Comparison of ATD and Human Body Models for Side Impact Scenarios

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Introduction

- In 2012, side impact accounted for 38% of fatalities during passenger car collisions (IIHS, 2013) with thoracic injuries being significant.
- Anthropometric Test Devices (ATD) are used to evaluate vehicle safety through virtual simulations followed by physical testing.
- Detailed Human Body Models (HBM) are used to investigate omni-directional loading scenarios and predict the potential for injury at the tissue level.

Objective

- To compare the kinetic and kinematic response of an ATD model and HBM for various loading conditions (concentrated load, distributed load and full vehicle scenario).

ATD and Human Body Model V&V

- The ES-2re finite element model (Dynamore, Version 6.0) met the calibration tests and response requirements used for the physical ATD (rib certification and thorax certification tests).
- HBM validated using pendulum (front, lateral, oblique) and side sled impact tests (Forbes 2005; Campbell 2009; Yuen 2009).

Methods

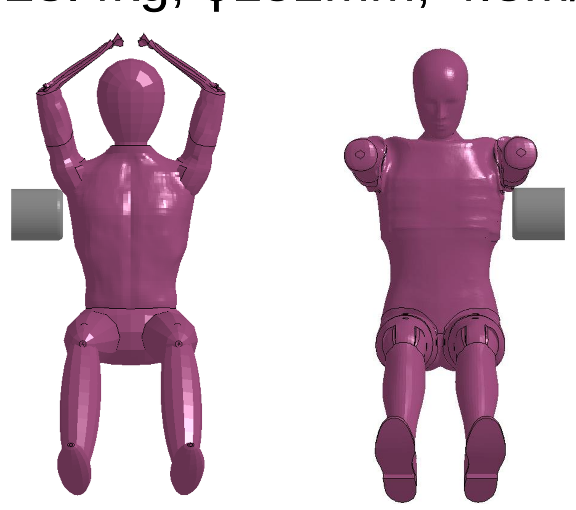
- HBM and ATD models were subjected to three loading scenarios: lateral pendulum impact, side sled and vehicle side impact. Predicted responses were compared to the PMHS data available in the literature. ATD and HBM responses were compared using cross-correlation (CORA).

Pendulum Impact

Response: pendulum force and displacement

Lateral **(Troseille et al., 2008)**

23.4kg, ϕ152mm, 4.3m/s



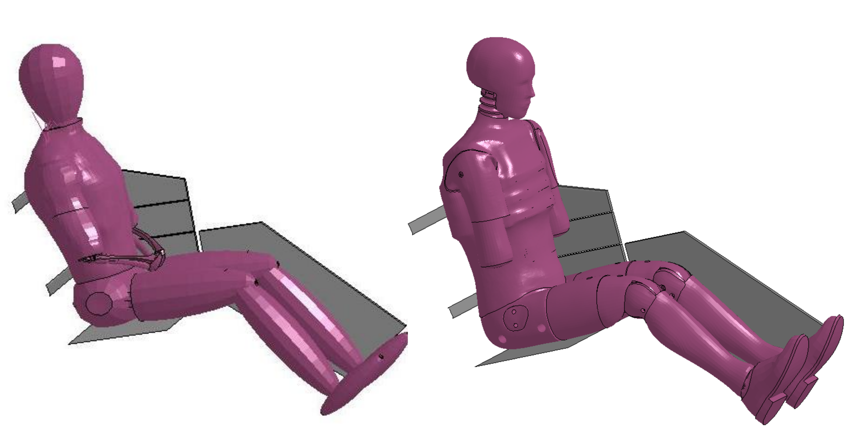
Lateral impact for HBM (left) and ATD model (right)

Side Sled Impact

Response: plate force, chestband compression

NHTSA **(Pintar et al., 1997)**

Impact velocity: 6.7m/s



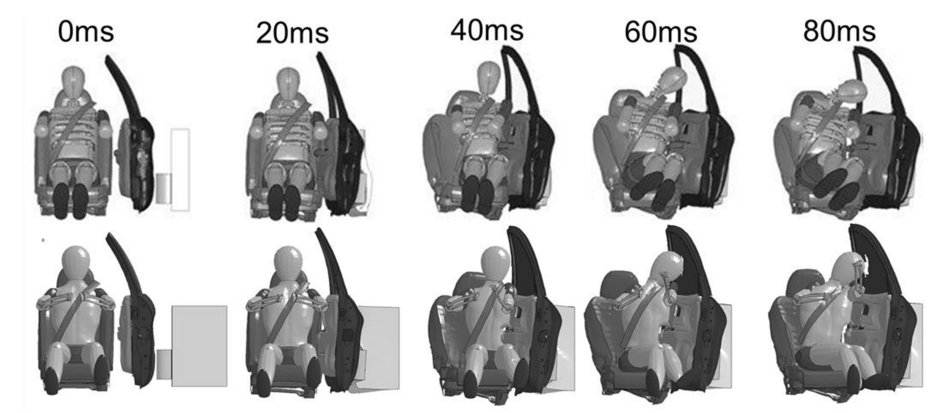
NHTSA configuration for HBM (left) and ATD model (right)

Methods Cont'd

Vehicle Side Impact

Response: chestband deflection

Vehicle side impact test configuration

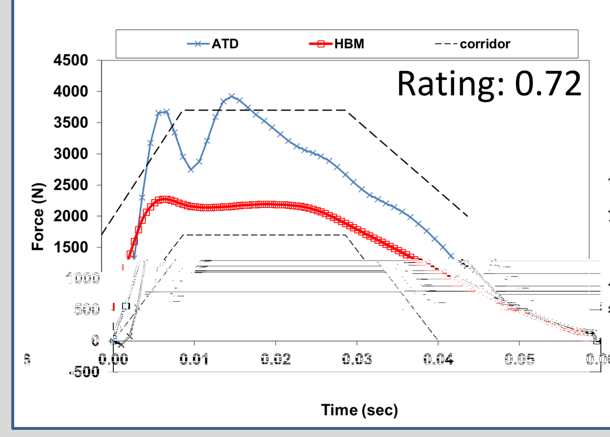


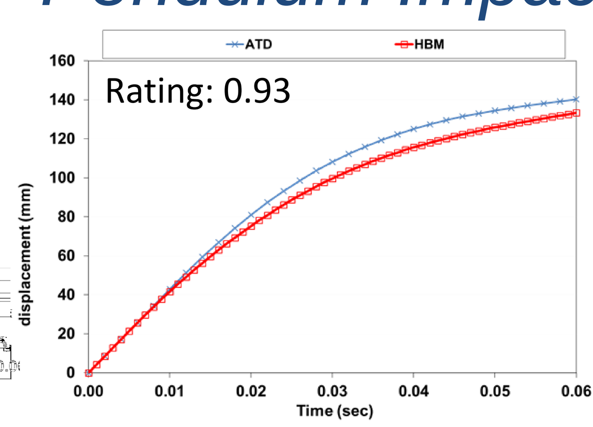
ATD (upper) and HBM (lower) model kinematics

- The ATD and HBM were integrated with a seat, restraint system and vehicle model (2001 Ford Taurus, NCAC). The vehicle was impacted by a moving deformable barrier model.
- Component and integrated model validation undertaken using NHTSA impact data (Watson et al., 2011; Campbell 2014).

Results

Pendulum Impact

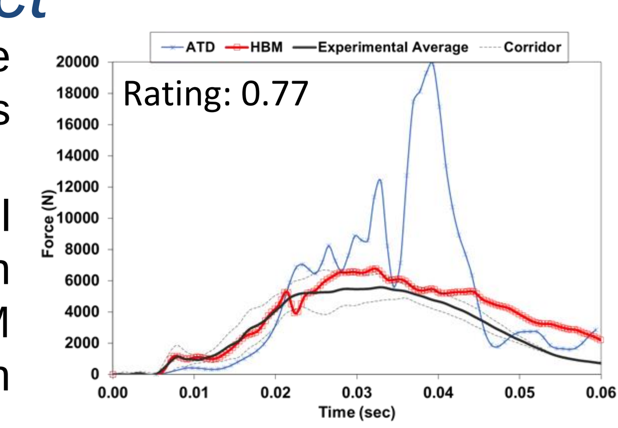




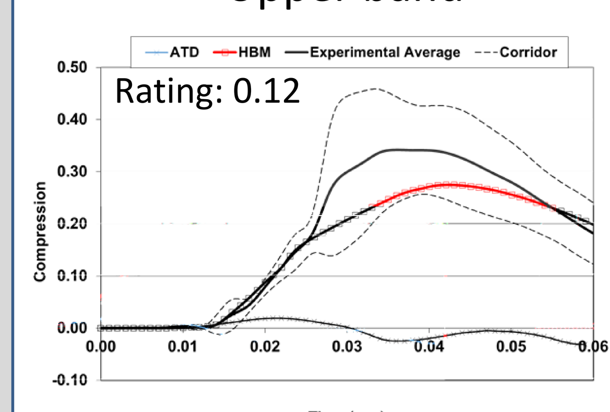
ATD and HBM demonstrated some differences in force-time response. Displacement-time response was comparable for both models.

Side Sled Impact

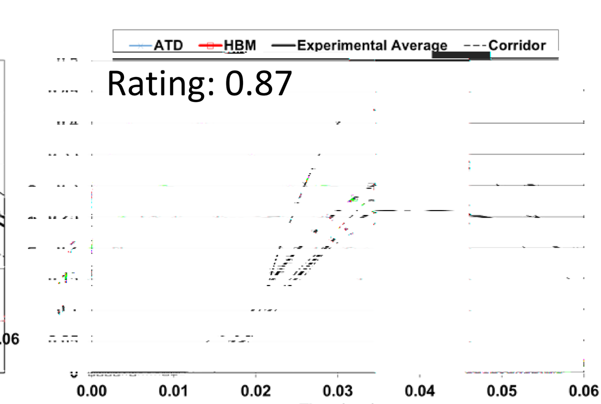
A difference in force-time response was noted for the thorax force plate. The sum of all force plates was comparable between the models (0.815 rating).
The HBM arm interaction resulted in compression at all three chest band levels. The upper chest band location of the ATD did not engage the thorax force plate. HBM response was comparable to the PMHS reference both in terms of force and compression.



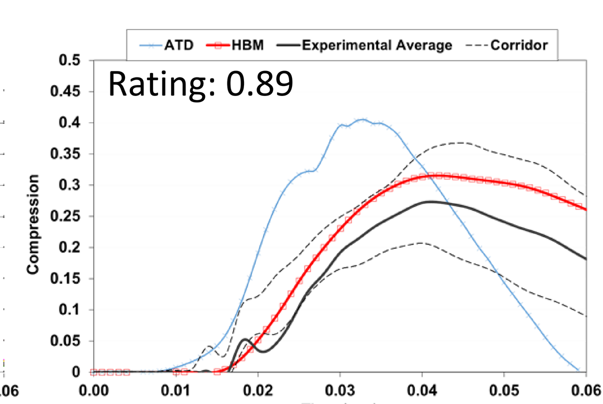
Upper band



Middle band



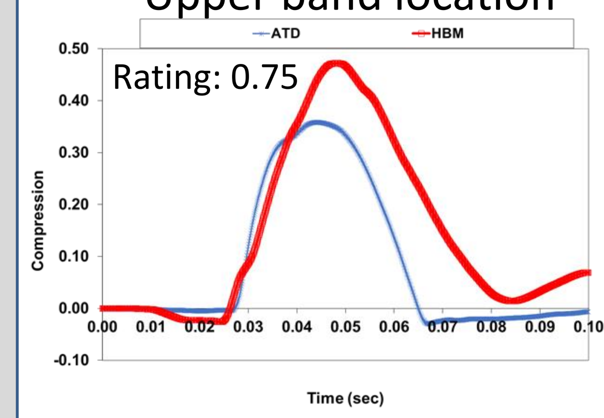
Lower band



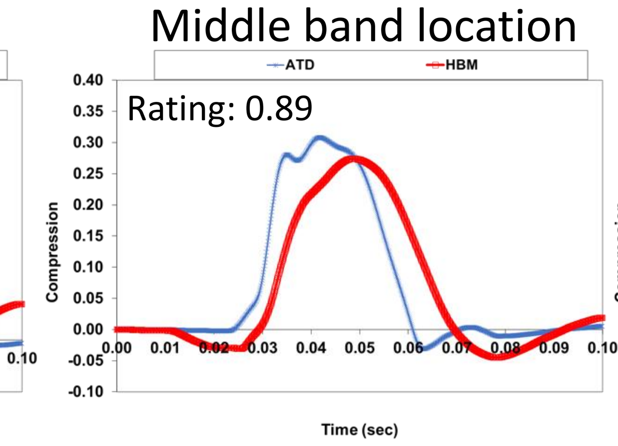
Results Cont'd

Vehicle Side Impact

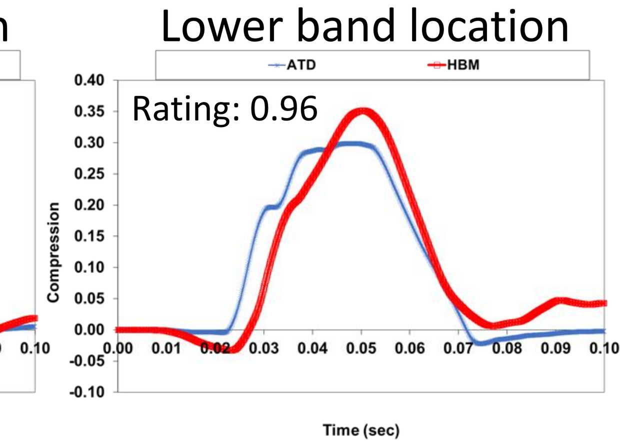
Upper band location



Middle band location



Lower band location



For the standard driving position in the car, the HBM predicted moderately higher chest compression response at upper and lower chest band levels. The global kinematics of both models was similar although differences in shoulder and arm kinematics were observed. Differences were observed for non-standard driving positions.

Discussion and Conclusions

- The HBM model response was in good agreement with the available PMHS response corridors.
- **Pendulum impact:** The ATD exhibited higher force response compared to the HBM. The response was sensitive to variations in the pendulum impact location.
- **Sled impact:** Deformation of the HBM thorax during impact distributed the load over multiple force plates, compared to the ATD thorax model. Interaction with the struck HBM arm was noted to have a significant effect on the HBM response.
- **Vehicle impact:** The kinematic results were generally similar between the ATD and HBM. Alternate arm or occupant positions were found to affect the kinematic response.
- Local differences in response (e.g. chest compression) have been identified between the HBM and ATD and were attributed to the engagement of different tissues/structures in the models. Future work will focus on understanding these local differences using a larger set of impact scenarios.

Limitations

- One impact condition for the three loading scenarios was considered. Ongoing research will include additional impact velocities.
- Future work will investigate of the effect of occupant position on response.