The Influence of Vertebral Body Geometry on Lumbar Spine Loading.

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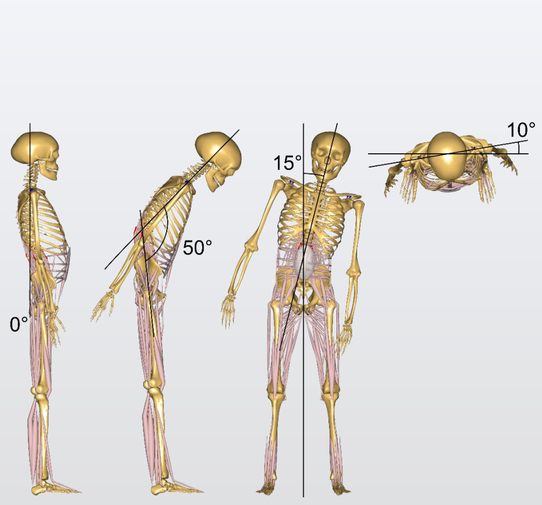
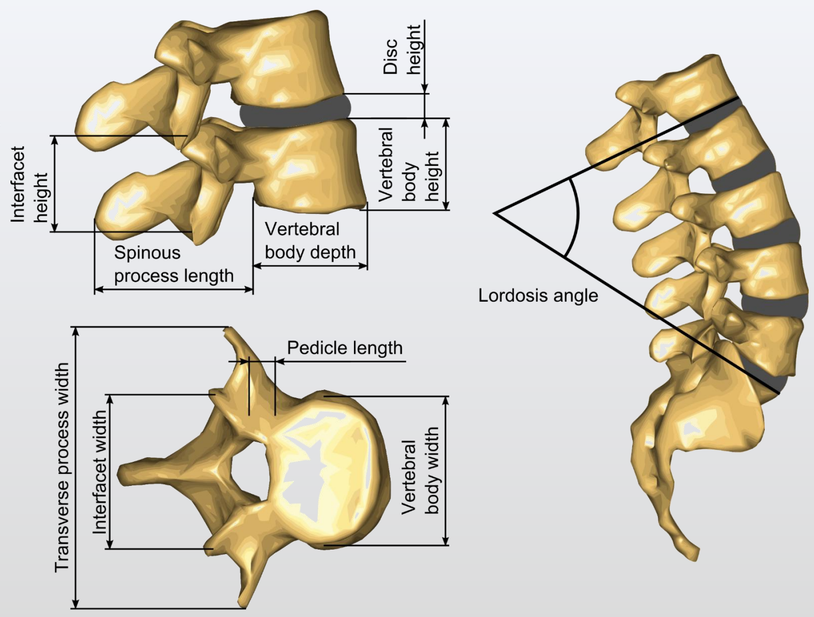
Introduction:

In former studies, simulations of musculoskeletal models (MM) have been used to study the effect of body height and body weight on lumbar segmental loads [1]. Furthermore, influences of the center of rotation of lumbar motion segments on joint, ligament and facet forces have been evaluated [2]. Those models included generic bone geometries introduced by the model of de Zee et al. [3]. However, other applications of MM, e.g. in the field of operation planning, require patient-specific bone geometries to compute realistic results but this data has an inherent inaccuracy. This study evaluates the influence of defined geometrical parameters on lumbar spine loading utilizing the AnyBody Modeling System and a parameterized musculoskeletal lumbar spine model for four different postures to determine specific lumbar dimensions with largest effect on lumbar loading.

Materials & Methods:

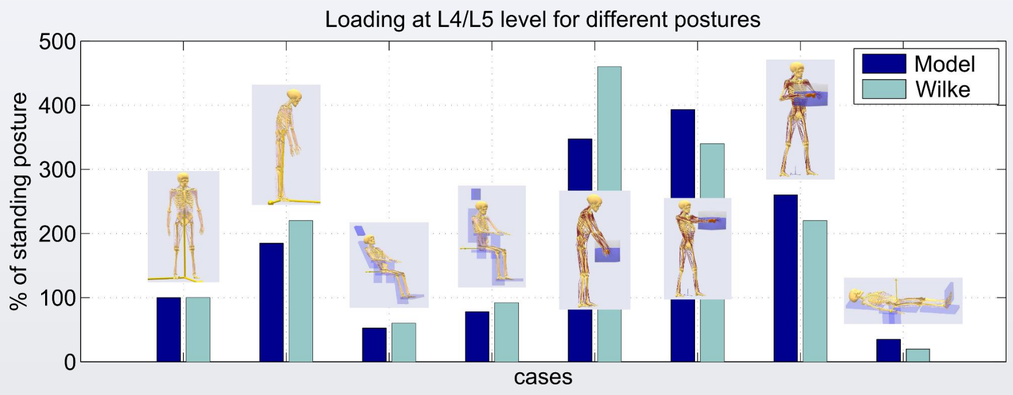
- Base model [3] was extended with subject-specific geometries from CT data of a healthy young adult and parameterized.
- The model was validated with relative changes of intradiscal pressure measurements provided by Wilke et al. [4, 5].
- A total of 987 simulations were conducted to study the influence of individual parameters and combinations of parameters in three different postures on L4/L5 joint force.





Body postures (left) and parameters of the lumbar spine (right) used in this study.

Results & Discussion:

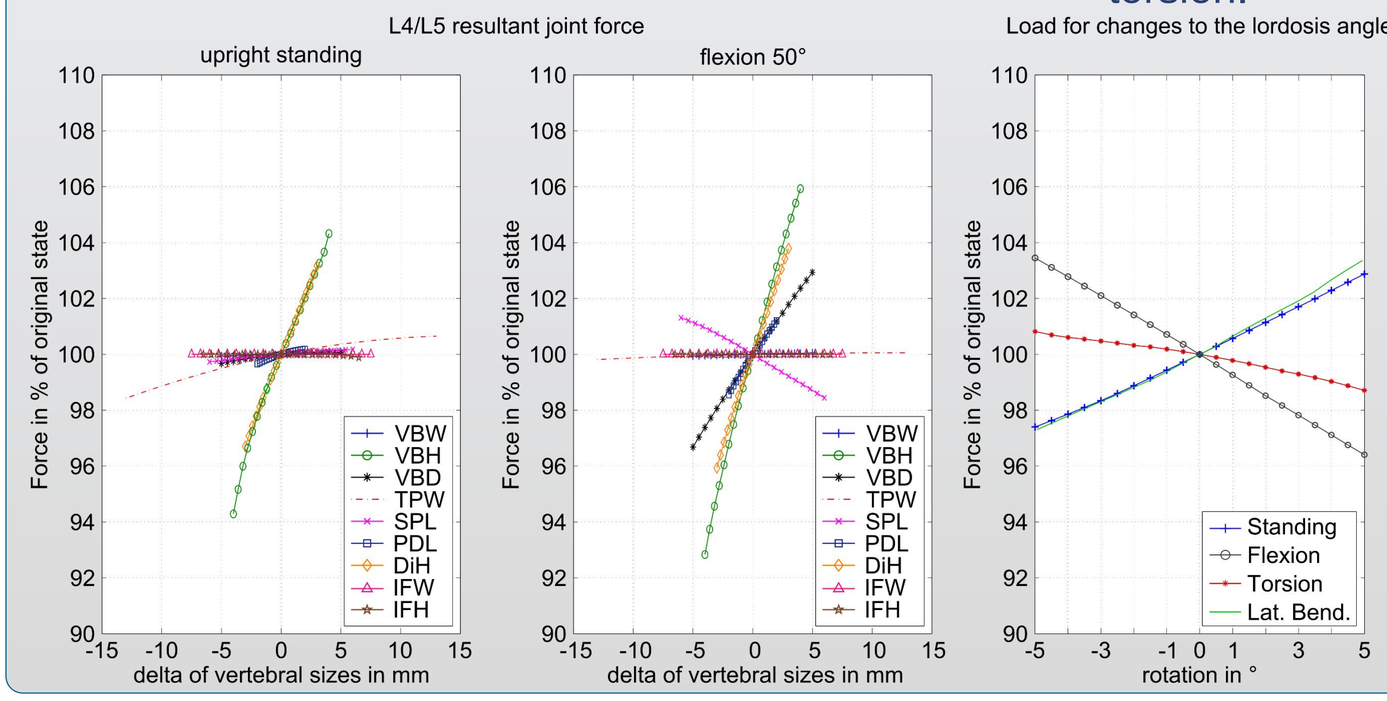


Validation:

- Model validation showed good agreement with experimental data.
- Differences for weighted and flexed postures resulted from unknown distance between weight and body and flexion angle.

Parameter study:

- Largest influences on lumbar loading resulted from changes to vertebral body height (VBH), disc height (DiH), vertebral body depth (VBD) and lordosis angle (LOR).
- Exceptions were VBD in an upright standing posture and LOR with torsion.



- Simultaneous alteration of two parameters led to a summation of the results from the single variable studies.
- Changes in loading were caused by alterations to attachment points of muscles and ligaments.

References:

[1] Han et al., Lumbar spinal loads vary with body height and weight, Med Eng Phys, 2012
[2] Han et al., Effect of centers of rotation on spinal loads and muscle forces in total disk replacement of lumbar spine, Proc Inst Mech Eng H J Eng Med, 2013
[3] de Zee et al., A generic detailed rigid-body lumbar spine model, J Biomech, 2007
[4] Wilke et al., New in vivo measurements of pressures in the intervertebral disc in daily life, Spine, 1999
[5] Wilke et al., Intradiscal pressure together with anthropometric data – a data set for the validation of models, Clin Biomech, 2001

Conclusion:

The results indicate that measuring vertebral body height, depth and disc height as well as the curvature of the lumbar spine are the most dominate geometrical parameters for musculoskeletal modeling of patient specific lumbar spine biomechanics.

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