The spine in gait – a differentiated analysis of spinal rotary motion

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MotionLab DIERS Formetric III 4D™ analyzing system
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- Separate, aggregated DICAM parameters
- Internal visualization of the course
- Raw data for continuous measuring and visualization of the course existed, but were not exportable
Kjell Roger Heitmann, declare: I am a research & development engineer and employee of the company DIERS International GmbH. My field of activities is software development for 3D and 4D surface topography and reconstruction and modeling of the spine.

Helmut Diers, declare: I am the former CEO of the DIERS International GmbH. I am retired, the company is managed by my sons, Carsten and Christian Diers. I receive a monthly retirement fee but I don’t hold shares of the company DIERS International GmbH.

Others: None
Software adjustments and data management

- Implementation of the export tool
- Course of rotation across three gait cycles of selected vertebral bodies
- Implementation of foot pressure data as variables in the raw data of the spinal model
Transformation in a Standardized Gait Cycle

- Linear transformation of the number of observations onto a scale from 0-100
- Averaging of data from three gait cycles
- Interpolating splines are applied to smooth curve progressions
Digression: The functional model of spinal dynamics

- T7 stays orthogonal to the direction of movement and is “dynamically stabilized”
  (Gregersen & Lucas, 1967; Suppé & Bongartz, 2013)

Gregersen & Lucas, 1967
Transformation in a Standardized Gait Cycle

- T7 stays orthogonal to the direction of movement and is „dynamically stabilized“
  (Gregersen & Lucas, 1967; Suppé & Bongartz, 2013)
- This segment (T8) shows the least rotatory motion compared to above and beneath
  (Needham et al., 2016)
- Existence of a „Point of Intersection“ can be postulated at ~ T7

Needham et al., 2016
Framework Project

- “The rasterstereographic investigation of intersegmental spinal movement pattern in healthy participants according to phases of gait at different walking speeds - a prospective cross-sectional study“

- Participants:
  - 201 structurally and functionally healthy participants in 3 age groups (N=67 per group)
    - Preliminary results of n=134
    - Current focus on 5km/h walking speed and rotational results
Means within Standardized Gait Cycle (SGC)

Mean course of all segments through SGC
5 km/h (n=134)
Means within Standardized Gait Cycle (SGC)

- Most rotation at T7

Mean course of all segments through SGC
5 km/h (n=134)
Means within Standardized Gait Cycle (SGC)

- Maxima/Minima pelvis and lumbar spine occur sequentially (one after another) with similar amplitudes at beginning of stance and swing phase
Means within Standardized Gait Cycle (SGC)

- Maxima/Minima of thoracic spine occur nearly simultaneously but with very different amplitudes
Scatter plots of maxima (left, blue) and minima (right, red) within SGC

- high pelvic and lumbar individuality
Individual courses of spinal rotary motion during gait at 5 km/h within SGC
Mean courses in SGC with 5% an 95% percentiles
Individual courses of spinal rotary motion during gait at 5 km/h within SGC
Point of Intersection: not static but dynamic!

0% of SGC (rotational mean of n=134)
Limitations

- Surface topography is sufficiently investigated for static measures and therefore was found to be valid and reliable (Frerich et al., 2012; Mohokum et al., 2015; Tabard-Fougere et al., 2017)
- For dynamic measures no formal validation beyond face validity has been possible yet.
- Influence of possible soft tissue artifacts (skin displacement, muscle activity, movement of the scapula) has to be taken into account, especially during high walking speeds.
Summary

- A differentiated analysis of spinal rotary motion (trunk surface) while walking is possible by surface topography.
- Most rotation at T7
- Maxima/Minima pelvis and lumbar spine occur sequentially (one after another) with similar amplitudes
- Maxima/Minima of thoracic spine occur nearly simultaneously but with very different amplitudes
- High pelvic and lumbar individuality
- Dynamic point of intersection
Thank you for your interest

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