The aims of the research are to characterize changes in the dynamics of the spine due to back pain therapies and total disc replacements, as well as to quantify the effects of passive and active stabilities. The research program features the analysis of a variety of models, experimental, and clinical data.

Among the components of the spine are a series of functional spinal units (FSU), each of which has 6 degrees of freedom: three translational $d$ and three rotational. Rotation tensors $R$ are traditionally parameterized by a 3-2-1 set of Euler angles (axial rotation, lateral bending & flexion/extension) [4]. Other components of the spine include muscles, tendons, and facet joints. Currently, we are working on incorporating stiffness matrices for the intervertebral joints and developing a simpler model to use with a spine testing facility. Although recent data has been used to develop the musculoskeletal model, significant validation remains to be performed.

For each FSU, conservative components of the force $F$ and moment $M$ can be represented by the gradient of a (scalar) potential function $U$ ($dU = dE_a, R$) [2]. Performing a Taylor expansion of $F_{\text{con}}$ and $M_{\text{con}}$ produces a variety of representations for Cartesian and non-Cartesian stiffness matrices [3, 4]. These concepts were applied to the spine and used to analyze total disc replacements in [4].

With the aim of characterizing the changes in stiffness due to a total disc replacement, measurements of the norm of a stiffness matrix $K$ were determined in [4]. A sample of some of our results are shown in the figure below.

In order to impose physiologic boundary conditions and muscle forces which more accurately simulate in vivo conditions, to quantify the role of the various muscle groups in the lower spine, and to calibrate our models, a novel spine testing facility has also been developed.

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Acknowledgments and Publications

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