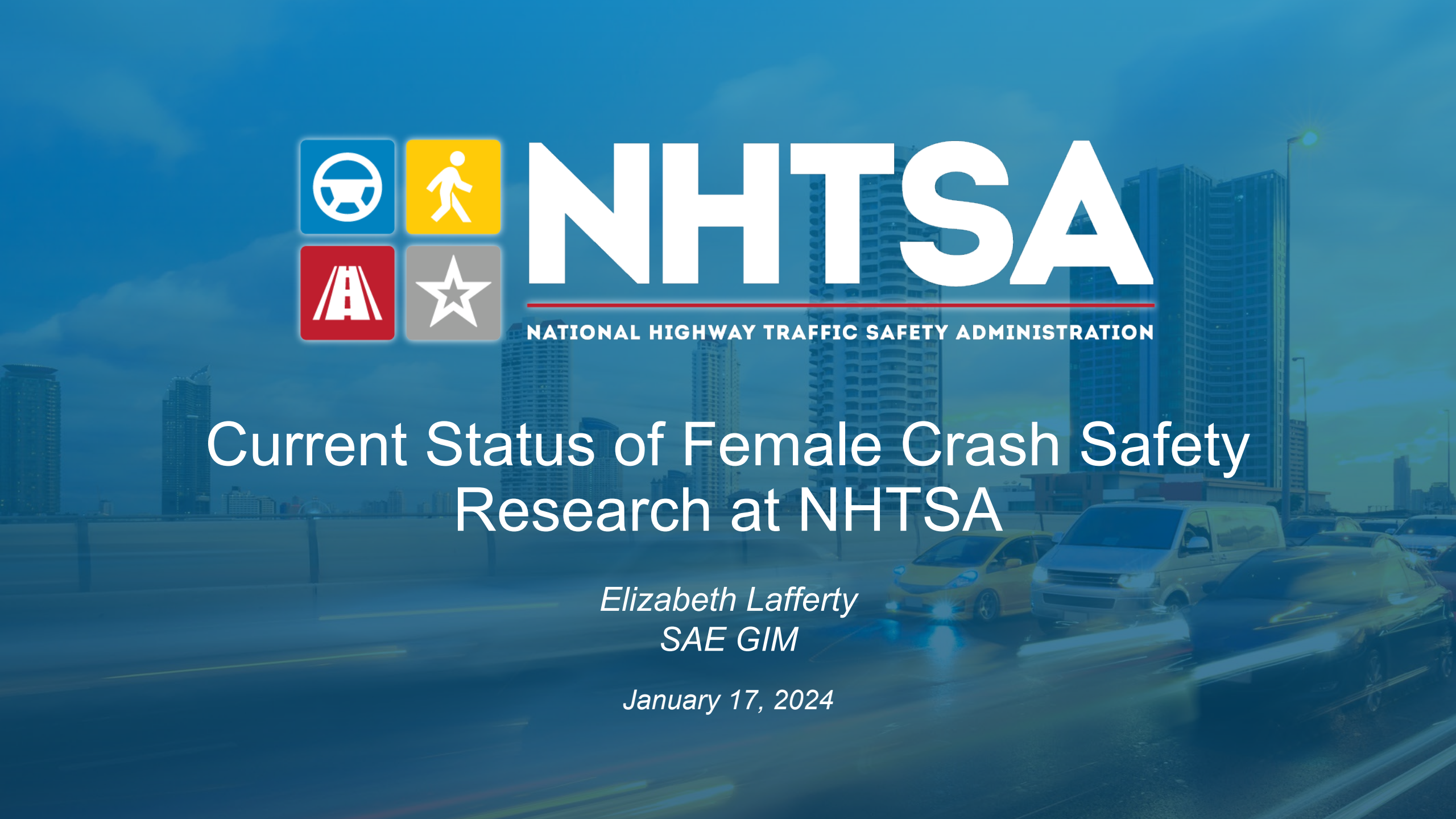


NHTSA

NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

Current Status of Female Crash Safety Research at NHTSA

Elizabeth Lafferty
SAE GIM

January 17, 2024

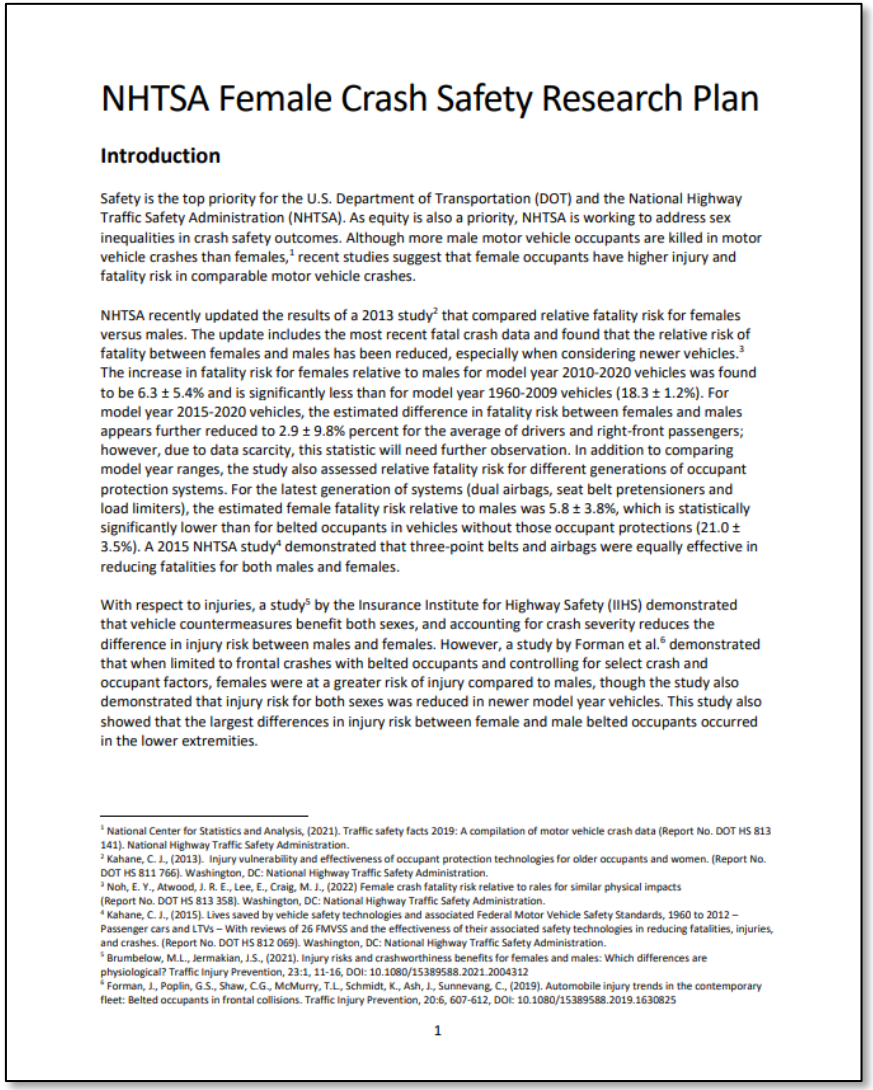
Female Crash Safety Research Plan

NHTSA Female Crash Safety Research Plan (2022)

- ***Research Questions:***

1. What is the current state of knowledge on fatality and injury risk for females involved in motor vehicle crashes?
2. What are the causes of elevated motor vehicle crash related risk for females?
3. What can be done to better protect females involved in motor vehicle crashes?

https://www.regulations.gov/document/NHTSA-2022-0091-0002



NHTSA Female Crash Safety Research Plan

Introduction

Safety is the top priority for the U.S. Department of Transportation (DOT) and the National Highway Traffic Safety Administration (NHTSA). As equity is also a priority, NHTSA is working to address sex inequalities in crash safety outcomes. Although more male motor vehicle occupants are killed in motor vehicle crashes than females,[1] recent studies suggest that female occupants have higher injury and fatality risk in comparable motor vehicle crashes.

NHTSA recently updated the results of a 2013 study[2] that compared relative fatality risk for females versus males. The update includes the most recent fatal crash data and found that the relative risk of fatality between females and males has been reduced, especially when considering newer vehicles.[3] The increase in fatality risk for females relative to males for model year 2010-2020 vehicles was found to be 6.3 ± 5.4% and is significantly less than for model year 1960-2009 vehicles (18.3 ± 1.2%). For model year 2015-2020 vehicles, the estimated difference in fatality risk between females and males appears further reduced to 2.9 ± 9.8% percent for the average of drivers and right-front passengers; however, due to data scarcity, this statistic will need further observation. In addition to comparing model year ranges, the study also assessed relative fatality risk for different generations of occupant protection systems. For the latest generation of systems (dual airbags, seat belt pretensioners and load limiters), the estimated female fatality risk relative to males was 5.8 ± 3.8%, which is statistically significantly lower than for belted occupants in vehicles without those occupant protections (21.0 ± 3.5%). A 2015 NHTSA study[4] demonstrated that three-point belts and airbags were equally effective in reducing fatalities for both males and females.

With respect to injuries, a study[5] by the Insurance Institute for Highway Safety (IIHS) demonstrated that vehicle countermeasures benefit both sexes, and accounting for crash severity reduces the difference in injury risk between males and females. However, a study by Forman et al.[6] demonstrated that when limited to frontal crashes with belted occupants and controlling for select crash and occupant factors, females were at a greater risk of injury compared to males, though the study also demonstrated that injury risk for both sexes was reduced in newer model year vehicles. This study also showed that the largest differences in injury risk between female and male belted occupants occurred in the lower extremities.

[1] National Center for Statistics and Analysis, (2021). Traffic safety facts 2019: A compilation of motor vehicle crash data (Report No. DOT HS 813 141). National Highway Traffic Safety Administration.
[2] Kahane, C. J., (2013). Injury vulnerability and effectiveness of occupant protection technologies for older occupants and women. (Report No. DOT HS 811 766). Washington, DC: National Highway Traffic Safety Administration.
[3] Noh, E. Y., Atwood, J. R. E., Lee, E., Craig, M. J., (2022) Female crash fatality risk relative to rales for similar physical impacts (Report No. DOT HS 813 358). Washington, DC: National Highway Traffic Safety Administration.
[4] Kahane, C. J., (2015). Lives saved by vehicle safety technologies and associated Federal Motor Vehicle Safety Standards, 1960 to 2012 – Passenger cars and LTVs – With reviews of 26 FMVSS and the effectiveness of their associated safety technologies in reducing fatalities, injuries, and crashes. (Report No. DOT HS 812 069). Washington, DC: National Highway Traffic Safety Administration.
[5] Brumbelow, M.L., Jermakian, J.S., (2021). Injury risks and crashworthiness benefits for females and males: Which differences are physiological? Traffic Injury Prevention, 23:1, 11-16, DOI: 10.1080/15389588.2021.2004312
[6] Forman, J., Poplin, G.S., Shaw, C.G., McMurry, T.L., Schmidt, K., Ash, J., Sunnevang, C., (2019). Automobile injury trends in the contemporary fleet: Belted occupants in frontal collisions. Traffic Injury Prevention, 20:6, 607-612, DOI: 10.1080/15389588.2019.1630825

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NHTSA Female Crash Safety Research Plan

- ***Core Areas of Research:***

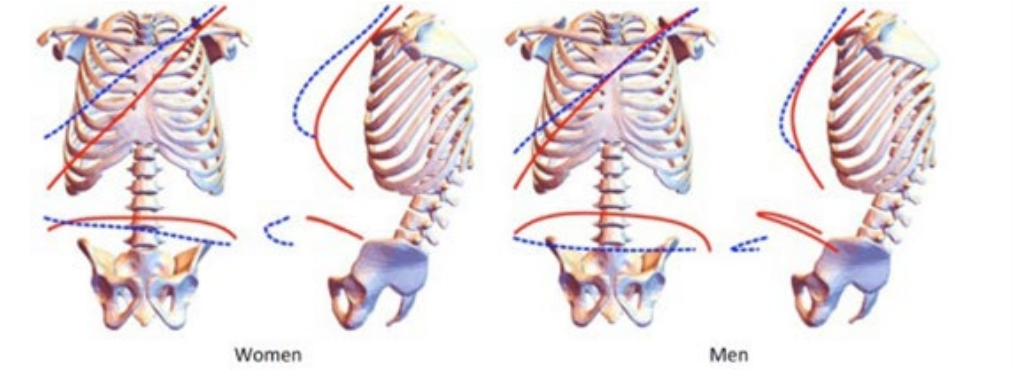
1. Field Data Analysis
2. Advanced Anthropomorphic Test Devices (ATDs) and Experimental Biomechanics
3. Human Body Modeling
4. Fleet Testing and Countermeasure Studies

Field Data

Current Task Orders addressing female crash safety in the field

Lower Extremity Injury Risk

- **Summary:** investigation of sex based lower extremity injury risk differences due to body shape and soft tissue distribution. This effort will involve using CIREN radiology images to investigate soft tissue distribution and its possible relationship to poor lower body lap belt restraint and increased risk of lower extremity injury.
- **Performer:** University of Virginia
- **Deliverable:** A report evaluating male and female injury risk differences through a logistic regression model when considering radiological and anthropometric data.

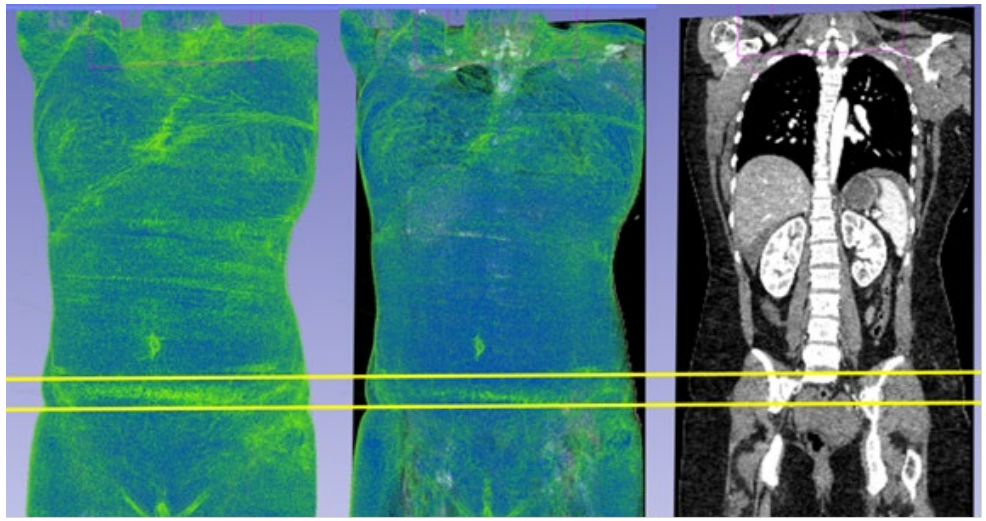


Mean belt paths for low (—, 30 kg/m²) and high (--, 55 kg/m²) BMI for men and women with mean stature (M=1630 mm, F=1750 mm) relative to scaled midsize-male skeleton.

Jones et al., 2017 Effects of High Levels of Obesity on Lap and Shoulder Belt Paths

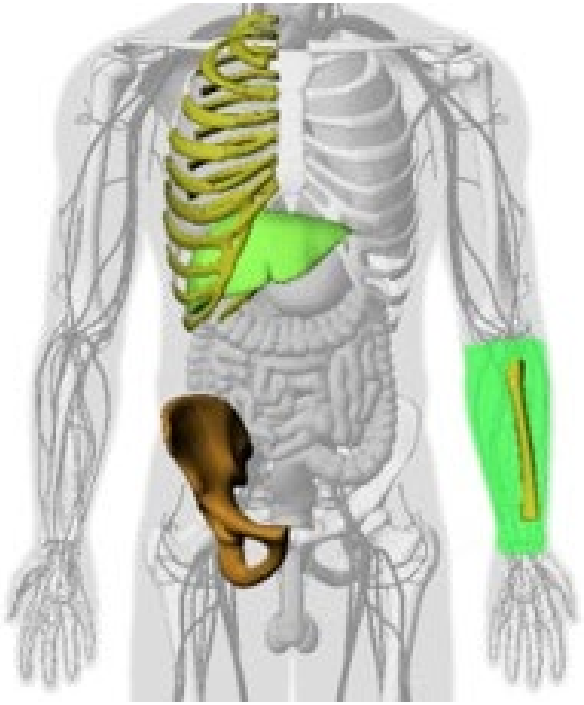
Abdominal Injuries in belted frontal impacts

- **Summary:** CIREN case study of male and female occupants with AIS 2+ injuries to the pelvis and abdomen attributed to the seatbelt in frontal crashes. The study includes detailed review of EDR crash data and NCAP test data, seat pan and seatbelt evidence, medical imaging, and ICS coding with emphasis on regional mechanism.
- **Performer:** Medical College of Wisconsin
- **Deliverable:** A report summarizing case results and underlying mechanism of injury as related to the seatbelt engagement.



Sex Differences in Thoracic Injury Patterns

- **Summary:** Identify and quantify the sex-specific disparities in chest, thoracolumbar, and abdominopelvic injury patterns and causation among seriously injured first row MVC occupants in frontal crashes using the CIREN database.
- **Performer:** Wake Forest University
- **Deliverable:** A report summarizing sex-based injury patterns from MVC leveraging injury causation data.



ATDs and Experimental Biomechanics

Current Task Orders addressing female crash safety through ATD and experimental biomechanics

THOR-05F and WorldSID-05F Upgrades

- **Summary:** Design and implement changes to the THOR-05F and WorldSID-05F dummies. Particularly to improve THOR-05F thoracic durability and WorldSID-05F thoracic biofidelity performance.
- **Performer:** Humanetics
- **Deliverable:** Upgraded THOR-05F and WorldSID-05F dummies and associated drawing packages for dummies that are both durable and biofidelic.

For more details see Advanced Dummies session:
3:20-3:40pm - THOR-05F Design Updates by Erin Hutter

THOR-05F Gold Standard 2 Retesting

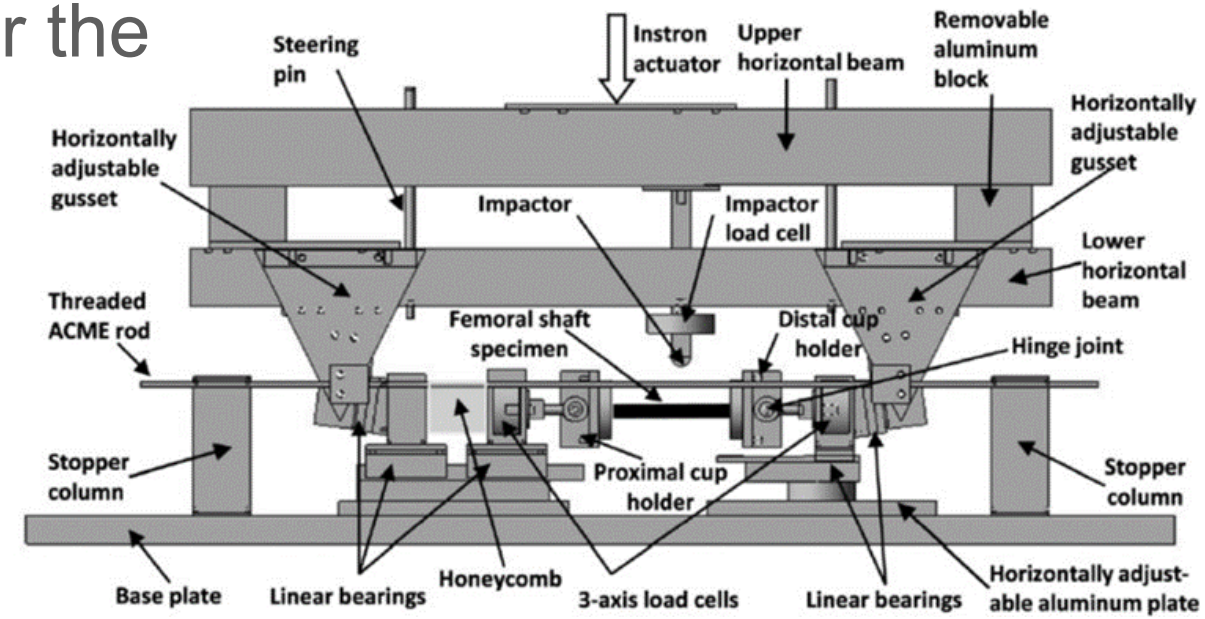
- **Summary:** Rerun the THOR-05F with an updated thorax in matched pair tests in the low, intermediate, and high speeds for Gold Standard 2 sled test configurations matching post-mortem human subjects (PMHS) in the biomechanics database.
- **Performer:** University of Virginia
- **Deliverable:** Identify any THOR-05F response changes after durability updates. Data will be used to support injury risk function development.

THOR-05F Oblique and Vehicle Buck Retesting

- **Summary:** Rerun the THOR-05F with an updated thorax in matched pair tests in oblique and frontal vehicle buck sled test configurations matching PMHS in the biomechanics database.
- **Performer:** Medical College of Wisconsin
- **Deliverable:** Identify any THOR-05F response changes after durability updates. Data will be used to support injury risk function development.

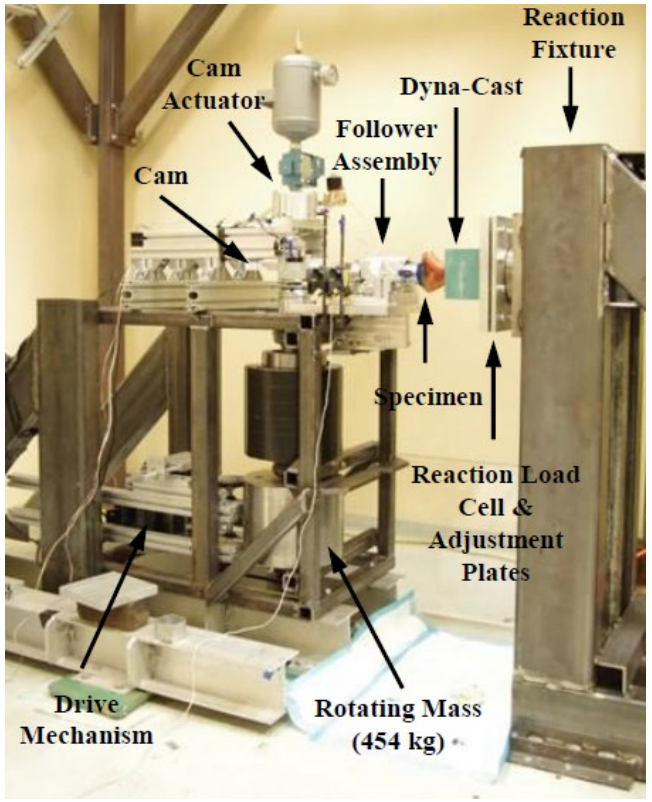
THOR-05F Tibia Bending Injury Criteria Development

- **Summary:** Collect small female PMHS and matched THOR-05F tibia response and injury data when loaded in compression and bending.
- **Performer:** University of Virginia
- **Deliverable:** PMHS loading and injury response. Data used to support injury risk function development for the THOR-05F dummy.



THOR-05F/50M Ankle Injury Criteria Development

- **Summary:** Collect PMHS (small female, mid-sized female, & mid-sized male) and matched THOR-05F/50M kinematic response and injury data for the ankle when loaded in dorsiflexion
- **Performer:** Virginia Tech Transportation Institute
- **Deliverable:** Kinematic and injury responses of the matched PMHS and THOR dorsiflexion tests. Data will be used to support injury risk function development for the THOR-05F dummy

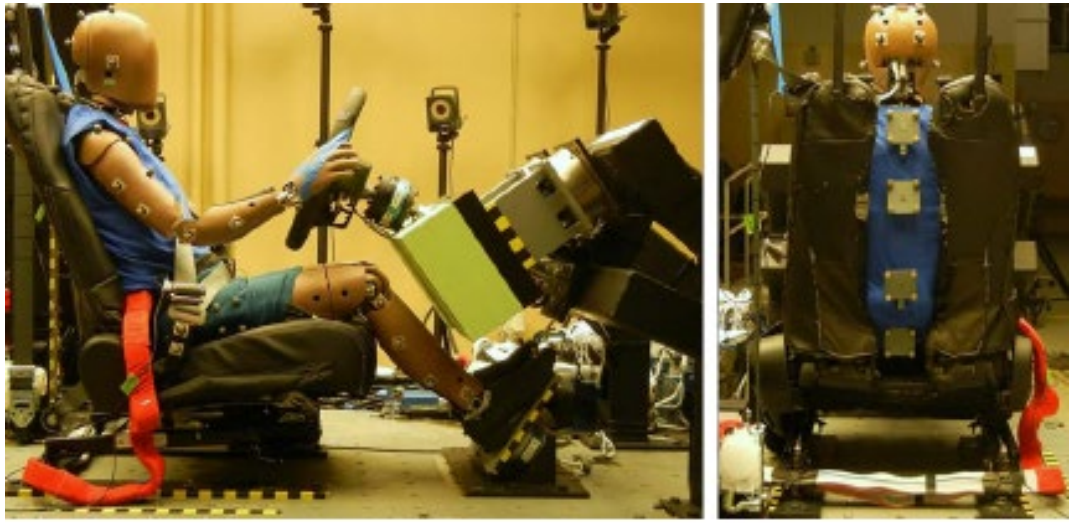


Female Specific Neck Data Collection for THOR-05F

- **Summary:** Create response corridors for evaluating dummy biofidelity for collected PMHS and THOR kinematic response and injury data in the NBDL sled test condition(s). Conduct numerical simulations using the Global Human Body Models Consortium (GHBMC) models in the same test conditions.
- **Performer:** University of Virginia
- **Deliverable:** Numerical neck biofidelity corridors and the methods and outcomes of the numerical simulations for the GHBMC neck. Data will be used to support development of a THOR-05F neck injury risk function

Female-Specific Thorax Data Collection

- **Summary:** Conduct frontal impact sled tests with realistic seat and restraint conditions on female PMHS, Hybrid III 05F, and THOR-05F.
- **Performer:** Virginia Tech Transportation Institute
- **Deliverable:** Kinematic and injury response of the matched PMHS and ATDs in realistic seat and restraint sled tests. Data will be used to support development of a THOR-05F thoracic injury risk function



Average-Sized Female and Vulnerable Occupant

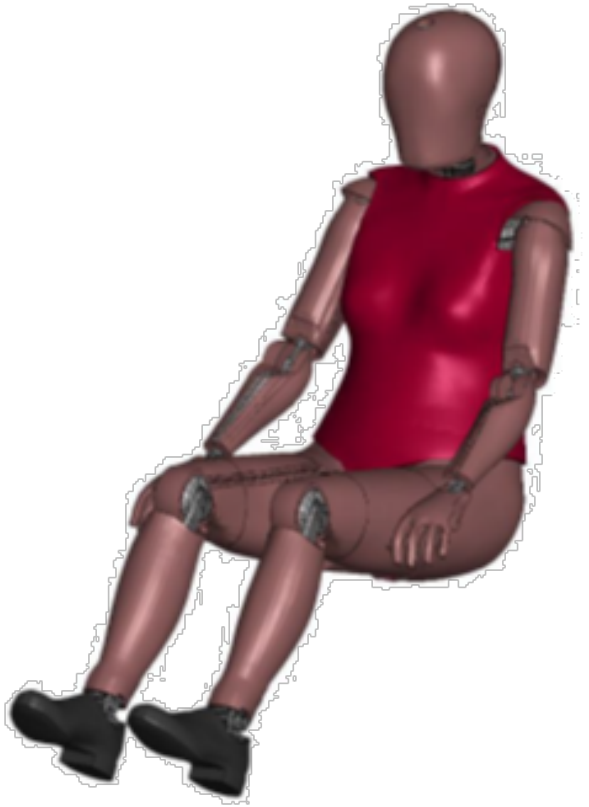
- **Summary:** Collect kinematic and injury response data for 50th percentile female and vulnerable (older/obese) occupants in belted frontal impact sled tests.
- **Performer:** University of Virginia
- **Deliverable:** Sled test results and biofidelity corridors for the 50th percentile female and vulnerable occupant. Data will be used to support injury risk function development.

THOR-05F Finite Element Model

- **Summary:** Develop open-source finite element model of THOR-05F and validate in qualification, sled test, and vehicle crash test conditions
- **Performer:** George Mason University
- **Deliverable:** Finite element model (LS-Dyna) of THOR-05F including models of test environment in validation conditions

Version 3.0

https://media.ccsa.gmu.edu/s/so9lwrgwxhe41lx/THOR-05F-V3.0-package.zip



Female Anthropometry and Foot Placement

- **Summary:** Create models and collect data for female and male seated occupant anthropometry and foot placement.
- **Performer:** University of Michigan Transportation Research Institute
- **Deliverable:** Review of male and female driver anthropometry, analysis of current male and female seated anthropometry data, and a software tool for posture, position, and body shapes for 95% of the adult population. This funded effort will also deliver a data collection plan and approval package.

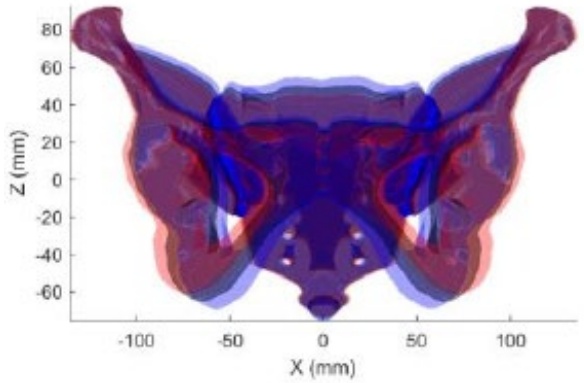
http://HumanShape.org/HERMES/

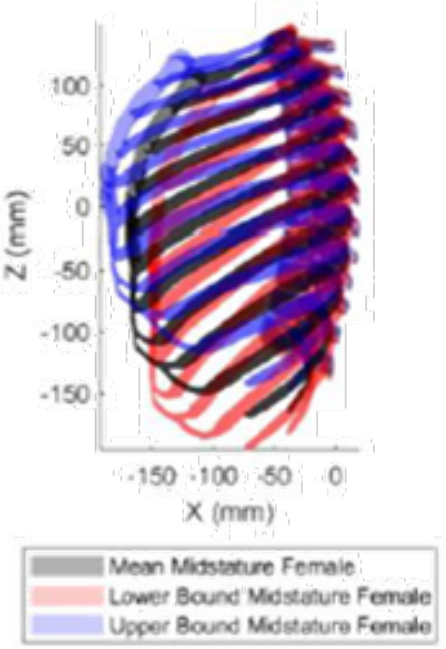
Human Body Modeling

Current Task Orders addressing female crash safety through human body modeling

Variability Study for 50th Females & Males

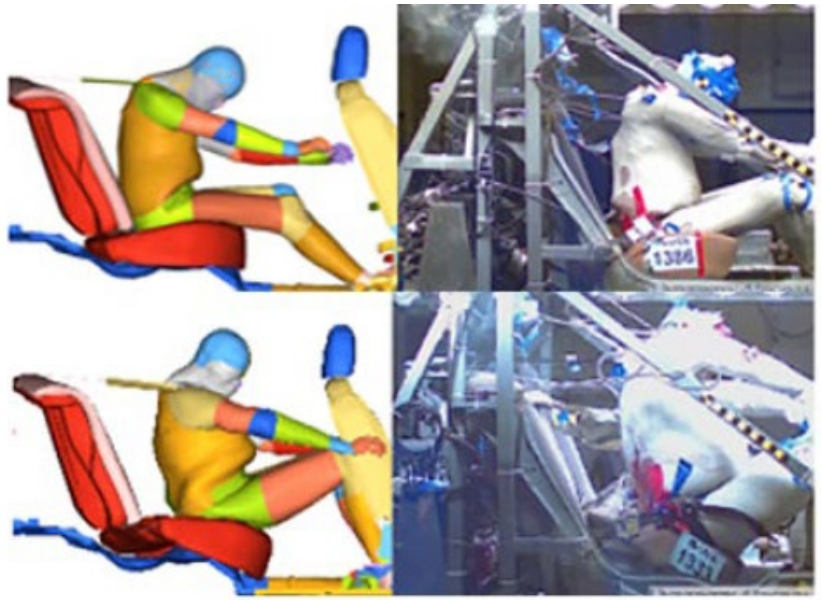
- **Summary:** Geometric variability will be measured in different body regions (rib cage, pelvis, femur) for both 50th percentile males and females. GHBMC 50th percentile male and female models will be morphed and injury response will be measured for these HBM variations in different loading conditions to assess affect of variability on injury outcome.
- **Performer:** University of Michigan Transportation Research Institute
- **Deliverable:** All LS-DYNA model input and set up files for all HBM simulations and a report comparing injury metrics of simulation results.





Subject-specific validation for female HBMs

- **Summary:** Build subject-specific GHBMC models using morphing and validate these models with existing experimental PMHS data. Compare HBM simulation kinematics, injury measures, and restraint interaction data for several versions of the morphed models and find important variables that can help enhance HBM responses.
- **Performer:** University of Michigan Transportation Research Institute
- **Deliverable:** Simulation and technical reports of results. Reports will also include Correlation and Analysis objective rating of time history results as well as injury measures.



Age targeted 50th female and obese female model

- **Summary:** NHTSA supports the Global Human Body Model Consortium's efforts to develop and validate human body models of occupants and pedestrians representing female and male humans of various sizes
- **Performer:** GHBMC
- **Performance End Da**
- **Deliverable:** Delivera agreement will include various refinements to existing models and development of new models. Areas of emphasis include alternative seating postures, high BMI, average female, and older occupant models

Not Yet Awarded
Delete if not awarded before SAE, with OST

Summary of Active Female Crash Safety Projects

- Active female crash safety research areas:
  - Field data analysis
  - ATDs and experimental biomechanics
  - Human body modeling
- 15 active task orders
- Over $10M of funding for active task orders

Thank you!

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