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BIOMECHANICAL RESPONSE OF THE LUMBOSACRAL REGION L4-S1 DURING STANDING, FLEXION, AND EXTENSION MOVEMENTS, CONSIDERING THE TRABECULAR/CORTICAL BONE RATIO IN THE VERTEBRAL BODY: A FINITE ELEMENT ANALYSIS

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Summary: The arrangement of cortical and trabecular bone in the vertebrae is critical in the distribution of forces throughout the neuroaxis. The objective of this study was to quantify the biomechanical response of the L4-S1 vertebrae by a finite element analysis (FEA). A healthy lumbosacral spine (L4-S1) model was built based on a computed tomography through an assisted design program CAD - Materialise (Belgium). The anatomic structures included in the model were the main components of the vertebrae, the facet joints (FJ) with cartilage, the ligaments, and the intervertebral disk. The novelty of this study is the explicit presence of the trabecular/cortical bone ratio (TCBM) in all the components of each vertebra. The TCBM was compared with a solid cortical bone model (SCBM). We simulated a perpendicular force applied over the upper terminal plate of the L4 vertebra of 300N, 460N and 600N, in neutral and flexion-extension moments of 5 Nm and 7.5 Nm. Both models were solved by means of FEA in Mechanical Ansys Workbench (USA). Total deformation, maximum principal stress (MPS), von-Mises stress (VM), and maximum principal strain were the main studied variables. Regarding the pars interarticularis (PI), the TCBM had greater values in all postures compared to SCBM (27,5-40,46 MPa MPS and 21,14-42,28 MPa VM vs 14,83-32,16 MPa MPS and 7,19-11,38 MPa VM L5 neutral position). The FJ also had greater values in the SCBM compared to the TCBM, with lowest values in extension moment at 7,5 Nm (2,91-5,10 MPa MPS and 2,86-3,82 MPa VM vs 1,90-2,31 MPa MPS and 2,84-4,07 MPa VM in L5S1). In both models, the structure with highest stress values was the bilateral PI, followed by the FJ. This study evidence the importance of consider the trabecular/cortical bone ratio to perform computational simulations that are representative of the biomechanical behavior of the spine. The authors acknowledge the necessity of clinical validation of the model.