Applied Motion Analysis

Walking

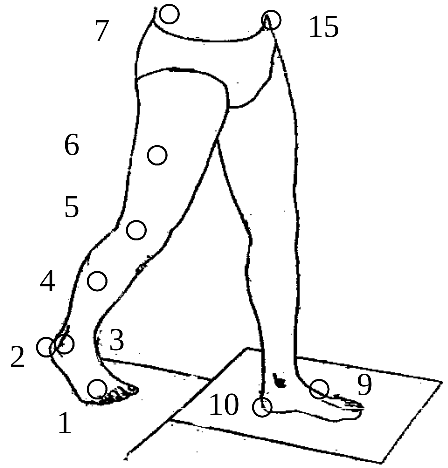
What we know?

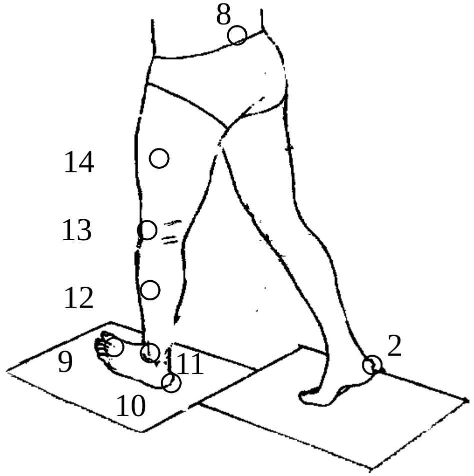
- Usin a motion analysis method we know the position of the sensors or the anatomical points.

Which anatomical points are needed?

Biomechanical model

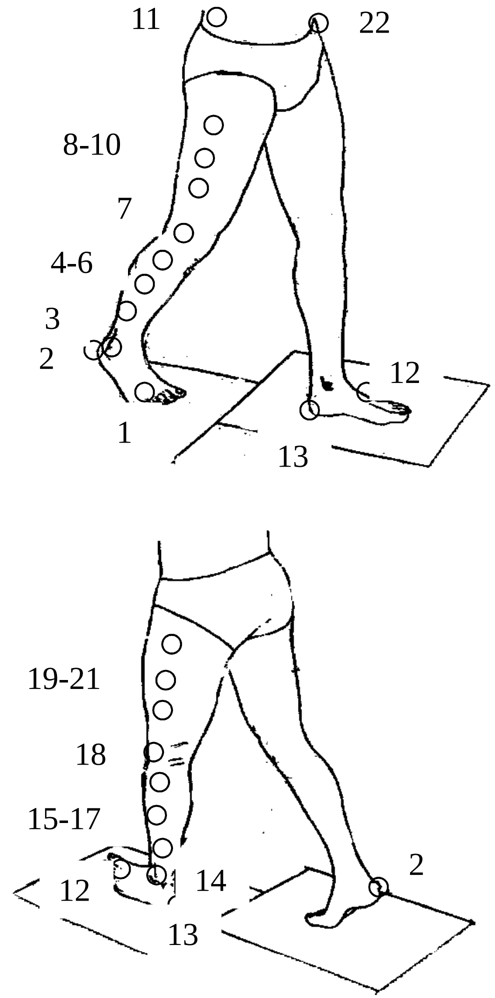
15 points based
biomechanical model





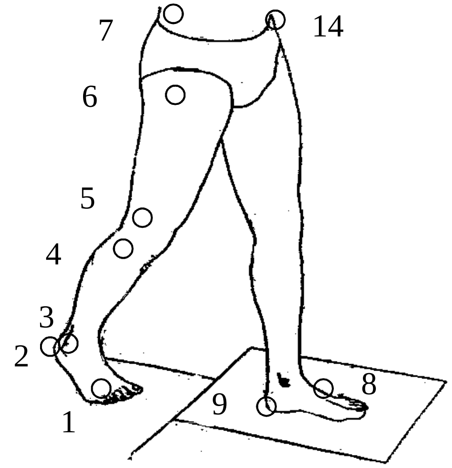
Biomechanical model

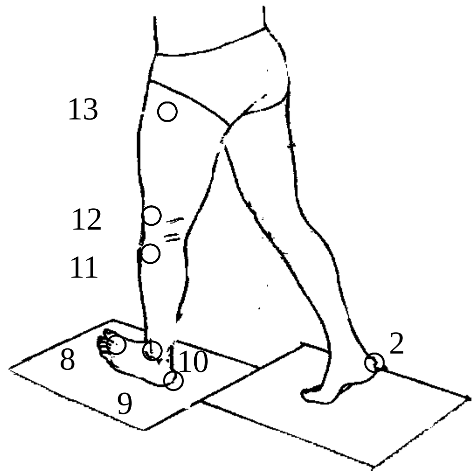
22 points based
biomechanical model



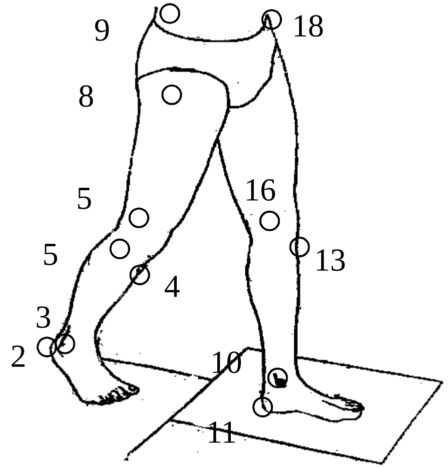
Biomechanical model

14 points based
biomechanical model

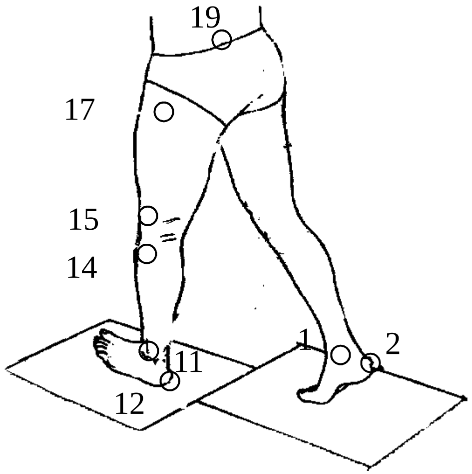




Biomechanical model



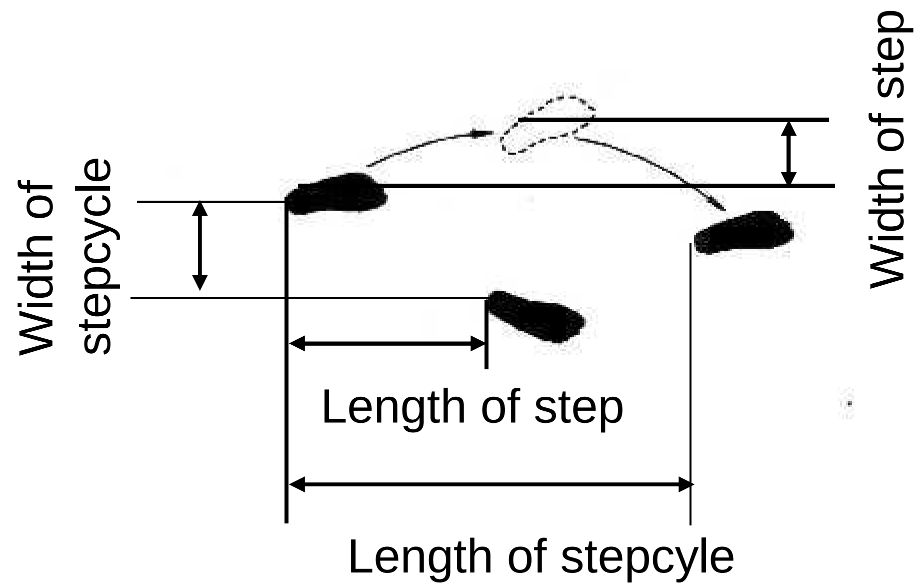
19 points based biomechanical model



What should we calculate from the spatial position of the anatomical points?

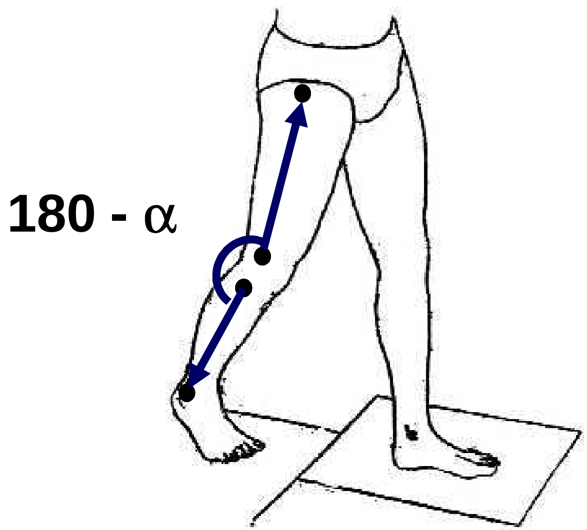
Displacement, time like parameters

- Displacement-time parameters
  - Length of the step
  - Length of stepcycle
  - Width of stepcycle
  - Length of swinging phase
  - Length of double support phase

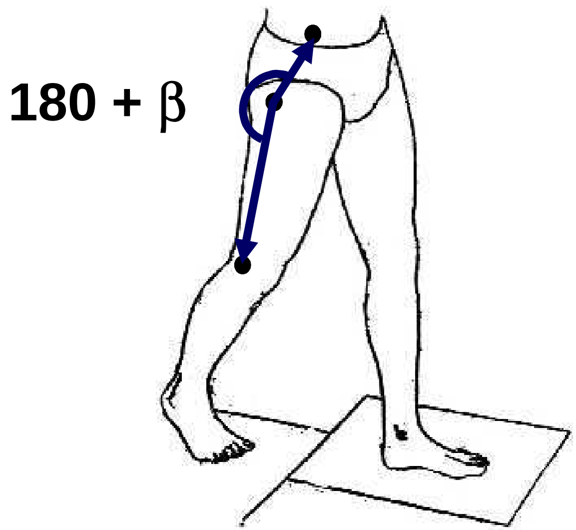


Angle like parameters

- Angle-like parameters
  - Knee-angle
  - Hip angle

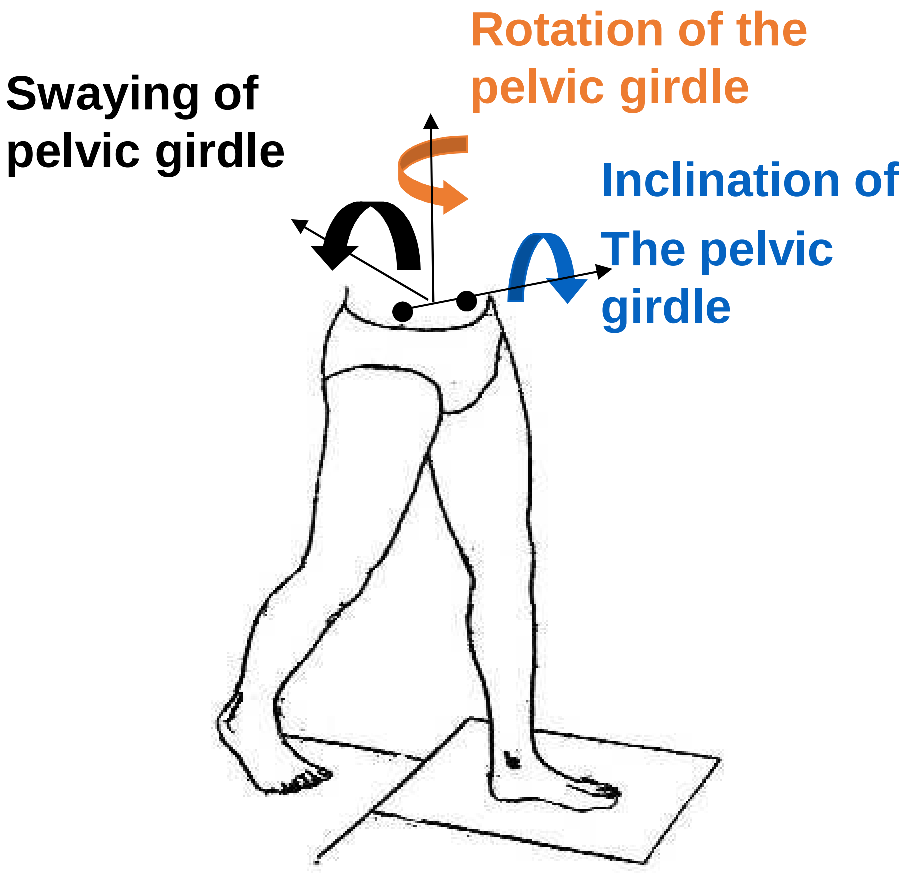


Knee angle



Hip angle

Angle-like parameters



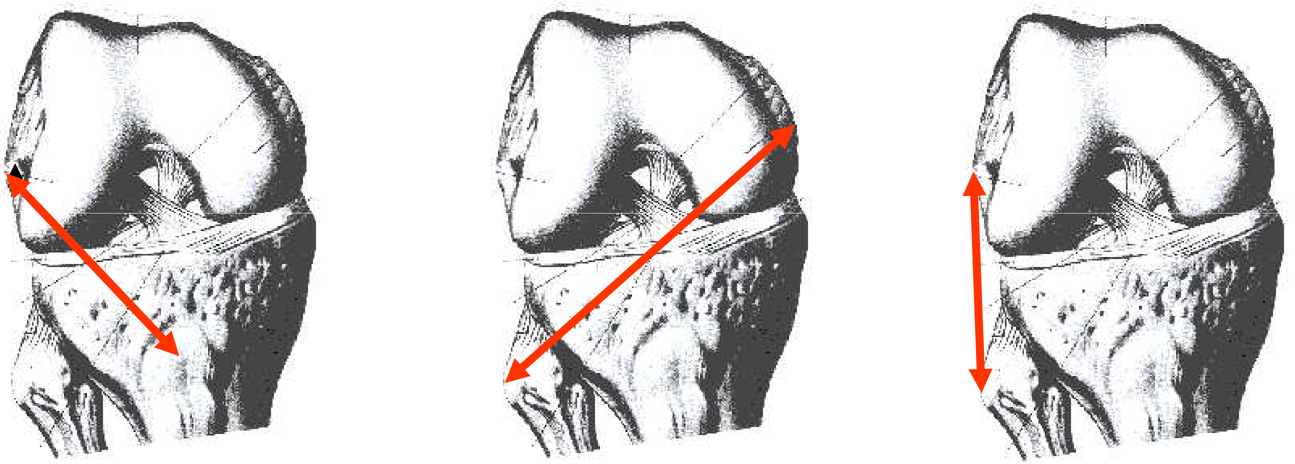
Defintion od the local coordinate system

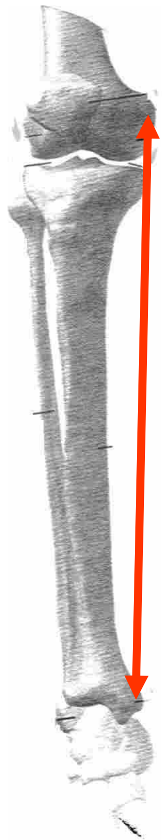
Turning of the pelvic girdle around the axises like a rigid body

Defomation like parameters

Relative ligament-point deformation

LCA LCP LCL LCM

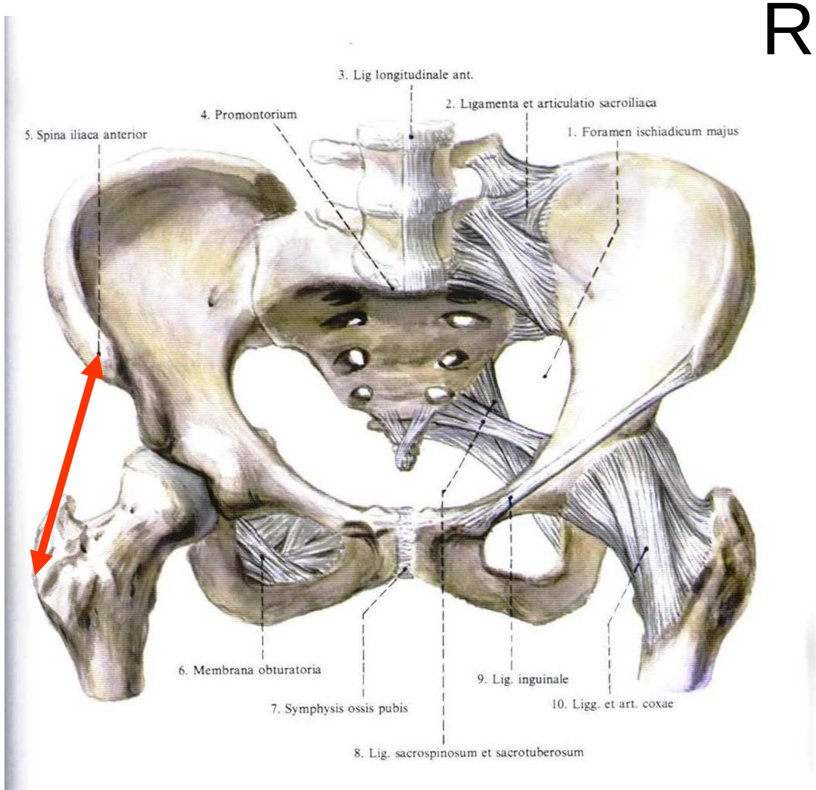




Between specified anatomical points
maximum value of normalized displacement.
High priority: ligament injuries
varus-valgus knee

Deformation like parameters

Relative hip-point changing



Donáth: Anatómiai atlasz

Between ASIS (anterior superior iliac spine) and the great trochanter

Normalized valued of the highest displacement

Important:

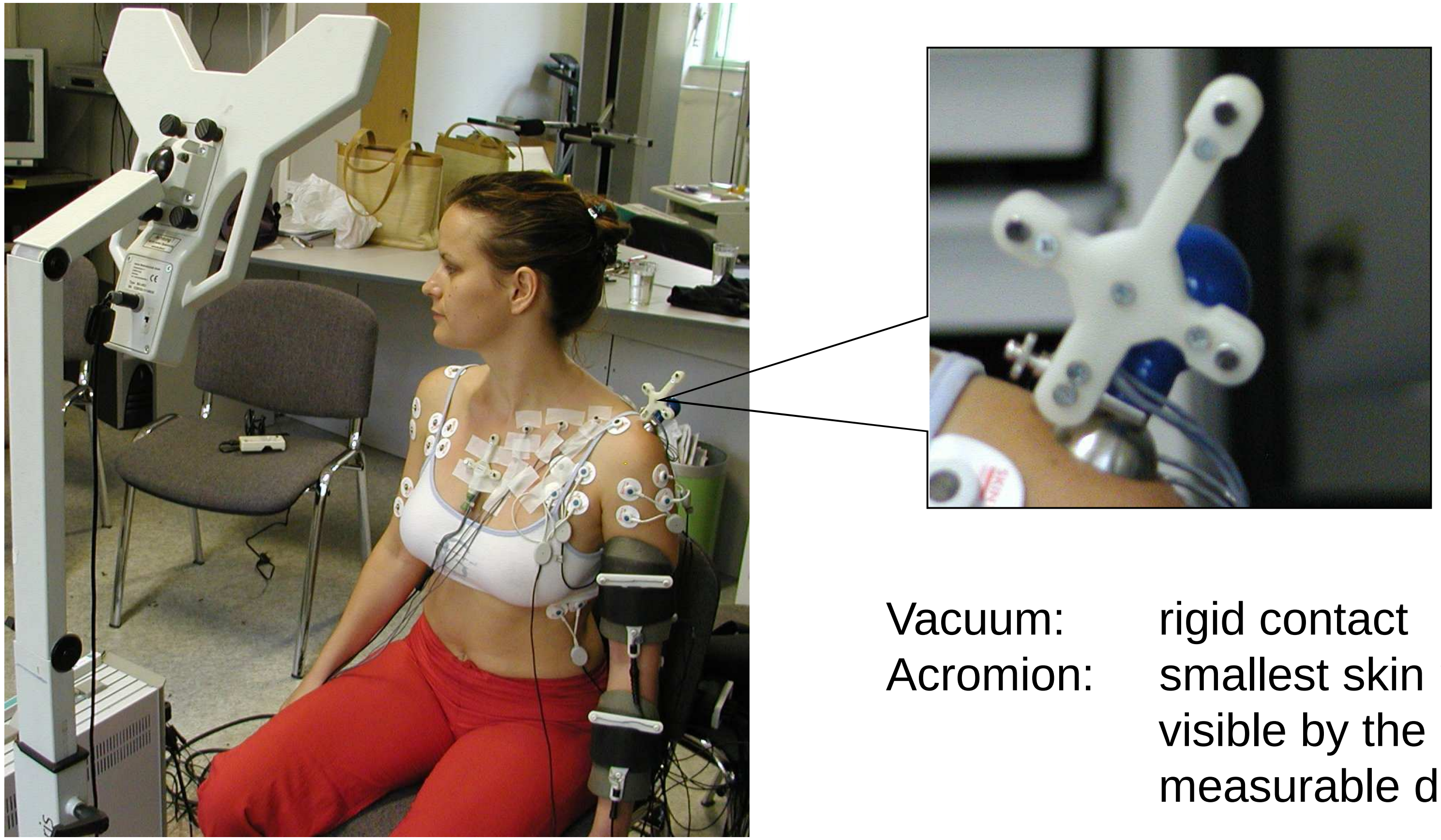
hip-joint

endoprsosthesis

Motions of the upper limb

Method

Measurement triplet for the motion of the scaplula



Vacuum: rigid contact

Acromion: smallest skin movement

visible by the measurement head

measurable during the motion

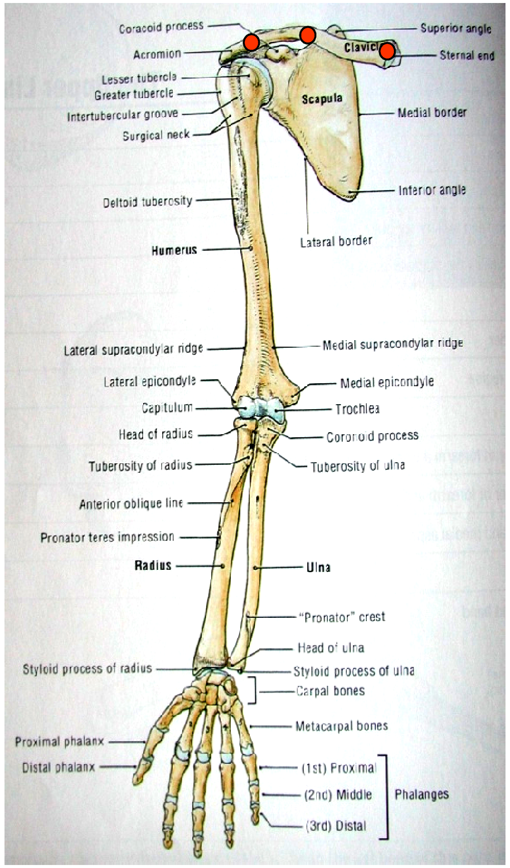
What we know?

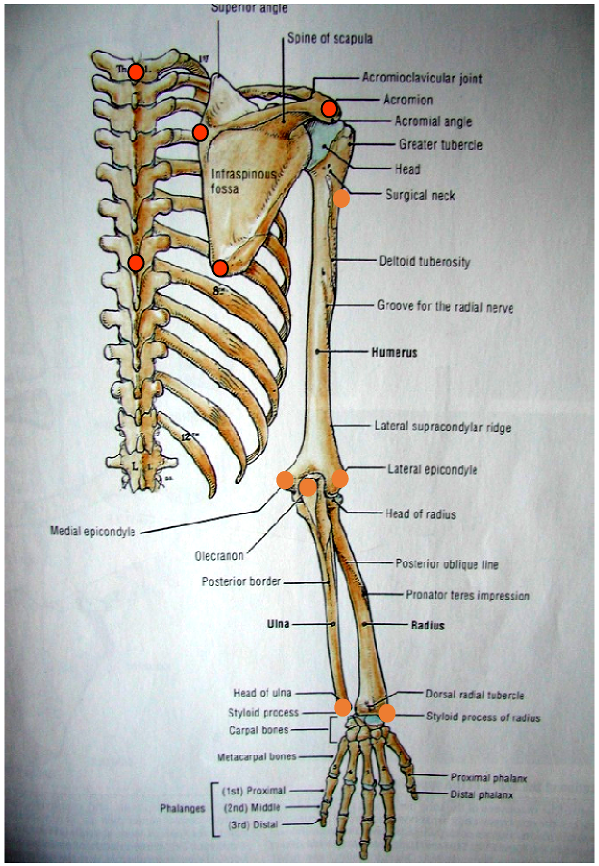
- Usin a motion analysis method we know the position of the sensors or the anatomical points.

Which anatomical points are needed?

Biomechancal model

The developed 16 points based biomechanical model





Anatomical points on the bones of the shoulder joint and at least three anatomical points of the lower arm should be investigated

The investigated motion

Armlifting in the plane of the scapula

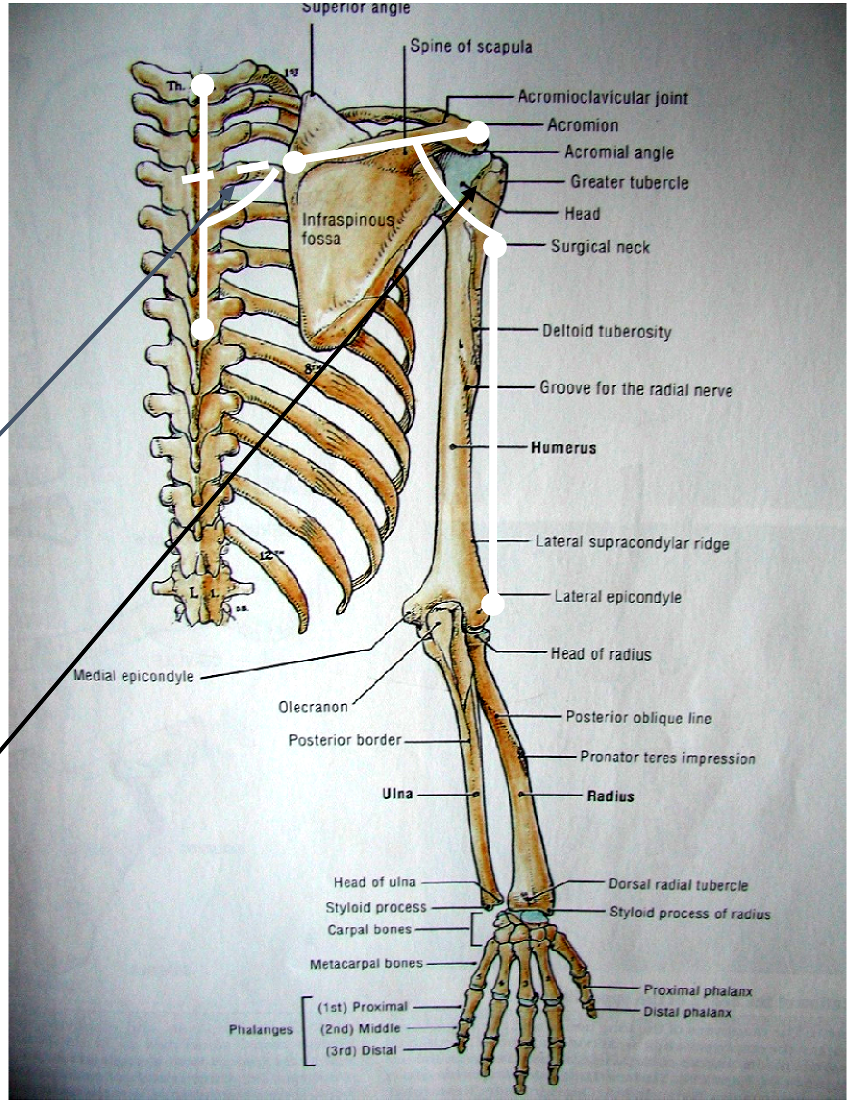
What should we calculate from the spatial position of the anatomical points?

Parameters – Spatial angles

HE the angle betweeen the trunk and the humerus (humerus elevation)

ST the angle between the trunk and the scapula (scapulo-thorocalis angle)

GH the spatial angle between the humerus and the scapula (glenohumeralis szög)



Angle-like parameters

Parametes of the angle changing

The difference between the initial and the present angle

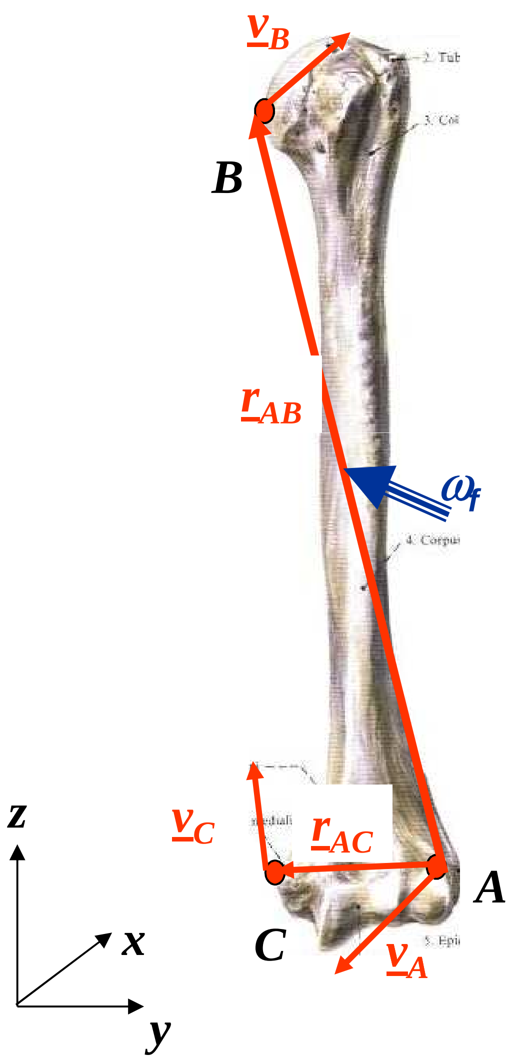
- Eliminating antropometric properties
- Dynamics is not measurable

Scapulothorocalis and glenohumeralis rythm

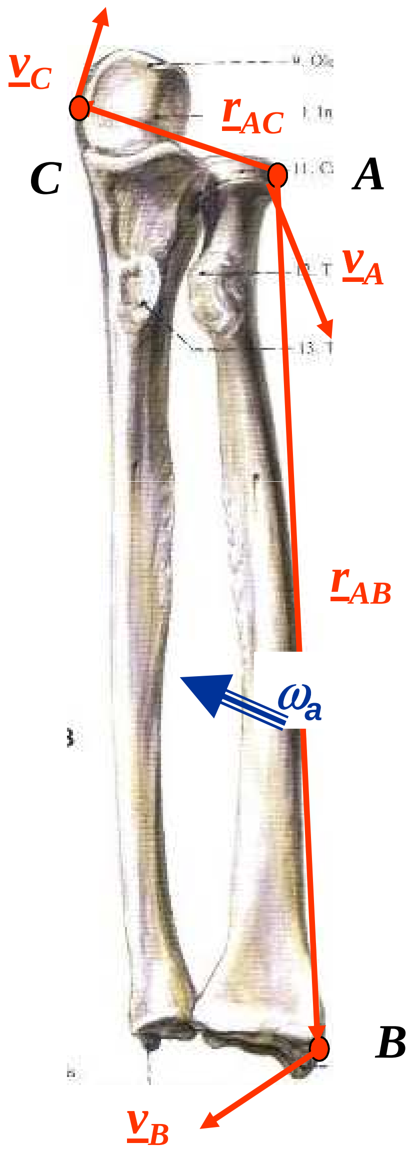
The scapulothorocalis and glenohumeralis angle in the function of elevation

- dinamika nem jellemezhető
- Durng the h

The determination of rotation point



Rigid bodies are supposed- Determination of the angular velocity of the lower and upper arm can be calculated from the velocities of three measured points

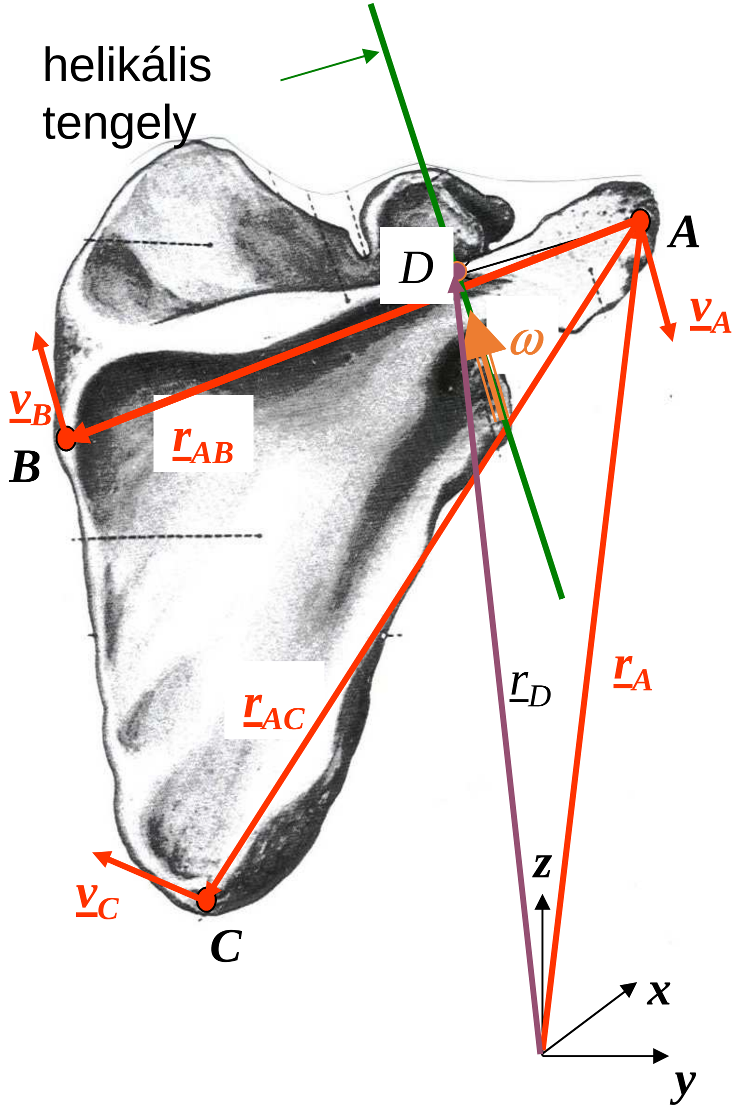


The angular velocity joint

ϖ_f-ϖ_a

Determination of the helical axis and the rotation point

Calculation of the rotation point

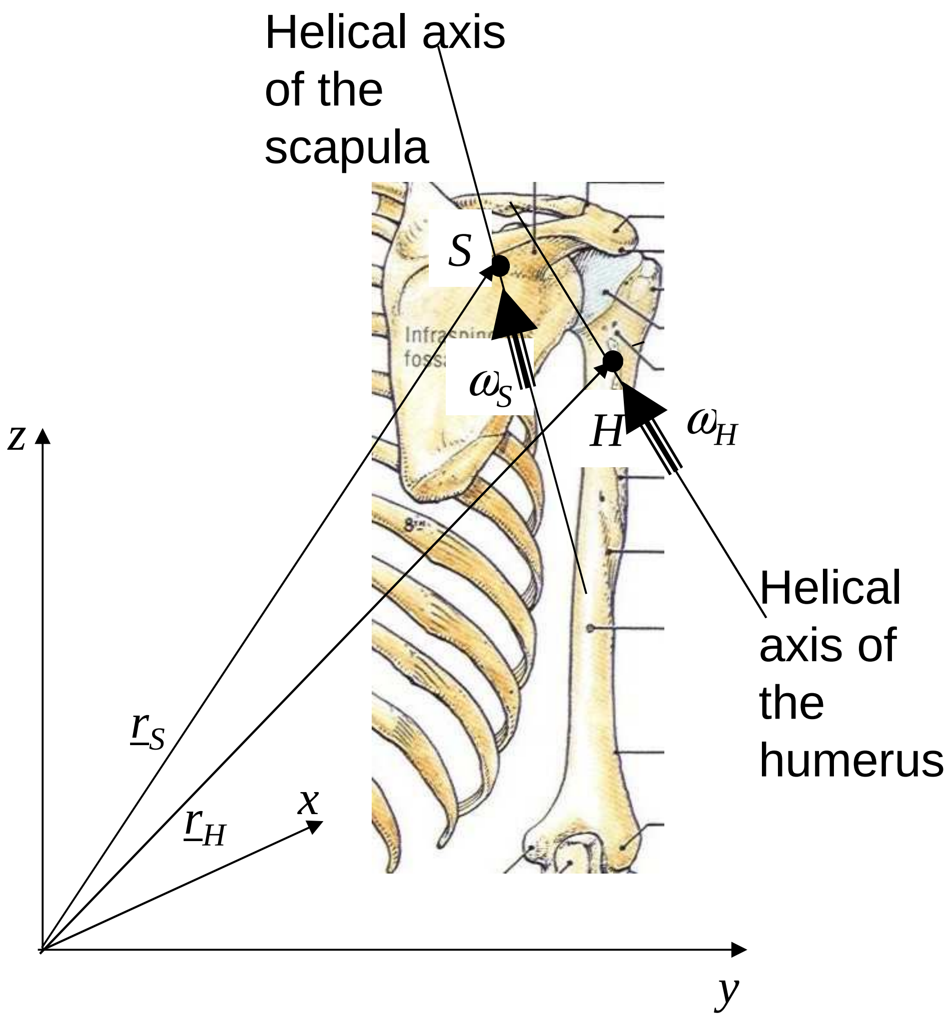


Determination of angular velocity of the segment – rigid body – from three known points of the rigid body can be calculateed(Kocsis-Béda)

Determination of the helical axis of the rigid body

Determination of the rotation point

Dynamical properties



Investigated paramters

- Distance between two rotation points (depend on the antropometric properties)
- Absolute displacement of rotation points (depend on the antropometric properties)
- Relative displacement of rotation points (depend on the antropometric properties)

Measuring of muscle activity

EMG

- EMG=elektromyography
- Electrode potential changing of the skeletal muscle between two points
- Recorded figure: elektromiogramm
- Types:
  - Surface (superficial muscle groups)
  - Needle (some muscle, deep muscle, painfull, sterilization, hard-hitting)
  - Based the method of wireing : monoplar, bipolar
- Fields of application:
  - Distinguish the nerve and muscle based paresis
  - Work, sports and orthopedic disorders usually have effects pn the activation sequence

What we know?

- Using superficial electromyography (EMG) the electrode potential changing of muscles are measured in time. (electromyogram).

Which muscles should be measured??

Walking –lower limb

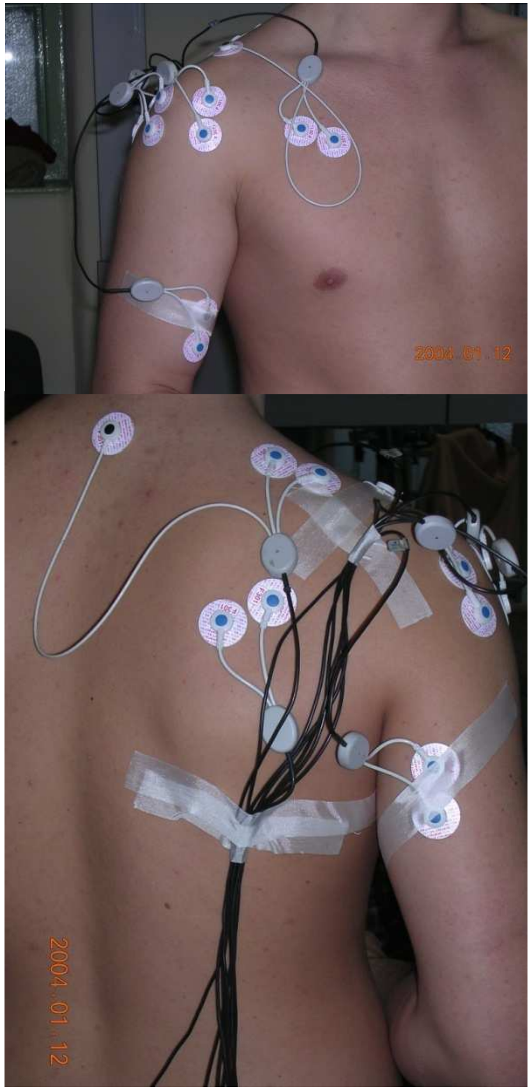
On surface EMG (elektromyograph) activation detection

- m. vastus med.
- m. vastus lat.
- m. rectus femoris
- m. biceps fem.
- m. adductor longus
- m. gluteus medius
- m. gastrocnemius med.
- m. gastrocnemius lat.

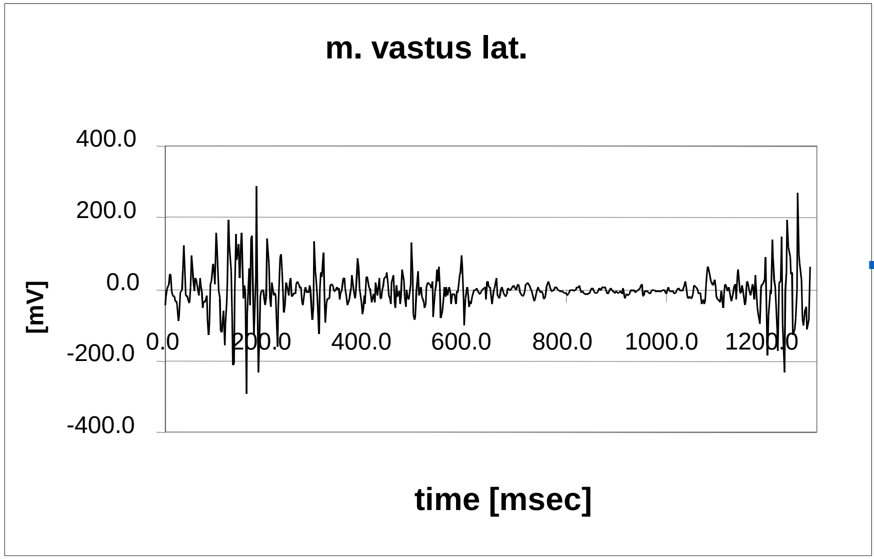
Upper limb motions

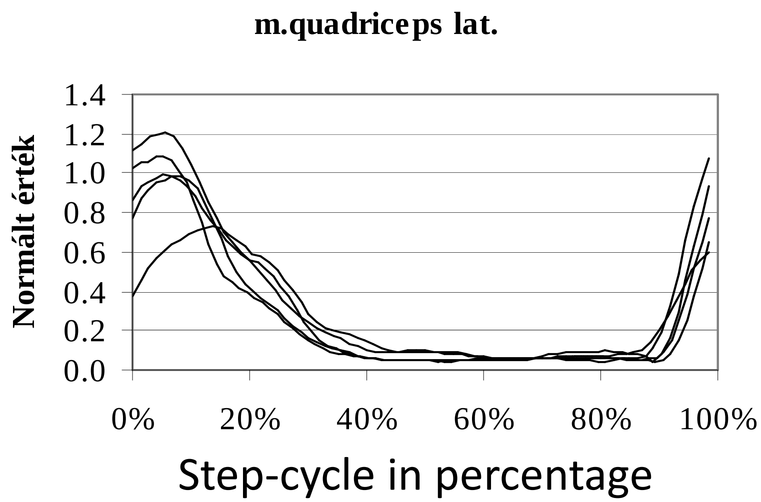
Measured muscles with electromyography:

- m. pectoralis major,
- m. infraspinatus,
- A deltoid-muscle frontal, mid and back head,
- m. supraspinatus trapesius,
- m. biceps brachii,
- m. triceps brachii



Muscle activity parameters



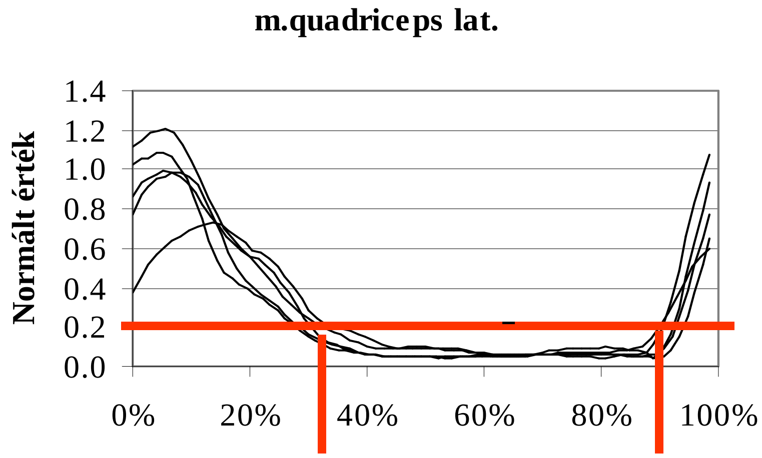


EMG creating envelope graph with rms (root mean square) method

Analysis of 6 gait cycles normalization of the average of the maximum values

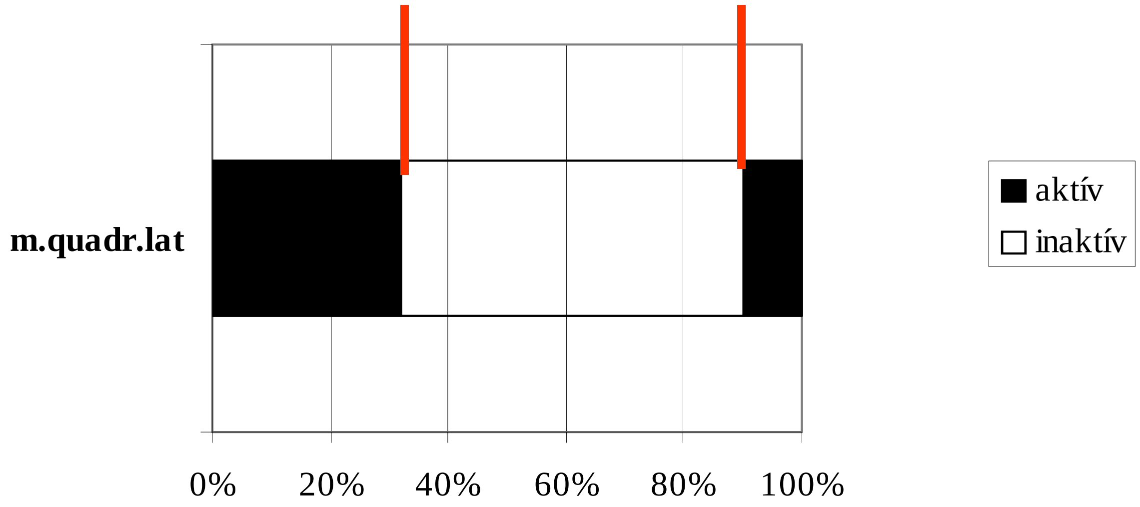
Muscle activity parameters

Activation time (>20%)



Step-cycle in percentage

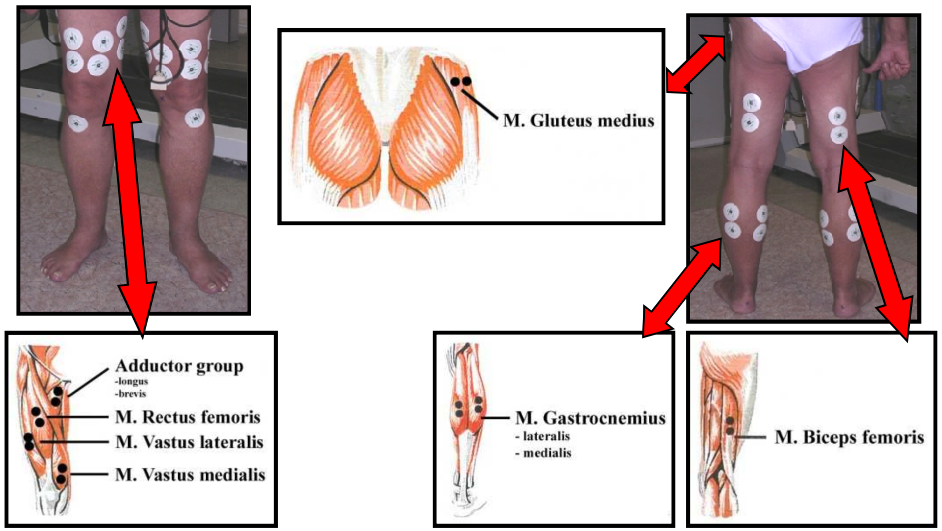
Intermuscular coordination



Step-cycle in percentage

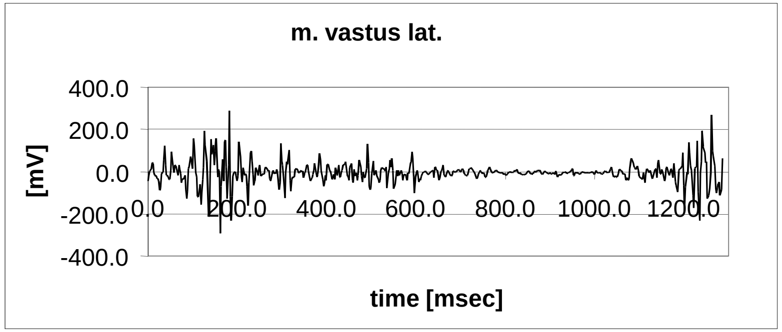
Conduction of the measurement I.

- Equipments
  - Fixing devices
  - Electrodes (superficial or nailed)
- Validation of the measurements (in general it is automatic)
- Finding measured muscles



Conduction of the measurement II.

- Determination of the maximum muscle force
  - Special exercises (izokinetic, isometric, e.g.)
  - Some cases not measured (walking)
- Capturing the motion
  - Recording the elektromyogram
- Analysis of the measured datas



Analysis

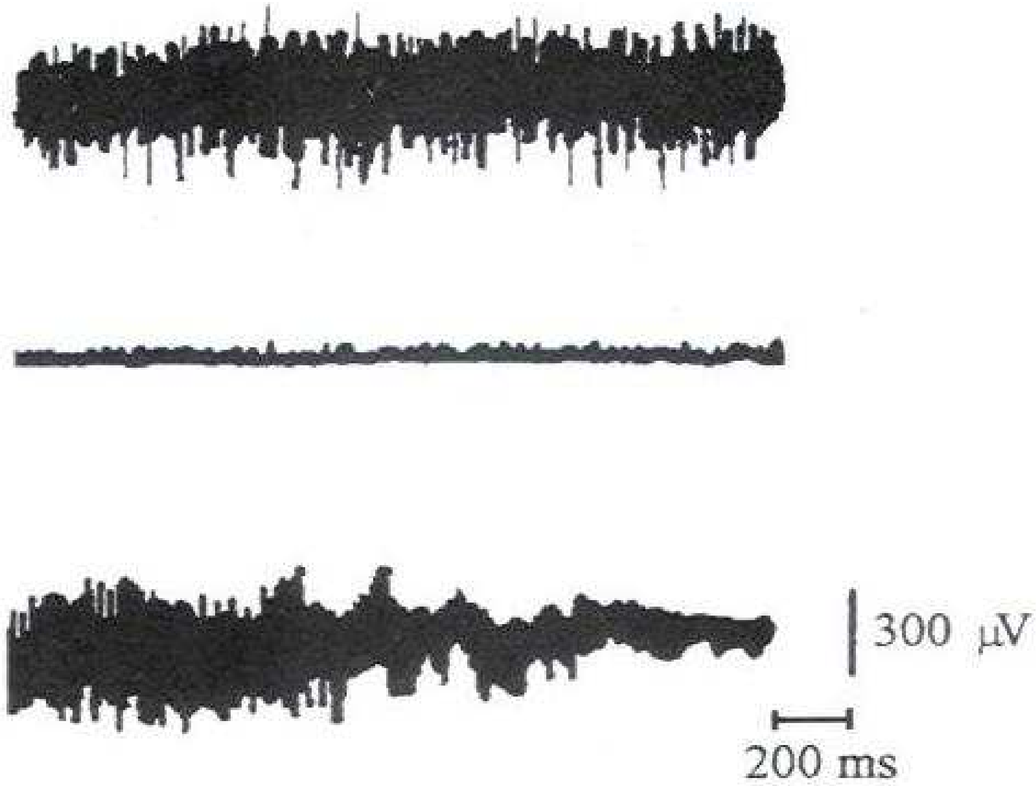
- Analysis of raw electromyogramm
  - contraction rate
    - In rest state (no electrical activity)
    - Moderate contraction
    - Maximum contraction (normalization require maximum muscle strength)
  - Record the changes of disease
  - Denervation potential (equal contraction)
  - Polyphasic potentials ("do not belong there" contractions)

Changes of disease

Normal
Muscle activity

Denervated
muscle

Myogen paralysis

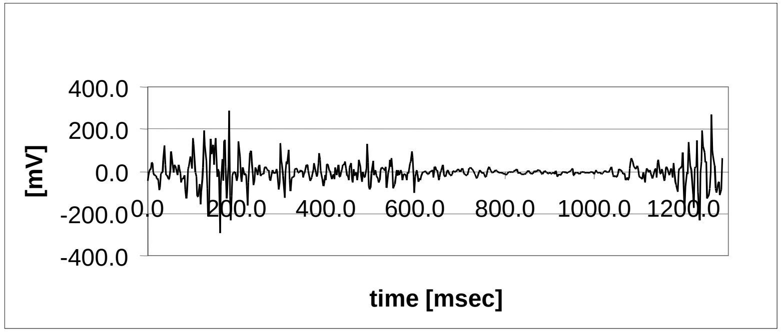


Ángyán: Az emberi test mozgástana

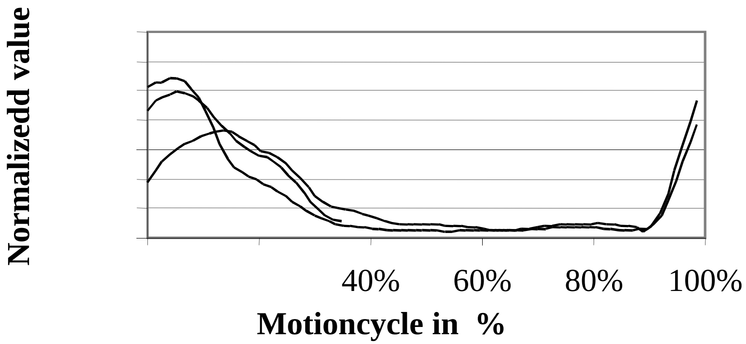
Processing I.

- Signal-processing:
  - Absolute value computing
  - Filtering
- Processing:
  - Time based processing:
    - Norming
      - With the maximal value of a special exercise (standarding, defined for each muscle, generally with elementary motions)
      - With the maximum value of the given motion
      - With the avarage value of the maximal values of the given motion-cycles (walking)
      - With the maximal value of more given motion
    - Avarage computing (Root-mean square)
  - Frequency based processing (determination of frequency properties):
    - Avarage frequency
    - Median frequency

Time based processing II.



Raw diagram

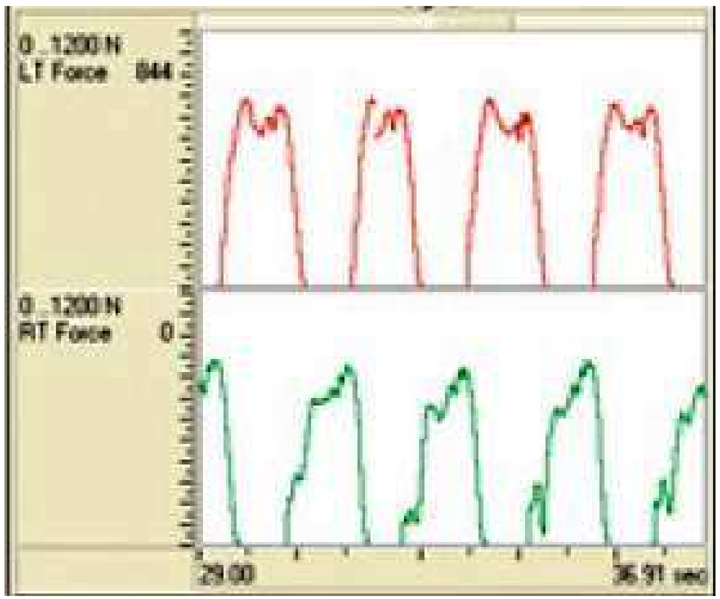


Envelope graph

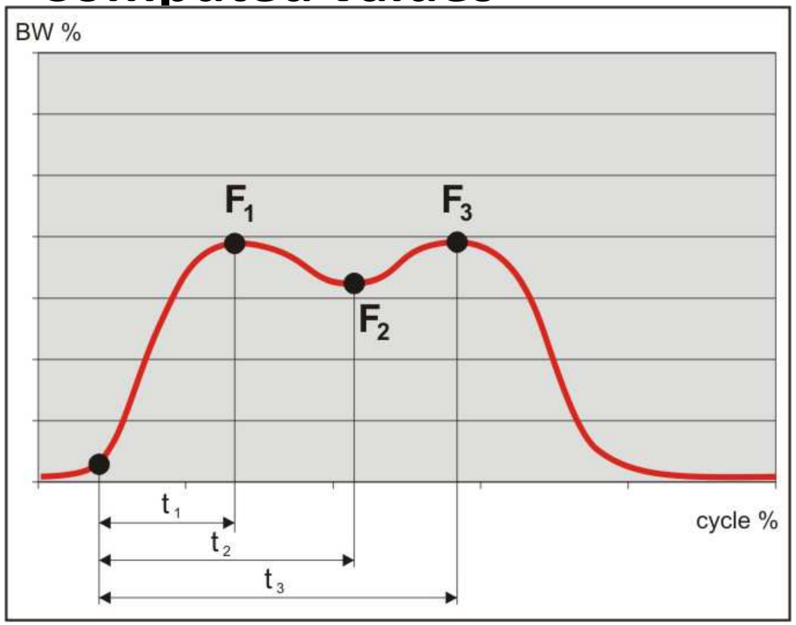
Reaction-force measurement

Reaction force

Measured values

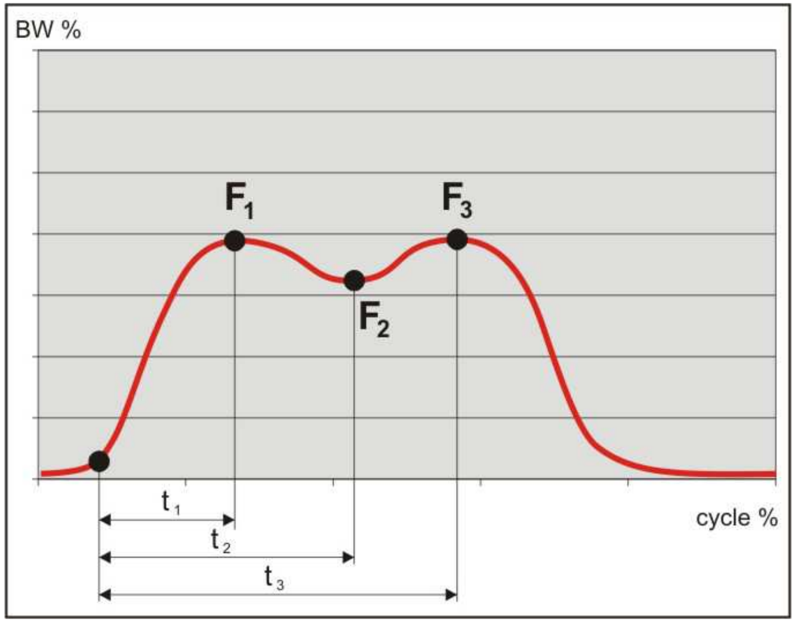


Computed values



F_1: Heel strike
F_2: Whole foot
F_3: Heel lifting
$T_{i:}$ Times pof phases

Reaction-force measurement– kinematical parameters



Constant velocity

Distances:
- •Length of step
- •Length of step-cycle

$T_{i:}$ times phases

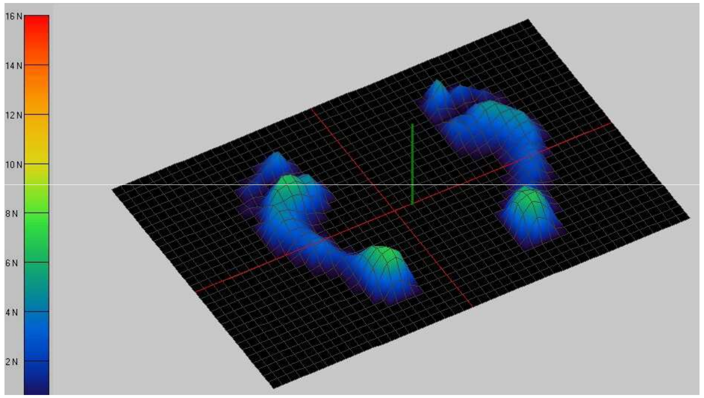
Foot-pressure distribution

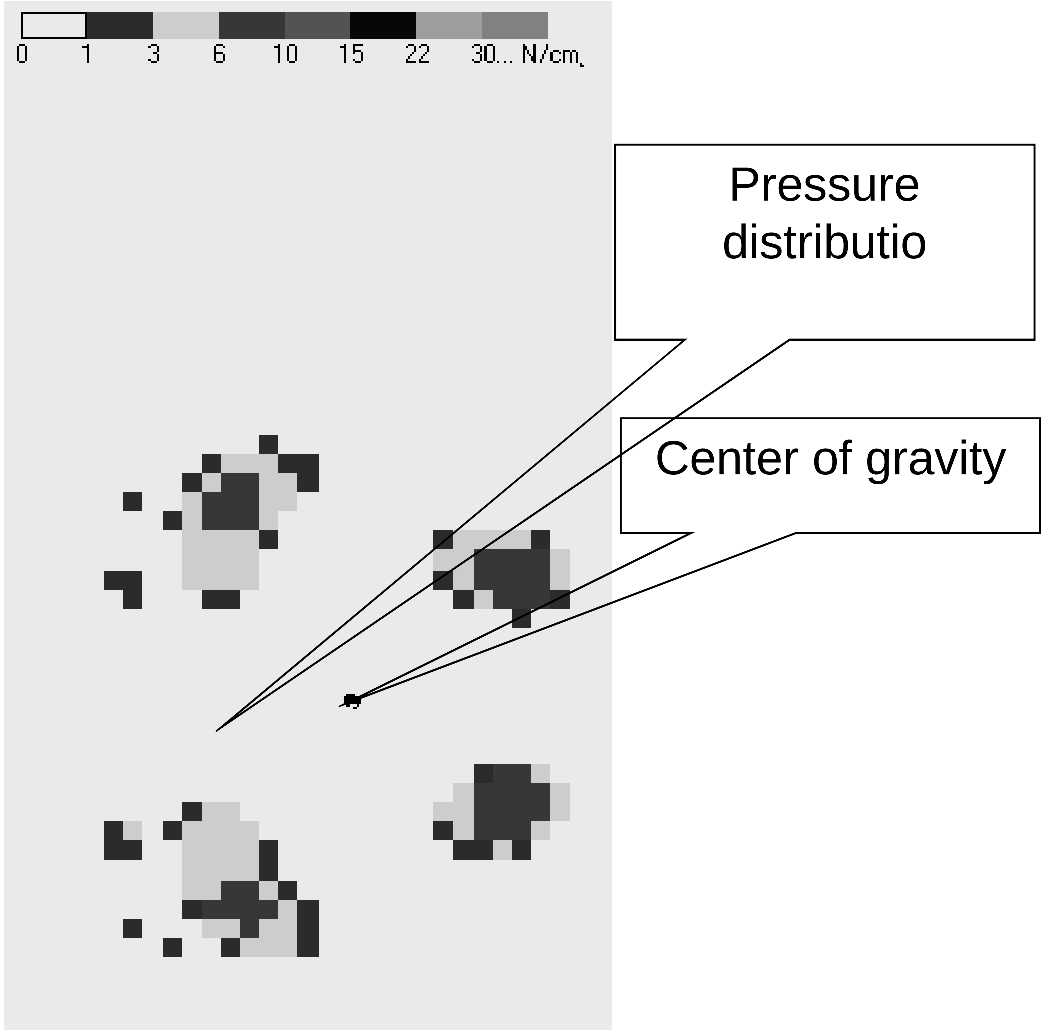
Static examination

Investigation the pressure under the foot

Special force measurement plate

Determined parameters

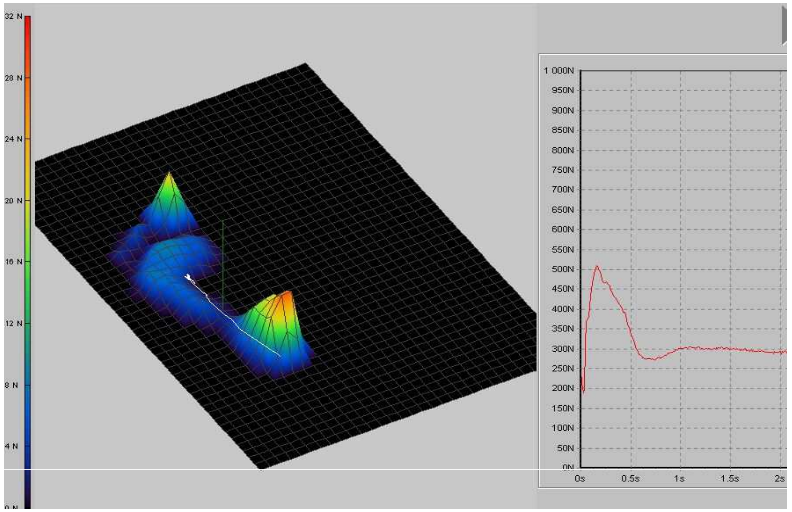


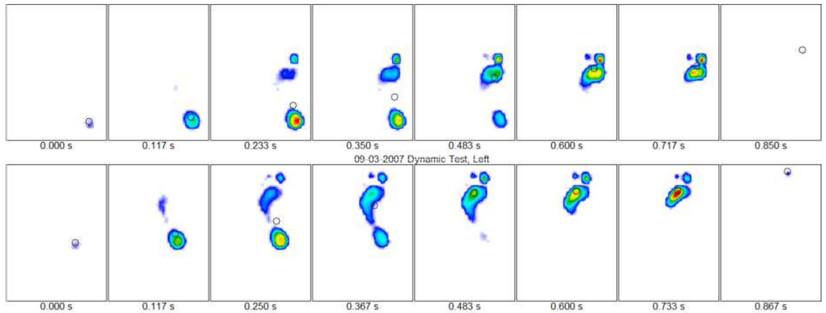


Applicability

- Investigation of the foot force distribution
  - Effect of flat-feet shoe insert
  - Effects of other diseases (diabetes, stroke,..)
- Stability investigation
  - Problem of closed and open eyes –eye-stabilization

Dynamical investigations





Balance investigations

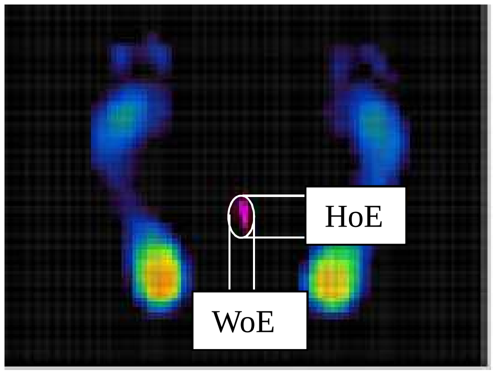
Balance investigation I.

- Types:
  - Static (closed or open eyes):
    - Investigation of foot force distribution
    - Investigation of head motion (Romberg-probe: standing for 1 minute with close eyes)
  - Dynamic:
    - Walking through a beam
    - Investigation of head motion walking in one place with closed eyes (Unterberger)
  - Special:
    - Proprioception (motion coordination)

Keeping the balance

Balancing: earning stable state, and keeping it

Proprioception — keeping the static equlibrium: Sensing the relative position of the body parts respect to each other in static position



The displacement of center of mass can be measured with foot force distribution measurement

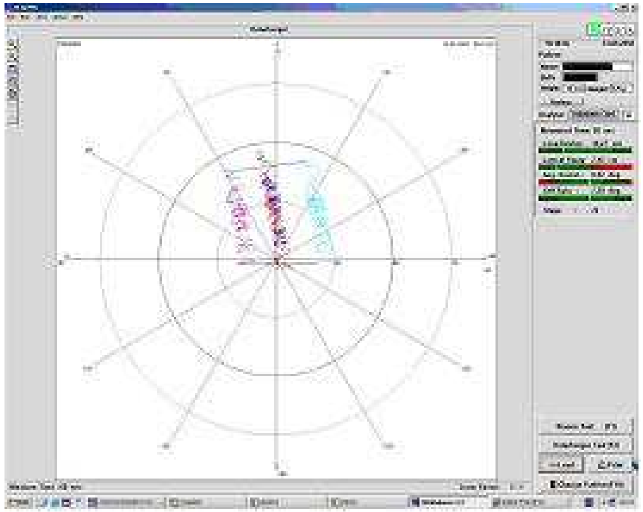
Keeping the balance

Proprioception — keeping the static equlibrium: Sensing the relative position of the body parts respect to each other in static position

- Investigation of head motion (Romberg-probe: standing for 1 minute with close eyes)

Keeping the balance

Kinesthesis – keeping the dynamic equlibrium: The relative position of moving body-parts respect to each other



- Investigation of head motion walking in one place with closed eyes (Unterberger)

Advantages

- Well known methods

Disadvantages:

- stability analysis
- Mainly analyze the effects of neurological problems
- Small shocks to the escalator, the bumpy streets, the streets, pets 'attacks' are not modeled
- After a sudden change of direction the keeping of balance and walking on moving ground is not analyzed