Biofidelity Evaluation of GHBMC M50-O, GHBMC M50-OS in near-side oblique frontal impact sled test

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Historically, occupant safety research has focused on full frontal impacts to define occupant response, assess injury risk, and develop countermeasures for occupant protection. Recently, research efforts have focused on oblique frontal collisions to better understand the occupant response and countermeasure efficacy for some of the most frequent real-world crash modes. Human body models (HBM) offer some promising advantages as advanced injury prediction tools to investigate the biomechanical response of the human body in this crash condition. The goal of this study was to assess the biofidelity response of the Global Human Body Model Consortium (GHMBC) 50th percentile male occupant models for near-side oblique crash conditions. Specifically, the models used in this study are GHBMC M50-O and GHBMC M50-OS which have been widely used to investigate the biomechanics in vehicle impact. Biofidelity evaluation was performed by comparing the HBM responses to PMHS sled tests performed at the University of Virginia (UVA). Biofidelity targets consisted of the 3D trajectories using VICON (head, T1, T8, L2, pelvis and shoulders), thoracic deformation, and restraint forces measured using three male PMHS with anthropometry approximate to a 50th percentile male. Sled test conditions are based on the UVA Gold Standard III setup, which simulates a 30 kph, 30 degree near-side oblique frontal collision. A quantitative assessment of model response was performed through metrics obtained with the CORA package.

M50-OS and M50-O were able to reproduce the predominant occupant motions as well as the predominant thoracic deformation observed in the PMHS. GHBMC M50-O was able to predict rib fracture as well as clavicle fracture which both were reported on PMHS. However, GHBMC M50-O was not able to reproduce the severity of chest damage observed for two of the three subjects. In addition, GHBMC M50-O model cannot reproduce the cervical damage observed for two of the three PMHS subjects. Finally, unlike GHBMC M50-O, the GHBMC M50-OS was not intended to predict crash induced injuries based on tissue-level criterion, but virtual instrumentation such as accelerometers or deflection sensors are mean to be the proxy.

While both models compared favorably to the PMHS responses, both models also showed some discrepancies compared to the PMHS response, including less spine lateral displacement between the HBMs and the PMHS. The results also suggest that the neck muscles of the HBMs might be stiffer than the average response of a PMHS. A parametric analysis on pre-test posture and restraint friction showed that these factors altered model kinematics but did not improve the overall biofidelity of the models. It is unclear to what extent model differences are caused by extrinsic factors (friction), where exact values in the experiment are unknown, and by model intrinsic factors (spine stiffness). Additional evaluation of the spine of M50-OS and M50-O from the component level (local) to the structure level (global) would help determine the correct model responses. Overall, both HBMs have been determined to be biofidelic in this case and will be valuable tools for the development of vehicle safety devices.