

Does female occupants have the same protection level as male occupants?

Are Crash test Dummies Representative of the Population?
A pre-study

Anna Carlsson, Stiftelsen Chalmers Industriteknik
Pernilla Bremer, Sweden

Purpose of this study?

- Have female occupants the same protection level as male occupants?
- How representative are crash test dummies of the female population?

General statistics

- Injury risks are higher for females than males^{*)}

^{*)} *when controlling for factors such as crash severity, restraint usage, blood alcohol content*

General statistics

Females in comparison to males:

- Narragon et al. (1965): **11%** higher injury risk
- Evans (2000): **35%** higher fatal injury risk (25 yo)
- Bedard et al. (2002): **54%** higher fatal injury risk
- Bose et al. (2011):
47% higher MAIS 3+ injury risk
71% higher MAIS 2+ injury risk
- Forman et al. (2019)
73% higher MAIS 3+ injury risk
142% higher MAIS 2+ injury risk

General statistics

Females greater risk of:

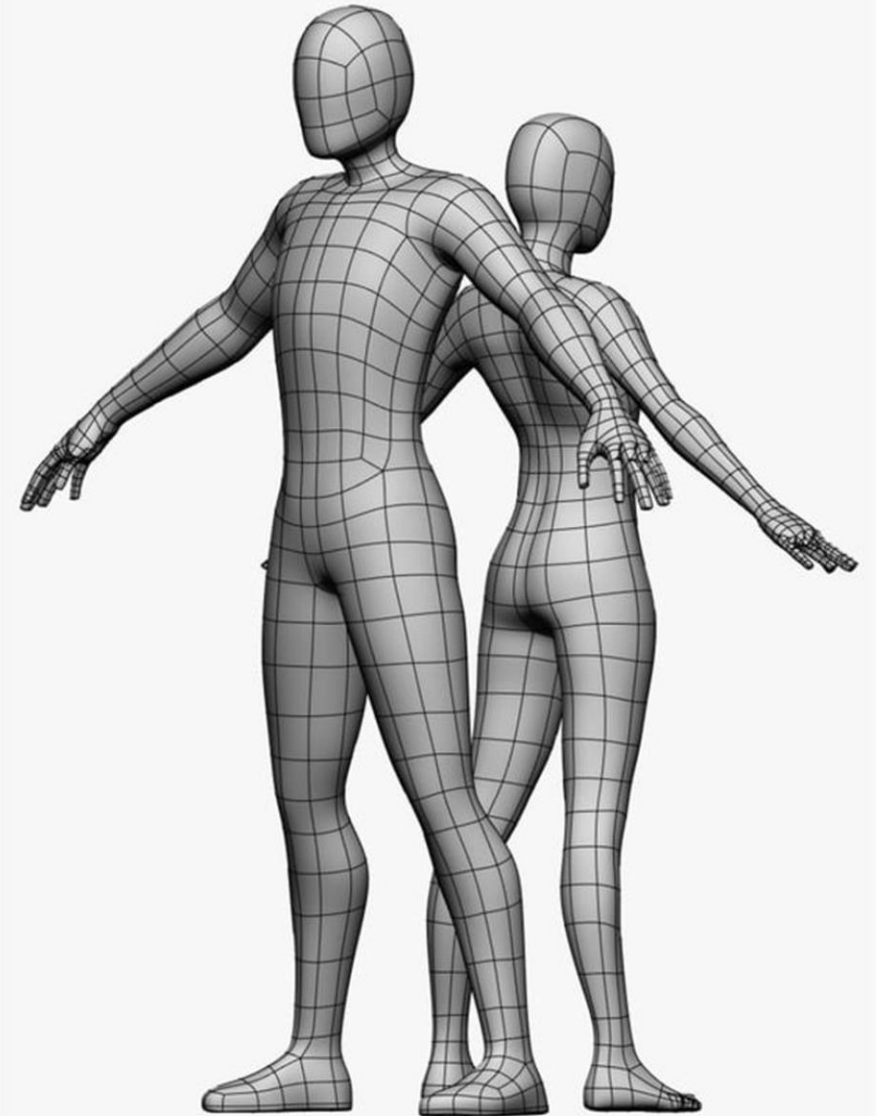
- Spine, thorax, extremity injuries

(Welsh & Lenard 2001; Bose et al. 2011;
Parenteau et al. 2013; Kahane 2013)

Males greater risk of:

- Head injuries

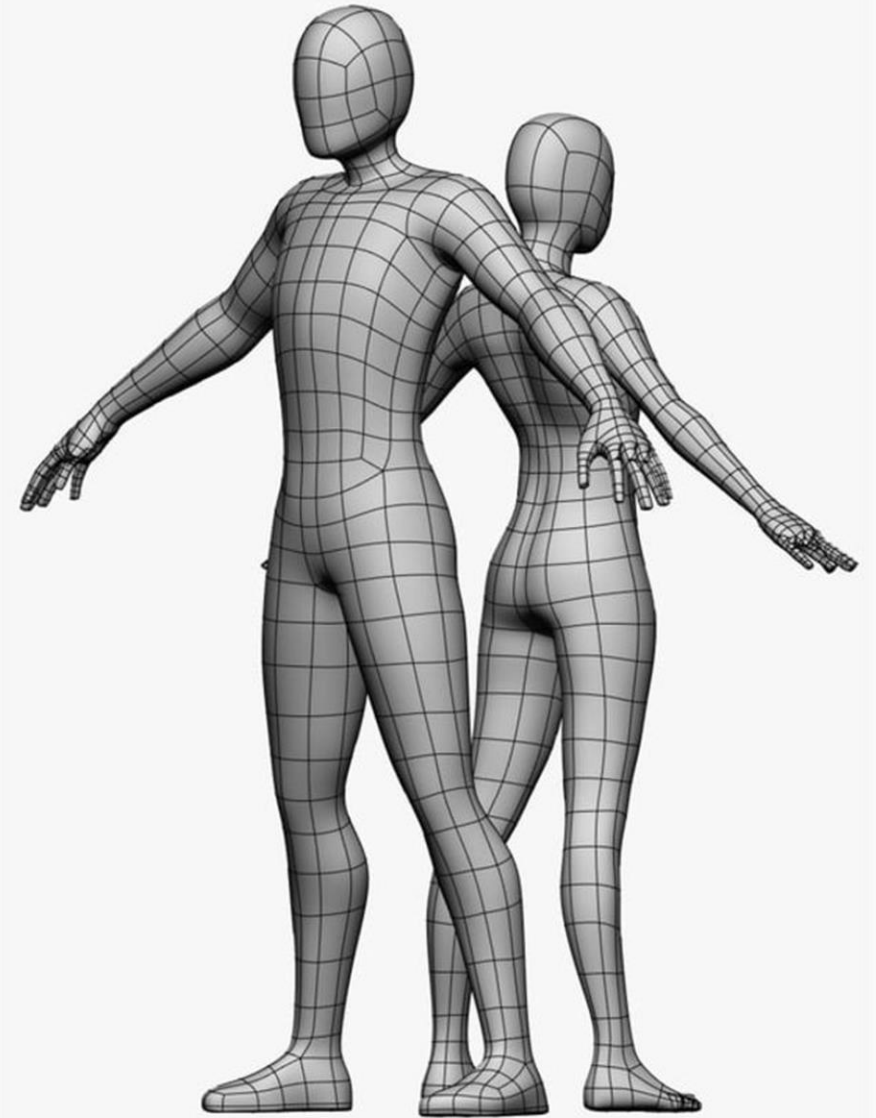
(Parenteau et al. 2013; Welsh & Lenard 2001)



General statistics

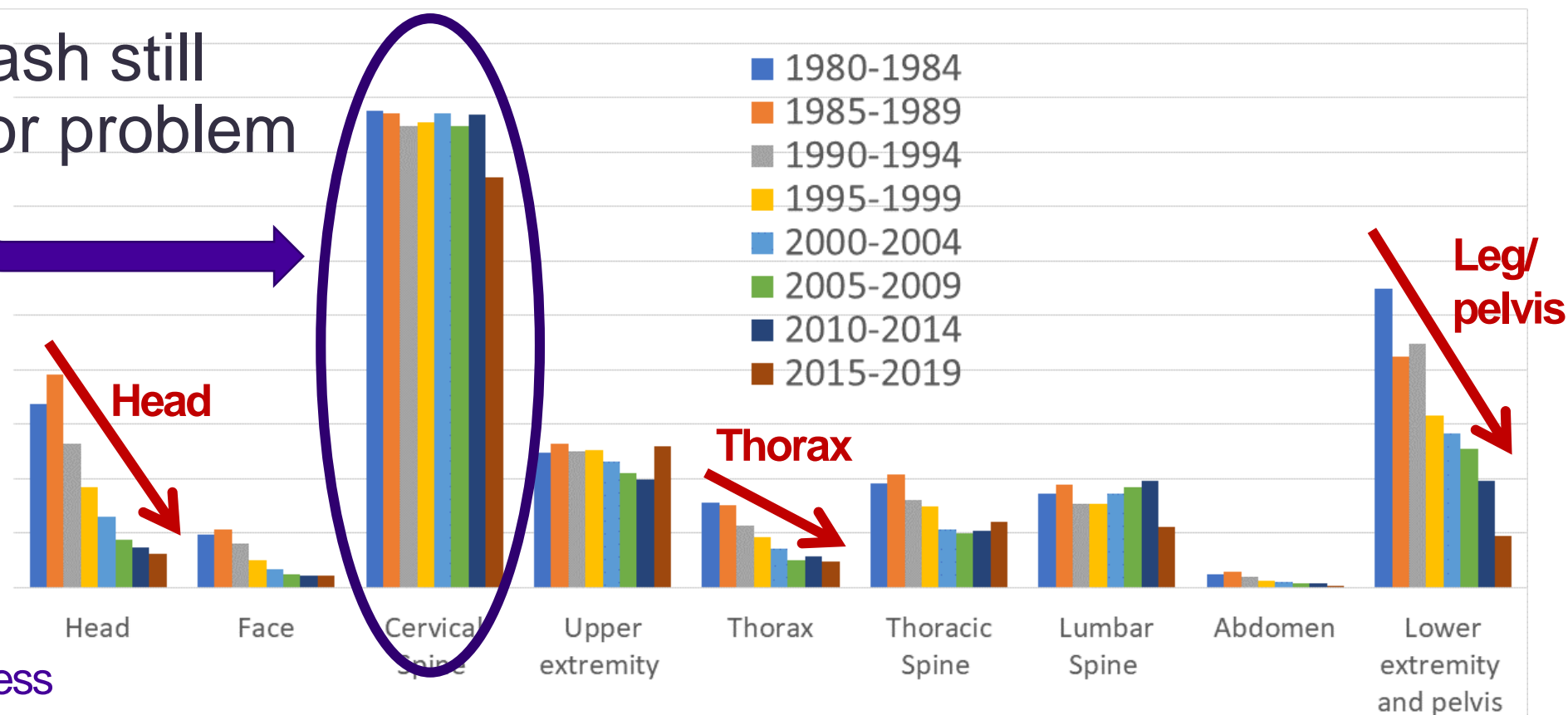
Females:

- Sustain injuries at lower velocity changes (Δv)
(Mackay & Hassan 2000; Welsh & Lenard 2001s)
- Show greater increase in thoracic injuries with increasing age
(Ridella et al. 2012; Forman et al. 2019)



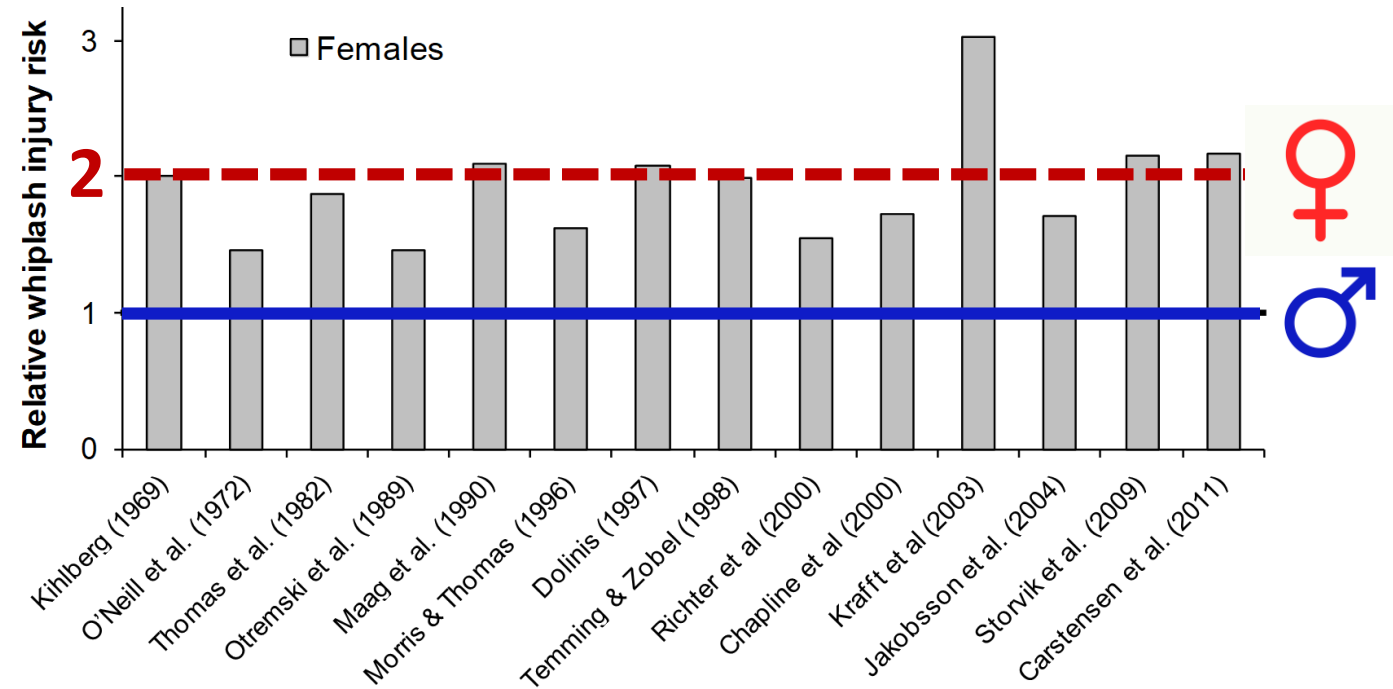
Permanent medical impairment

- Whiplash still a major problem



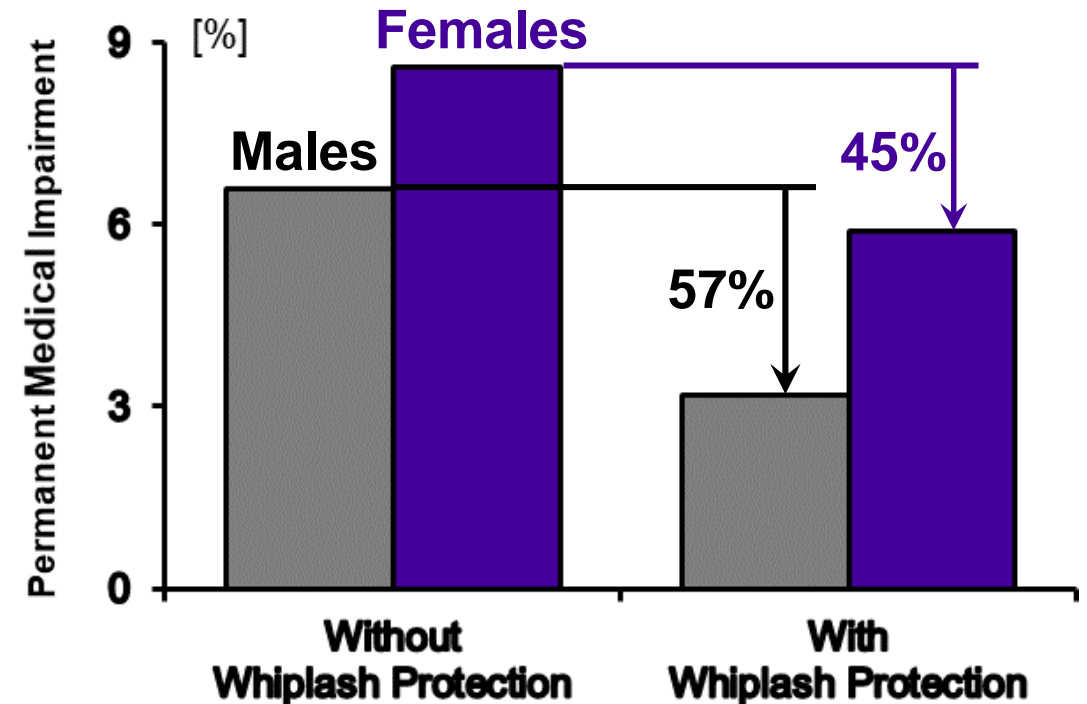
Whiplash

- Females have a higher risk of whiplash injury



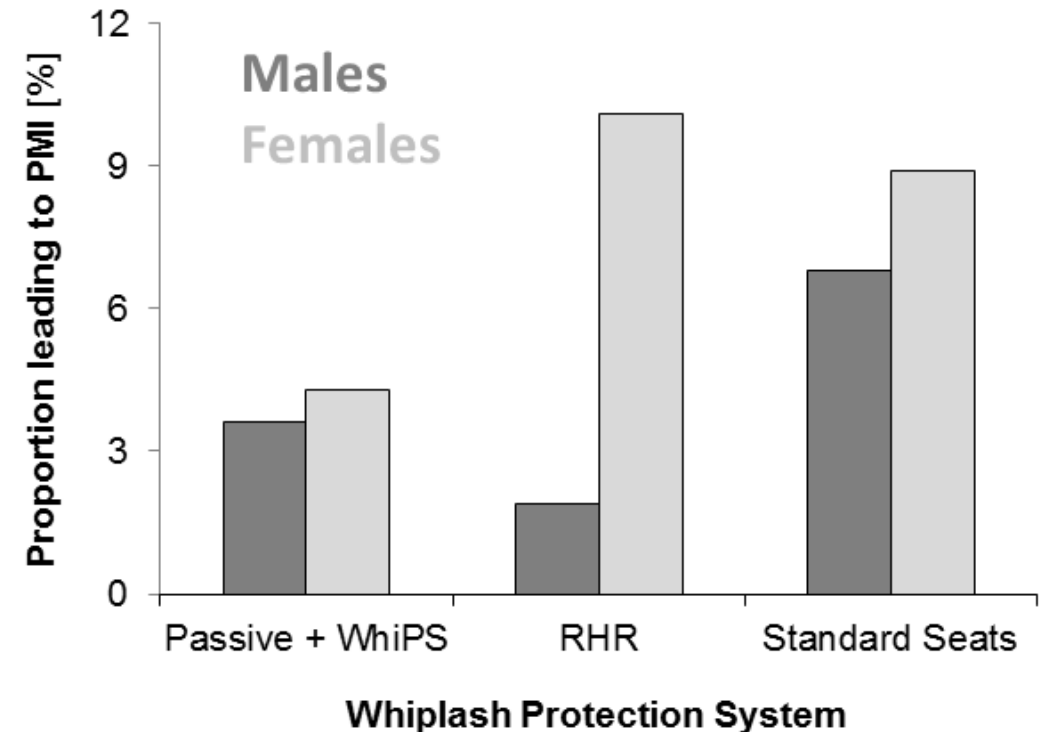
Whiplash

- Whiplash protection systems are (in general) less effective for females compared to males (Kullgren & Krafft 2010)



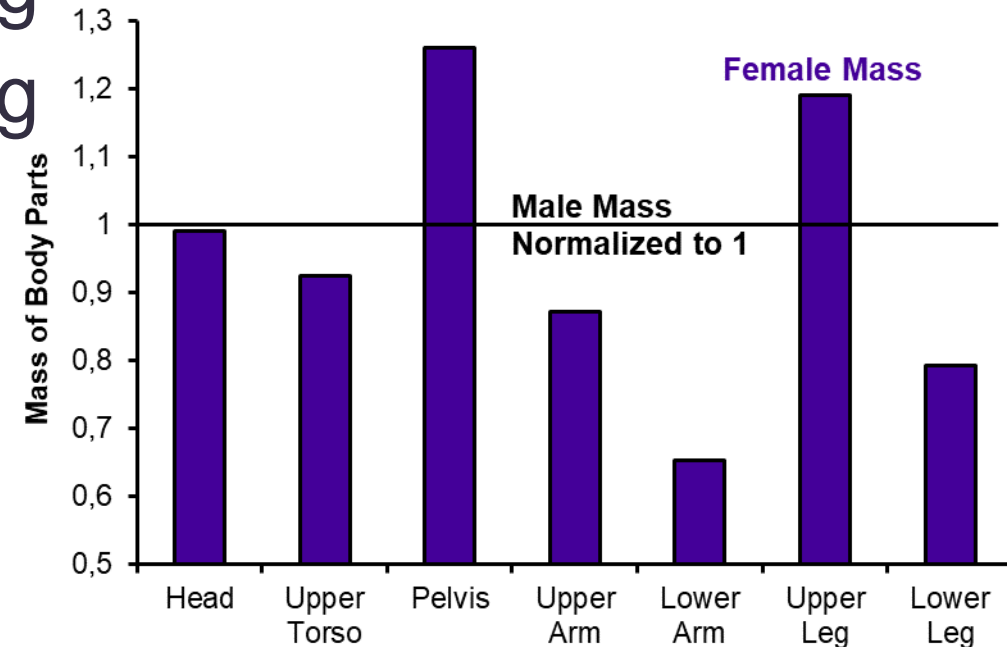
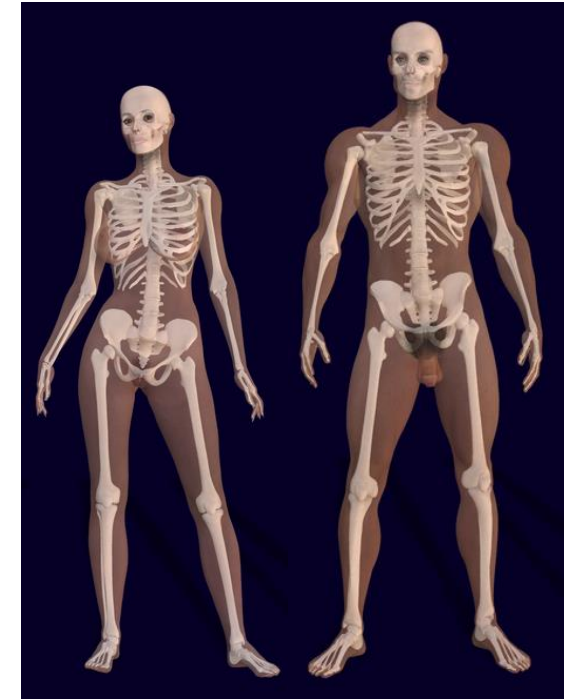
Whiplash

- Different effectiveness in protecting females with different types of whiplash protection systems
(Kullgren et al. 2013)



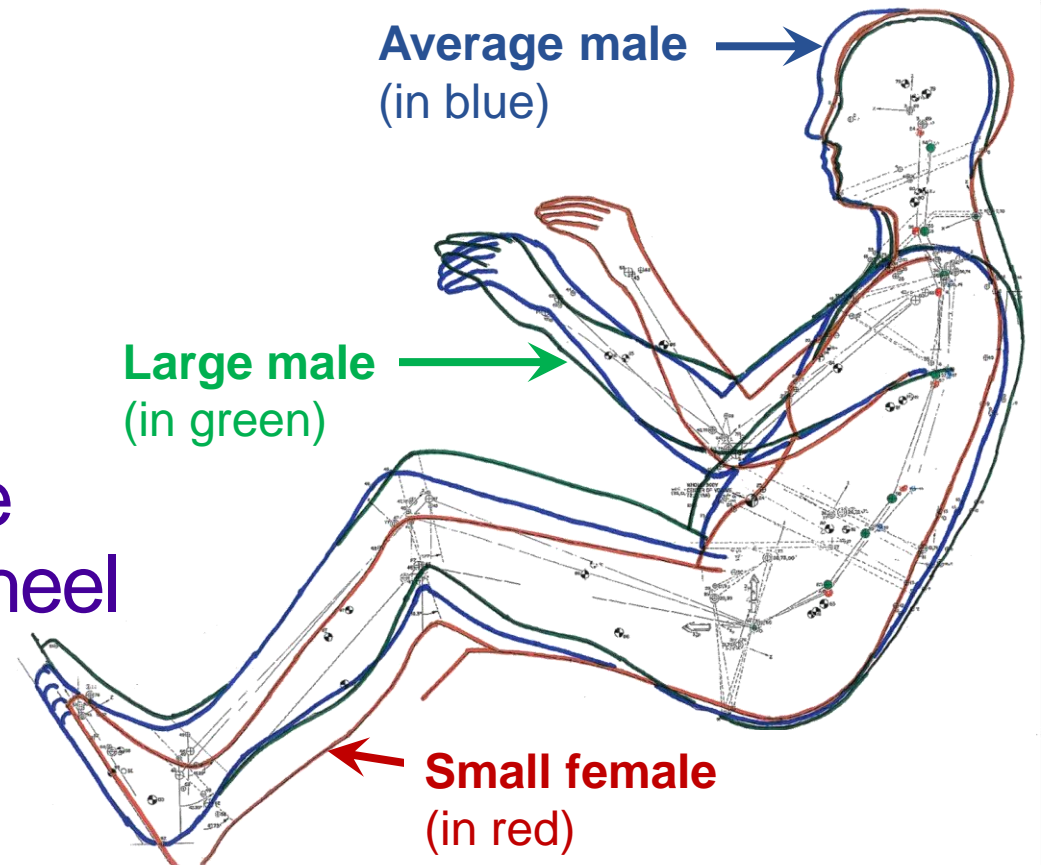
Are we different?

- Size:
Average female: 162 cm / 62 kg
Average male: 175 cm / 77 kg
(Schneider et al. 1983)
- Mass distribution
(Young et al. 1983; McConville et al. 1980)



Different size

- Different seated posture
- Females tend to have:
 - Different arm position
 - Shorter head restraint distance
 - Shorter distance to steering wheel
 - Different leg position
 - More upright seated posture
 - Shorter distance to floor pan



Picture based on UMTRI data

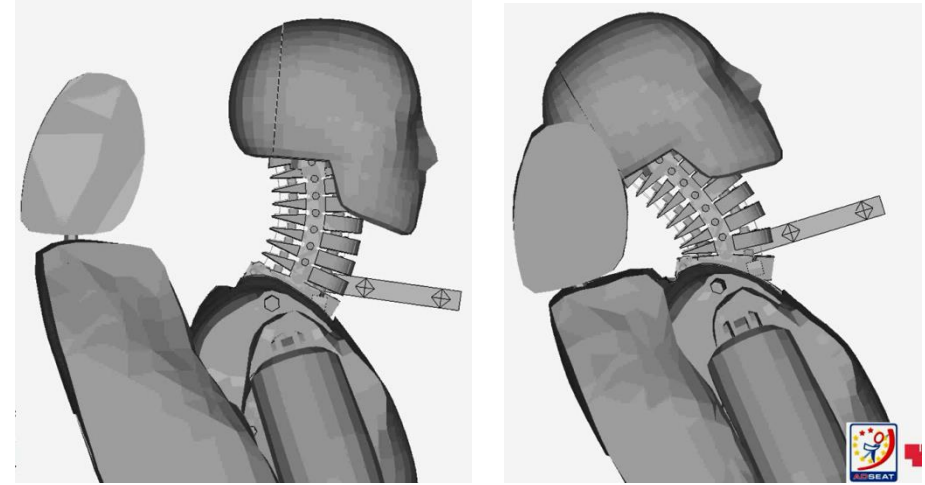
Different geometry

Example:

- Focus on the HR being positioned too low (“males”),
- No focus on the HR being positioned too high (“females”)

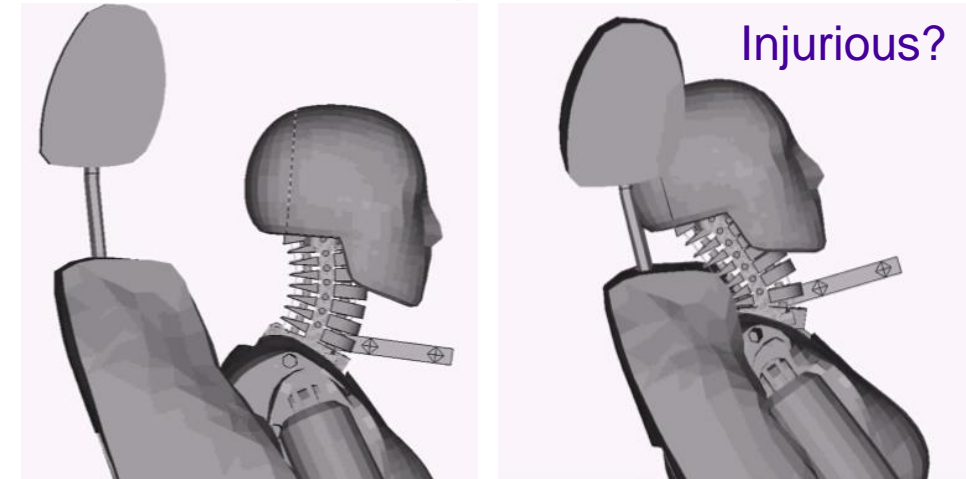
Head restraint in low position

Average male



Head restraint in high position

Average female



Are we different?

- Size
- Mass distributions
- Age dependence
- Hormones
- Pregnancy
- Anatomy
- Osteoporosis



Existing Crash Test Dummy Sizes

Small female
(5th percentile)



Stature: 1.51 m
Mass: 47 kg

Average female
(50th percentile)



Stature: 1.62 m
Mass: 62 kg

Average male
(50th percentile)



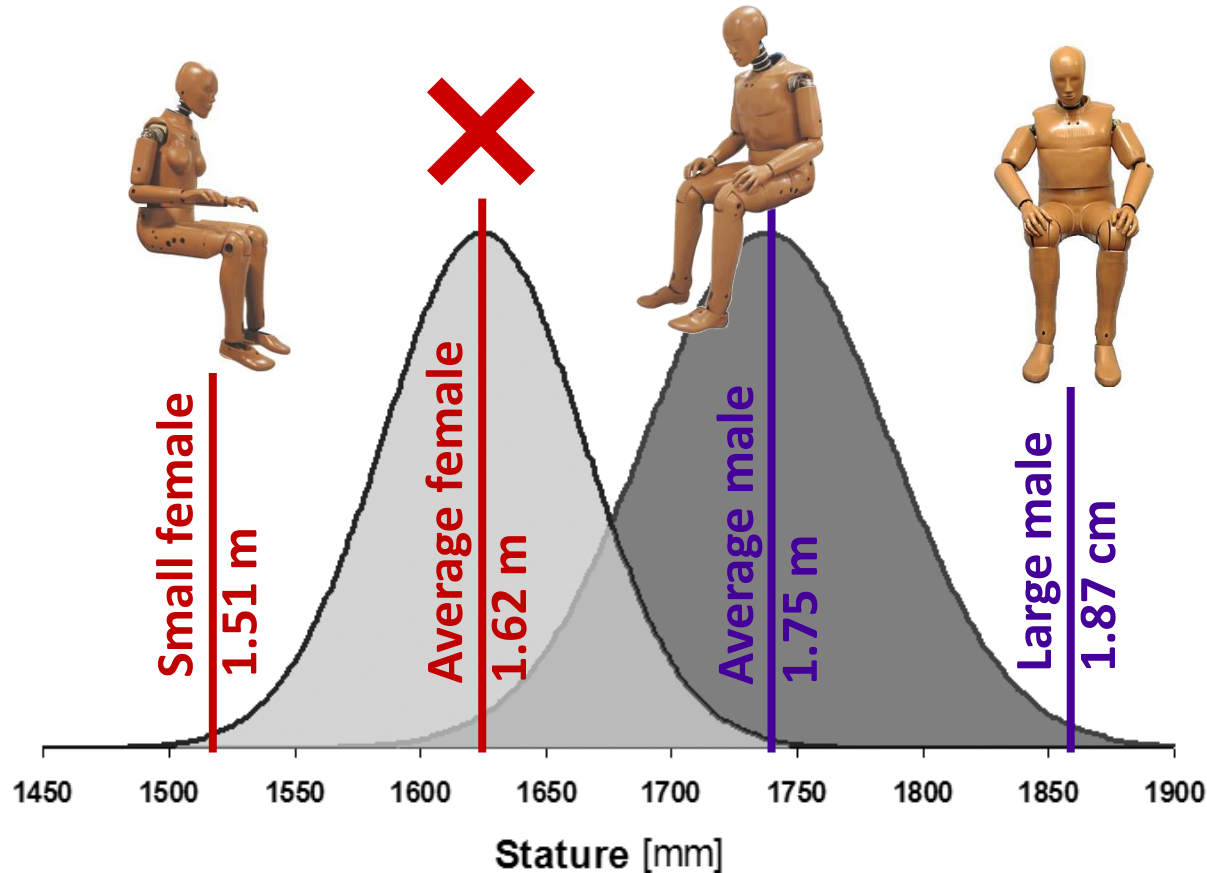
Stature: 1.75 m
Mass: 77 kg

Large male
(95th percentile)



Stature: 1.87 m
Mass: 102 kg

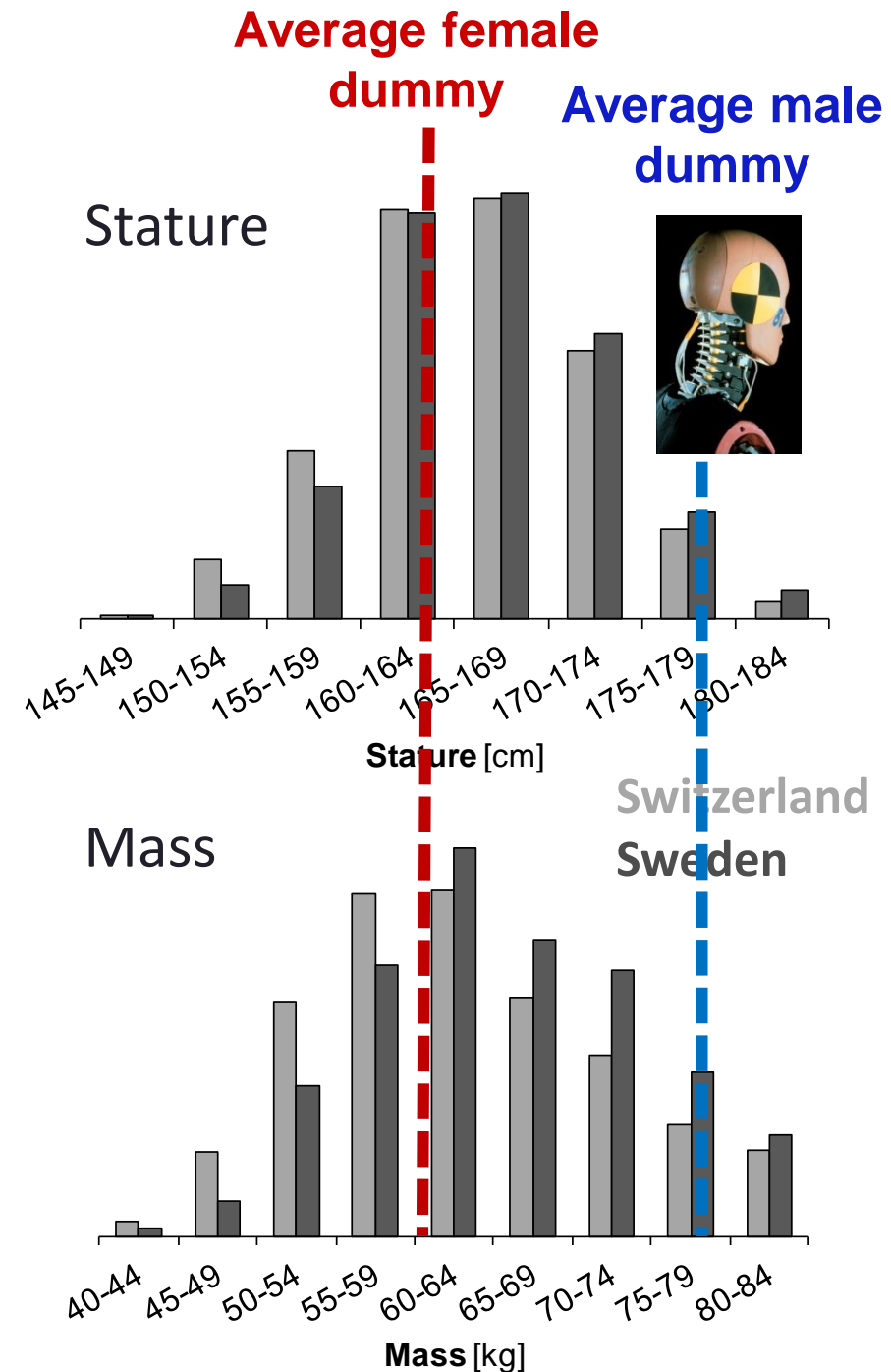
Distribution of statures



Based on
Pheasant & Haslegrave (2006)

Rear impacts

- Statures & masses of females with whiplash injuries in Switzerland & Sweden
- An average female dummy would correlate in size to the females most frequently injured



Available Crash Test Dummies

| Impact Direction | Dummy Type | Dummy Size | | | |
|------------------|------------|------------|---------|---------|-------|
| | | Female | | Male | |
| | | Small | Average | Average | Large |
| Frontal | THOR | x | | x | |
| | HIII | x | | x | x |
| | HII | | | x | |
| Side | SID-IIs | x | | | |
| | ES-2 | | | x | |
| | ES-2re | | | x | |
| | WorldSID | x | | x | |
| Rear | BioRID-II | | | x | |

To conclude

- Crash related injury risks are higher in females
- Females poorly represented by existing dummies



Future needs

- Dummies of both men and women, of different sizes and ages, for robust vehicle safety assessment
- Information about body size (stature and mass) in traffic injury databases
- Injury data reported for females and males separately



Future possibilities

- Human body models of females and males may provide a powerful extension to the crash test dummies in future virtual test procedures



Thank you for your attention!

