Methods for Assessing Passive Cervical Spine Flexion in Human Volunteers

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ABSTRACT

Head trauma is the most frequent injury sustained by children in car crashes, and the neck plays a key role in governing head kinematics during the crash. Pediatric anthropomorphic test devices (ATDs) are useful for the assessment of head injury in frontal car crashes, yet the pediatric ATD neck is a size-scaled model of the adult ATD neck, with no consideration for the tissue and morphological changes during human development. Thus, the primary objective of this study is to compare the passive cervical spine flexion of children in specific age groups (6-8, 9-12, 13-15 years) with adults (18-25 years). Subjects with restrained torsos and lower extremities were exposed to a 1G inertial load in the posterior-to-anterior direction, such that the head-neck complex flexed when the subject relaxed their neck musculature. Electromyography with audio feedback was used to coach the subjects to relax their neck musculature. A multicamera 3-D target tracking system was employed to capture the motion of specific landmarks on the head (Frankfort Plane), thoracic spine (T1 and T4), and torso (acromion processes, manubrium, and xyphoid process). The maximum neck flexion angle with muscles relaxed was calculated for the child and adult volunteers, subjects were grouped by age and the students t-test was conducted for age group comparison. The mean neck flexion was 33.8 degrees (standard deviation SD=4.43) for the 9-12 year olds (n=4, avg age=10), while the mean neck flexion was 35.54 degrees (SD=16.9) for the 18-25 year olds (n=4, avg age=22), though results were not statistically significant. Future research with these methods will help determine if the tissue and morphological changes in the cervical spine during human development lead to functional differences in the passive flexion of the neck. These data are also useful for the validation of finite element and multibody models of the human pediatric and adult cervical spine.