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

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

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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

• 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

RESULTS

Females in comparison to males:

11% higher injury risk
35% higher fatal injury risk (25 yo)
54% higher fatal injury risk
47% higher MAIS 3+ injury risk
71% higher MAIS 2+ injury risk
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 ($\Delta v$) (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")
Are we different?

- Size
- Mass distributions
- Age dependence
- Hormones
- Pregnancy
- Anatomy
- Osteoporosis
**Existing Crash Test Dummy Sizes**

**Small female**
(5<sup>th</sup> percentile)
- Stature: 1.51 m
- Mass: 47 kg

**Average female**
(50<sup>th</sup> percentile)
- Stature: 1.62 m
- Mass: 62 kg

**Average male**
(50<sup>th</sup> percentile)
- Stature: 1.75 m
- Mass: 77 kg

**Large male**
(95<sup>th</sup> percentile)
- Stature: 1.87 m
- Mass: 102 kg

www.humaneticsatd.com/crash-test-dummies
Based on Pheasant & Haslegrave (2006)

Distribution of statures

- Small female: 1.51 m
- Average female: 1.62 m
- Average male: 1.75 m
- Large male: 1.87 cm
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

<table>
<thead>
<tr>
<th>Impact Direction</th>
<th>Dummy Type</th>
<th>Dummy Size Female</th>
<th>Dummy Size Male</th>
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<td>Rear</td>
<td>BioRID-II</td>
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[www.humaneticsatd.com/crash-test-dummies](www.humaneticsatd.com/crash-test-dummies)
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!