COMPUTER VISION FOR BIOMEDICINE: *KINESIOLOGICAL BIOMECHANICS*

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Faculty of Kinesiology - Since 1959

University of Zagreb - Since 1669

Tradition in developing biomechanical experimental techniques (1987) ...

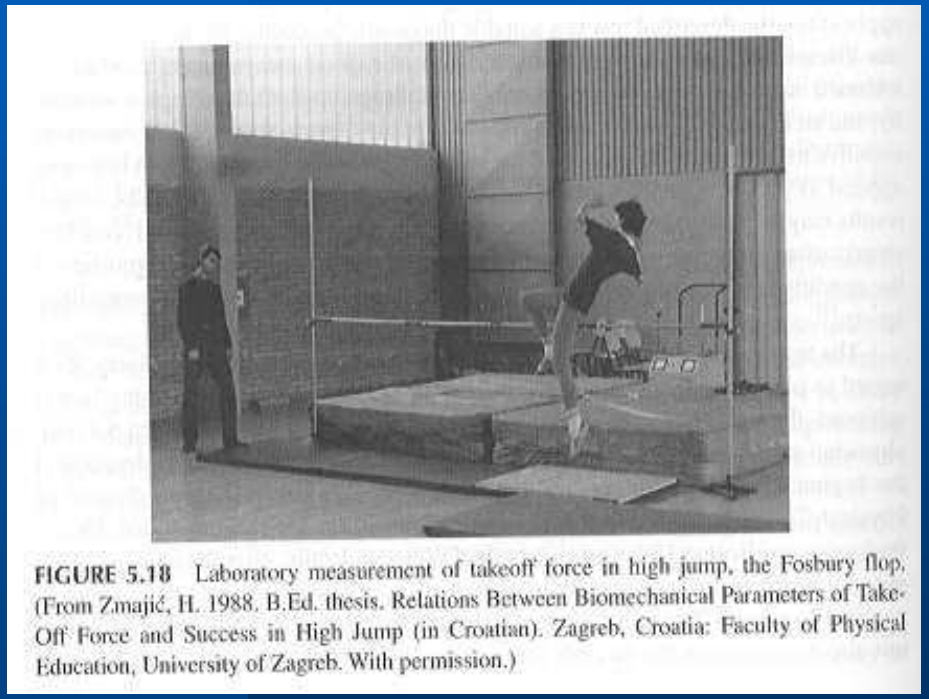
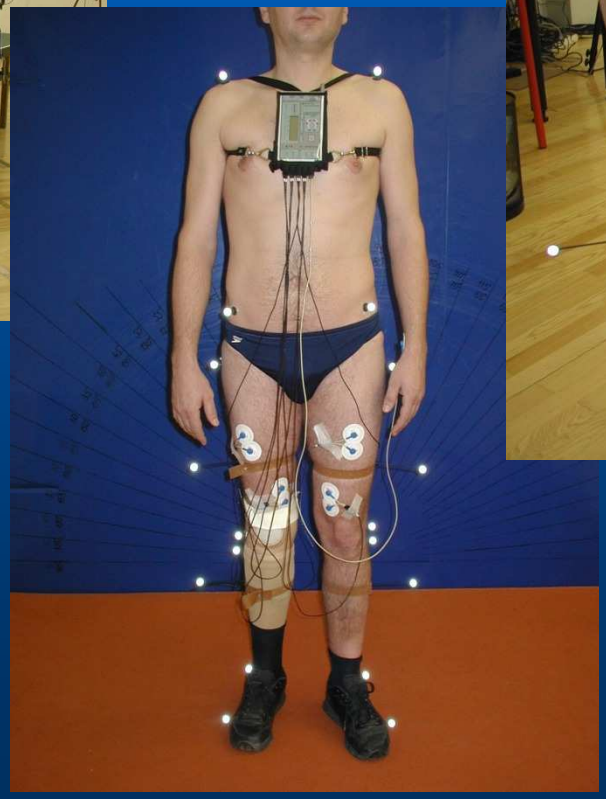


FIGURE 5.18 Laboratory measurement of takeoff force in high jump, the Fosbury flop. (From Zmajić, H. 1988. B.Ed. thesis. Relations Between Biomechanical Parameters of Take-Off Force and Success in High Jump (in Croatian). Zagreb, Croatia: Faculty of Physical Education, University of Zagreb. With permission.)

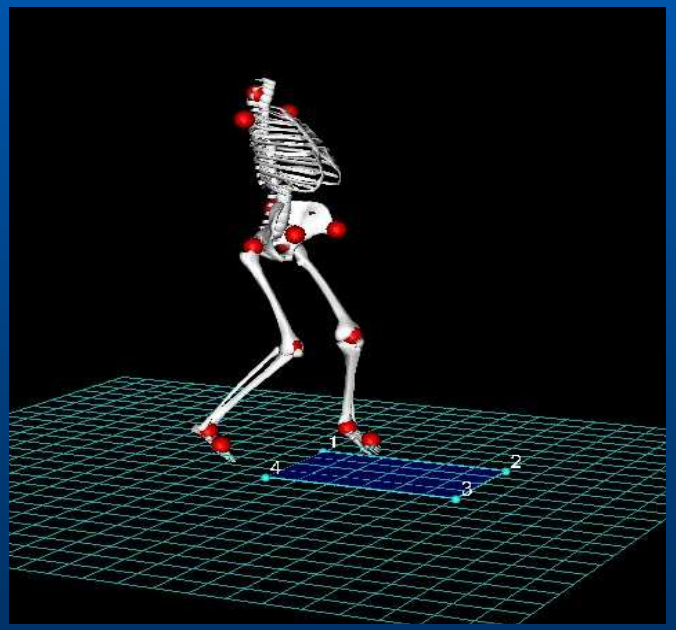
...leading to a modernly equipped laboratory facility (2003).

Table tennis research



Gait analysis in amputees wearing prostheses

Automated motion capture and data visualisation...



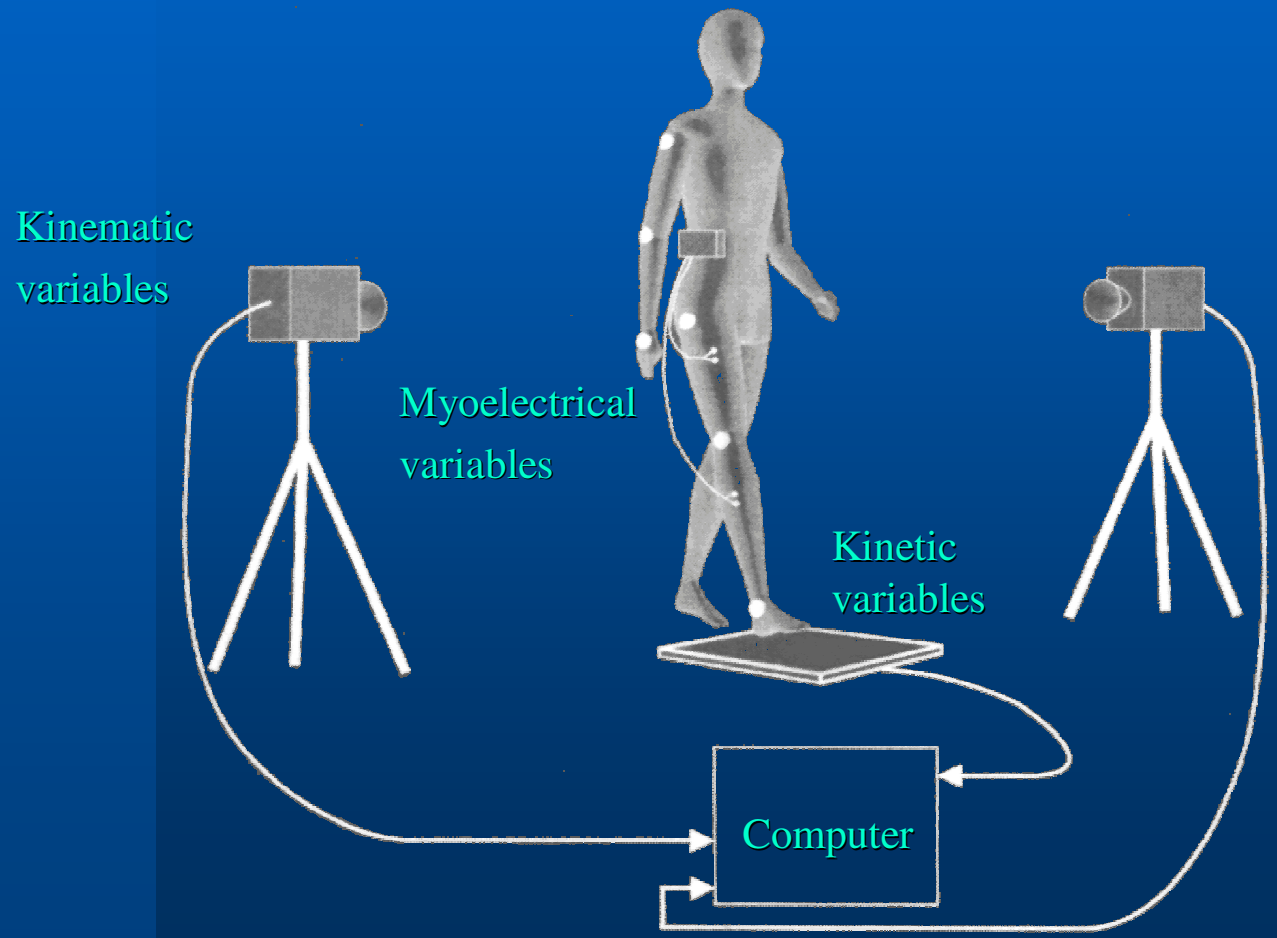
Kinesiological biomechanics: methodology

- Human locomotion is studied by combining theoretical approaches of biomechanical body modelling and neural control of movement, with experimental data gathering.

Motion capture

- To capture human motion means to acquire data describing the geometry of movement of the human body in space and time (spatial or 3D kinematics). In biomechanics, capturing motion serves as a necessary prerequisite for subsequent biomechanical analysis, including the realisation of an inverse dynamic approach.

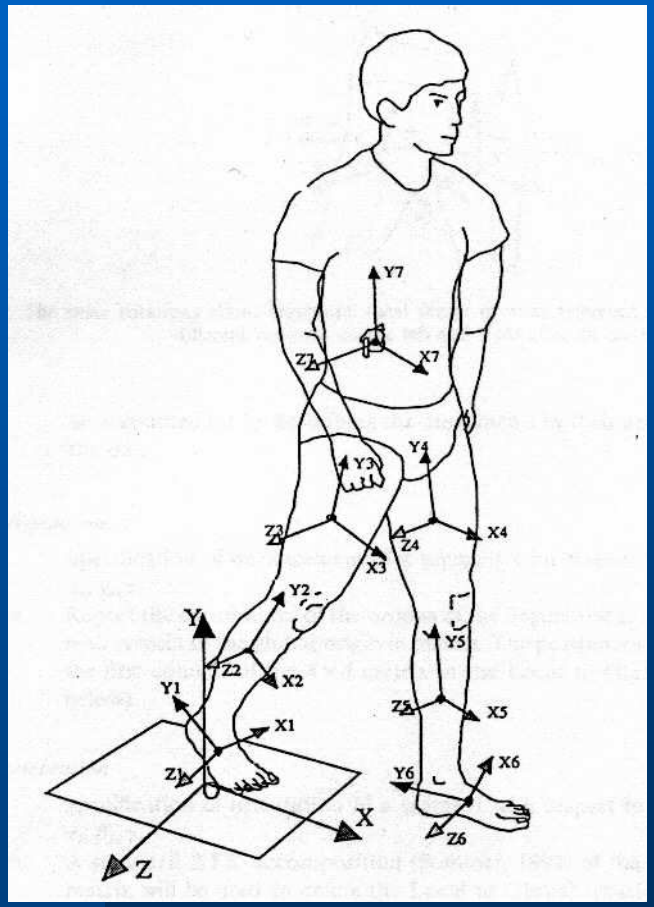
Basic measurement setup - locomotion laboratory

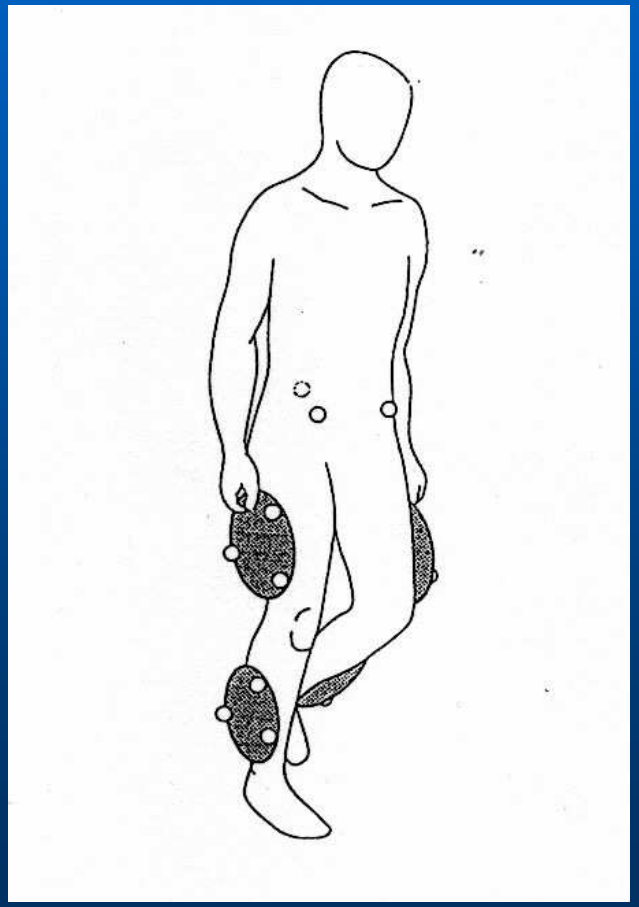


Stereometric methods - the standard principles

- To calculate spatial (3D) body segment position, at least three noncolinear markers per body segment are needed.
- Markers may be active or passive.
- Based on measured marker positions, 3D positions of body segments are calculated.

Stereometric methods - the definition of local coordinate systems and body marker positioning





Automatic marker detection and tracking

- detection of the brightness threshold and, when the threshold is surpassed, storage of coordinate values in the computer memory,

or

- marker shape recognition: marker shape is memorised (a template of 6 x 6 pixels) and 2D cross-correlation functions between digitised image parts and the memorised shape are calculated, and position of marker centroid is further calculated,

followed by

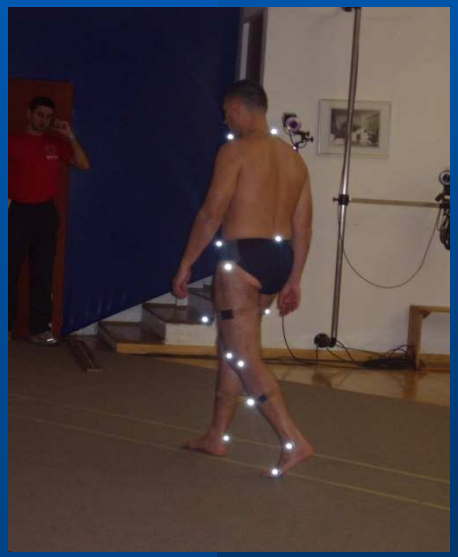
- automatic marker position tracking in time and storing of successive coordinate values into computer memory.

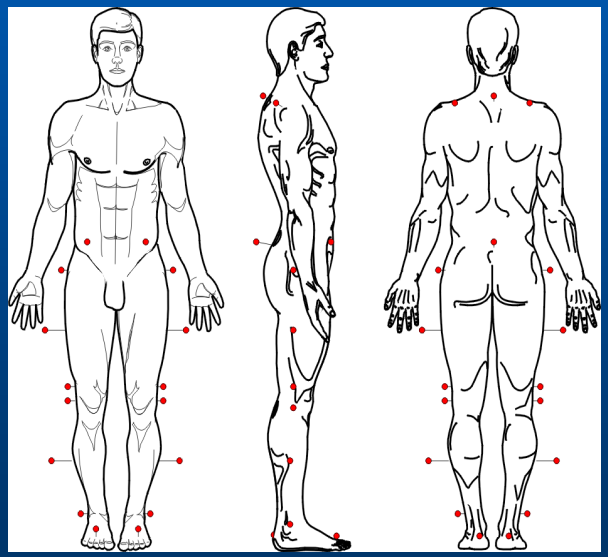
Movement structure and its kinematic signals

As a result of measurement process, a particular movement structure studied is described by a set of kinematic signals (curves).

The example of normal gait will be shown, using the Davis protocol employed for measurement.

Measurement of normal gait (Heimer Ž., 2005)

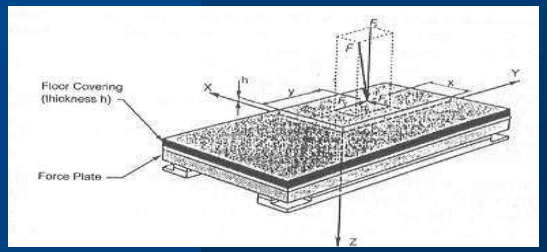




Laboratory equipment

The ELITE system, by the firm BTS, Milan

- 8 cameras, body mounted markers
- force platform
- 8 channel surface electromyography (sEMG)
- computer

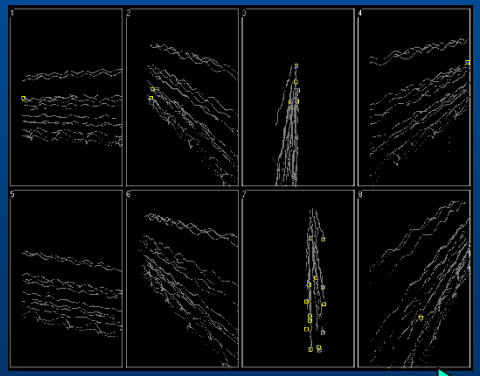


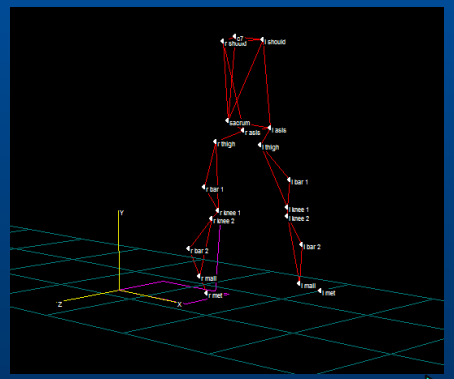
Laboratory procedure

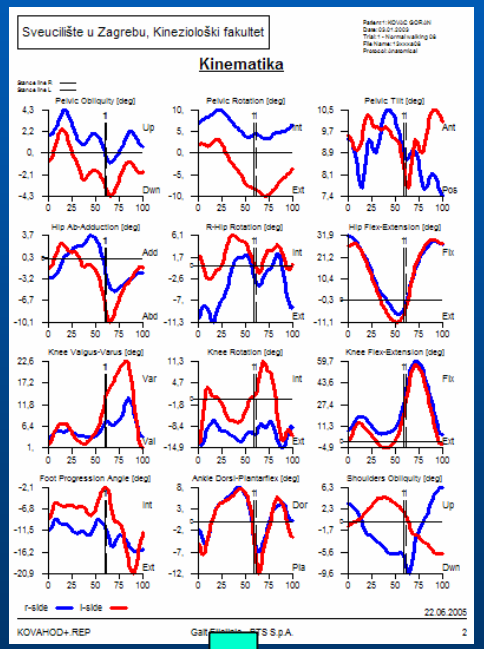
- System calibration
- Data acquisition
- Trajectories reconstruction
- Calculation
- Data analysis

2D data

3D data

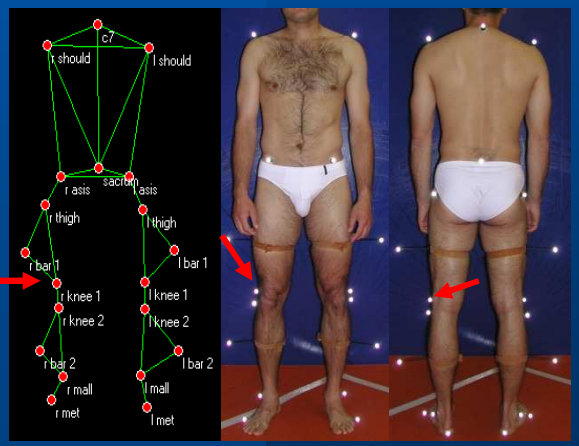


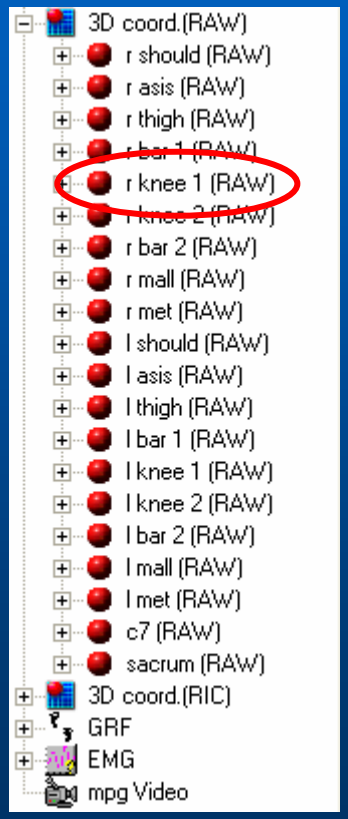


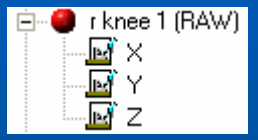


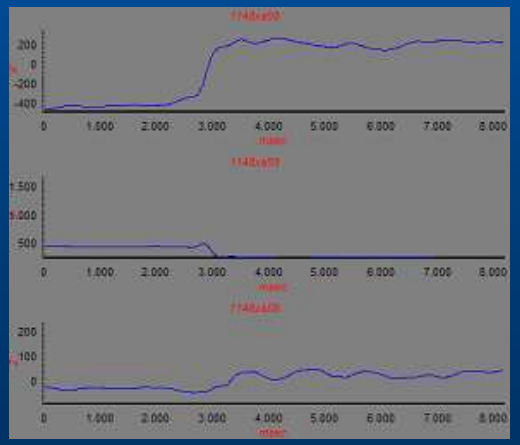
Data acquisition → Trajectories reconstruction → Calculation → Data analysis

Laboratory procedure: details









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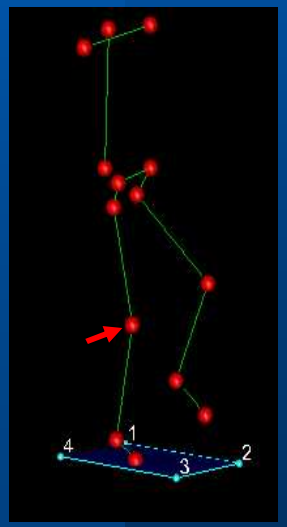
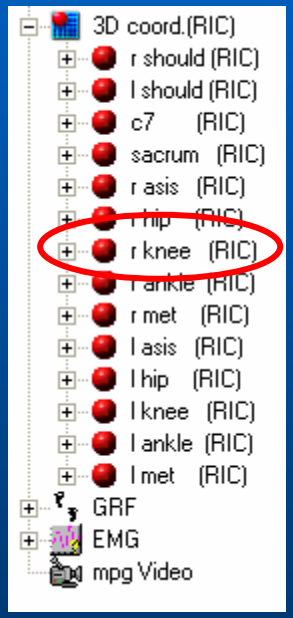
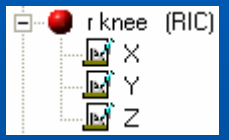
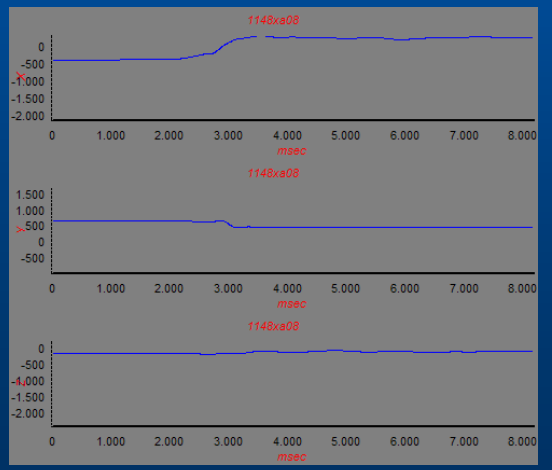
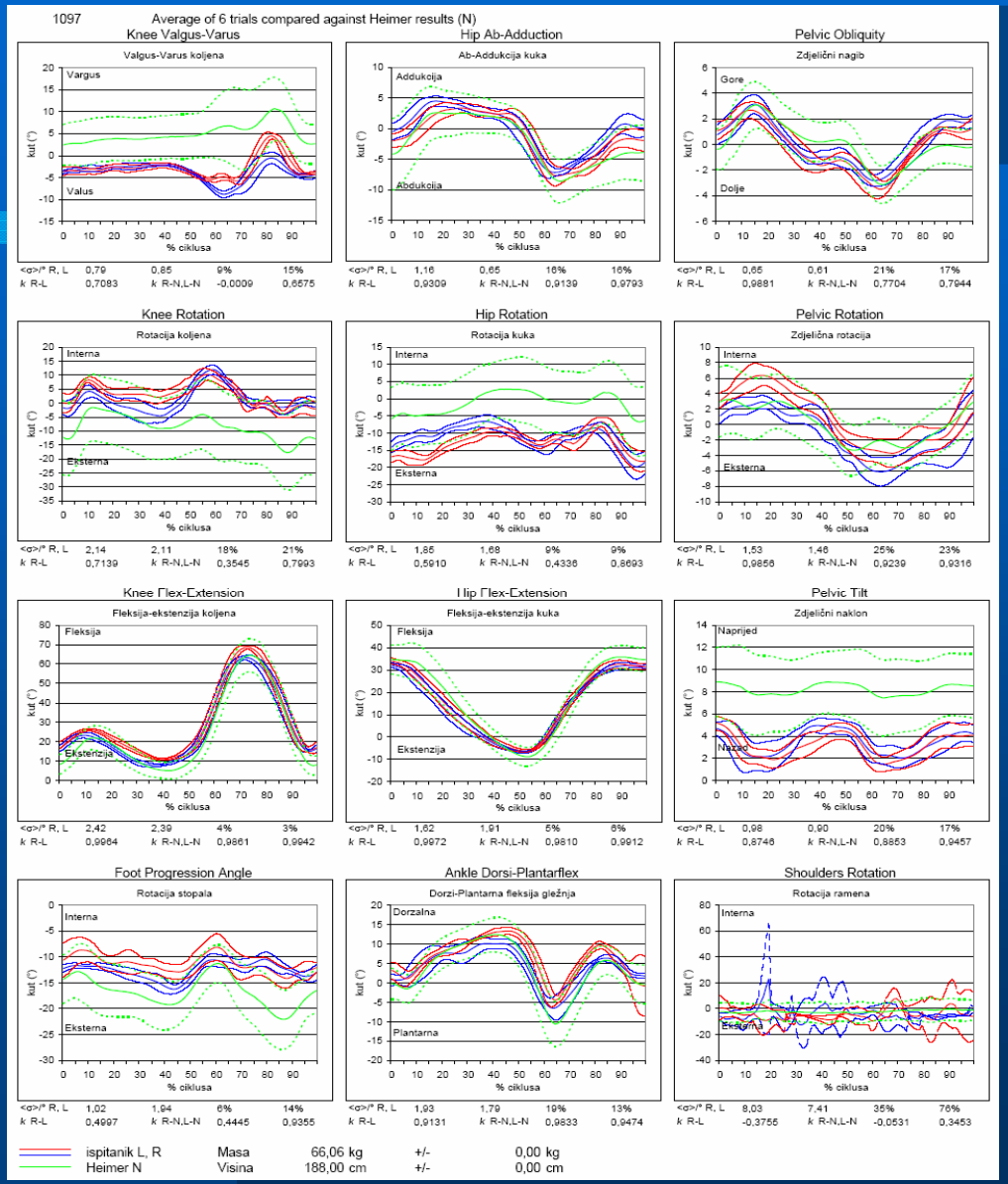










Normal gait kinematics

Legend:

Blue - right side

Red - left side

Green - average values

Subject sample:

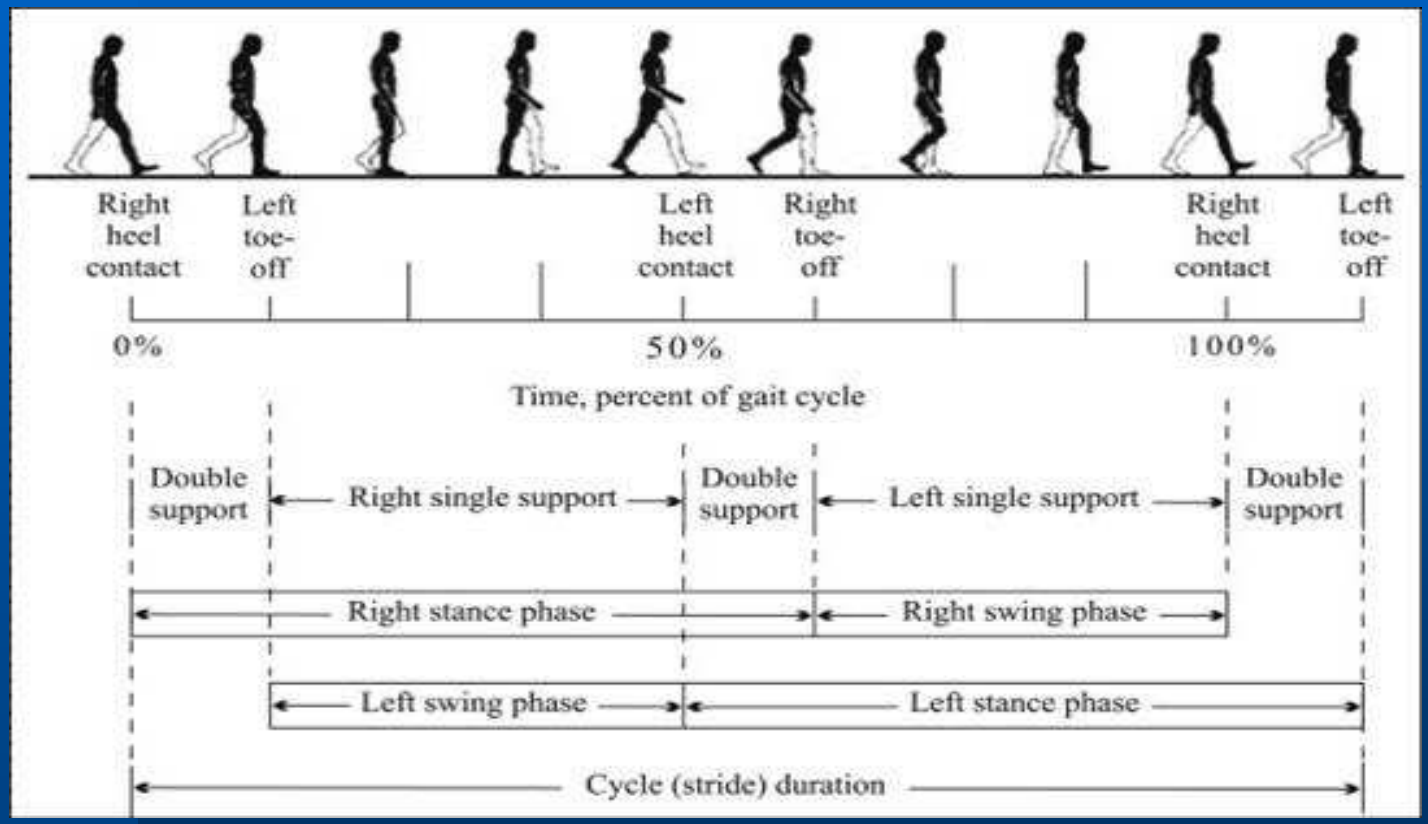
14 healthy males

age (years) 29 - 44 (37.50 ± 5.25)

mass (kg) 74 - 103 (86.40± 10.00)

height (cm) 170 - 188 (177.9 ± 5.1)

Gait cycle (Inman V.T., Ralston H.J., Todd F., 1981)



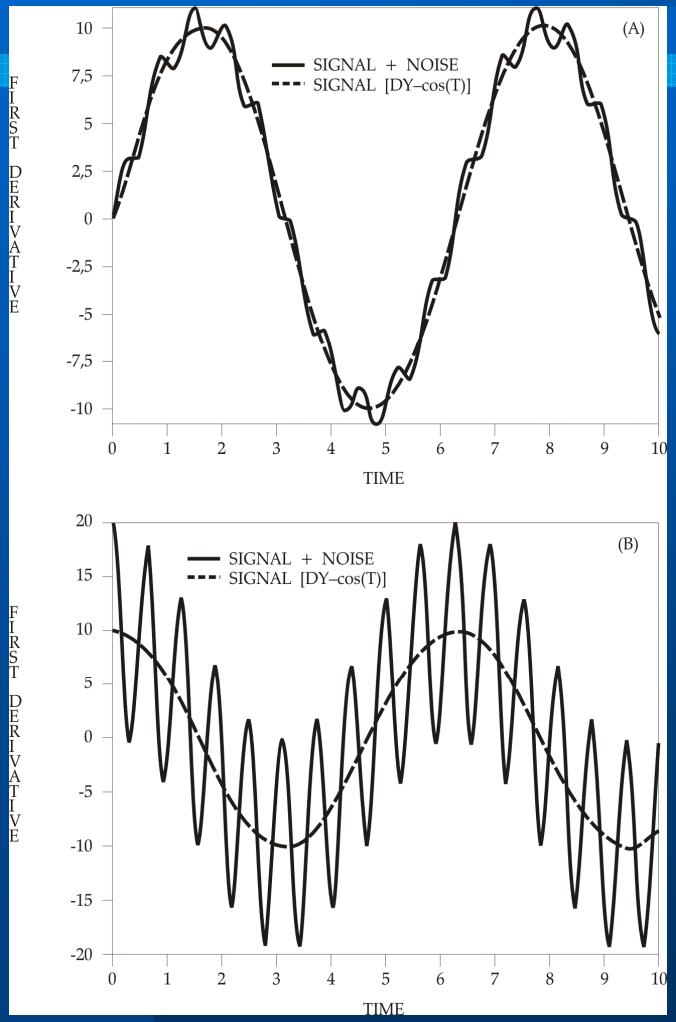
What to do with kinematic data?

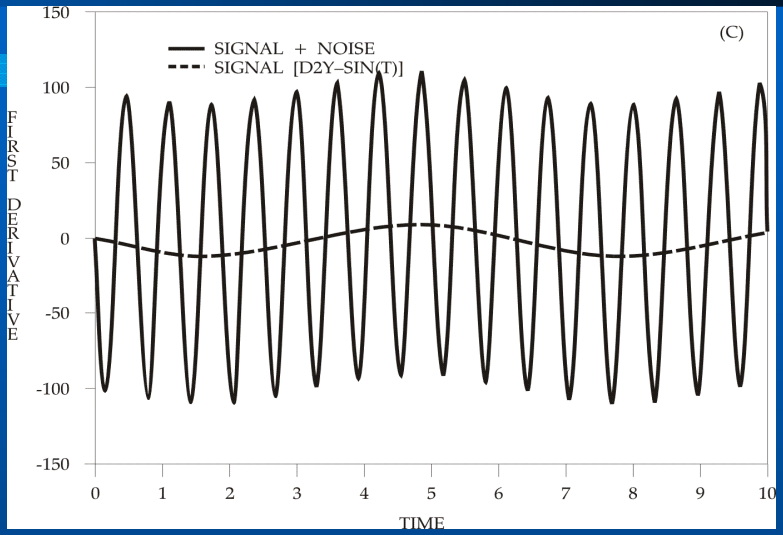
- Motion capture results with kinematic data. In biomechanics, they may be directly interpreted or, *via* inverse dynamics, used for estimation (computation) of kinetic data. To realise this task, mechanical model of the body is assumed.

Kinematic data processing: Summary

- Reconstruction of 3D marker positions (noise level below 0.1 mm in a viewing area of several m)
- Signal smoothing/interpolation
- Application of body model, calculation of anatomical values from the measured ones
- Derivative calculation (numerical differentiation) of kinematic data: Inverse dynamic approach

Problems with noise in kinematic data





Numerical differentiation increases high frequency noise components (f, f^2)

3D kinetic data: joint resultant forces and moments in lower extremities estimated by inverse dynamic approach

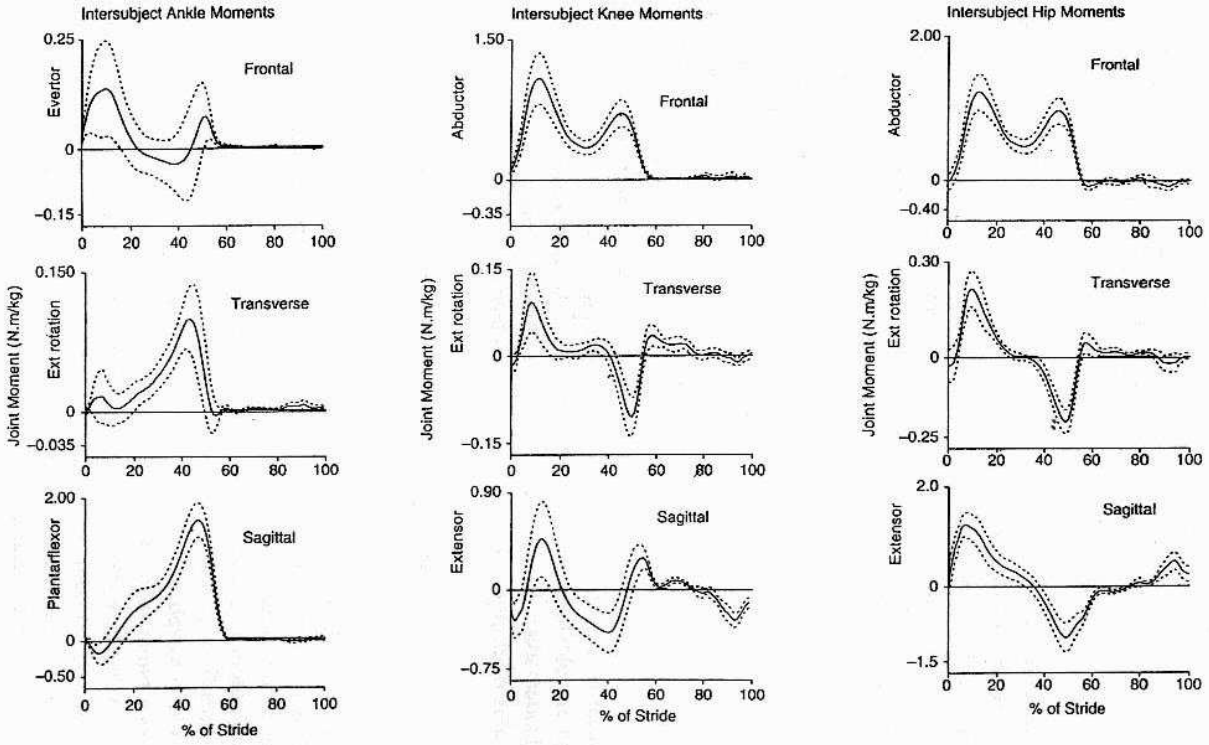


FIGURE 4.35 Numerically (mathematically) estimated moment curves in imaginary joint centers of the hip, knee, and ankle as a function of time during walking in a healthy individual: the result of an inverse dynamic approach. The measurement encompassed nine subjects, each performed five trials, while the kinetic values were calculated as "ensemble averages" of the group. (From Winter, D.A., Eng, J.J., and Ishac, M.G. 1996. *Human Motion Analysis,* G.F. Harris and P.A. Smith, Eds., New York: IEEE Press, 71–83. With permission.)

From: Winter D.A., Eng J.J., Ishac M.G. (1996)

Projects

- Neuro-muscular biomechanical diagnostics of sportive and pathological locomotions,1996-2001.
- Creating centre of excellence for locomotion study, 2002-2006.
- Computer aided neuro-muscular biomechanical analysis and diagnostics of complex movements, 2006-2007.
- Automated motion capture and expert evaluation in the study of locomotion, 2007-2012.