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Kinetics of the cervical spine in pediatric and adult volunteers during low speed frontal impacts

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Abstract— Previous research has quantified differences in head and spinal kinematics between children and adults restrained in an automotive-like configuration subjected to low speed dynamic loading. The forces and moments that the cervical spine imposes on the head contribute directly to these age-based kinematic variations. To provide further explanation of the kinematic results, this study compared the upper neck kinetics - including the relative contribution of shear and tension as well as flexion moment - between children (n=20, 6-14 yr) and adults (n=10, 18–30 yr) during low-speed (<4 g, 2.5 m/s) frontal sled tests. The subjects were restrained by a lap and shoulder belt and photo-reflective targets were attached to skeletal landmarks on the head, spine, shoulders, sternum, and legs. A 3D infrared tracking system quantified the position of the targets. Shear force (Fx), axial force (Fz), bending moment (My), and head angular acceleration (??head) were computed using inverse dynamics. The method was validated against ATD measured loads. Peak Fz and ??head significantly decreased with increasing age while My significantly increased with increasing age. Fx significantly increased with age when age was considered as a univariate variable; however when variations in head-to-neck girth ratio and change in velocity were accounted for, this difference as a function of age was not significant. These results provide insight into the relationship between age-based differences in head kinematics and the kinetics of the cervical spine. Such information is valuable for pediatric cervical spine models and when scaling adult-based upper cervical spine tolerance and injury metrics to children.

Index Terms— Kinetics; Inverse dynamics; Pediatrics; ATD

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