Evaluation of Pediatric ATD Biofidelity as Compared to Child Volunteers in Low-Speed Far-Side Oblique and Lateral Impacts

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Abstract

Traumatic brain injuries are the most common type of serious injury sustained by children in motor vehicle crashes. Anthropomorphic test devices (ATDs) are used to mitigate these injuries by evaluating the preventative efforts in vehicles. However, there is limited data that correlates the biofidelity of these pediatric ATDs to living children. Previously, we demonstrated that the Hybrid III and Q-series 6 and 10-year-old ATDs exhibit significant differences in head, cervical spine, and thoracic spine kinematics, reaction loads, and upper neck kinetics when compared to pediatric volunteers in low-speed frontal impacts. . While the tests provided important information for frontal impact countermeasure design, motor vehicle crashes do not consist of more than frontal impacts. In fact, side impacts represent an increased fatality rate compared to frontal impacts. Consequently, there is a need to evaluate the biofidelity of the ATDs in side impacts to aid in the development of side impact safety systems. .

To evaluate the biofidelity of the ATDs in side and far-side impacts, low-speed (2g) far-side oblique and lateral sled tests were conducted using the Hybrid III and Q-series 6 and 10-year-old ATDs. The ATDs were restrained via a standard 3-point belt. A 3-D target tracking system was used to collected kinematic data. Photo-reflective targets were attached to areas corresponding to anatomical landmarks on the head, spine, shoulders, and sternum. Data collected from 6 and 10-year-old pediatric ATDs were compared to previously collected 6-8 year old (n=5) and 9-11 year old (n=5) pediatric volunteer tests, respectively. Data were processed through a custom designed MATLAB program. Quantitative metrics that were collected include maximum excursion, reaction loads, shoulder belt slip-out, and change in belt-to-torso angle.

Results indicated that ATDs overestimated downward excursion (ΔZ) of the head top compared to pediatric volunteers in both oblique (HIII6 = -146 mm; Q6 = -68 mm; Child 6-8 = -39 ± 6 mm | HIII10 = -41 mm; Q10 = -86 mm; Child 9-11 = -24 ± 5 mm) and lateral (HIII6 = -116 mm; Q6 = -88 mm; Child 6-8 = -45 ± 5 mm | HIII10 = -65 mm; Q10 = -64 mm; Child 9-11 = -41 ± 8 mm) impacts. This difference in excursions can be attributed to a more rigid thoracic spine when compared to pediatric children. The ATDs have more arc-shaped thorax trajectories when compared to pediatric volunteers who have had flatter trajectories. These kinematics lead to increased shoulder belt slip-out for the ATDs in oblique impacts, with slip-out present in 90% of ATD trials vs. only 36% of volunteer trials. This may be attributed to the lack of an articulating ATD shoulder. In contrast, increased shoulder belt slip-out was observed for the volunteers in lateral impacts (ATDs = 60%; Volunteer = 78%). It is also interesting to note that the HIII6 ATD performed differently than the Q6 ATD.

These results identify areas of potential improvement in pediatric ATD design including a more flexible thoracic spine and a more biofidelic shoulder joint to improve belt-to-torso interaction. Improvements to these areas will help aid the development of future pediatric motor vehicle safety systems.