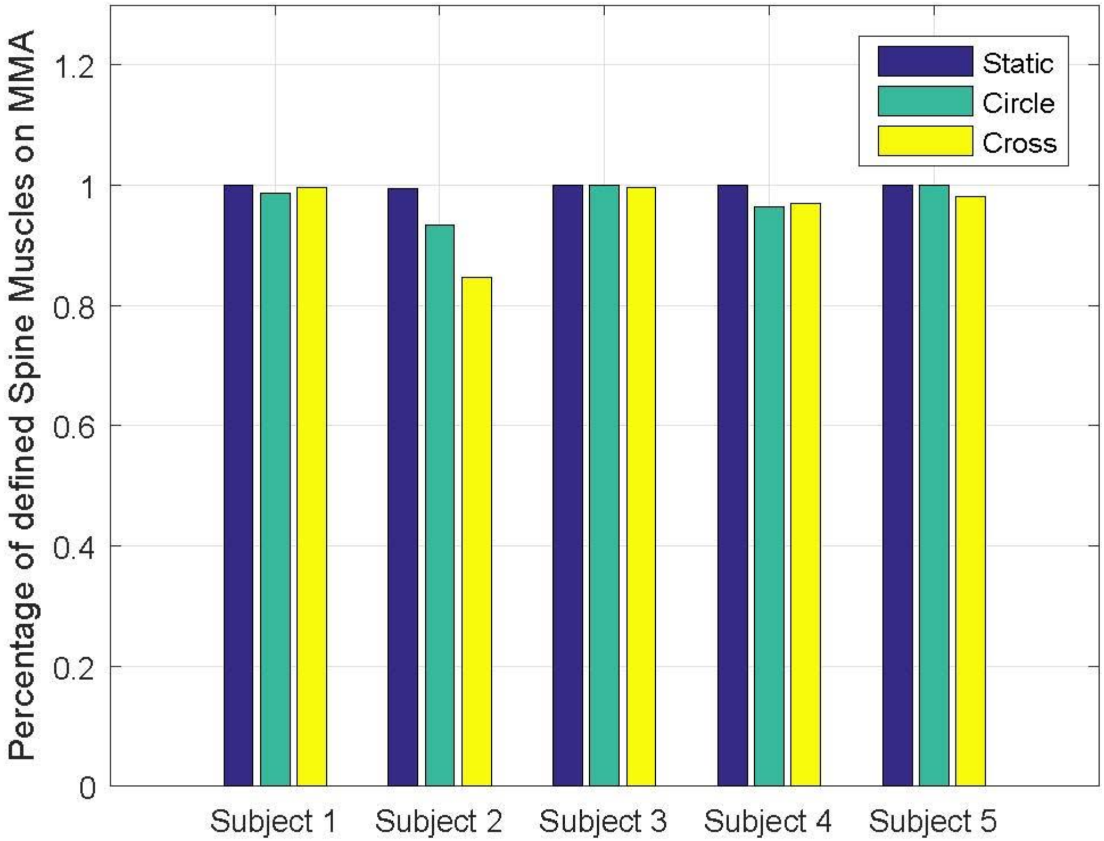
4.2. Activation of specific Muscle Groups on MMA

<u>Defined Group:</u>

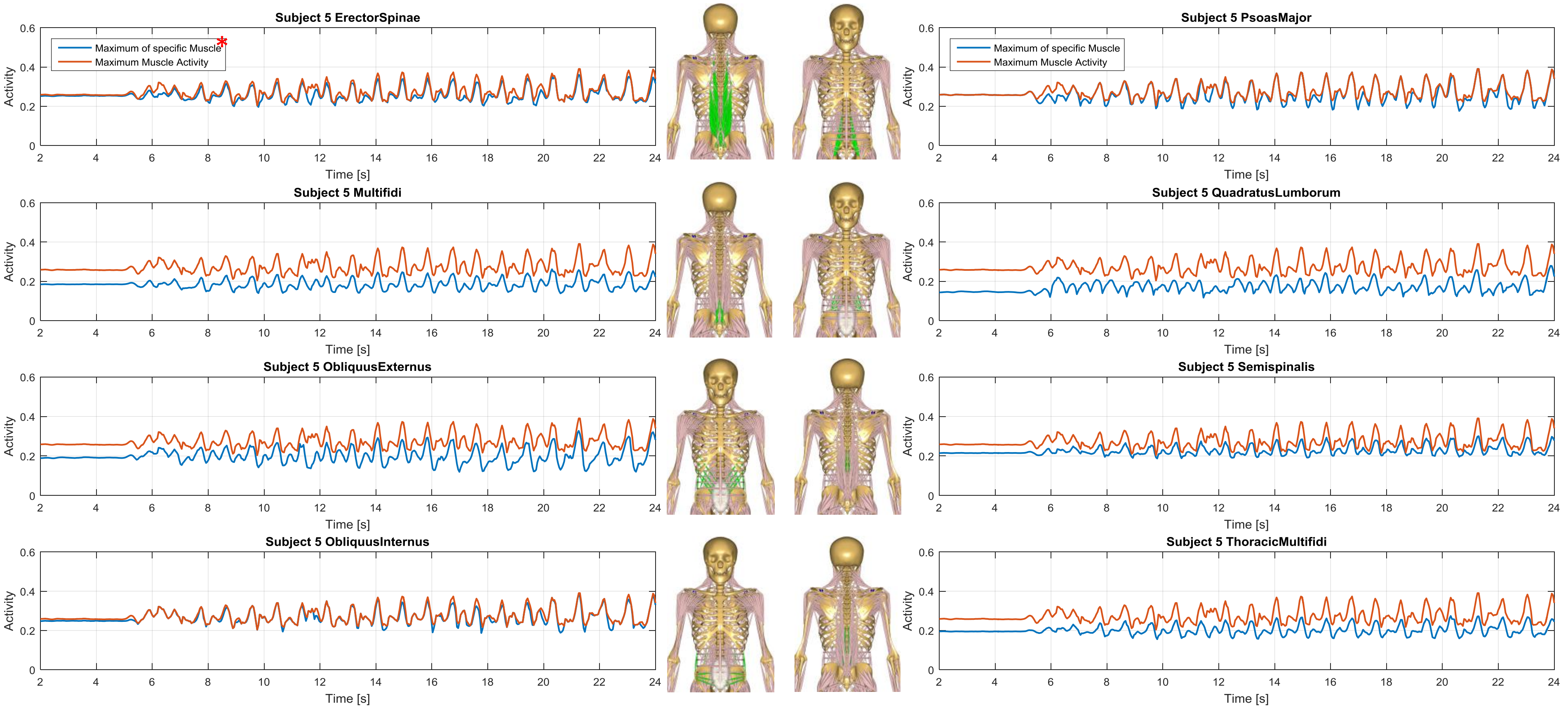
- Erector Spinae (ES)
- Multifidi (MF)
- Obliquus Externus (OE)
- Obliquus Internus (OI)
- Psoas Major (PM)
- Quadratus Lumborum (QL)
- Semispinalis (SS)
- Thoracic Multifidi (TM)

→ **Total of 213 muscles**



$$Bar = \frac{\int_{t_1}^{t_2} \max\{(MMA_{ES}, MMA_{MF}, MMA_{OE}, MMA_{OI}, MMA_{PM}, MMA_{QL}, MMA_{SS}, MMA_{TM})(t)\} \cdot dt}{\int_{t_1}^{t_2} MMA(t) \cdot dt}$$

Circle – Subject 5



$$*MMA_{Specific\ Muscle\ Group}\ (t) = \max\left\{{}_{first}^{last} Muscle\ Activity_{Muscle\ of\ Specific\ Muscle\ Group}(t)\right\}$$

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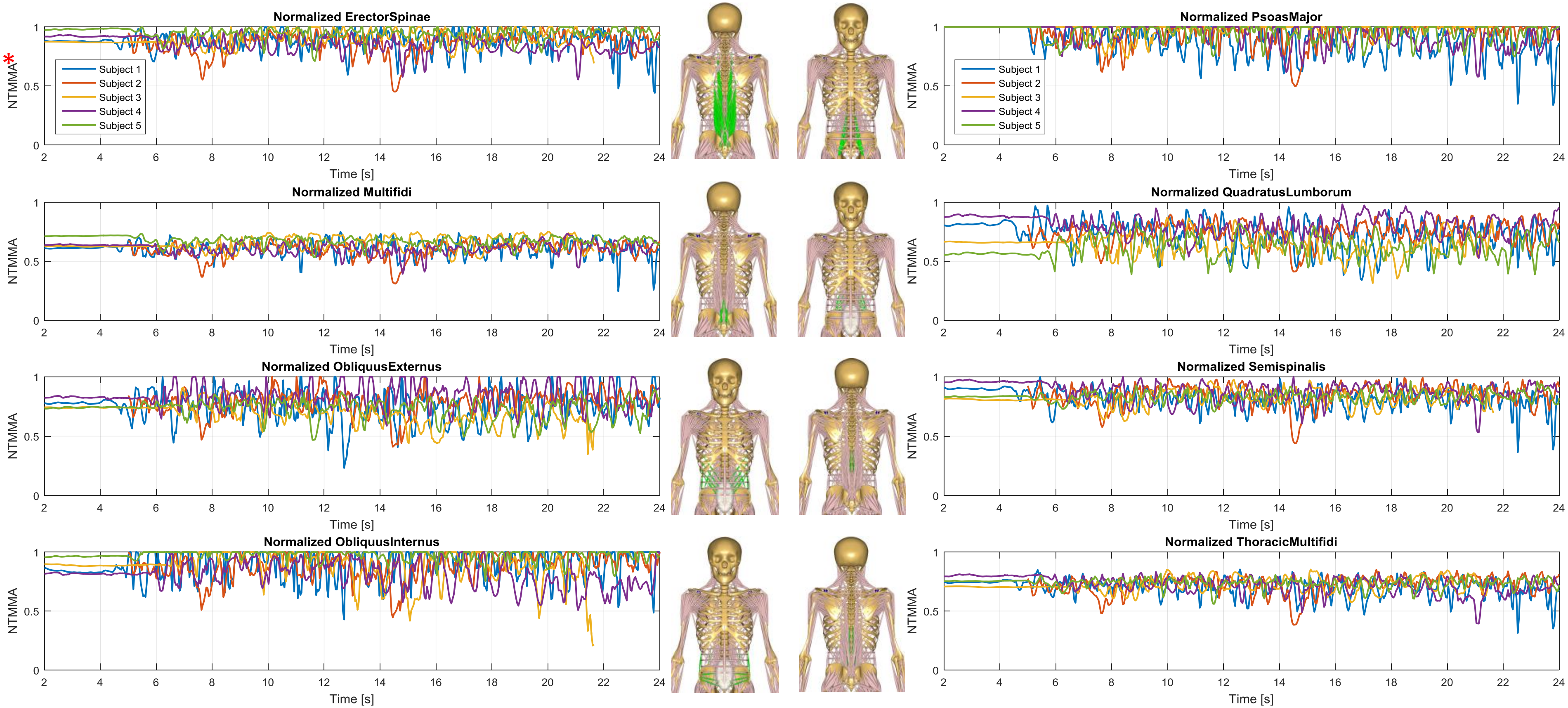
4.4. Normalized to Maximum Muscle Activity

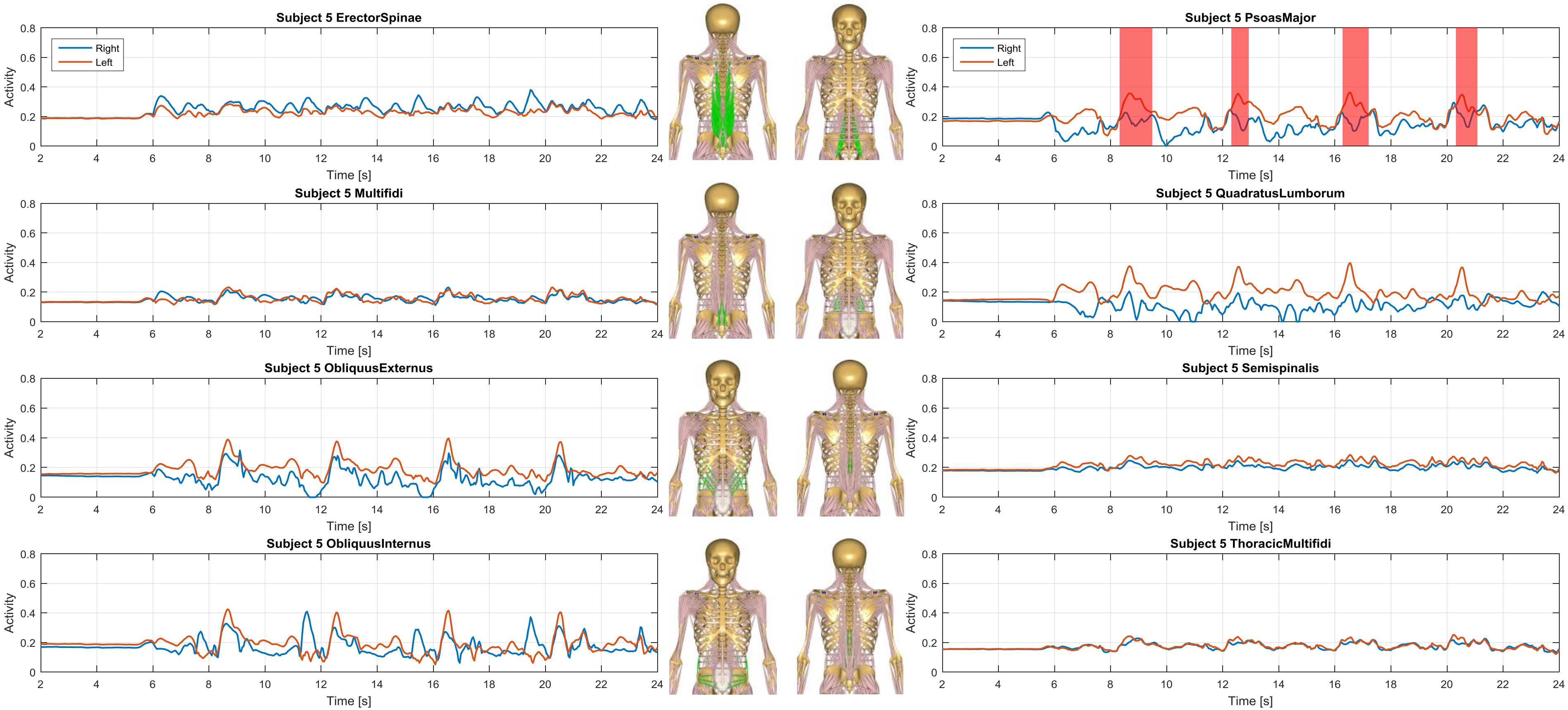
Circle



$$*NTMMA(t) = \frac{MMA_{Specific\ Muscle\ Group}(t)}{MMA(t)}$$

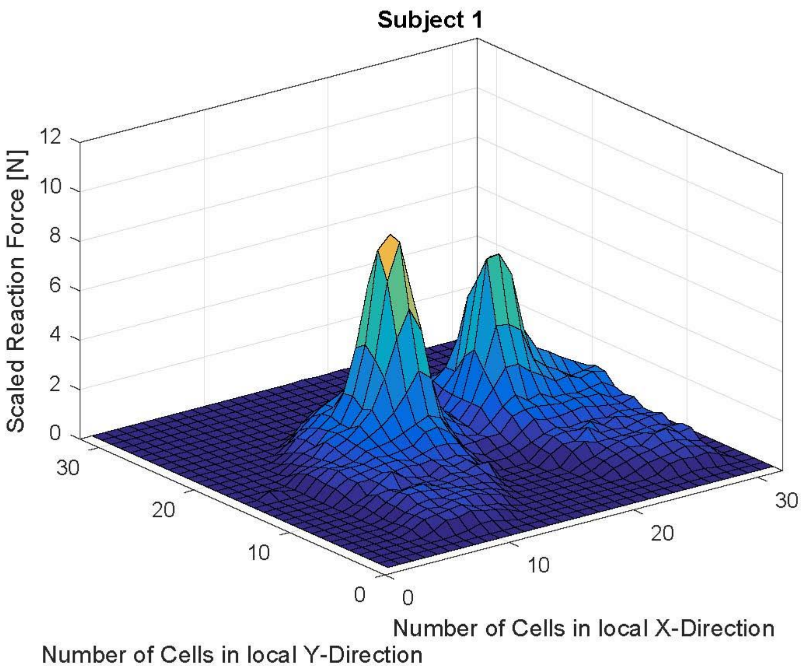
4.5. Differences in Muscle Activation on Right and Left Side

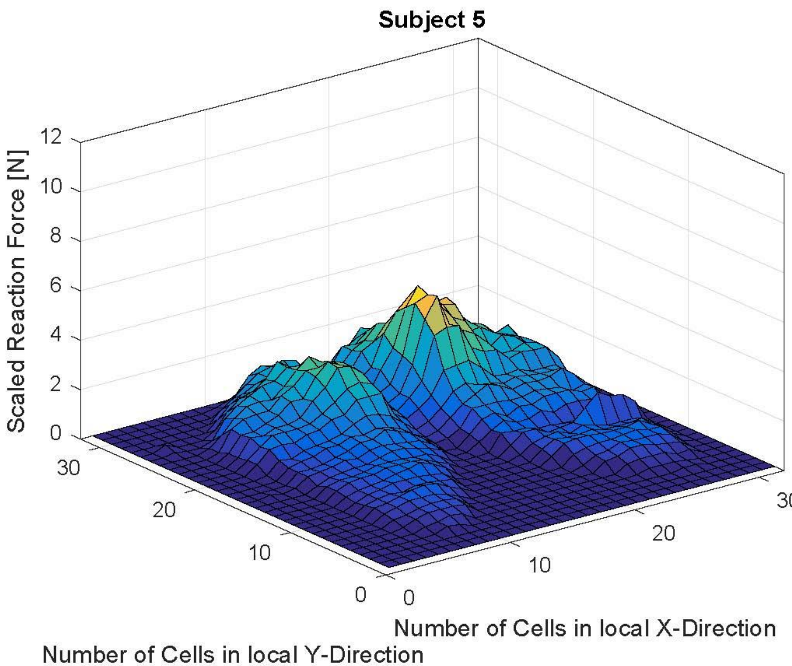
Cross – Subject 5



4.6. Pressure Distribution

- Subject-specific seating-preferences
- Pressure distribution on the opposite body-half in comparison to seating position





5. Discussion

Maximum Muscle Activity

- Highest MMA during cross-trial due to non-continuous motion with phases of acceleration and deceleration of body mass
- Smaller spans between the upper and lower whiskers in circle-trial due to continuous preservation of movement

Pelvis Position

- Higher deviation of fore- and backward movement resulting from transfer of the swing to the sideward position
- Smaller deflection to left side due to summation of restoring forces of the pendulum to the acceleration of the body mass

5. Discussion

Involvement of Considered Muscle Groups in Maximum Muscle Activity

- Stabilizing function
- Inducing movement
- Smaller strength values in comparison to other muscle groups

Function of Muscles

- Minor activation of Multifidi and Thoracic Multifidi due to stabilizing function
- Higher activation in other muscle groups for conducting movement and/ or maintaining posture
- Accordance with function found in literature

Right and Left Activation of Muscles

- Opposite-oriented for conducting one-sided movement
- Equal-oriented
  - Stabilizing function (e.g. Multifidi)
  - Flexion of upper body

Pressure Distribution

- Pressure maxima due to slight lateral bending of the hip
- One-sided psoas major activation to balance the translation of the center of gravity

Potential benefits of office chair (only short-time application with exercise)

- Alternation of muscle activity possibly preventing continuous activation of type I motor units

  → Prevent back discomfort experienced during prolonged sitting

- Possibly minor spinal shrinkage in comparison to other active seating devices (e.g. exercise ball)
  - Stable seating position
  - Potential positive effects on diffusion in intervertebral discs

6. Conclusion and Future Work

Conclusion

- Highest activation of considered muscle groups for maintaining posture and conducting movement
- Potential positive effect of active seating

Future Work

- Longtime study for determining movement-preferences on chair
- In-field study e.g. with Inertial Measurement Units
- Consideration of psychologic effects

Thank you for your attention

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Webcasts:

Check our YouTube channel for previous webcast

Events:

- Free AnyBody workshop at ESB 2016, Lyon, France
  - 10th July 2016, from 12 pm – 4 pm
  - **Find registration link on www.anybodytech.com**

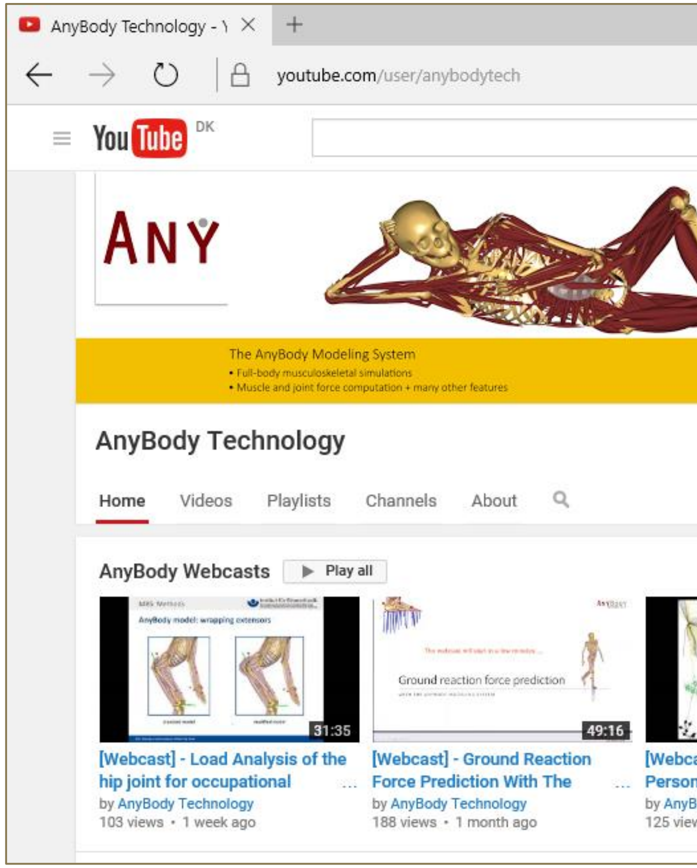
- Also meet us at:
  - ICRA 2016 - IEEE International Conference on Robotics and Automation Stockholm, Sweden, 16-21 May.

www.anybodytech.com

- Events, dates, publication list, ...

www.anyscript.org

- Wiki, Forum



Time for questions: