

Comparison of Human Body Model and PMHS Occupant Kinematic Response in Laboratory Rollover Tests

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Abstract

To date, no human body computational models (HBM) have been shown to possess any level of biofidelity in predicting human occupant responses in rollover crashes. The goal of this study was to assess the kinematic response biofidelity of a HBM for rollover crash simulations by comparing model kinematics to biofidelity targets from the literature. The TASS MADYMO Active Human Model was chosen as the HBM for this study because it is hypothesized that the active musculature will have a greater effect on kinematic response in rollover crashes compared to other crash modes. Considering the range of possible occupant responses—from atonic to fully tensed—this study compared the passive response of the HBM, which was examined by disabling the active features, to post mortem human surrogate (PMHS) response in controlled laboratory rollover tests from the literature. Four PMHS subjected to a passenger-side leading pure dynamic roll (360 deg/s) and a roll (360 deg/s) with a superimposed linear acceleration (~3g), in both the driver and right front passenger seat, were identified in the literature. The kinematic trajectories generated from tracking reflective markers attached to the head, T1, T4, T10, L1, sacrum, and left/right acromion. In the current study, the HBM was seated in a model of the test buck and was subjected to kinematics replicate of the test conditions. To make a comparison between the HBM and the PMHS, some assumptions had to be made due to variability in PMHS anthropometry, restraint fit, and orientation with respect to seat position. Thus, to understand the implications of the various assumptions, a sensitivity analysis was conducted that varied seat friction, pre-test restraint tension, and occupant positioning. After making some minor modifications to the HBM, the overall response predicted by the HBM fell generally within the published corridors. Specifically all of the torso kinematic trajectories remained within the YZ (lateral) trajectory corridors for three of the four test conditions, and on the fourth only small (<20 mm) deviations were observed in the upper torso. However, as indicated to be a problem with crash dummy biofidelity, the fore-aft (XZ) motion of PMHS was not accurately predicted by the HBM. The imposed (vehicle) kinematics and restraint resulted in a low sensitivity of initial position to peak lateral and vertical excursion. However, varying the friction coefficient between the seat and HBM resulted in relatively large changes in kinematic response (e.g. friction coefficients that were too high prevented the HBM from the characteristic upward-outward trajectory seen in rollover crash studies). Now that the model has been shown to have satisfactory kinematic biofidelity in the atonic configuration, it

will be used to examine the effect of variations in active muscle tensing to lend insight into protecting humans in rollover crashes.