BIOMECHANICAL MODELS FOR ESTIMATING LOADS AND INJURY RISK TO THE LUMBAR SPINE – A REVIEW

Ali Asghar Valiani
University of Guilan, Rasht. I.R.Iran

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INTRODUCTION: The use of mathematical models to estimate tissue loads and injury risk to lumbar spine, and to provide insight into its function, has increased over the last 30 years. It is important to review model features because lumbar tissue loading predicted by these models forms the cornerstone for the development of lifting guidelines. The following brief review is an attempt to analyze underlying modeling philosophies and to interpret the output of a few spine models.

One of the most widely used models for analyzing industrial tasks and predicting lumbar compression assumes the extensor tissues of the spine to be reasonably represented with a single equivalent reaction moment force generator. This most simple model implicitly assumes that a single vector representing the extensor tissues connects adjacent posterior spinous processes to generate force through a moment arm distance that is usually 5 cm from the disk center, producing an extensor moment extending the lower back.

This extensor force is necessary to counterbalance the weight of the upper body when a person is in a lifting posture and has an external load in the hands. This approach to modeling has proved to be valuable for use in industry. Injury statistics and low back compression forces estimated from a 5-cm model have been successfully used to set industrial lifting. The prediction of the size of lumbar disc compression imposed by lifting tasks tends to be quite high. If there is error in the prediction, it is in the direction of safety, and for this reason this approach is justifiable. However, some other researchers have worked beyond the intended limitations of the model and expected this simplified anatomical surface recordings of synergists, to estimate activity. Furthermore, the biological approach rarely predicts moments about the three orthogonal axes that equal those measured. Therefore, whereas full credit is given to coactivation of muscle pairs, some errors occur in moment equilibrium for the non-dominant axes.

Although both biological methods and optimization techniques are presently used to partition load-generating duties among the many tissues, future directions will demand analysis of complex dynamic motion. The EMG-based biological method is in need of basic research to better elucidate the muscle activation- force relationship. The optimization method requires development of complex algorithms that integrate mechanical and motor control variables to faithfully predict observed complex muscle patterns such as antagonist co-contraction displayed throughout the skeletal linkage. Furthermore, trial-to-trial and subject to subject variability in lifting tasks that have the same kinematics and reaction moment demands can be accommodated by biologically driven models but not by current optimization models. This article explained details of this model and review advantages and disadvantages of it.