

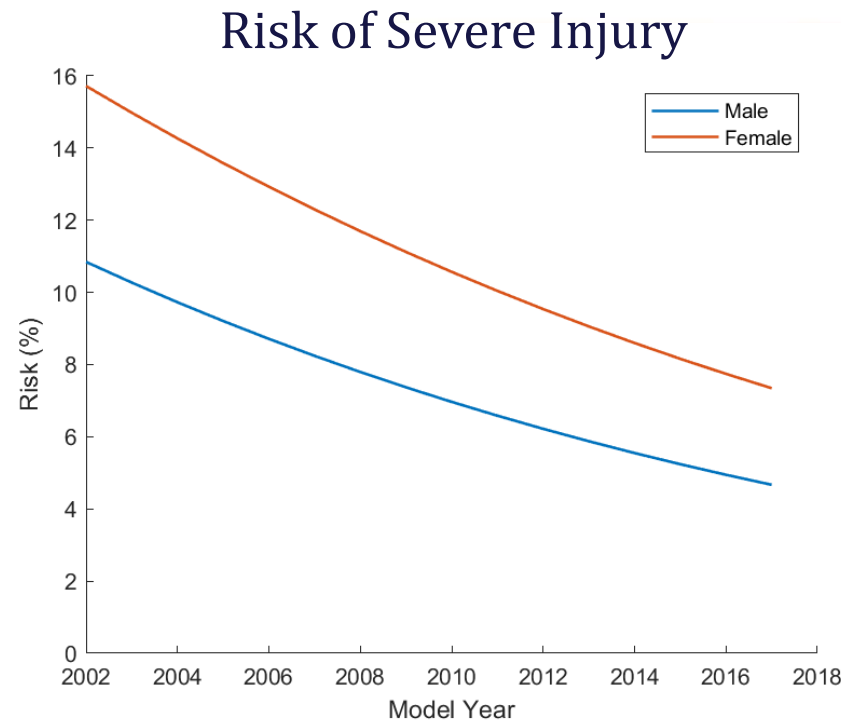
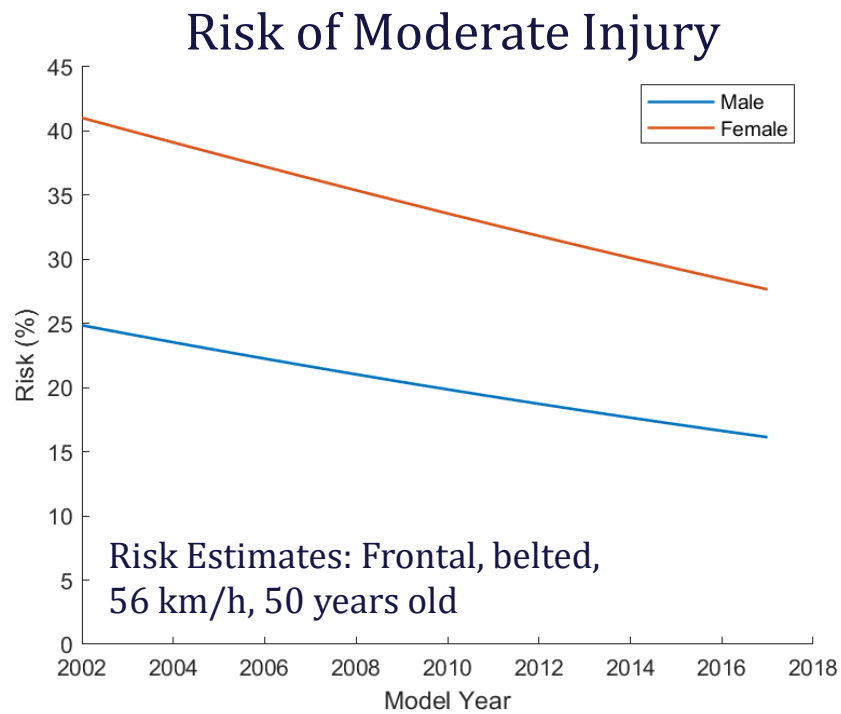
# Updates on Research in Population Variability

Jason Forman

*University of Virginia Center for Applied Biomechanics*

# Vehicle Safety in Time

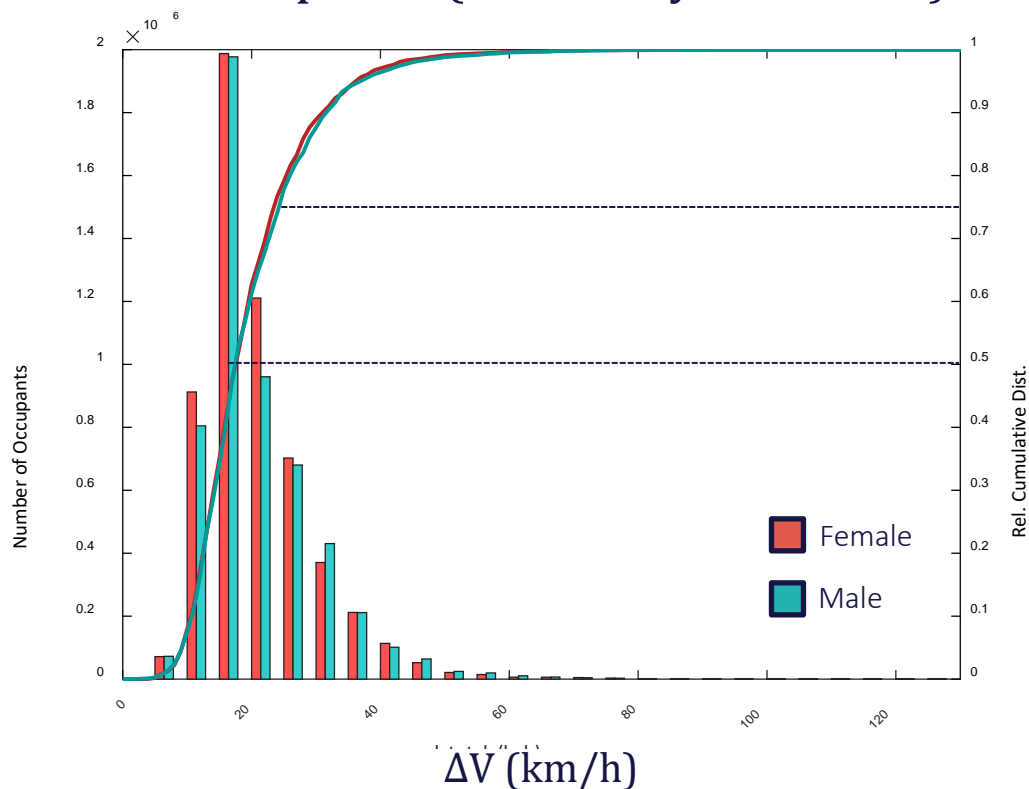
- ▶ Crashworthiness efforts have resulted in real, tangible improvements in vehicle safety



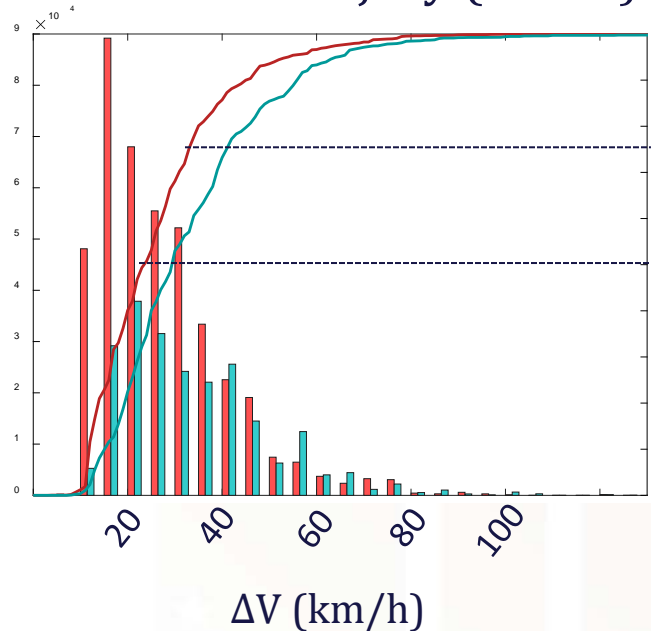
- ▶ Assumption: We want to continue to do better.

# What types of collisions cause injury? --- All of them!

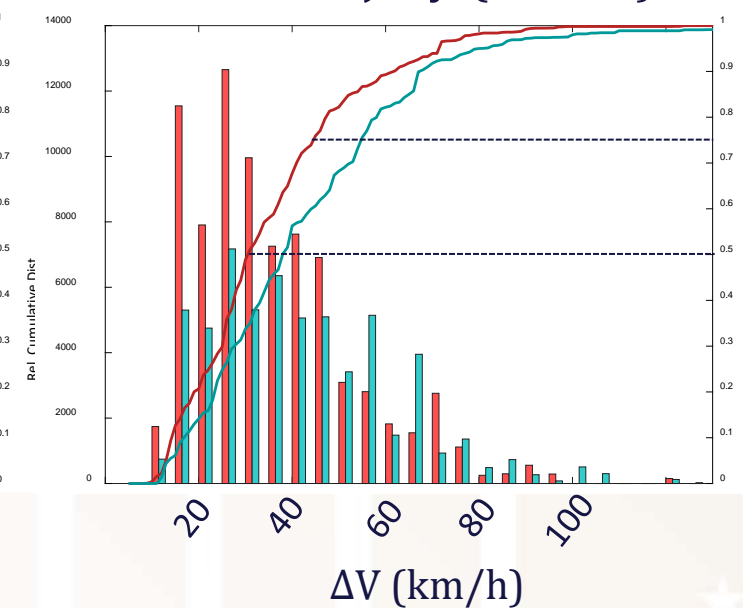
All Exposed (Tow-away Collisions)



Moderate Injury (AIS2+)



Severe Injury (AIS 3+)



# of Injury Cases = Risk x **Exposure**

NASS-CDS 1998-2015 CISS 2017-2018

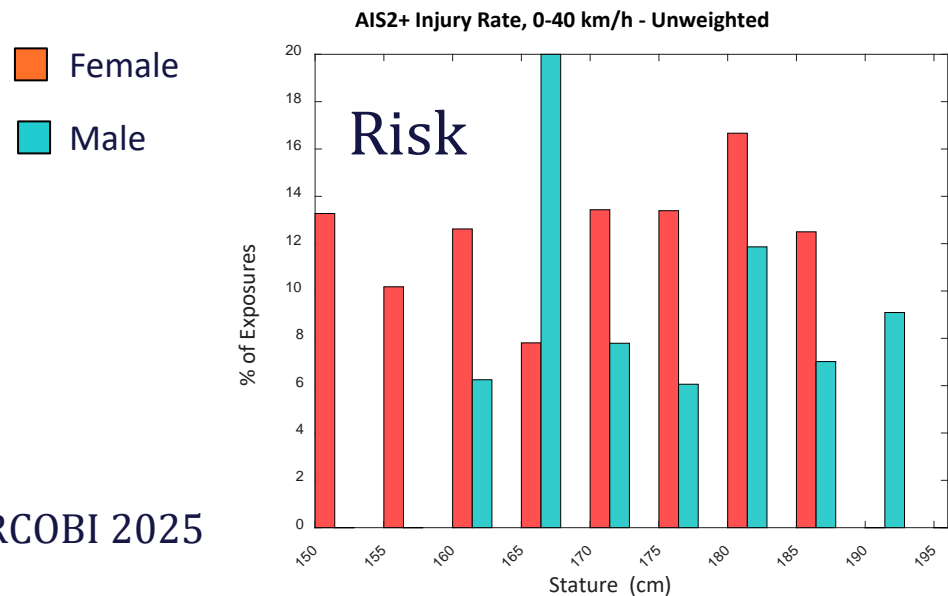
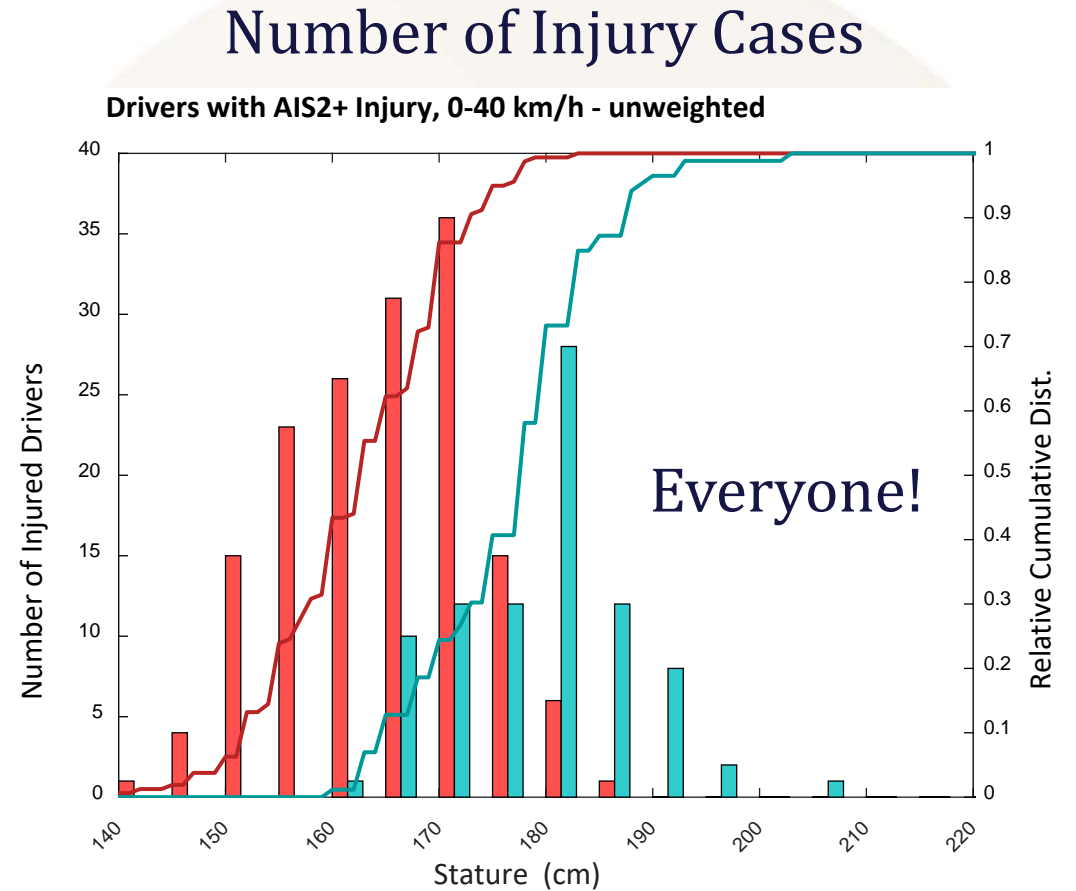
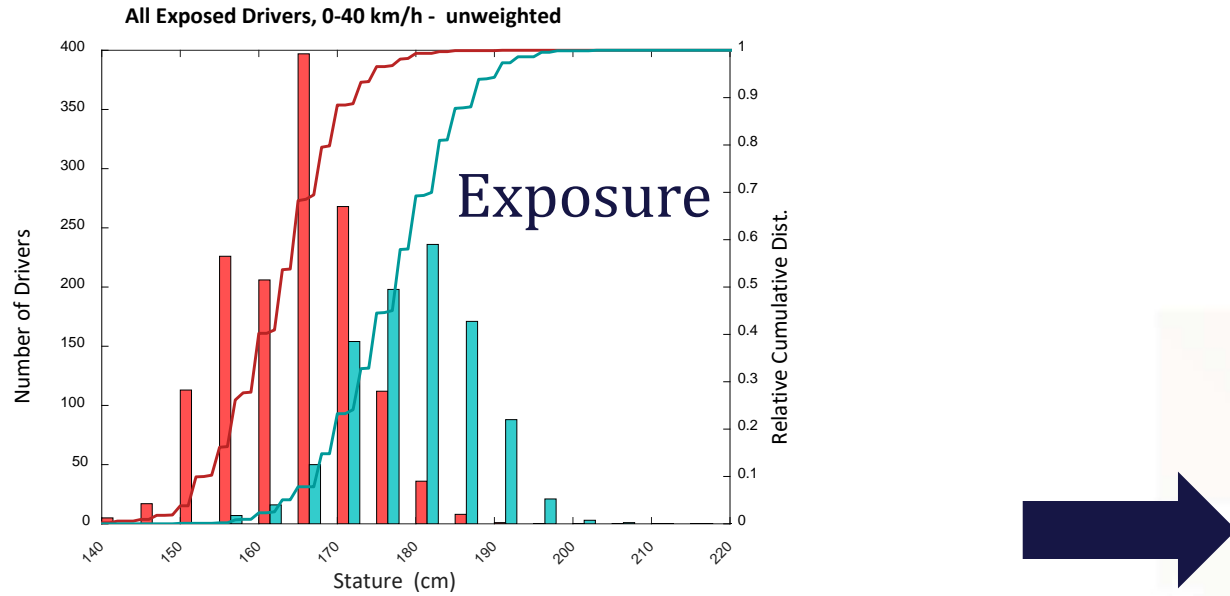
Frontal Collisions, Belted Occupants, Weighted

Median ΔV (approx.)

- All exposed: 20 km/h
- Moderate injury: 25 km/h
- Severe injury: 35 km/h

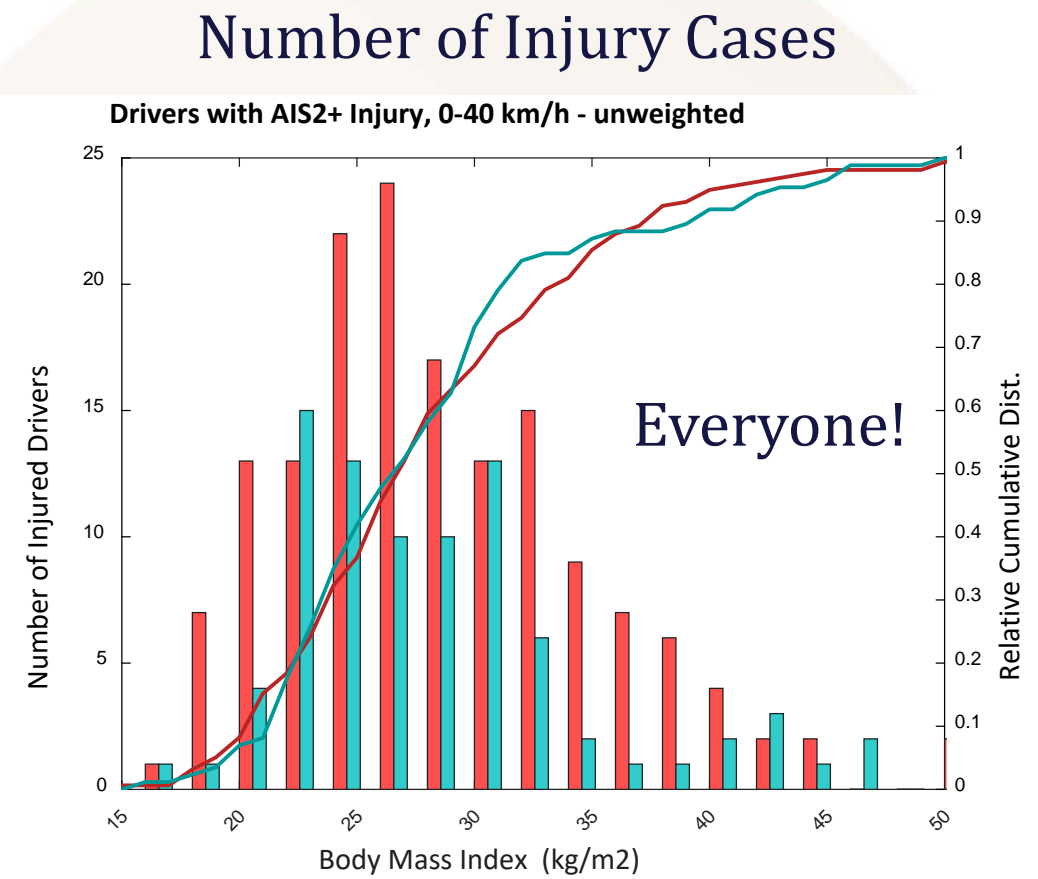
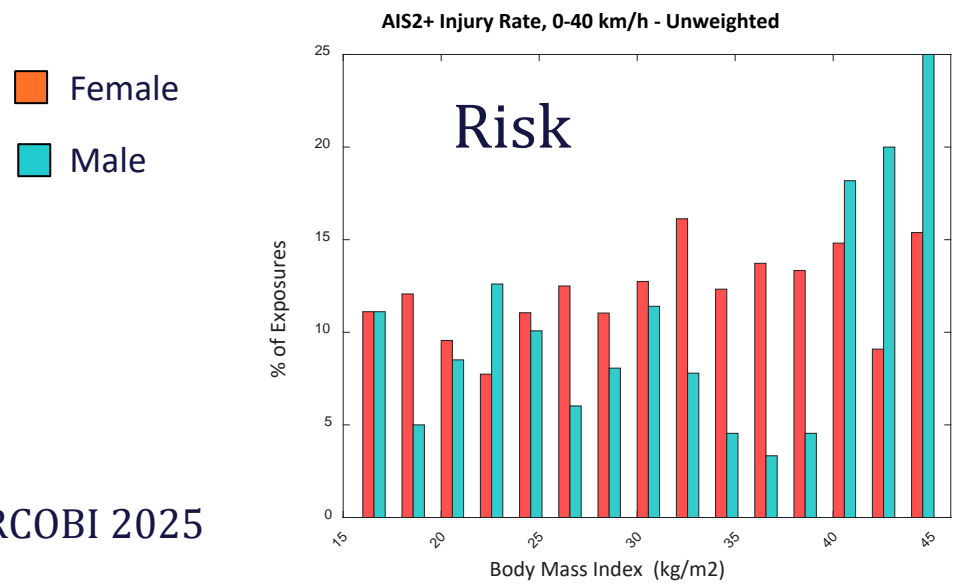
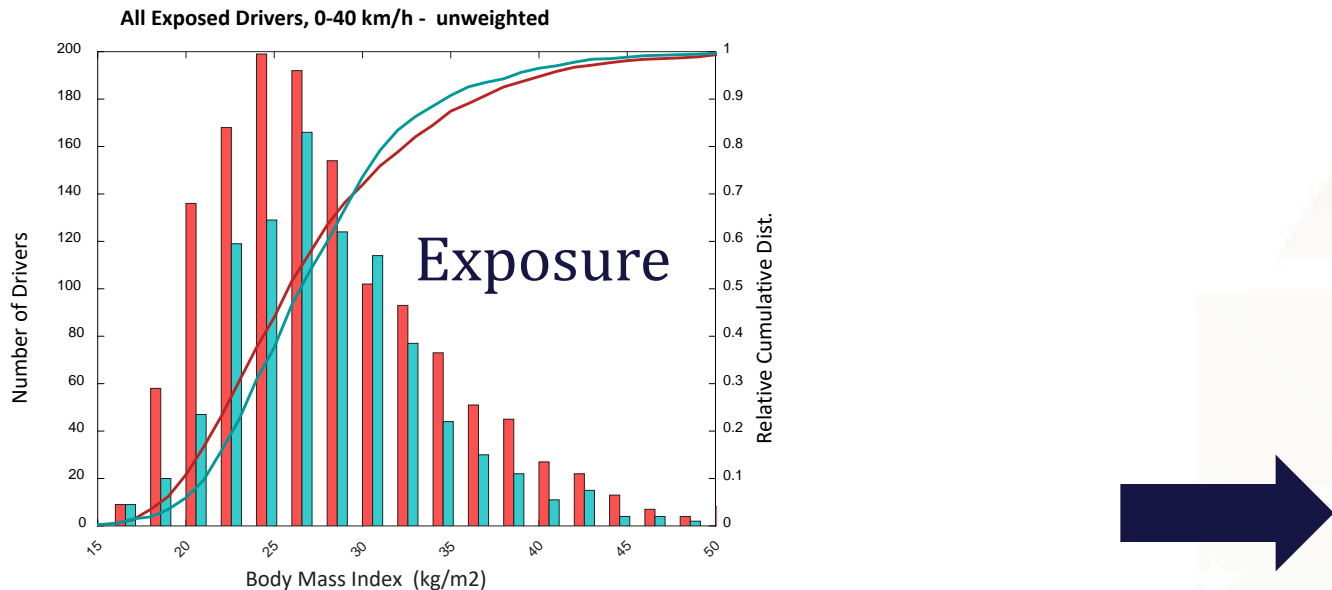
Most injuries happen in collisions with very low risk

# Who Gets Injured? --- Stature



CISS 2017-2022, MY 2002+  
Frontal Collisions, Belted Drivers, Single-Event

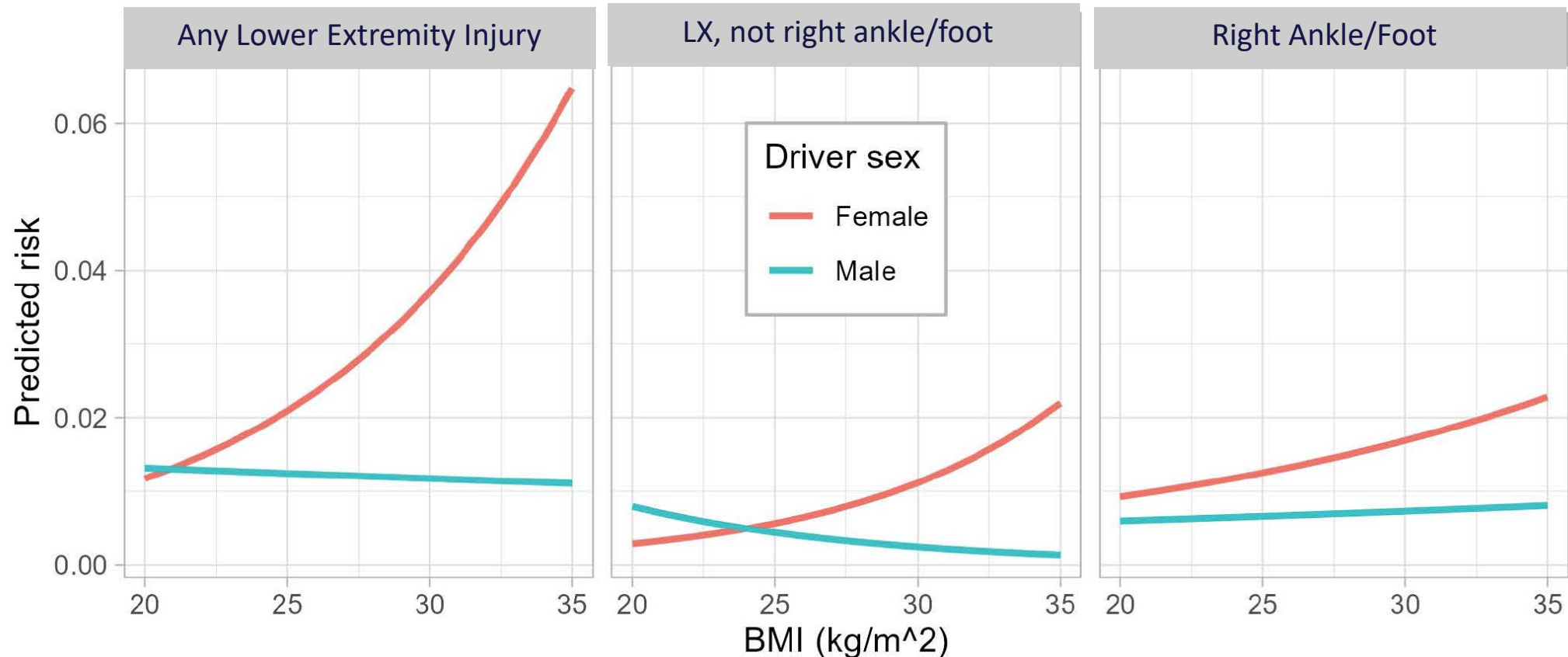
# Who Gets Injured? --- Body Mass Index



CISS 2017-2022, MY 2002+  
Frontal Collisions, Belted Drivers, Single-Event

# Body Shape & Restraint Interaction?

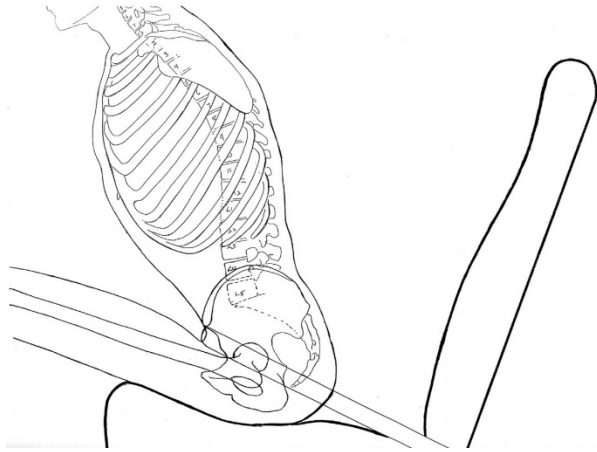
## Increased body mass affects females more than males



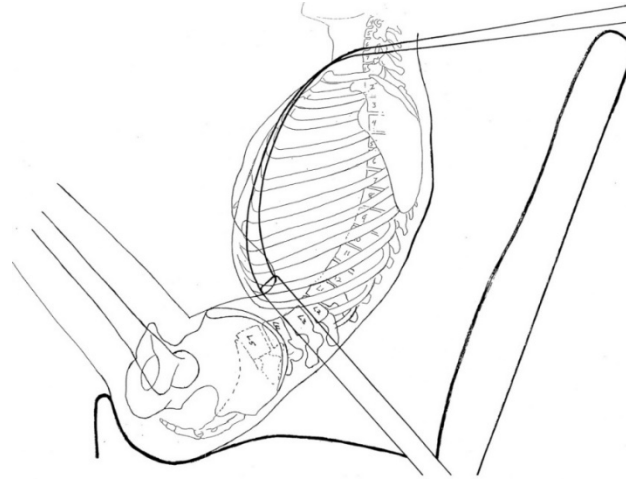
Predicted moderate-severe lower extremity injury risk, 50 year-old driver in a 25 mph crash.  
Brumbelow et al. 2023, Insurance Institute for Highway Safety

# Body Shape & Restraint Interaction?

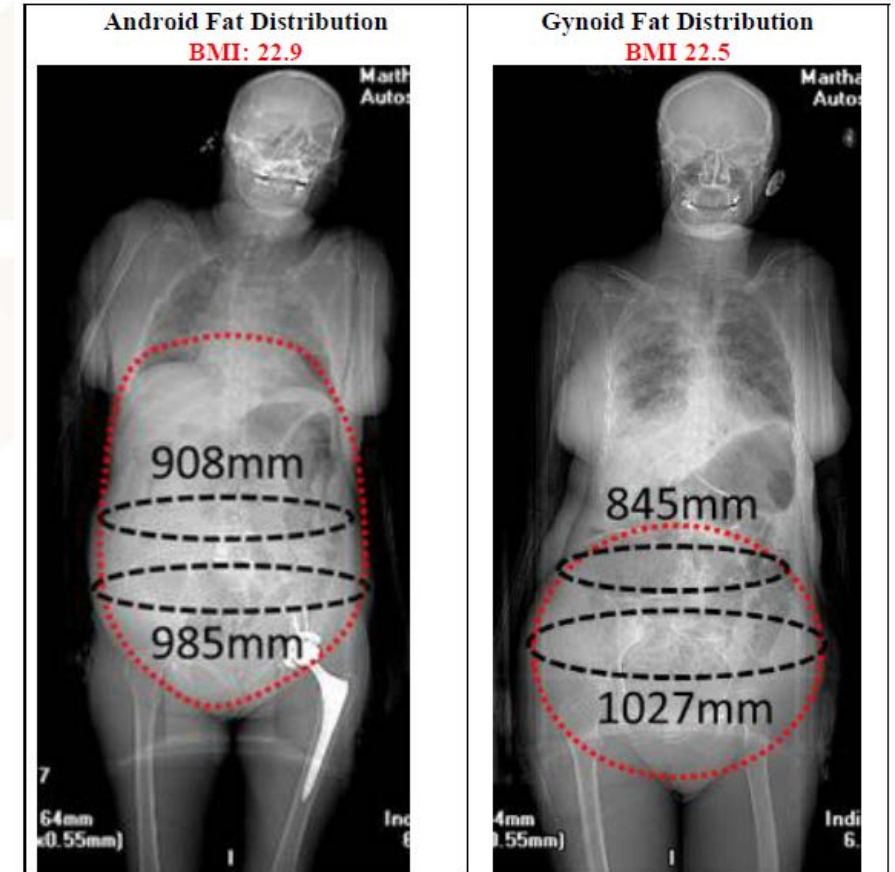
## Preferred Kinematics



## Submarining



↑ Pelvis motion  
LX Loading



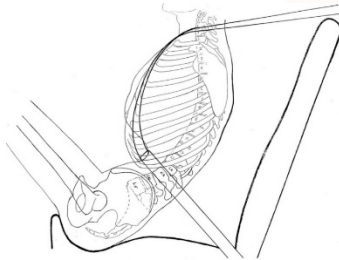
Females: Lower center of gravity, more soft tissue around hips & pelvis

↳ Greater risk of sliding under the lap belt?

# 2020 Crossover SUV

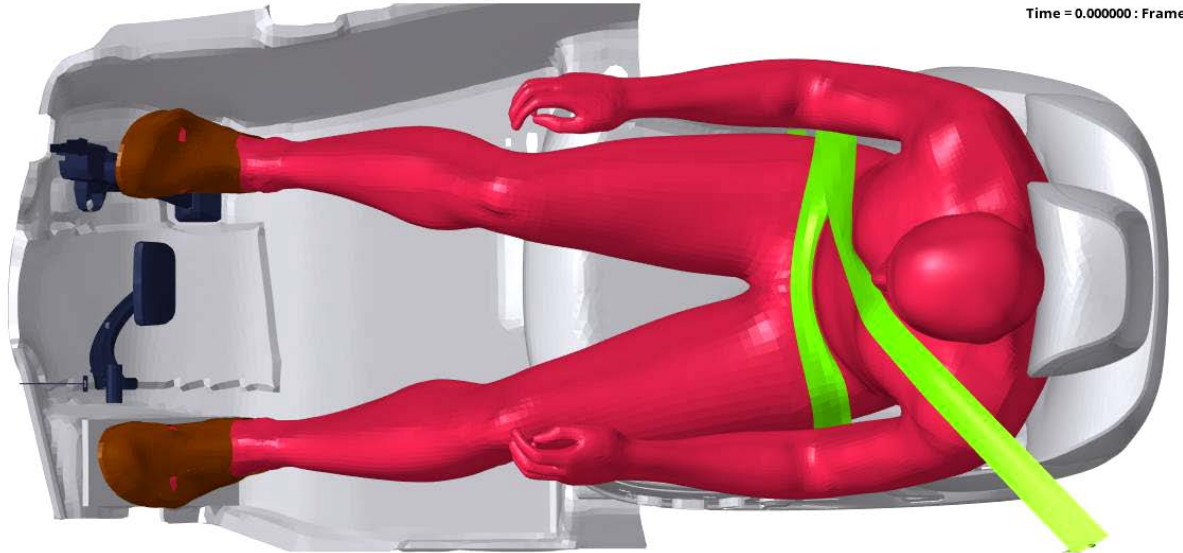
61 y.o. female  
 170 cm 89 kg  
 BMI 30.7  
 $\Delta V$  59 km/h, -20° PDOF  
 Driver, Belted  
 Flats

R. Fibula fx., R. Tibia fx, distal  
 Sacrum fx.  
 Rib fxs., Sternum fx.,  
 Lung contusion, bilateral  
 Omentum & mesentery contusions  
 Rectus abdominus muscle rupture  
 Minor spine fxs.

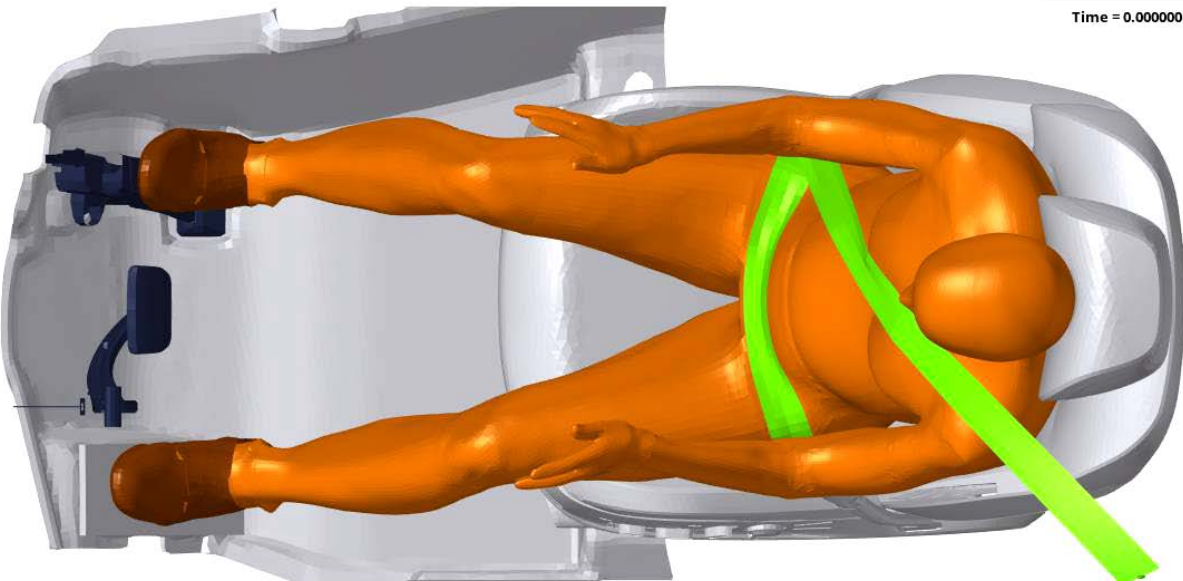


# Comparison, 50<sup>th</sup> Male vs. 50<sup>th</sup> Female, 0° PDOF

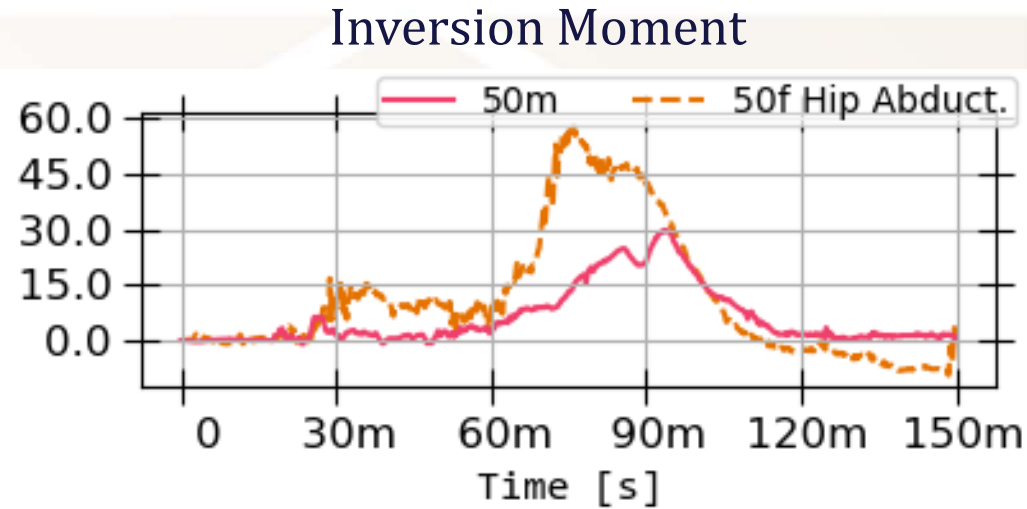
50M



50F



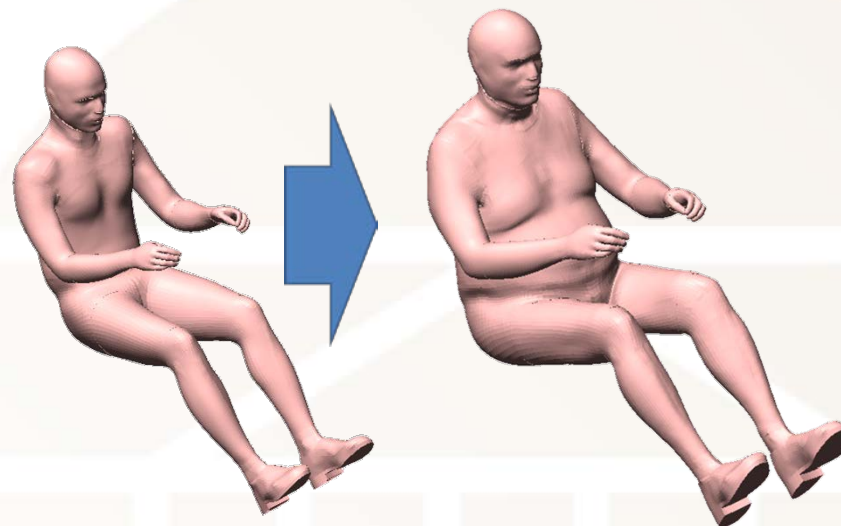
R. Ank. Mx [Nm]



# 50<sup>th</sup> Percentile Female, Elderly, & Obese Testing

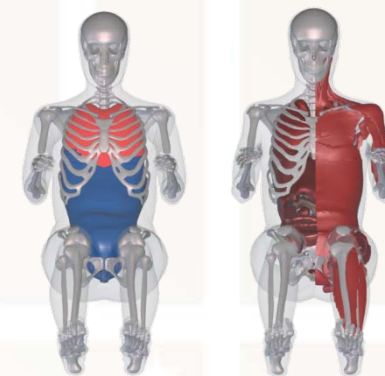


PMHS image removed



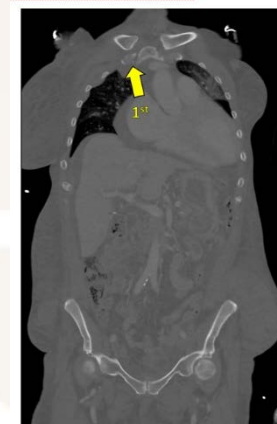
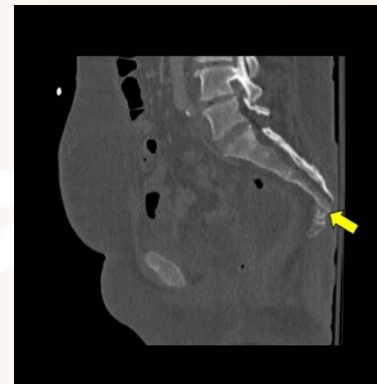
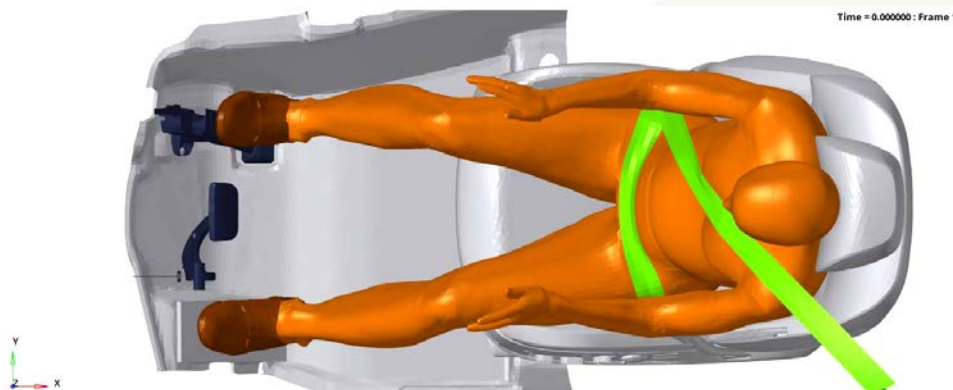
Reference tests of various vehicle occupants  
for human body model development

- Mid-sized female
- Elderly mid-sized female
- Obese female
- Obese male



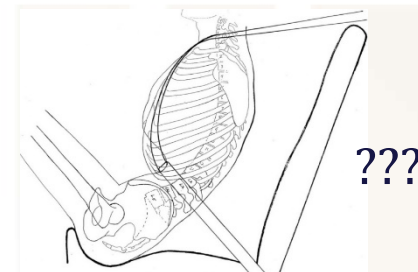
# Research Need – PMHS Tests in Real Vehicle Buck

PMHS image removed



Much of our validation info is in highly simplified environments

Need to complement with PMHS tests in real vehicle environment for final validation of real-world prediction



Final Challenge! ---  
PMHS tests **must** be accompanied by well-validated model of test environment

# Updates on Research in Population Variability



Questions?

Email: [jlf3m@virginia.edu](mailto:jlf3m@virginia.edu)

Jason Forman

*University of Virginia Center for Applied Biomechanics*