Comparison of Anthropomorphic Test Dummies with a Pediatric Cadaver Restrained by a Three-Point Belt in Frontal Sled Tests

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ABSTRACT

Validation data for assessing dummy child biofidelity are limited, especially with regard to whole-body kinematics. Therefore, the goal of this study was to assess the kinematic biofidelity of current child dummies relative to results obtained from analysis of a child cadaver sled test. The baseline data were obtained from an unpublished test performed with a 13 year-old pediatric cadaver restrained by a three-point belt. The cadaver test conditions were reconstructed using two dummies with anthropometry closest to that of the cadaver, the HIII 10-year old and HIII 5th female (~size of 12-year old) dummies. In addition to photo targets, the cadaver was instrumented with head accelerometers. The test dummies were equipped with triaxial accelerometers in the head, chest, and pelvis; load cells in the upper neck, lower neck, and lumbar region; and a chest deflection sensor. Due to anthropometric differences between the dummies and the child cadaver, geometric scaling was performed based on the seated height and material properties. To validate the scaling, comparisons among dummy sizes were performed as a first step before comparing to the child cadaver data. Kinematic evaluations of head, hip, and knee trajectories were obtained from film analysis. Accelerations of the head, shoulder and lap belt loads were measured and compared among the scaled dummy and child cadaver data. While this study shows that the HIII 10-year old and HIII 5th female reasonably approximate the shoulder belt force, the resultant head acceleration, and the maximum head excursion of a 13-year old pediatric cadaver, differences in dummy kinematics were identified that resulted in differences in the trajectories and the peak head acceleration following head strike to the chest. Some of these differences in dummy kinematics were attributed to nonbiofidelic motion of the rigid thoracic spine. Specifically, the dummies exhibited extensive bending at the junction of the cervical and thoracic spine that resulted in modified head kinematics. In addition to new cadaver data, the paper provides insight into the applicability of geometric scaling for dummy evaluation and suggestions for improved dummy biofidelity.