Application of modeling and experimental research of the musculoskeletal system in diagnostics and physioprophylaxis

Robert Michnik

Ministerstwo Edukacji i Nauki

Program:
SPOŁECZNA ODPOWIEDZIALNOŚĆ NAUKI

AFTER COVID - Popularyzacja nauki i sportu jako element niwelowania konsekwencji pandemii COVID-19

finansowanego przez MEiN

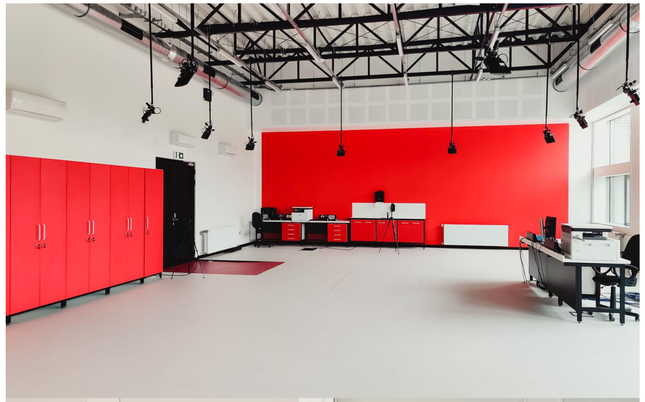
konkursu Społeczna Odpowiedzialność Nauki

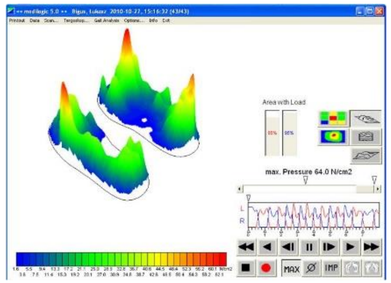
Wydział Inżynierii Biomedycznej

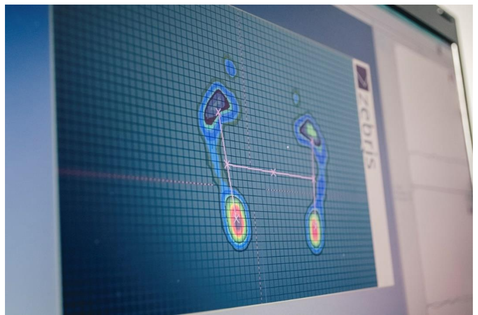
Politechnika Śląska

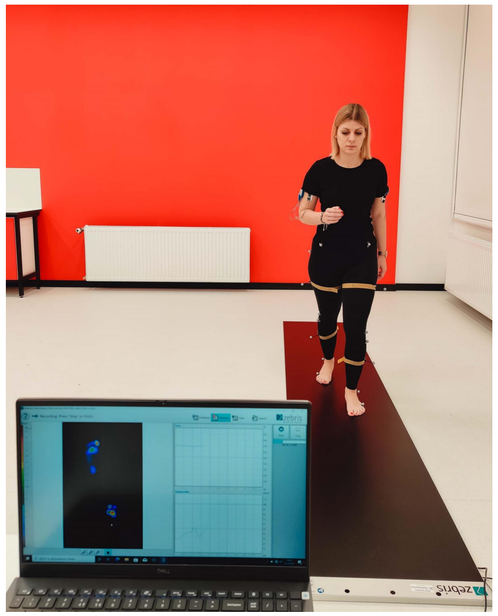
UCZELNIA BADAWCZA
INICJATYWA DOSKONAŁOŚCI

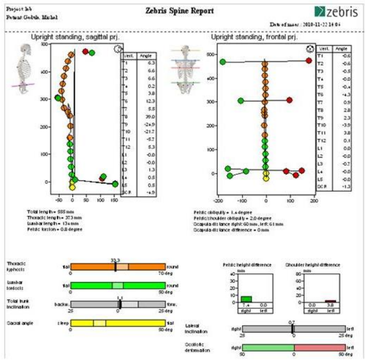
Laboratory of Biomechanics of the Human Locomotor System











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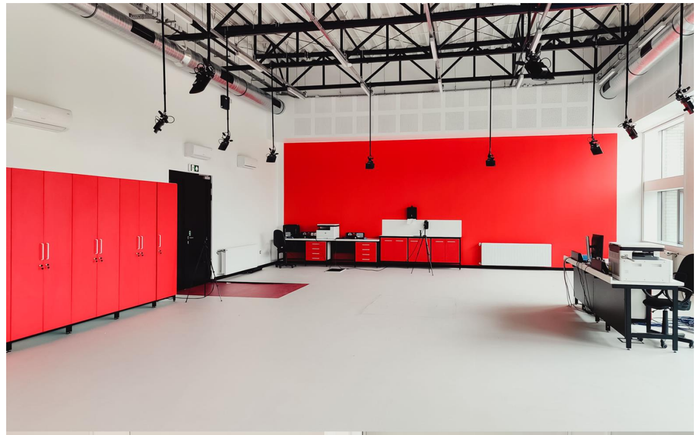
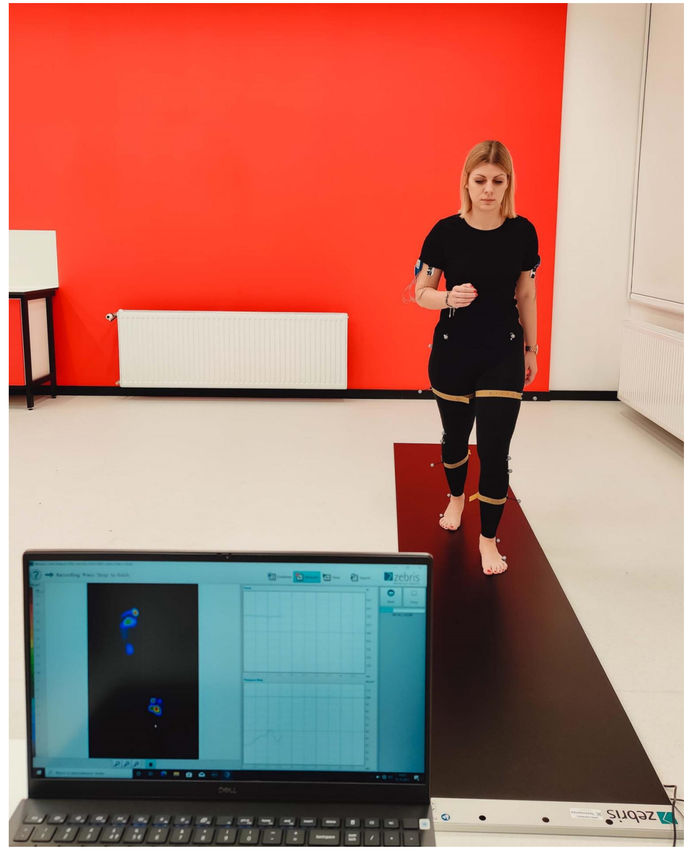
European HealthTech Innovation Center Laboratories
- Human Motor System Research Laboratory





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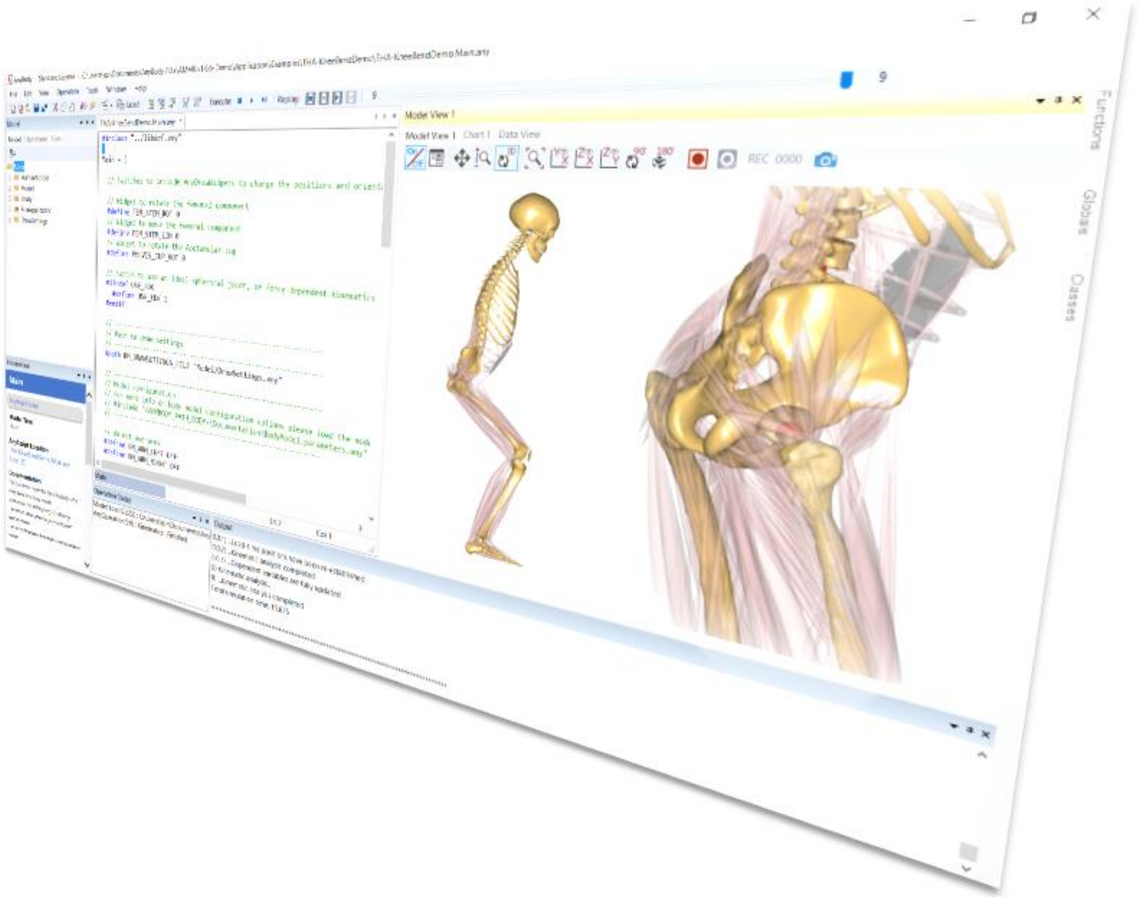
AnyBody Modeling System



- Computer-aided engineering (CAE) tool for modeling the musculoskeletal system.
- Advanced simulations to calculate:
  - Individual muscle forces.
  - Joint contact-forces and moments.
  - Metabolism.
  - Elastic energy in tendons.
  - Antagonistic muscle action.
- The AnyBody Managed Model Repository (AMMR) - open library of components and examples .

https://www.anybodytech.com/

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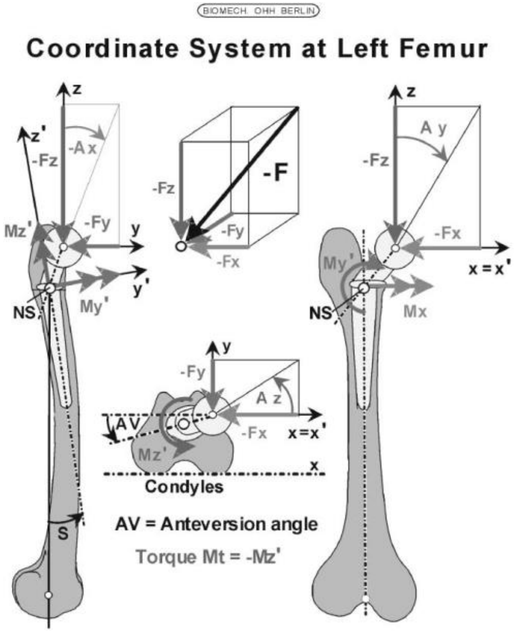

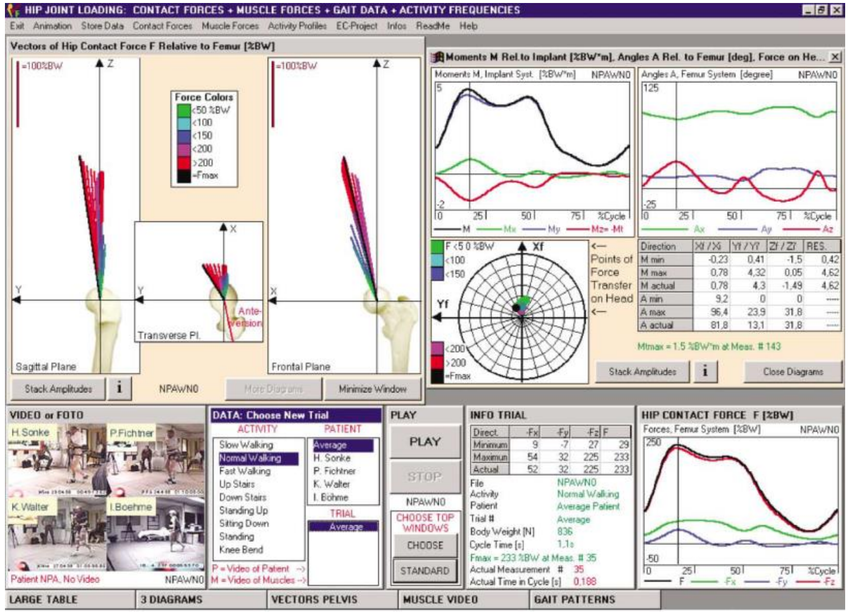

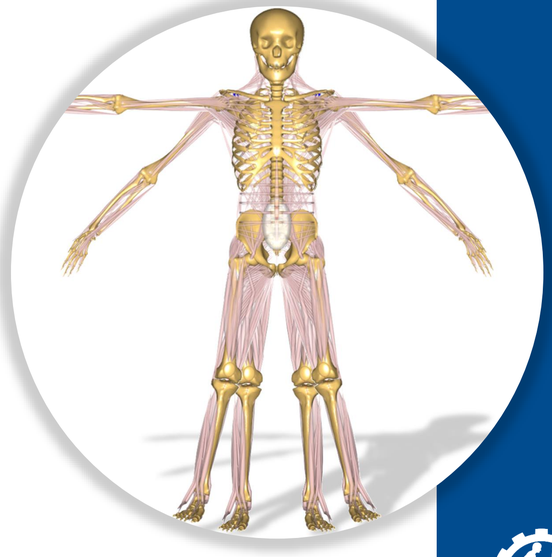

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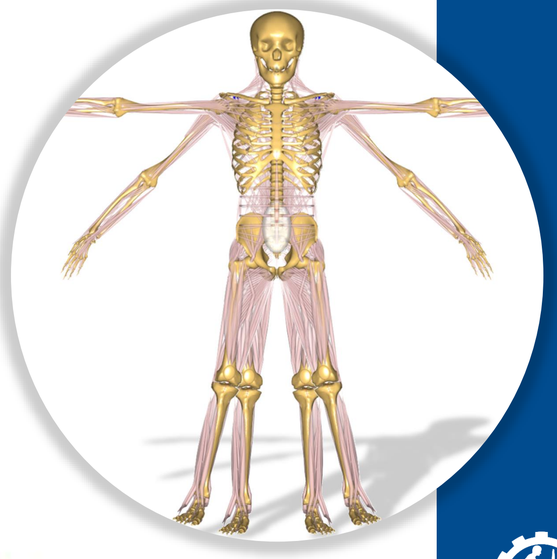
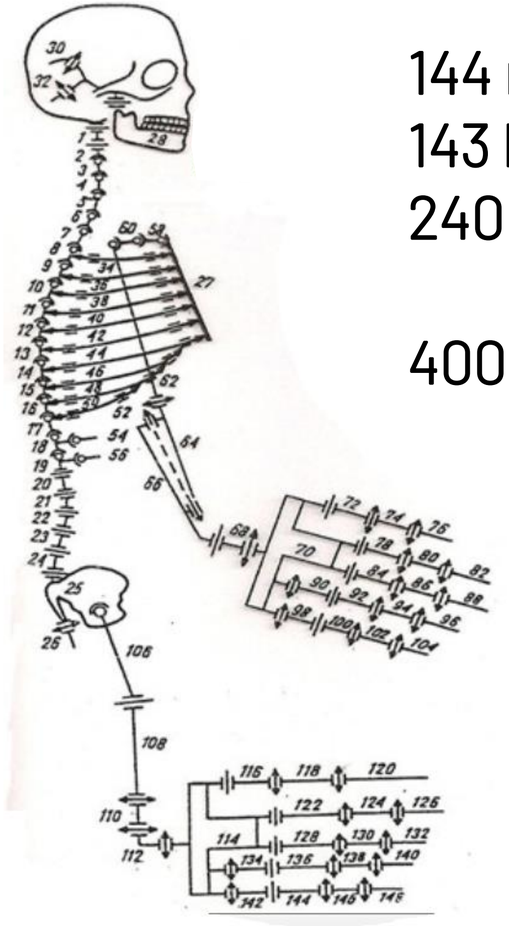
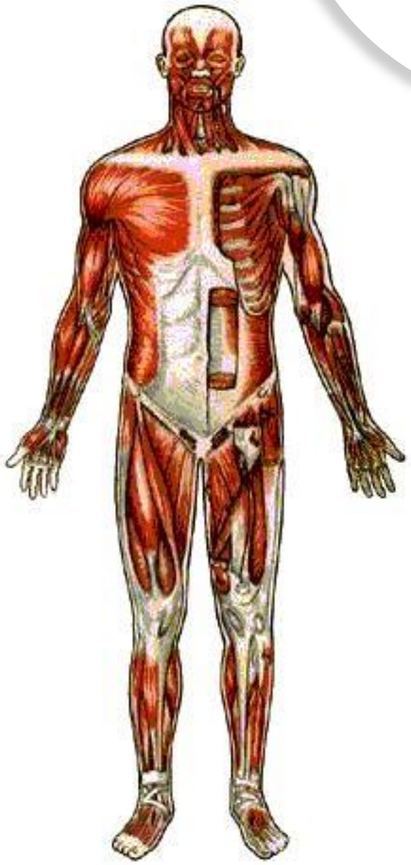




144 rigid bodies
143 kinematic pairs
240 degrees of freedom

400 muscles



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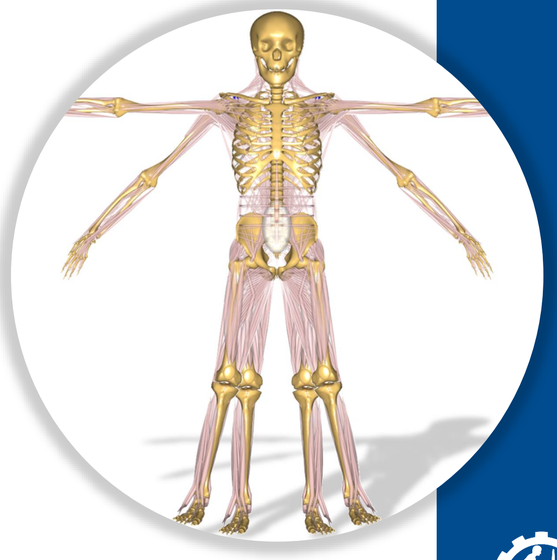

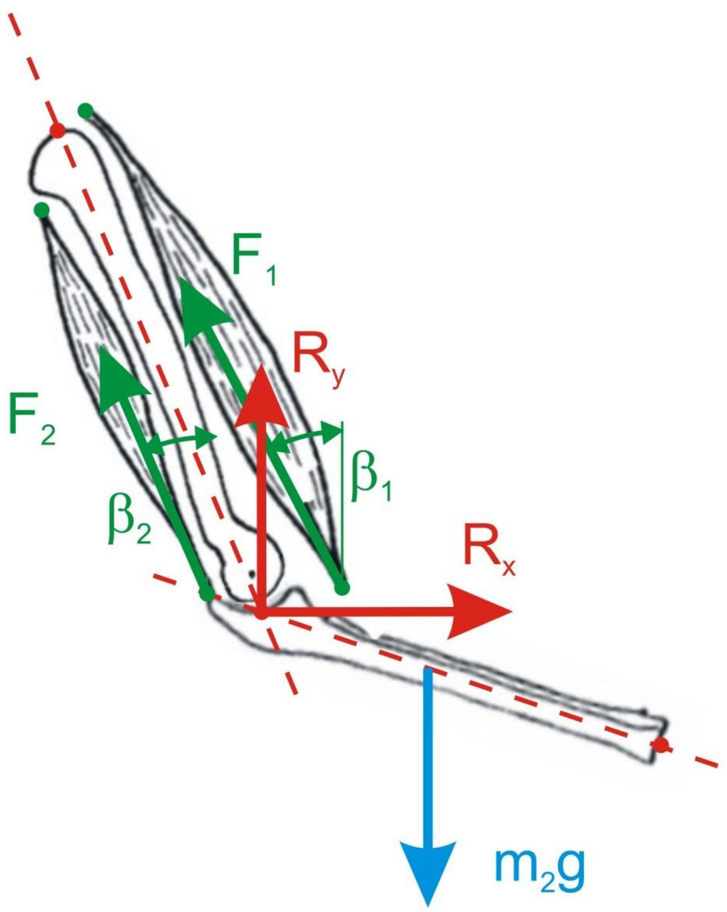

1) $\sum F_{ix} = 0$

$$R_x - F_1 \sin(\beta_1) - F_2 \sin(\beta_2) = 0$$

2) $\sum F_{iy} = 0$

$$R_y + F_1 \cos(\beta_1) + F_2 \cos(\beta_2) - m_2 g = 0$$

3) $\sum M_i = 0$

$$F_1 r_1 - F_2 r_2 - m_2 g d_2 \sin(\alpha_2) = 0$$

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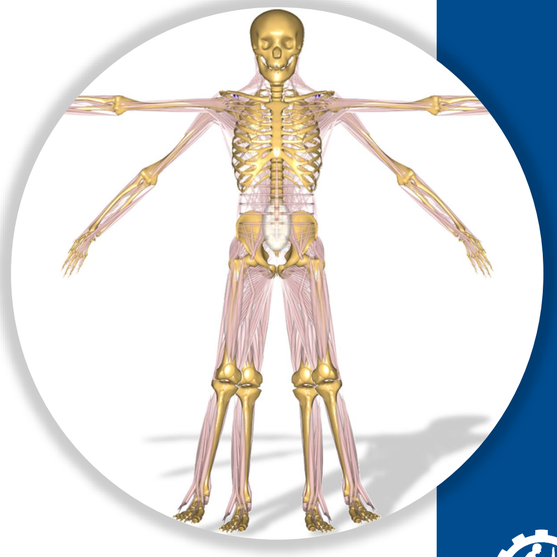

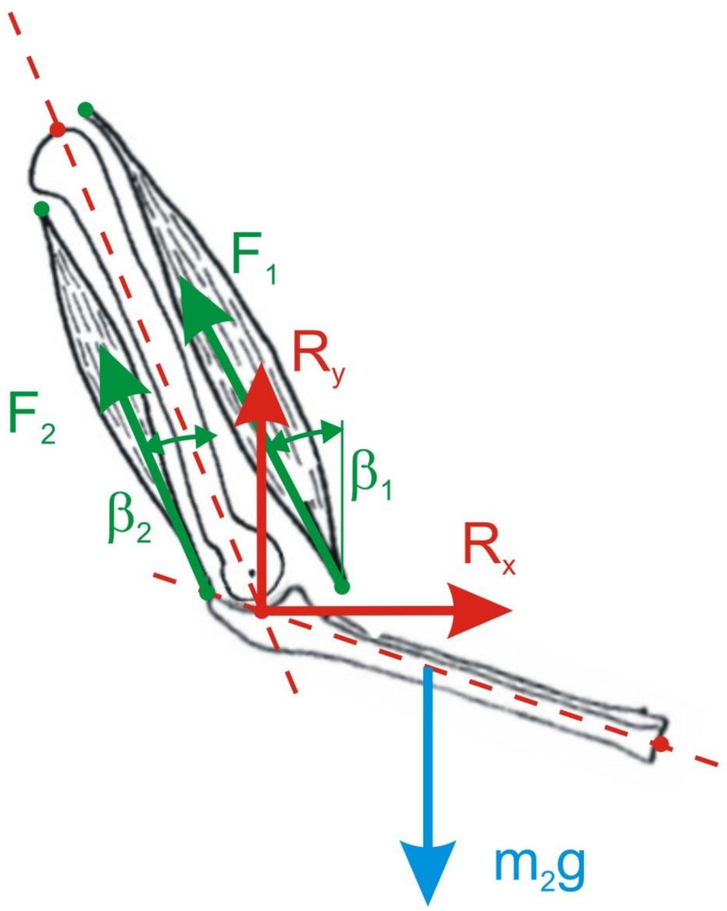

$$J = \sum_{i=0}^{n} \left(\frac{F_i}{A_i} \right)^2$$

$$M_j = \sum_{i=0}^{n} r_i F_i$$

$$F_{i\min} \le F_i \le F_{i\max}$$

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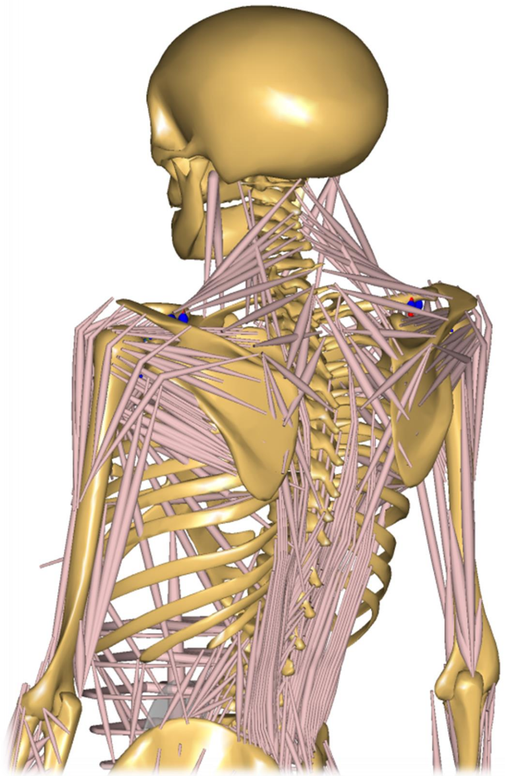
ANTROPOMETRIC DATA
- Body mass
- Height
- Segments lengths

KINEMATIC DATA
- Angular values of the joints
- Spatial positions of body segments

INERTIAL PARAMETERS OF BODY SEGMENTS
- Mass
- Positions of COM
- Moments of inertia

EXTERNAL FORCES
- Reactions of forces resulting from contact with other bodies

ANYBODY™ TECHNOLOGY



- **Scaling methods**
- **Muscular model**
- **Optimization criterion**

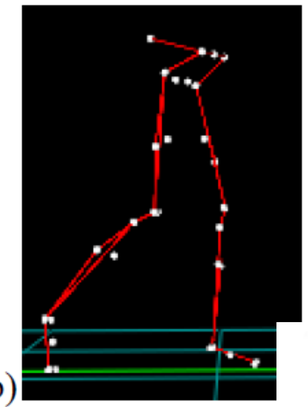
MUSCLE ACTIVITY

MUSCULAR FORCES

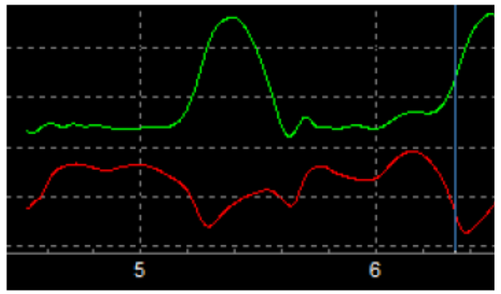
JOINTS REACTIONS

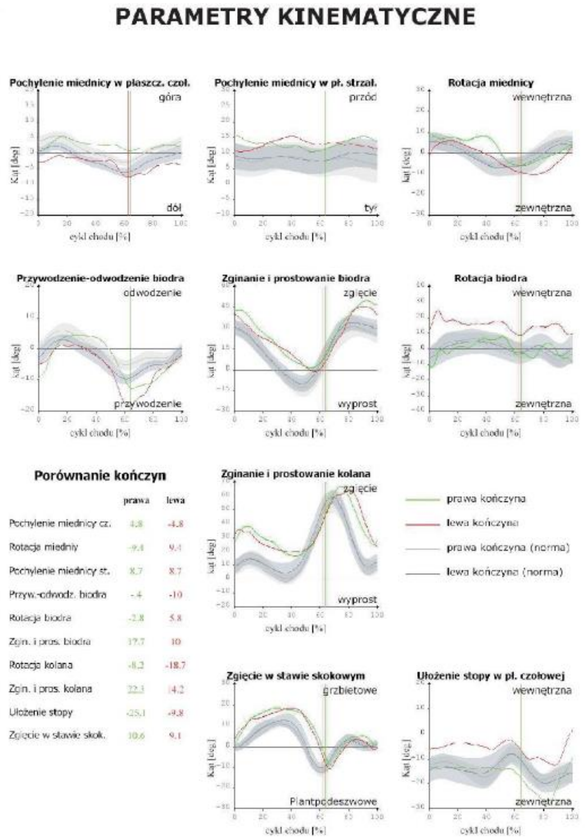
RESULTS ANALYSIS

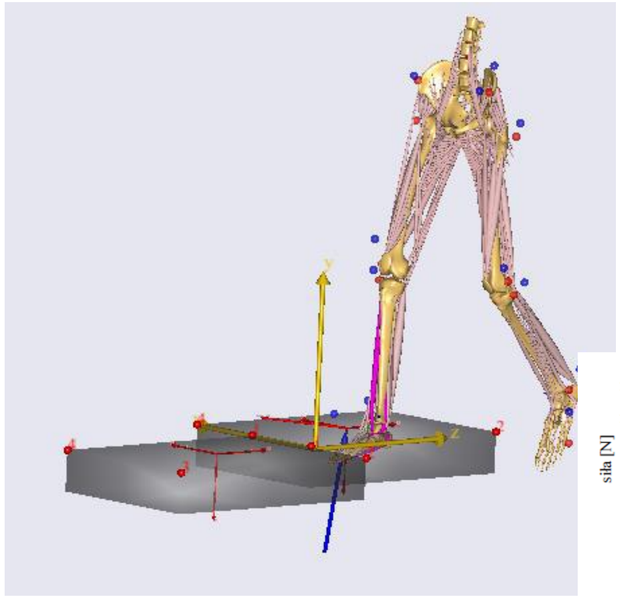
METHOD FOR DIAGNOSIS AND MONITORING OF THERAPY FOR PATIENTS WITH CEREBRAL PALSY

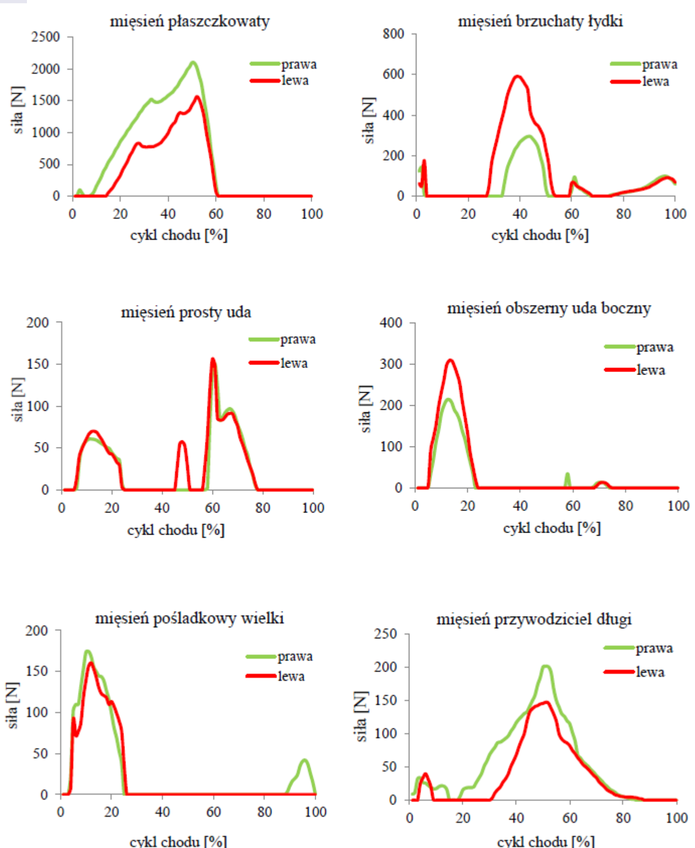


b)









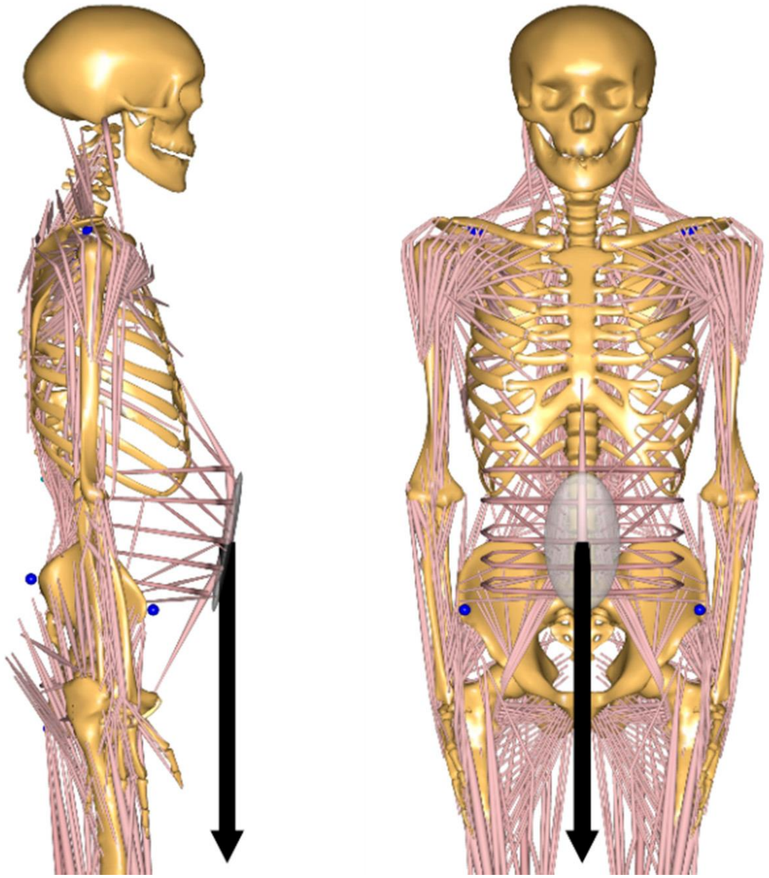
METHOD FOR DIAGNOSIS AND MONITORING OF THERAPY FOR PATIENTS WITH CEREBRAL PALSY

The most important effects of the conducted research include:

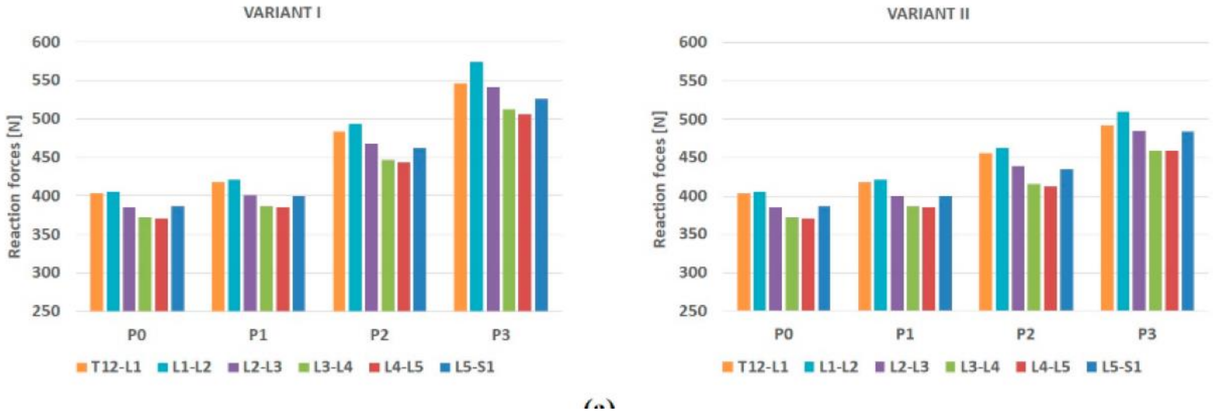
- development of reference gait kinematic data for healthy children aged 7 to 17 years,
- conducting simulation of numerical loads of the skeletal and muscular system during healthy gait,
- development of normative courses: muscle forces and reactions in joints acting during walking,
- simulation of numerical loads of the skeletal-muscular system during the gait of patients with cerebral palsy and assessment of the usefulness of this method for diagnosis and monitoring of therapistsand,
- new algorithms for assessing gait kinematics have been developed: Gait Cycle Energy Disbursement Index (EE), Gait Kinematics Index (GKI), Global Gait Symmetry Index (GSI) and Gait Variability Profile (GDP)

MULTI-VARIANT SIMULATIONS OF NUMERICAL LOADS OPERATING IN THE LUMBAR SPINE

ERGONOMIC ASPECTS OF BODY POSTURE IN PREGNANT WOMEN



The simulations were performed in relation to two female body models:

VARIANT I—taking into account a change in the body mass in the following trimesters of pregnancy;

VARIANT II—taking into account a change in the body mass and alignment of individual body segments as a consequence of changing the angle of pelvic inclination in the sagittal plane in the following trimesters of pregnancy.