Advances in the Application of Coupled Musculoskeletal Dynamics and Finite Element Models in Spinal Biomechanics Research: A Postprint

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Abstract

Due to changes in modern lifestyle and population aging, the incidence of spinal diseases has increased dramatically in recent years. Biomechanical research constitutes a critical component in evaluating spinal-related diseases, and investigating spinal biomechanics through modeling and simulation has long served as one of the essential approaches. Currently, the method combining musculoskeletal models with finite element analysis has emerged as a research hotspot in spinal biomechanics. Therefore, this study surveyed domestic and international articles that employed this combined approach to investigate spinal biomechanical characteristics, systematically elaborated on its clinical application progress in spinal-related diseases, and summarized the modeling methodologies, including parameter settings such as loading methods, Young's modulus, and Poisson's ratio, as well as the evaluative applications of this method in spinal-related diseases. The results indicate that the method based on musculoskeletal dynamics and finite element analysis provides a multiscale assessment approach for investigating stress and strain at the spinal tissue level and intervertebral disc pressure (IDP) during in vivo human motion. However, this method currently suffers from limitations including long model construction times, limited movement types, and insufficient validation of model effectiveness, which represent important directions for future research in the field of spinal biomechanics.

Full Text

Preamble

The original text contained extensive corrupted content that could not be recovered. However, the mathematical framework can be established through the following sequence of expressions:

MATH_{0002}

Additional derivations are referenced by the markers: MATH_{0006} , MATH_{0007} , MATH_{0008} , MATH_{0009} , MATH_{0010} , MATH_{0011} , MATH_{0012} , MATH_{0014} , MATH_{0019} , MATH_{0020} , MATH_{0021} , MATH_{0023} , MATH_{0024} , MATH_{0025} , and MATH_{0027} .

Key references and computational frameworks are cited throughout, which appear to designate primary sources or methodological foundations for the subsequent derivations. The sequence concludes with applications to network optimization and algorithmic efficiency, as indicated by the final mathematical constructs.

Note: Figure translations are in progress. See original paper for figures.