Effect of Seatback Recline on Occupant Model Response in Frontal Crashes

Hongnan Lin, Bronislaw Gepner, Taotao Wu, Jason L. Forman, Matthew B. Panzer

Introduction

- The introduction of new highly automated vehicles holds the promise to influence occupant seating behavior and seat design.
- The increased seatback recline angles may challenge occupant restraint systems currently available in the vehicle fleet.
- It is currently unknown if current occupant injury assessment tools are capable of simulating these novel postures and predicting the resulting occupant responses and restraint interactions in realistic manner.

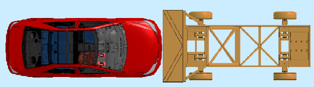
Objective

Assess the usability and performance of the Global Human Body Model Consortium (GHBMC) owned 50th percentile male detailed occupant model (GHBMC M50-O) and simplified occupant model (GHBMC M50-OS) in various reclined seating positions in frontal collisions.

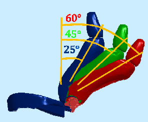
Methods

Environment model

Vehicle model and RMDB

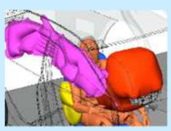


- 2012 Toyota Camry with 3 reclined seats [4]
- Research moving deformable barrier [2]
- V = 56 km/h
- Frontal impact



Restraint system

- Passenger airbag (PAB), curtain airbag (CAB), side airbag (SAB)
- Standard D-ring seatbelt, seat-integrated D-ring seatbelt



Occupant model

- GHBMC M50-O [3]
  - Designed to predict injuries based on tissue-level criterion.
- GHBMC M50-OS [1]
  - A derivative model of M50-O.
  - Not intended to predict crash induced injuries based on tissue-level criterion.
  - Obtain kinematics from accelerometers or deflection sensors.

GHBMC M50-O (Detailed) GHBMC M50-OS (Simplified)

Human body model instrumentation

- Assessing tri-axial linear accelerations and velocities of head, cervical spine (C1), thoracic spine (T1, T8 and T12) and pelvis.
- Measuring tri-axial angular accelerations and velocities of head, cervical spine (C1), thoracic spine (T1, T8 and T12) and pelvis.
- Evaluating reaction forces between occupants and surrounding vehicle parts.

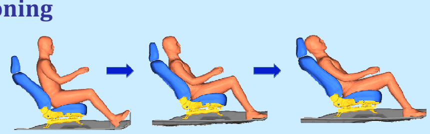
GHBMC M50-O/OS positioning

Method

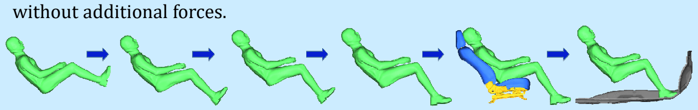
- Pre-simulation

Challenge

- Both models are too stiff to settle into seatback under gravity without additional forces.



Semi-reclined seated M50-OS

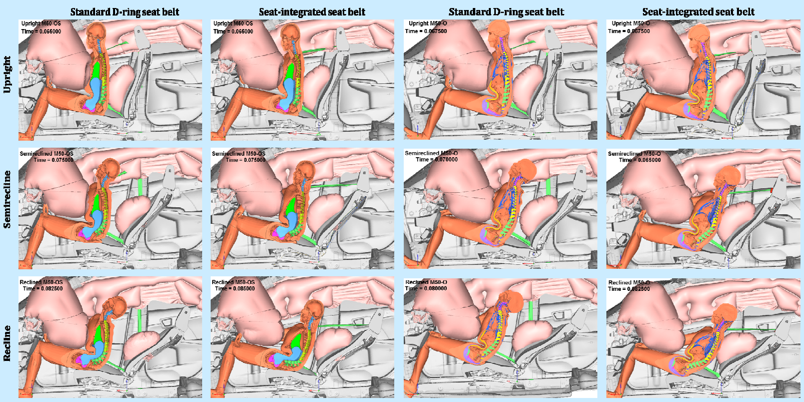


Semi-reclined seated M50-O

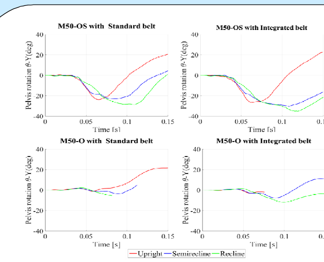
Results

Kinematics

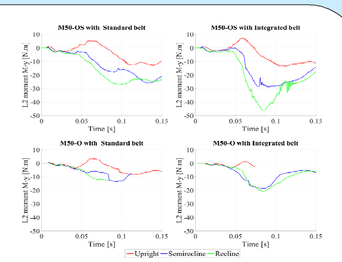
GHBMC M50-OS GHBMC M50-O



Kinematics at the point of maximum forward excursion of the lower extremity into the knee bolster for GHBMC M50-OS model in upright, semi-reclined and reclined positions, comparing results from a standard D-ring (left) and a seat-integrated D-ring (right).



Pelvis rotation about Y-axis of M50-O/OS



Moment from the intervertebral disc between L1 and L2 for M50-OS/O

Discussion

- The GHBMC M50 models were too stiff to allow the HBM to settle into the seat under gravity without applying additional forces.
- In semi-reclined and reclined postures, both GHBMC M50 models submarined resulting in the lap belt sliding over the anterior iliac spine. M50-OS displayed greater pelvis backward rotation compared to the M50-O model.
- Compared with the standard belt, seat-integrated D-ring belt caused more pelvis backward rotation in the matched posture.
- GHBMC M50-OS exhibited a greater flexion angle compared to the M50-O model.

Conclusions

1. Effect of seatback recline on human body model usability, restraint interaction, and occupant kinematics in simulated frontal collisions was investigated.
2. Both models tended to exhibit submarining with the lap belt sliding over the pelvis and directly loading into the abdomen.
3. Different coupling definitions between pelvis, lumbar spine and flesh might potentially explain the different kinematics in both models.
4. Generating reference data to assess the bio-fidelity of the models in this type of loading scenario in future.

References

[1]Gayzik, F.S., Moreno, D.P., Vavalle, N.A., Rhyne, A.C., and Stitzel, J.D. Development of the Global Human Body Models Consortium mid-sized male full body model. Injury Biomechanics Research Workshop, 2011.

[2] Saunders, J., Craig, M.J., Suway, J., NHTSA's Test Procedure Evaluations for Small Overlap/Oblique Crashes. 22nd ESV Conference. 2011; Paper No. 11-0343.

[3] Schwartz D, Guleyupoglu B, Koya B, Stitzel J，& Gayzik F. Development of a Computationally Efficient Full Human Body Finite Element Model. Traffic Inj Prev, 16 Sup1, S49-S56.

[4] Reichert, Rudolf, Validation of a Toyota Camry Finite Element Model for Multiple Impact Configurations. SAE, 2016.

Acknowgement

The authors would like to thank NHTSA for the sponsorship of this project (NHTSA contract #DTNH2215D00004/0002)

University of Virginia - Center for Applied Biomechanics

Hongnan Lin, hl5df@Virginia.edu
4040 Lewis and Clark Drive
Charlottesville, VA 22911