DEVELOPMENT OF A MUSCULOSKELETAL MODEL FOR ESTIMATION OF IN VIVO SPINE LOADING

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Musculoskeletal models can be used to estimate in vivo skeletal loading during functional activities related to daily life or occupational tasks. Our research group is interested in understanding injury patterns in the spine, with a particular focus on age-related vertebral fractures, the majority of which occur under unknown circumstances. The overall goals of our research program are to 1) identify the activities/mechanical mechanisms responsible for vertebral fracture, and 2) determine how individual variation in spine curvature and muscle morphology influence spine loading and risk of vertebral fracture. Prior efforts to understand the contribution of altered spine mechanics to vertebral fractures have been limited by the inability to accurately assess in vivo spine loading, especially in the thoracic region because of the anatomic complexity of the ribcage. Our laboratory previously developed a musculoskeletal model of the thoracic and lumbar spine [1]; however it was limited by the fact that it did not include the detailed anatomy of the ribcage or the muscles that support the ribs, such as the external and internal intercostals.

Therefore, the aim of the current study is to develop an anatomically detailed musculoskeletal model of the spine, including the lumbar and thoracic vertebrae, ribs, sternum, and associated musculature using OpenSim musculoskeletal modeling software, and to integrate this model with previously developed OpenSim cervical and upper extremity models. The model will allow for patient-specific estimates of spinal loading by incorporating individualized measurements of body size, spinal curvature, and muscle morphology. To validate the model, we will compare our estimates of in vivo vertebral compressive forces to in vivo measurements of intradiscal pressure that have been reported in the literature for a variety of activities. We hypothesize that force estimates from our new model will be more strongly correlated with intradiscal pressure than force estimates from our previous model. We will also compare predicted trunk muscle activation patterns to previously reported EMG measurements, and compare the new model’s predictions to those from the existing model.

Successful development of an anatomically detailed model will allow us to better understand the biomechanical etiology of vertebral fractures. The model can also be broadly applied to the study of other mechanical injuries of the spine and thorax, such as intervertebral disc herniation and rib fractures, among many others. Individualized musculoskeletal models of the spine will also be useful for estimating vertebral loading and fracture risk in astronauts during spaceflight operations and exercise countermeasures. Spinal curvature and trunk muscle morphology are altered by extended time in partial gravity environments, and these changes likely influence spine loading and risk of injury.

REFERENCES