Hybrid III 6YO ATD Head and Neck Responses and Repeatability with Varied Neck Tension in Frontal Impacts

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Background: Occupant safety in motor vehicle collisions (MVCs) is typically assessed via humanlike Anthropometric Testing Devices (ATDs) subject to simulated impacts. Pediatric injury in MVCs poses challenges to quantification and prediction, due to sparsity of pediatric biomechanical data for ATD design. Current pediatric ATDs, including the Hybrid III 6-year-old (HIII 6YO), are designed according to scaled adult biomechanical responses established for ATDs. The HIII 6YO contains a molded neck and center cable, calibrated by applying a torque (2.0 ± 0.2 in-lbs); after neck calibration, the HIII 6YO can be subject to multiple sled tests. However, head and neck responses of the HIII 6YO may vary by prolonged testing and differences in initial neck cable tension.

Purpose: No studies have investigated neck cable tension on the HIII 6YO head kinematics and quantified the number of consistently repeatable trials before head and neck responses deviate. Therefore, the objectives of this study are to investigate repeatability of the HIII 6YO head kinematics by observing how many tests can be run before head responses are altered in frontal impact scenarios using a well-controlled mini-sled system and characterize the influence of the neck cable tension on repeatability.

Methods: The HIII 6YO head and neck assembly was fixed to the mini-sled, and frontal impacts were simulated by impacting the sled with a pneumatic ram. The resulting nominal sled velocity was 14 km/h, matching the child ATD T1 acceleration in FMVSS 213 sled tests. The responses were quantified by a six-axis load cell mounted at the base of the neck to measure loads during the events, and three accelerometers and three angular rate sensors in the HIII 6YO head to measure 3D kinematics. Initial neck cable tension, calibrated by applying a torque of 2.0 in-lbs, was altered by adjusting torque on the jam nut at the base of the center cable. Repeated trials were conducted to determine the maximum number of tests run before the responses showed significant deviation. The data from each impact was filtered according to SAE J211 standards and processed in MATLAB (MathWorks, Natick, MA), and the coefficient of variation (CV) values were calculated for all trials.

Results and current conclusions: The CV value was calculated for the first 27 baseline tests, with neck tension 2.0 in-lbs. Forces in the x direction remained within CV = 2.8% and forces in the z direction within CV = 4.5%. Moments in the y direction remained within CV = 4.9%. Peak acceleration values for x and z remained within CV = 3.2% and CV = 4.3%, respectively. Consistent repeatability was observed, and all CV values were less than the target 5%; thus, no deviation was observed and repeatability was confirmed when neck tension was 2.0 in-lb. Repeatability of head and neck responses with varied neck cable tension will be included in the final analysis.