Preliminary Impact and Injury Response of Varied Anthropometry PMHS in Frontal Sled Tests

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Introduction: Robust restraint system design requires effectiveness across varied anthropometries. Biofidelity reference data sets of post-mortem human surrogates (PMHS), a necessary component of informing and assessing restraint system design, exist for the mid-size male and small female, but there is limited research for other anthropometries such as the mid-size female and obese populations.

Objective: The goal of this study was to evaluate the kinematic and injury response of mid-size female, elderly mid-size female, obese female, and obese male PMHS in upright frontal impacts in a simplified restraint environment which isolated thoracic response and restraint by the shoulder belt.

Methodology: The test condition in this study was a full-frontal 30 kph impact. The test fixture consisted of a rigid seat, knee bolster, foot pan, a custom (non-production) shoulder belt force limiter, and separate shoulder and lap belts. The lap belt was rigidly attached at the anchor locations, and the shoulder belt was attached to a force limiter designed to deliver a nominal 3 kN force limit. PMHS were instrumented with six-degree-of-freedom acceleration and angular rate packages and rigid 3D motion tracking arrays attached to the head, T1, T8, L2, and the pelvis, as well as the sternum and bilateral 4^{th} and 8^{th} ribs. Strain gauges were also installed on the 4^{th} and 8^{th} ribs bilaterally. PMHS positioning targets were defined to match previous tests of mid-sized male PMHS in the same condition, prioritizing H-Point location, femur angle, and torso posture. Twelve tests are planned to be completed with PMHS of varied anthropometries: three per occupant type (mid-size female, elderly mid-size female, obese female, and obese male). Spine motions and chest deflections were calculated from the attached 3D motion tracking arrays.

Results: The restraint environment limited the movement of the lower extremities, isolating the thoracic response. Preliminary spine motion and chest deflection results will be included. Injuries observed in post-test dissections will also be included. Six tests were completed in spring 2025 and six tests are currently in progress in winter 2026. In the first seven tests, force limiter payout, shoulder belt lengths, and positioning varied by occupant type. Force limiter payout ranged from 38 to 210 mm with peak shoulder belt force values between 2.8 and 4.4 kN. Differences in soft tissue distribution (including the hips, abdomen, and breasts) affected the pre-test path of the shoulder belt on the thorax and the subsequent motion of the shoulder belt relative to the thorax during the test. Rib fractures were observed across all four occupant types ranging from two to 13 fractures.

Conclusions: Occupant anthropometry affected the impact and injury response of the PMHS in this study, demonstrating the breadth of the population over which restraint system robustness is required. This varied anthropometry PMHS occupant data set fills a gap in understanding of varied occupants' response in frontal impacts. The dataset also provides a reference for assessment of computational human body models.