Inverse Dynamics Based Determination of Cervical Spine Loads on Pediatric and Adult Volunteers During Low Speed Frontal Impacts

Terry Hopely, BS [1], Sriram Balasubramanian PhD [2], Tom Seacrist MS [2], Kristy Arbogast PhD [2], Matt Maltese MS [2], Eric Constans PhD [1], Jennifer Kadlowec PhD [1], Robert Sterner PhD [1]

[1] Department of Mechanical Engineering, Rowan University;
[2] Center for Injury Research and Prevention, The Children's Hospital of Philadelphia

ABSTRACT

Little is known about the biomechanical response of children to dynamic loading such as that seen in an automobile crash. Pediatric anthropomorphic test devices (ATD), the tools used to study such response, have been scaled from adult biomechanical data and do not explicitly mimic the response of an actual child. In particular, the developmental changes associated with the cervical spine may limit the accuracy of this scaling process and thus result in a pediatric ATD spine of limited biofidelity that inaccurately positions the ATD head during crash loading. The objective of this study was to use inverse dynamics methods to determine the upper and lower neck forces and moments from the average head and cervical spine trajectory of volunteer subjects in a low speed frontal impact. This data would provide insight into the biomechanical response of the cervical spine of children, particularly the forces generated within the neck. A total of 40 male subjects in four age groups (6-8 years, 9-12 years, 13-15 years, 18-40 years) were tested. Volunteers were restrained in a custom fit three point restraint system and subjected to a 3.1 g frontal impact in a purpose built crash sled. For the purpose of this study, the three-dimensional kinematics data were obtained using reflective spherical markers attached to anatomical landmarks tracked using a 3D motion capture system and the head angular velocity was measured using an angular rate sensor mounted to a bite plate. Forces and moments within the cervical spine were then calculated from the kinematics data using an inverse dynamics approach. These data can then be used to develop a computer model of the cervical spine for crash simulations, as well as recommendations for a physical model for more accurate pediatric ATDs.