Comparison of Upper Neck Loads of the Large Omni-Directional Child ATD to Pediatric Volunteers in Low-Speed Sled Tests

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Abstract

Motor vehicle crashes are the leading cause of pediatric mortality and injury, with head injuries as the most common. To better mitigate these injuries, pediatric ATDs must mimic pediatric motion and internal forces as well as accurately predict injury potential during a crash. Previous studies of pediatric ATDs have shown an overestimation of upper neck loads and injury risk due to limited biofidelity of the ATDs. Recently, a large omni-directional child ATD has been developed in an effort to improve biofidelity through a more realistic shoulder construction, softer cervicothoracic junction, and a multi-segmented, more flexible thoracic spine compared to the Hybrid III 10. This study sought to evaluate the influence of these modifications on LODC neck loading by comparing its response to previously collected child volunteer data in low-speed frontal sled tests.

Low-speed (<4g) frontal sled tests were conducted with the LODC. The LODC was restrained using a 3-point belt. Photo-reflective targets were placed on important anatomic landmarks, such as head top, and were captured using a 3D near infrared tracking system. Variables considered were shear force (F_x), axial force (F_z), and bending moment (M_y) about the upper neck. These parameters were calculated using standard equations of motion. This data is compared to previous data from 9-11 year old pediatric volunteers, the Hybrid III 10, and the Q10 that were tested utilizing similar methods.

The LODC significantly underestimated mean shear force (LODC = -98 N; HIII 10 = -138 N; Q10 = -151 N; Volunteers = -132 N) compared to the HIII 10, Q 10 and volunteers. The LODC also underestimated axial force compared to the volunteers (LODC = 41 N; Volunteers = 67 N) yet was closer to volunteer levels than both the HIII 10 and Q 10 (HIII 10 = 15 N; Q 10 = 13 N). These differences are likely due to the LODC's greater flexibility, especially in the thoracic region of the spine. A shift in force distribution from shear to axial is displayed, likely due to greater head rotation displayed by the LODC than the HII 10 or Q 10 ATDs. These data provide valuable information on the biofidelity of the recently developed LODC.