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Impact of material and morphological parameters on the mechanical response of the lumbar spine — A finite element sensitivity study

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Abstract

Finite element models are frequently used to study lumbar spinal biomechanics. Deterministic models are used to reflect a certain configuration, including the means of geometrical and material properties, while probabilistic models account for the inherent variability in the population. Because model parameters are generally uncertain, their predictive power is frequently questioned. In the present study, we determined the sensitivities of spinal forces and motions to material parameters of intervertebral discs, vertebrae, and ligaments and to lumbar morphology. We performed 1,200 model simulations using a generic model of the human lumbar spine loaded under pure moments. Coefficients of determination and of variation were determined for all parameter and response combinations. Material properties of the vertebrae displayed the least impact on results, whereas those of the discs and morphology impacted most. The most affected results were the axial compression forces in the vertebral body and in several ligaments during flexion and the facet-joint forces during extension. Intervertebral rotations were considerably affected only when several parameters were varied simultaneously. Results can be used to decide which model parameters require careful consideration in deterministic models and which parameters might be omitted in probabilistic studies. Findings allow quantitative estimation of a model's precision.

Keywords

Finite Element Modelling; Lumbar Spine; Sensitivity Analysis; Model Validation; Coefficient of Determination

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