Head restraint geometry and seat interaction

Anna Carlsson, Stiftelsen Chalmers Industriteknik

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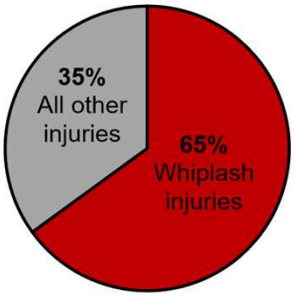
Whiplash injuries

- In front seat occupants, whiplash injuries account for 65% of all injuries leading to permanent medical impairment following a vehicle collision.

[Folksam Insurance Group 2022]

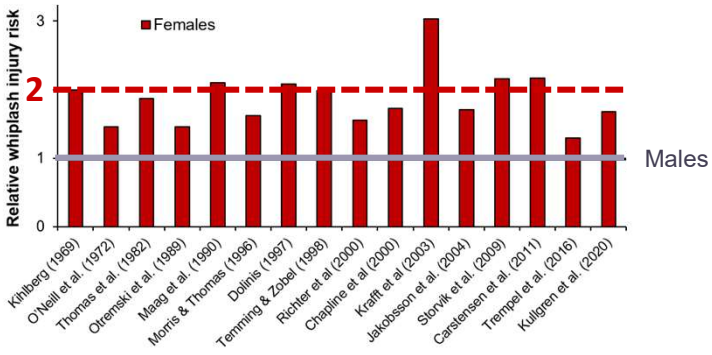


2

Whiplash injuries

- Greater risk for females

[Based on a mix of studies representing different risk measures, crash directions and methodologies]



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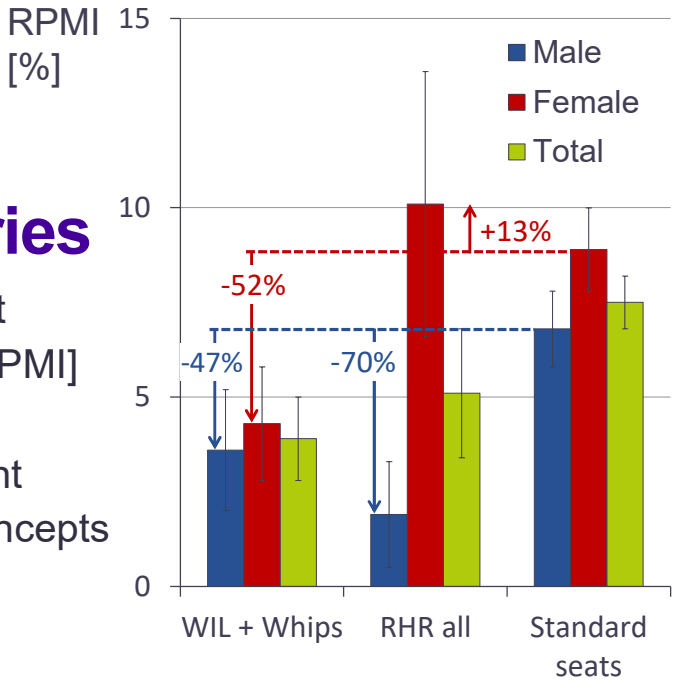
Whiplash injuries

- The Risk of Permanent Medical Impairment [RPMI] (i.e. long-term injury) differs between different whiplash protection concepts

[Kullgren et al. 2013]



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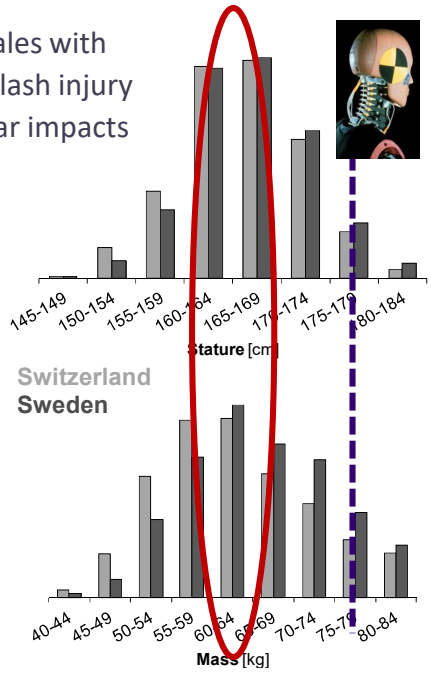
Whiplash injuries

- Females are poorly represented by the 50th percentile male BioRID II

[Carlsson et al. 2014]



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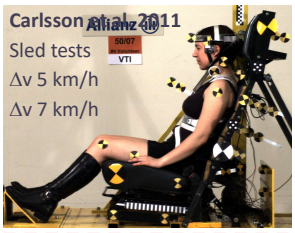
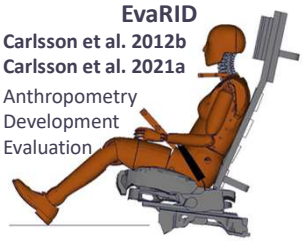
Rear Impact Volunteer Tests



50th Percentile Female Size



Occupant Models

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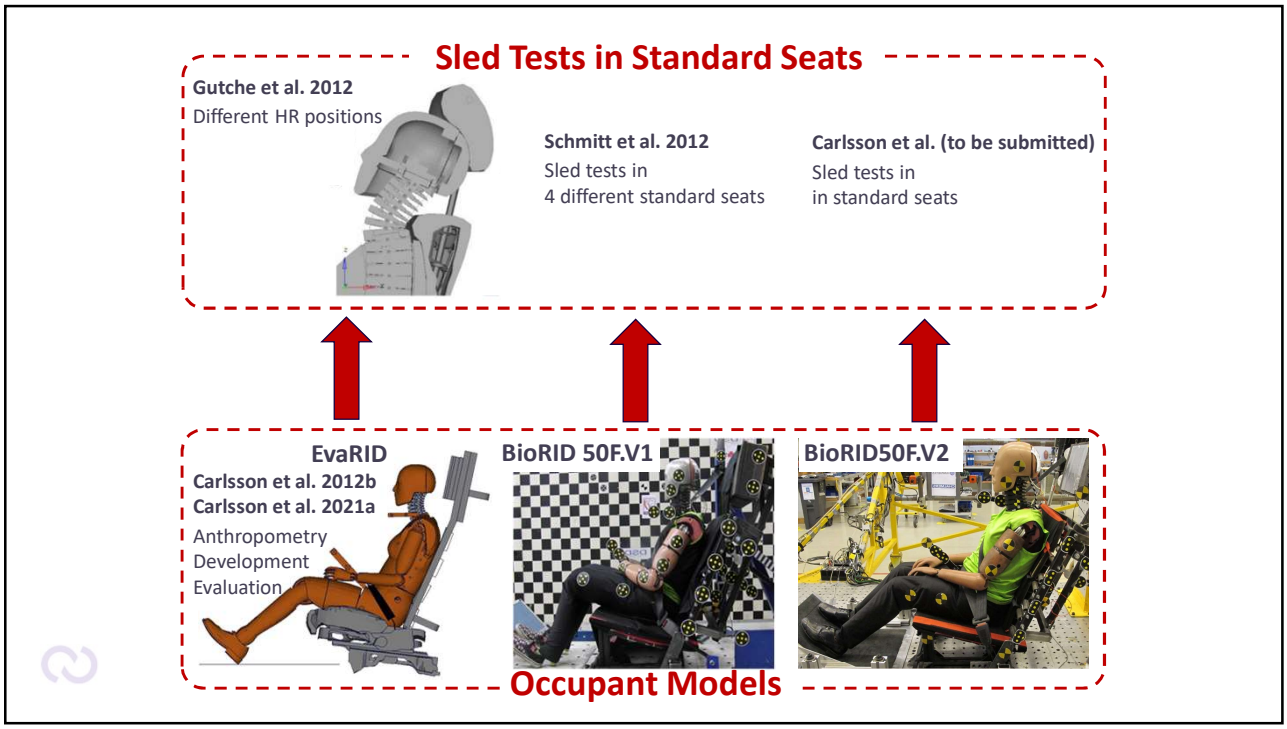

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What did we learn?

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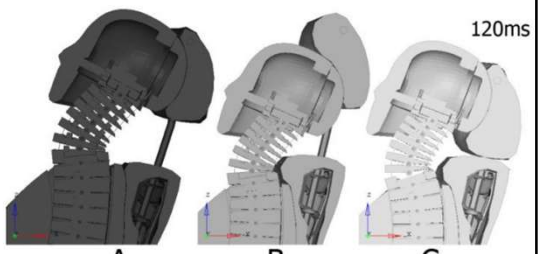
HR position

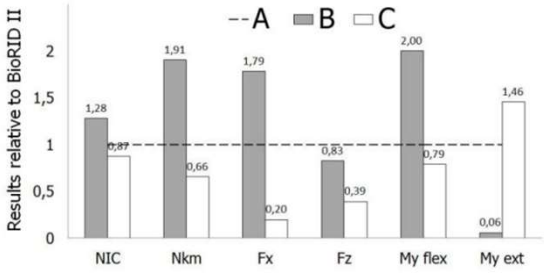
- The optimal head restraint (HR) position is different for males and females

[Gutsche et al. 2012]

Virtual rear impact tests with BioRID and EvaRID:



A (HR: Top) B (HR: Top) C (HR: Low)



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Real world HR adjustment (Saab 9-3)

- 89% in any of the 3 top positions
- 59% in the top position
- No major differences between males/females

[Carlsson et al. 2017]

		Distribution		
	HR height	Females (%)	Males (%)	All (%)
Low[1]	−80%	—	2	1
	−60%	—	—	—
	−40%	—	—	—
	−20%	—	—	—
Low[2]	0%	9	5	7
	20%	—	—	—
	40%	3	2	3
Mid[2]	60%	15	10	12
	80%	18	19	18
Top[1,2]	100%	56	62	59
	Total	100	100	100

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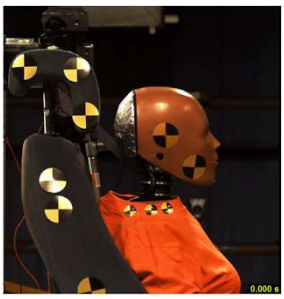
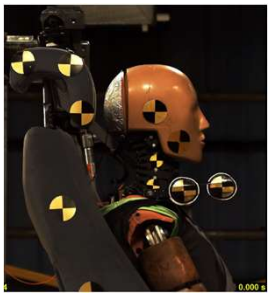
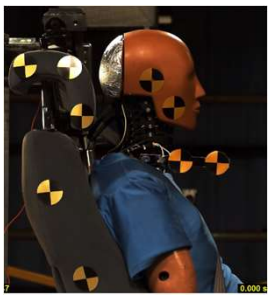
Top HR position (Saab 9-3)


5th percentile female


50th percentile female


50th percentile male


95th percentile male

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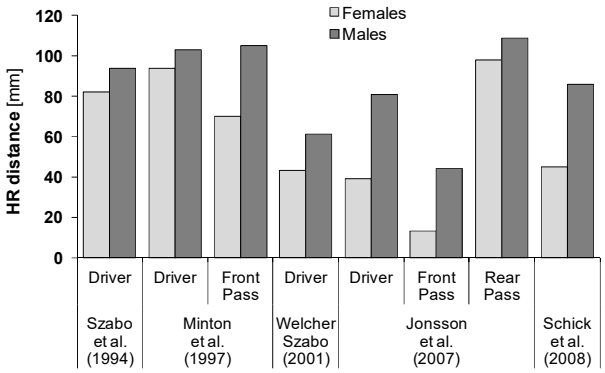
Backset

- Females tend to have shorter backset

[Carlsson et al. 2012]



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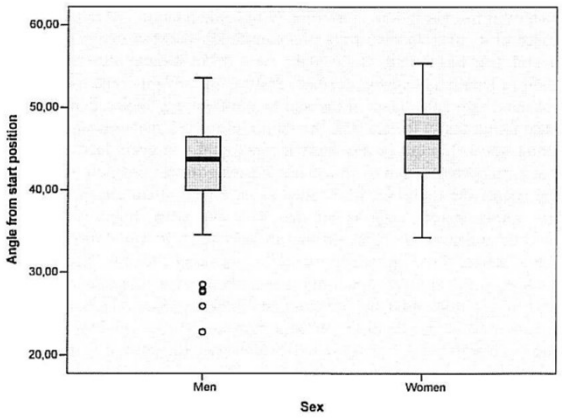
Seatback angle

- Females have on average 3° more upright seatback angle than males

[Jonsson et al. 2008]



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Sled tests with BioRID P50F_V1

- Seats A, B & D:
  Equipped with different types of whiplash protection system
  Good ratings in EuroNCAP
- Seat C:
  A basic seat design
  Marginally performance in EuroNCAP

[Carlsson 2012; Schmitt et al. 2012]

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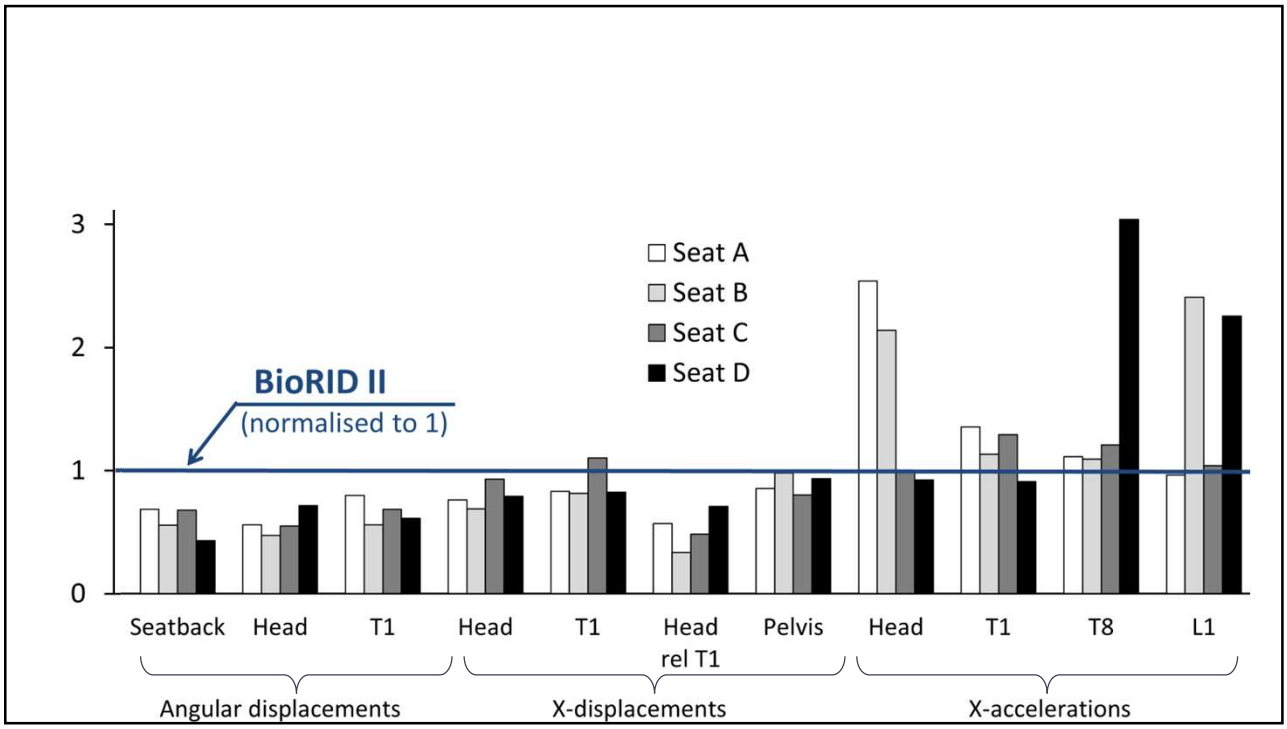
3
2
1
0
Seat A
Seat B
Seat C
Seat D
BioRID II
(normalised to 1)
Seatback
Head
T1
Head
T1
Head
rel T1
Pelvis
Head
T1
T8
L1
Angular displacements
X-displacements
X-accelerations

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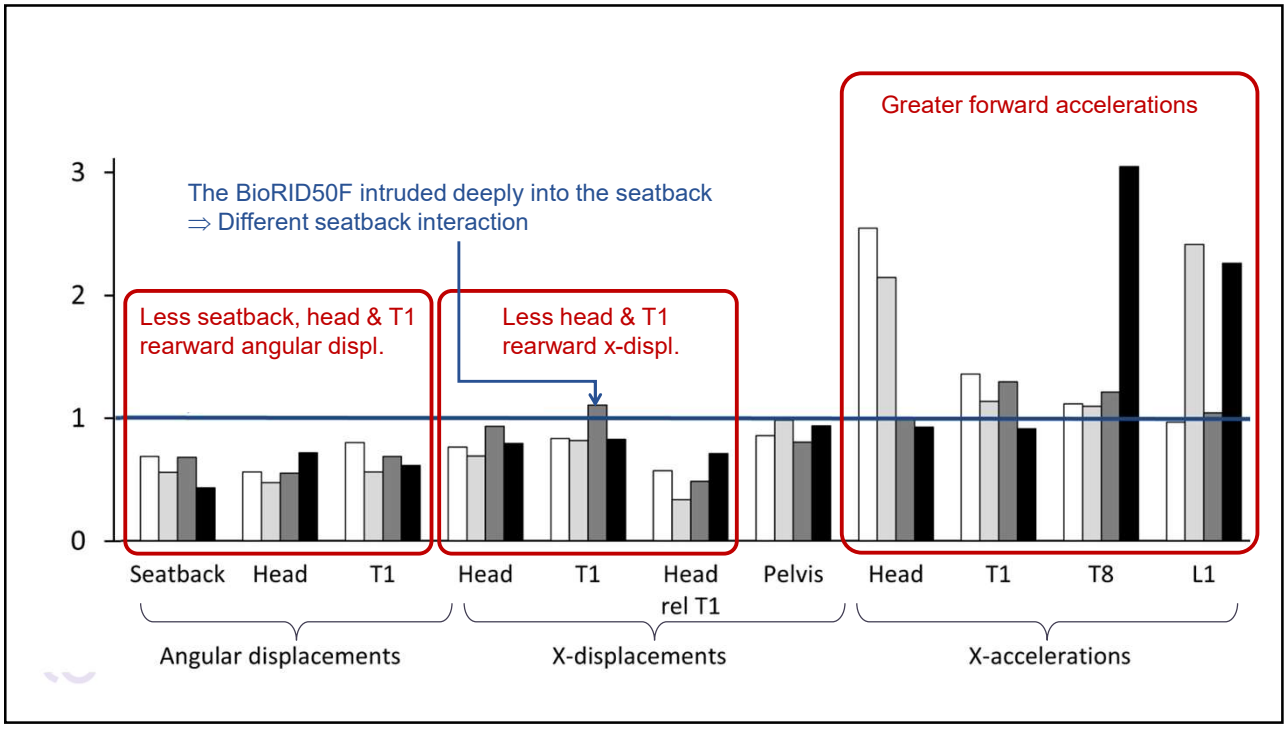
Greater forward accelerations
3
2
1
0
The BioRID50F intruded deeply into the seatback
⇒ Different seatback interaction
Less seatback, head & T1
rearward angular displ.
Less head & T1
rearward x-displ.
Seatback
Head
T1
Head
T1
Head
rel T1
Pelvis
Head
T1
T8
L1
Angular displacements
X-displacements
X-accelerations

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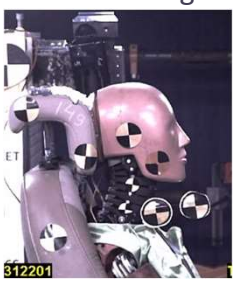
Sled tests (Saab 9-3)

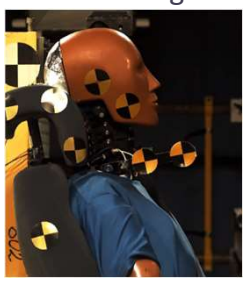
Males: 70% injury risk reduction
Females: 0% injury risk reduction

- Neck protraction in female dummy
  => Not enough with static measures
- $NIC_{protraction}$ higher in female dummy
  => Not included in test protocols

BioRID 50F_V2
50%-ile female
Mid HR height



BioRID II
50%-ile male
Mid HR height



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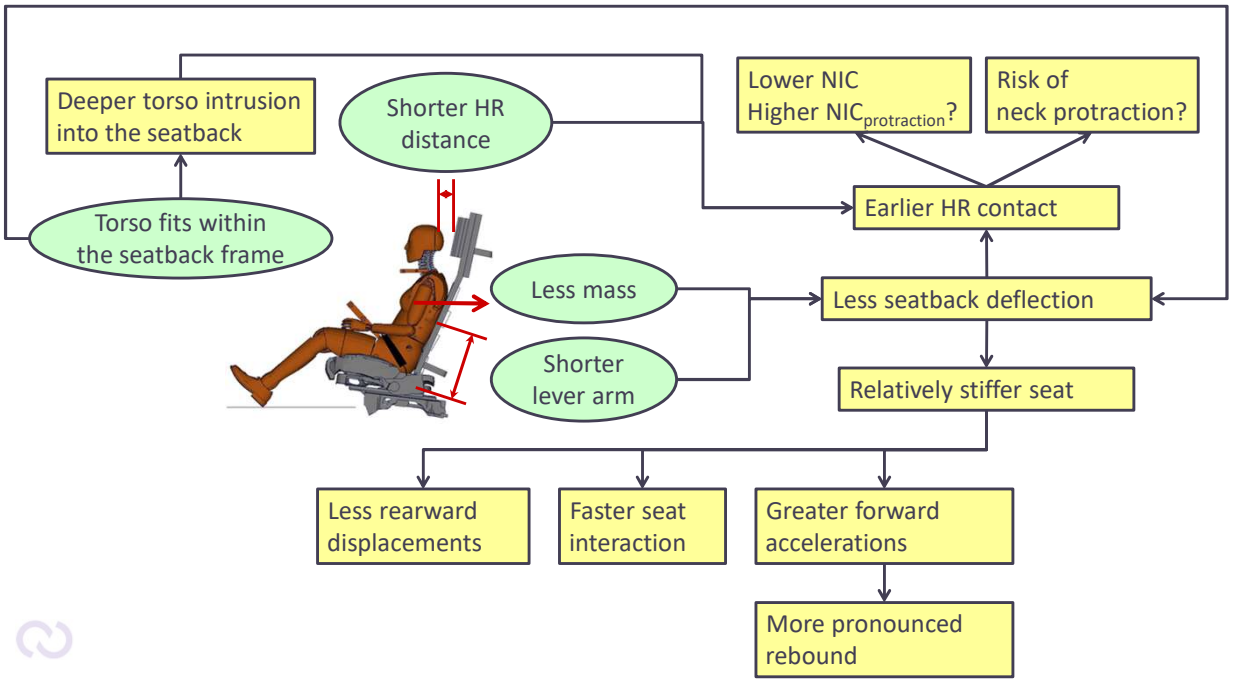

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In summary

- Females have twice risk for whiplash injury
- The effectiveness differs considerably between various whiplash protection concepts
- Seat geometry and posture differs for males and females

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In summary

- Important to mirror differences in risk between males and females and to support robust whiplash protection concepts.
- Static measurement is not sufficient to measure risk for whiplash. Seats with good static rating can perform poor in real-world.
- Improved dynamic tests are essential to further reduce the whiplash injury risk.

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