Spinal Kinematics in Children Exposed to Low Speed Frontal Acceleration

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BACKGROUND

Head injuries are the most common injuries sustained by children in motor vehicle crashes. Prevention of these injuries through advances in vehicles and restraint systems requires a biofidelic anthropomorphic test device (ATD). Pediatric ATDs are primarily developed from scaling down adult volunteer and cadaver impact test data. Limited experimental data exist on pediatric head and neck kinematics in order to evaluate the biofidelity of the ATDs. The aim of the current study is to evaluate the head and spinal kinematics of pediatric and adult volunteers in response to a dynamic low-speed frontal crash. The data will be used to to develop mathematical models and to provide empirically derived scaling factors between children and adults

METHODS

- Safe limits on a volunteer crash pulse (Figure 1) were defined from measuring the impact of a bumper car in an amusement park setting

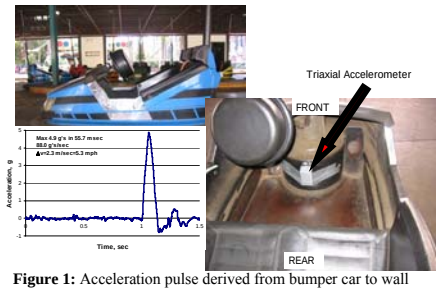

Figure 1: Acceleration pulse derived from bumper car to wall impact

- A pneumatically actuated – hydraulically controlled sled (Figure 2) was used to provide the acceleration pulse to the volunteer

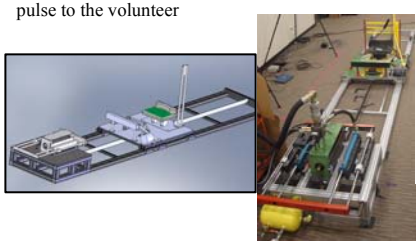

Figure 2: Low speed volunteer sled

METHODS

- Pilot testing was performed on a 14 year old male subject
- Spherical reflective markers were placed on head, neck, torso, upper and lower extremities and tracked using a 3D motion analysis system
- An angular rate sensor was mounted to a bite plate of an athletic mouth guard to measure head rotational velocity
- Acceleration pulse was measured using a sled-mounted accelerometer
- Subject was aware of impending impact and a total of 6 runs were conducted

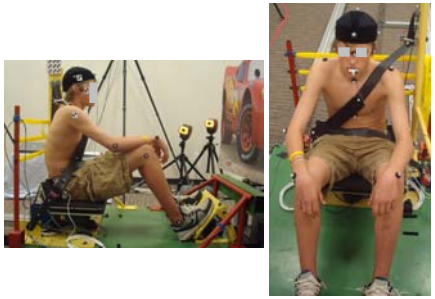

Figure 3: Pilot testing with 14 year old male subject using a three point restraint

RESULTS

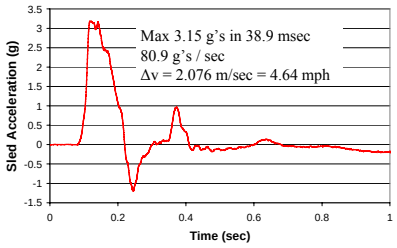

Figure 4: Sled acceleration pulse measured by sled-mounted accelerometer. The raw data was filtered using CFC 60 according to SAE J211 standard

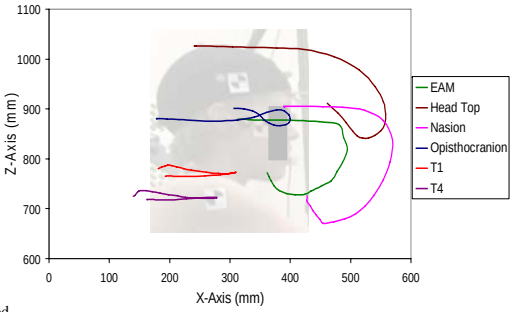

Figure 5: Motion analysis marker trajectories along the sagittal plane superimposed over an image of the subject

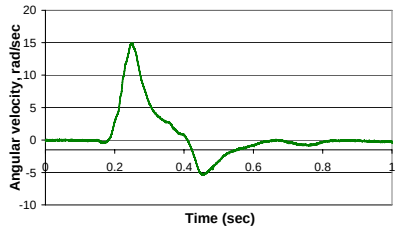

Figure 6: Head angular velocity measured by the angular rate sensor mounted to bite plate of athletic mouth guard. The raw data was filtered using CFC 1000 according to SAE J211 standards

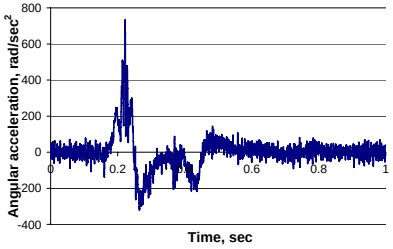

Figure 7: Head angular acceleration computed from head angular velocity. The raw data was filtered using CFC 1000 according to SAE J211 standards

DISCUSSION

- This study provides the first measure of pediatric kinematics in a dynamic frontal crash environment
- The head angular accelerations are considerably lower than the injury threshold values (Figure 8)

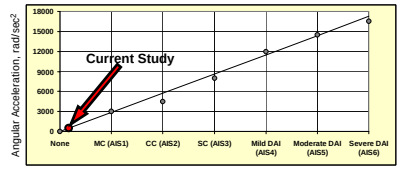

Figure 8: Comparison of head angular acceleration from current study to Injury threshold values from Gennarelli et al., 2003

FUTURE WORK

- Low speed volunteer testing of male subjects ages 6-40 years will be performed
- Compare trajectories of Hybrid III adult and pediatric ATD's to volunteer data
- The head and spine kinematics obtained from this study will be used to develop scaling factors between adults and children
- This data will be used as part of the validation dataset for a computational model of the child that could further be used to establish pediatric biofidelity corridors

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Reference: Gennarelli T.A., Pintar F.A., Yoganandan N (2003) Biomechanical tolerances for diffuse injury and a hypothesis for genotypic variability in response to trauma. Proceedings of AAAM Conf. American Assoc for Automotive Medicine, Chicago 624–628