Preliminary Thoracic Biofidelity Evaluation for GHBMC, THUMS, and VIVA+ Midsize Female HBMs Using Female-Specific Biofidelity Corridors

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Introduction:

Thoracic injuries are common for belted female occupants in frontal motor vehicle collisions. Computational human body models (HBMs) are used to better understand thoracic injuries and improve safety systems by simulating human occupants in various impact scenarios. Typically, female HBM frontal thoracic response is validated using a simplified hub impact. However, the thoracic responses of midsize female HBMs have yet to be compared to biofidelity corridors from midsize female post-mortem human subjects (PMHS) due to limited availability of female PMHS data.

Objective:

The objectives of this study were to generate midsize female thoracic biofidelity corridors from PMHS frontal hub impact tests and to evaluate the thoracic biofidelity of three midsize female HBMs.

Methodology:

Midsize female PMHS (n=3) were positioned upright on a rigid seat with arms and legs supported and were impacted at mid-sternum with a 14 kg cylindrical impactor at 4.3 m/s. External thoracic deflection was defined as the relative difference in horizontal displacement between the impactor and the spine using a linear potentiometer on the impactor and motion block at the T8 level. Deflection is presented as a normalized value (%) relative to initial chest depth. A load cell installed behind the impactor face was inertially compensated to calculate the impact force applied to the PMHS. These experiments were replicated in a finite element (FE) environment using the LS-DYNA solver and three midsize female HBMs: the Global Human Body Models Consortium (GHBMC) F50-O v6.0.3, Total Human Model for Safety (THUMS) AF50 v7.1, and VIVA+ 50F v1.1.1. HBMs were positioned and impacted the same as the PMHS using a rigid impactor model. Impact force was quantified using the contact force between each HBM and the impactor, and nodal outputs were used to obtain displacements of the impactor and spine. The force versus deflection (FD) responses of the HBMs were compared to a 1 standard deviation (SD) corridor from the PMHS experiments for biofidelity evaluation. Average NHTSA Biofidelity Ranking System (BRS) scores were calculated for HBM percent deflection versus time (DT) and force versus time (FT) responses.

Results:

PMHS FD response was very consistent between subjects, with an average peak deflection of 29.4±1.8% and peak force of 1363±146 N. FD response varied greatly between HBMs. The GHBMC and VIVA+ peak deflections were similar to the PMHS, while peak deflection was lower for the THUMS. The shape of the VIVA+ FD response was most similar to the PMHS corridor. BRS scores indicated the HBMs differed from the PMHS response by at least 1.5 SDs on average. However, BRS scores were inflated due to low variation in response between PMHS. The GHBMC and VIVA+ both had BRS scores less than

2.0, while the THUMS BRS score exceeded 3.0, suggesting the GHBMC and VIVA+ were more biofidelic.

Conclusions:

This study provides a preliminary evaluation of thoracic biofidelity for the GHBMC, THUMS, and VIVA+ midsize female HBMs in a frontal hub impact scenario. This study highlights the importance of generating more PMHS biomechanical data and utilizing female PMHS data to improve female HBMs.

Insert one figure or table to support your work (optional):