Biofidelity Assessment of a GHBMC M50 in Rear-facing Seating Configuration during a High-Speed Frontal Impact

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Background

Future vehicles equipped with Automated Driving Systems are likely to utilize nontraditional seating configurations. One potential seating configuration is rear-facing for the front seat occupants. A recent PMHS study generated biomechanical corridors in two different recline angles in 56 km/h rear-facing frontal sled tests. Finite element (FE) human body models (HBMs) are being more frequently used to supplement post mortem human subjects (PMHS) studies and to assess biomechanical responses and potential injury risk. However, HBMs have not yet been validated in nontraditional seating scenarios (e.g., high-speed rear-facing frontal impacts) to realize if they exhibit human-like characteristics under such loading conditions.

Objective

The objective of this study is to evaluate the biofidelity of the Global Human Body Models Consortium (GHBMC) M50-O v5.1.1 occupant model seated in a rear-facing seat with a 25 degree seatback angle in a 56 km/h frontal impact.

Methodology

An OEM seat with an integrated seat belt system (ABTS) was used for the FE simulations, and boundary conditions were defined to replicate the PMHS experiments. A rigid seatback structure attached to the sled was modeled to prevent the seat from reclining during the impact, and the head restraint (HR) was attached to this structure using tied contact. The GHBMC was seated using a gravity simulation, and its final position was adjusted based on the average anatomical landmarks obtained from the PMHS experiments. The continuity between the shoulder and lap belts restraining the GHBMC was established using a slipring. A retractor-pretensioner mechanism was used to set up the static belt tensions. The simulation was run using the FE solver LS-DYNA. Whole body kinematics of the GHBMC were quantified using constrained interpolated nodes at locations corresponding to PMHS instrumentation, in their respective moving local coordinate systems. Forces in the seatback, HR, and seatbelts from the same instrumentation locations as in the PMHS tests were quantified as the sum of nodal forces from cross sectional interfaces. Biofidelity of the GHBMC responses was evaluated using the NHTSA Biofidelity Ranking System (BRS).

Results and Current Conclusions

The GHBMC M50-O ramped up the seatback more than the PMHS resulting in BRS values of 1.93, 2.70 and 2.09 for head, T1 and pelvis z-displacements respectively. Spinal kinematics observed in the GHBMC were similar to PMHS, with T1, T4 and T8 rotating forward, while T12 and pelvis rotated rearward. The T12 and pelvis angular velocities measured from GHBMC were at least 30% higher than the PMHS. Unlike the PMHS, the upward movement of abdominal contents in the GHBMC was minimal and subsequent chest expansion was not observed, resulting in a BRS value of 2.00. The total contact energy of the GHBMC going into the rigidized frame, obtained by summing seatback and head restraint loads, was similar to that observed in the PMHS tests (BRS=1.14). Another key observation was the forward rotation of the head of the GHBMC upon contact with HR, unlike the PMHS, possibly due to different head-HR positioning due to seated height differences between the GHBMC and PMHS. Although the GHBMC did not exhibit PMHS like responses throughout, the results are encouraging for potential use in the given condition with improvements to the model.