Influence of CRS Fit and Effects on Adjacent Seat Positions in Side Impacts

John H Bolte IV, PhD

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INJURY BIOMECHANICS
RESEARCH CENTER

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INFLUENCE OF CRS FIT ON FAR SIDE IMPACTS

Yun-Seok Kang, PhD

Julie Mansfield, Gretchen Baker, Yun-Seok Kang
Injury Biomechanics Research Center, The Ohio State University

Children's Hospital of Philadelphia RESEARCH INSTITUTE | The Ohio State University WEXNER MEDICAL CENTER

BACKGROUND

- Side impacts are the second most frequent type of collision
  - Cause serious head, neck and chest injuries to pediatric occupants (Sherwood et al., 2003; Maltese et al., 2007; Sullivan & Louden, 2009; Arbogast & Durbin, 2013)
  - Number of child fatalities from side impacts is similar as that from frontal impacts
    - 20.2% in frontal impacts, and 19.6% in side impacts based on FARS data from 1996 to 2005 for rear-seated children 0 to 7 years-old (Viano & Parenteau, 2008)

BACKGROUND

- Side impacts are the second most frequent type of collision
  - Number of fatalities for near-side impacts as 2.6 times greater than the that for far-side impacts (Starnes and Eigen, 2002)
    - Due to direct loading from door intrusion

    (Fildes et al., 2003; Franklyn et al., 2007; Klinich et al., 2005; Howard et al., 2004)

  - Significant injuries also occurred with minor or even no intrusion of vehicle structures (Arbogast et al., 2000)

BACKGROUND

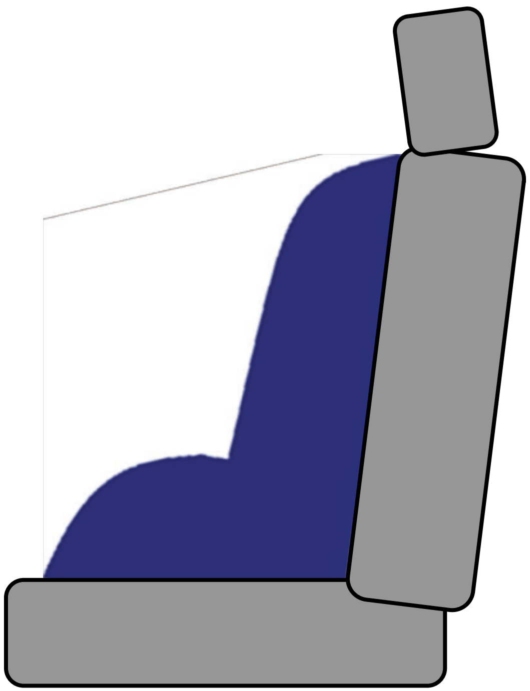
- Incompatibilities between CRS and vehicle models might cause problems
  - Decrease the stability and the effectiveness of the restraint in motor vehicle crashes.
  - 36.7% of RF CRS and 37.8% of FF CRS combinations were not ideal (Bing et al., 2015)
    - The width of CRS was compared to the width of vehicle seat along the bight line
    - The CRS was required to be installed on top of the vehicle seat's side bolsters.
- Influence of the CRS fit into vehicle seats on ATD kinematics in side impacts is not well understood yet

OBJECTIVES

- To quantify responses of the CRS and ATD in far-side impacts with respect to different CRS fits
  - physical CRS incompatibilities without a dynamic aspect
  - dynamic aspects of CRS performance without realistic physical fits

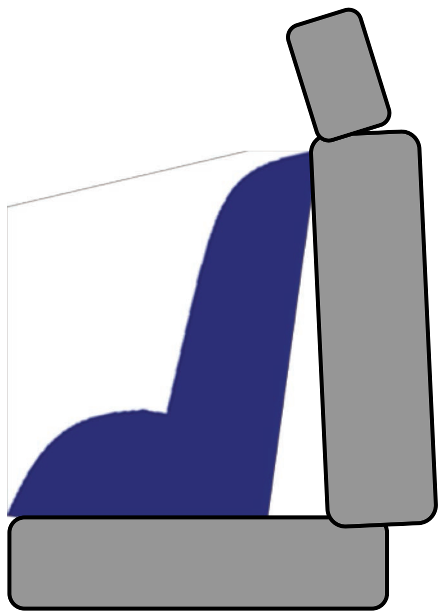
METHODS: FORWARD-FACING

- CRS fit configurations
  - Control (good fit)



METHODS: FORWARD-FACING

- CRS fit configurations
  - Seat angle too <u>acute</u>



Interference predicted in 35% of FF CRS installations (Bing et al. 2015, 2017)

METHOD ... ACING

- CRS fit c...
  - Seat a...

Interference pred... s (Bing et al. 2015, 2017)

METHOD… ACING

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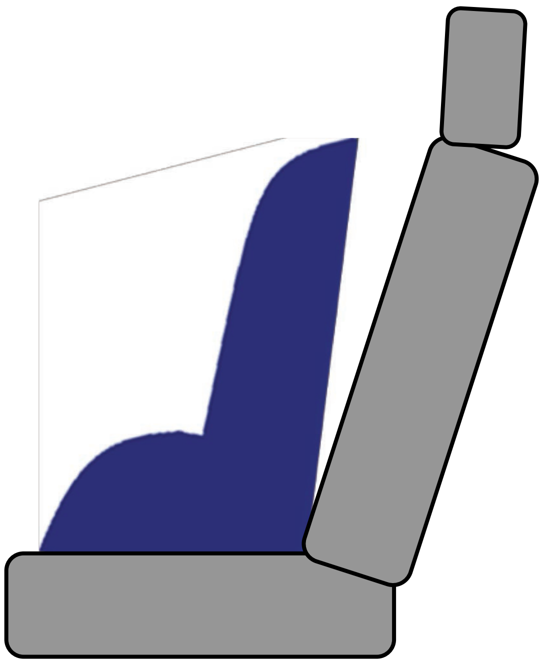
METHODS: FORWARD-FACING

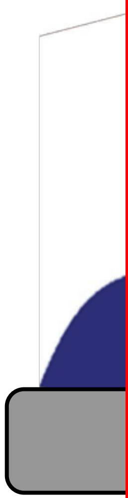
- CRS fit configurations
  - Seat angle too <u>obtuse</u>



Issue is not very common but can occur in center positions.

METHOD… CING

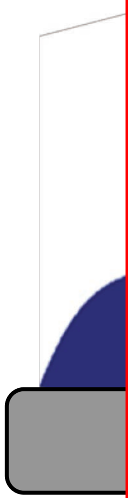
- CRS fit
  - Seat a



Issue is … positions.

METHOD ... CING

- CRS fit
  - Seat a



Issue is ... positions.

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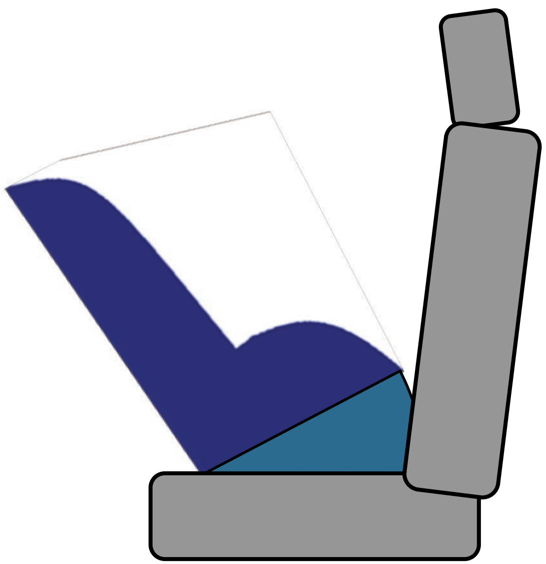
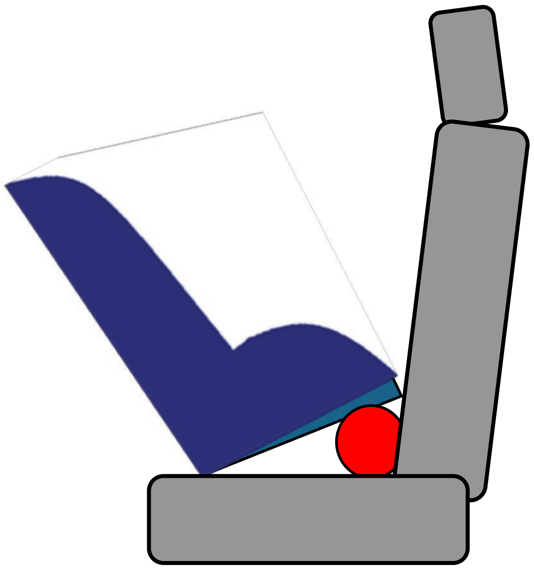
  - Control (good fit)



METHODS: REAR-FACING

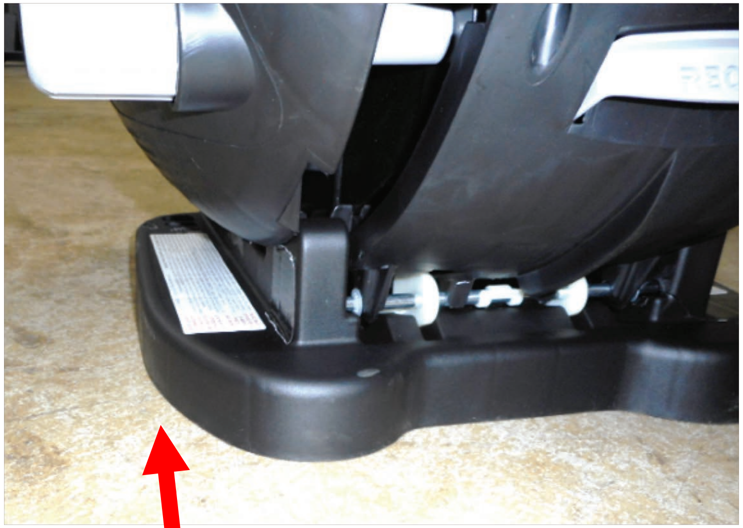
- CRS fit configurations
  - Pool noodle installation



Intervention needed in 42% of RF CRS installations (Bing et al. 2015)

METHODS: REAR-FACING

- CRS fit configurations
  - Typical vs. narrow base



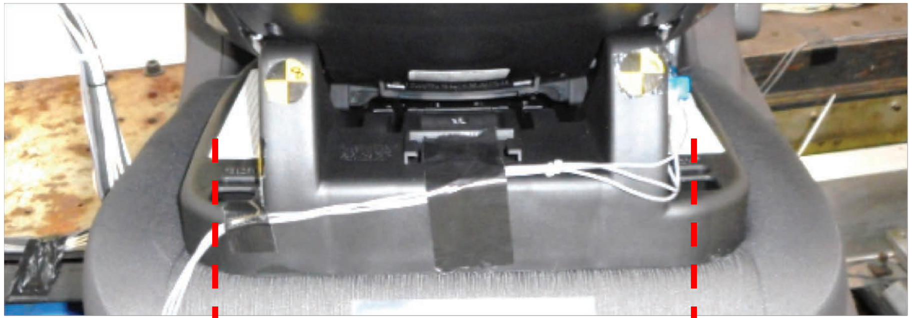
Control (38.4 cm)

Narrow (29.9 cm)

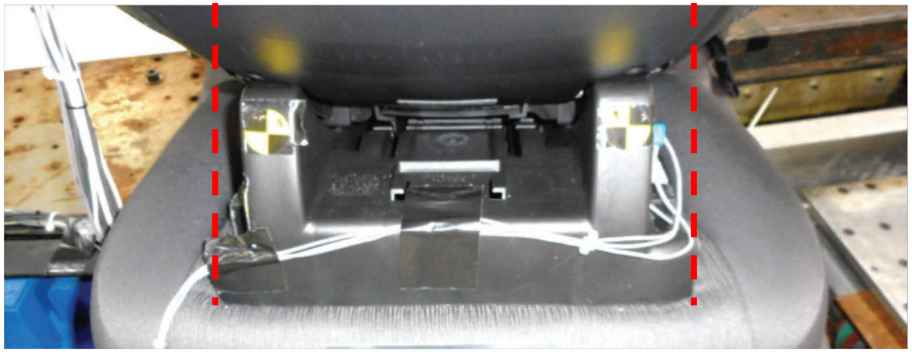
Side bolster interference predicted in 27% of RF CRS installations (Bing et al. 2015)

METHODS: REAR-FACING

Control: 38.4 cm



Narrow: 29.9 cm



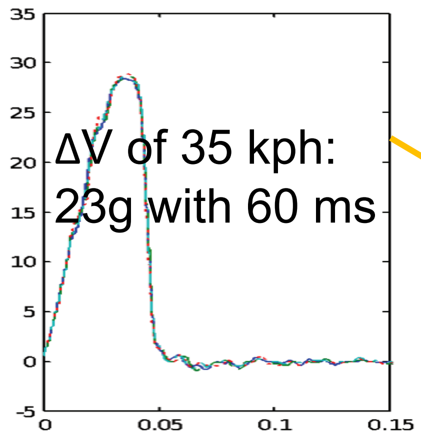
8.5 cm cut off; 4.25 cm from each side

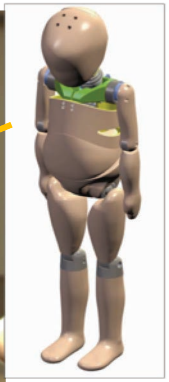
METHODS

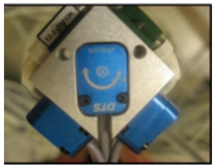
- Q3s
  - 3-year-old designed for side impact
- LATCH installations
  - More uniform across different vehicle types
- CRS replaced after each trial
- Vehicle seat replaced after each trial

METHODS

- Far-side impact HYGE sled test
  - 10° forward of pure lateral



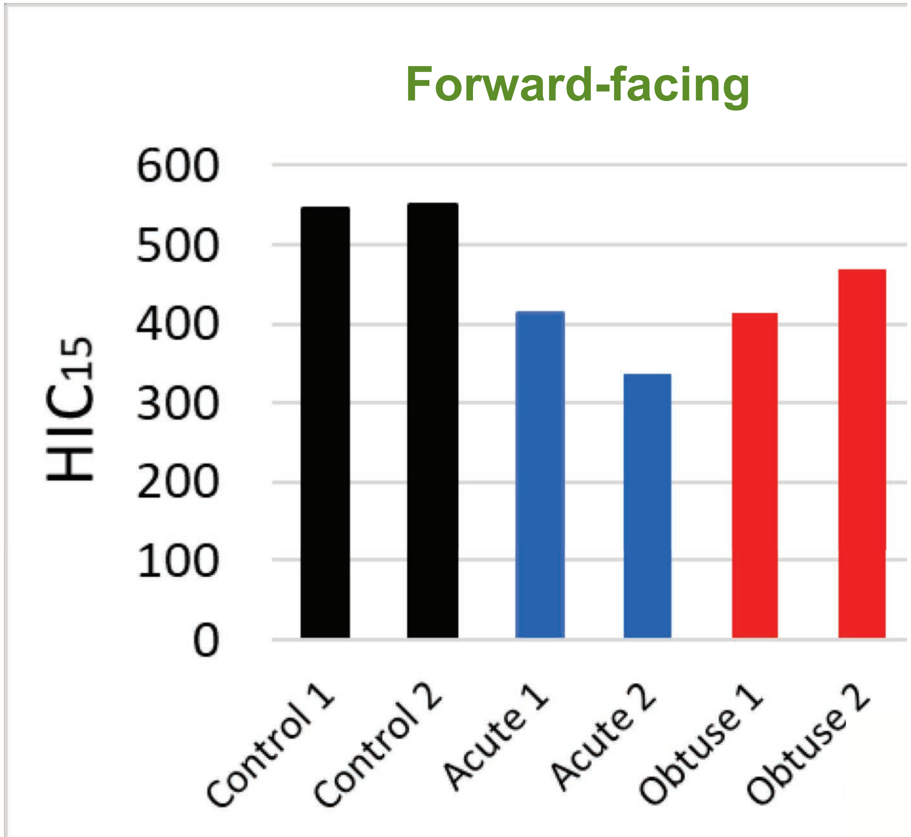




- Kinematic and kinetics of Q3s
- Injury measures
- CRS kinematics

RESULTS – HIC_{15}

IARV: 570 (FMVSS 213 side impact NPRM)



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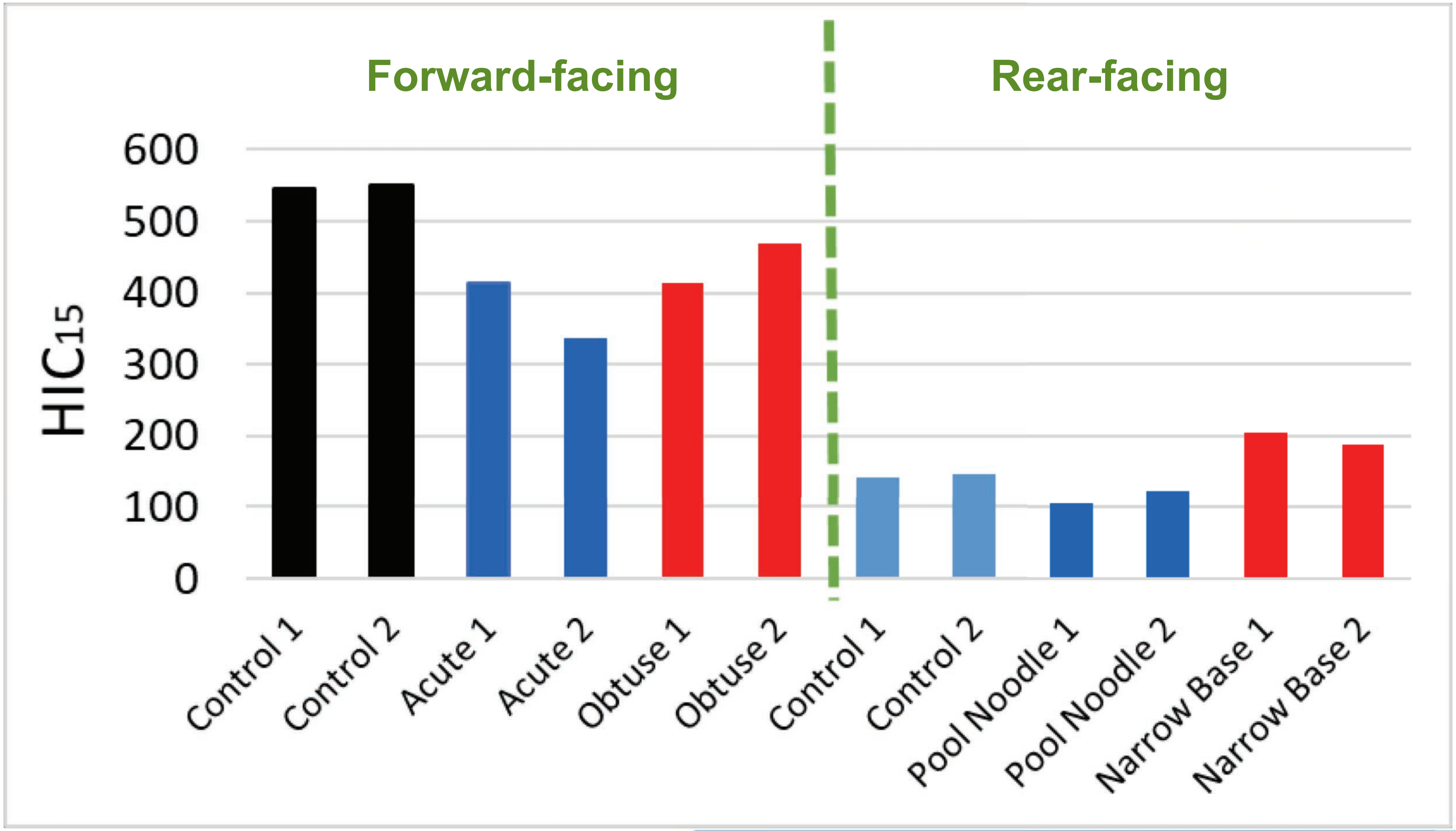
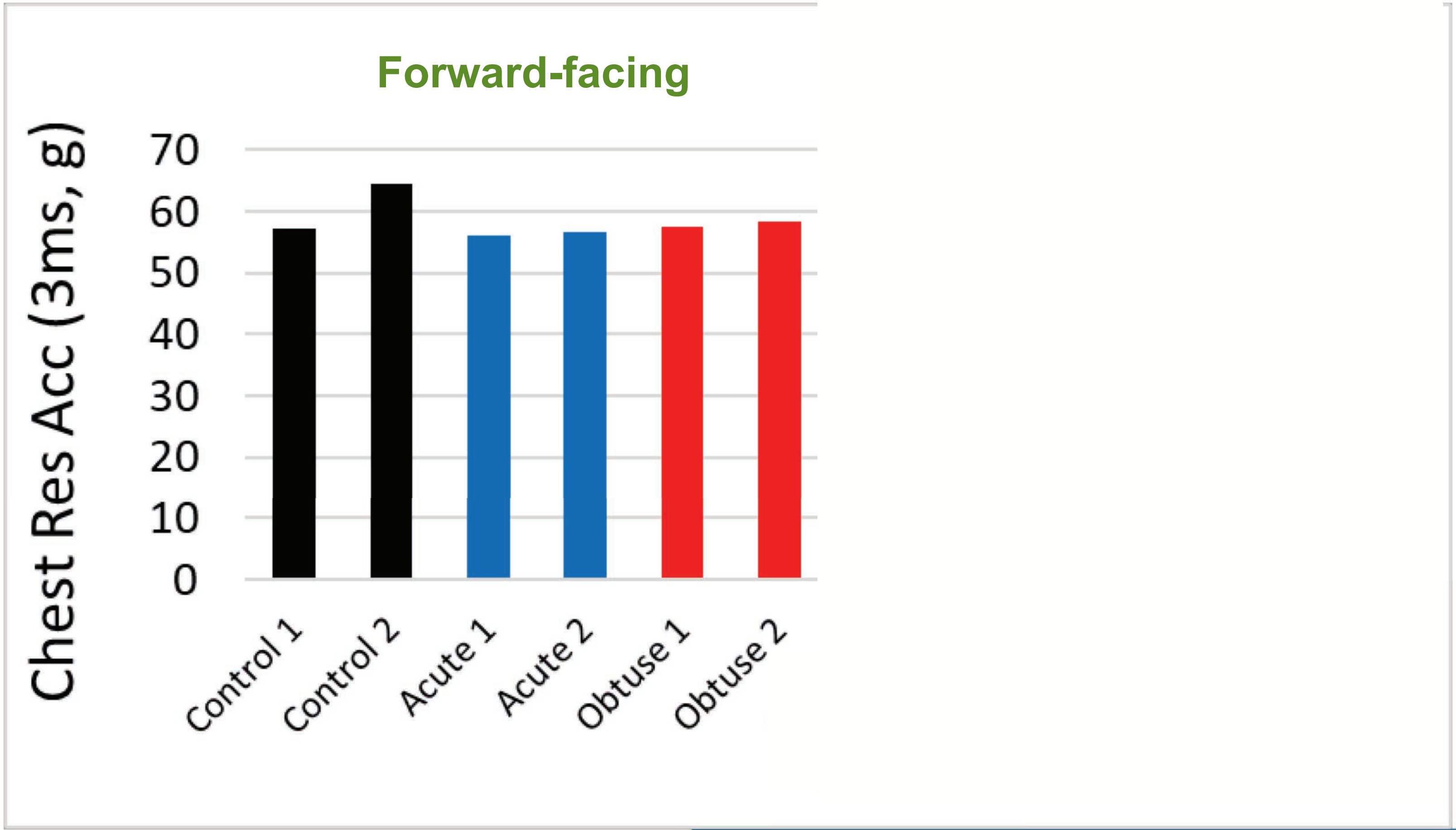


RESULTS – Chest G

IARV: 60 (FMVSS 213) and 92 (Mertz et al., 2016)



RESULTS – Chest G

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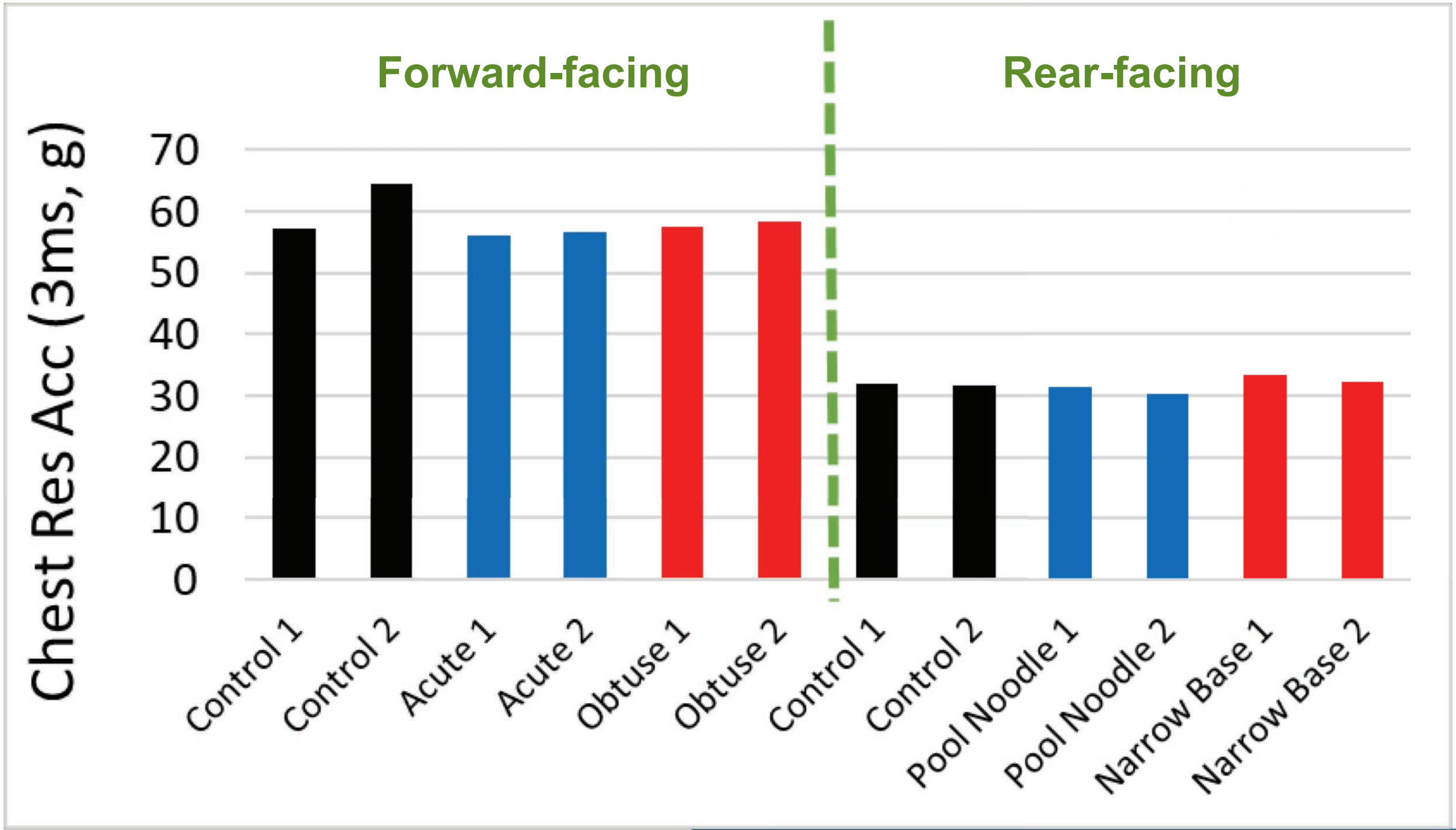
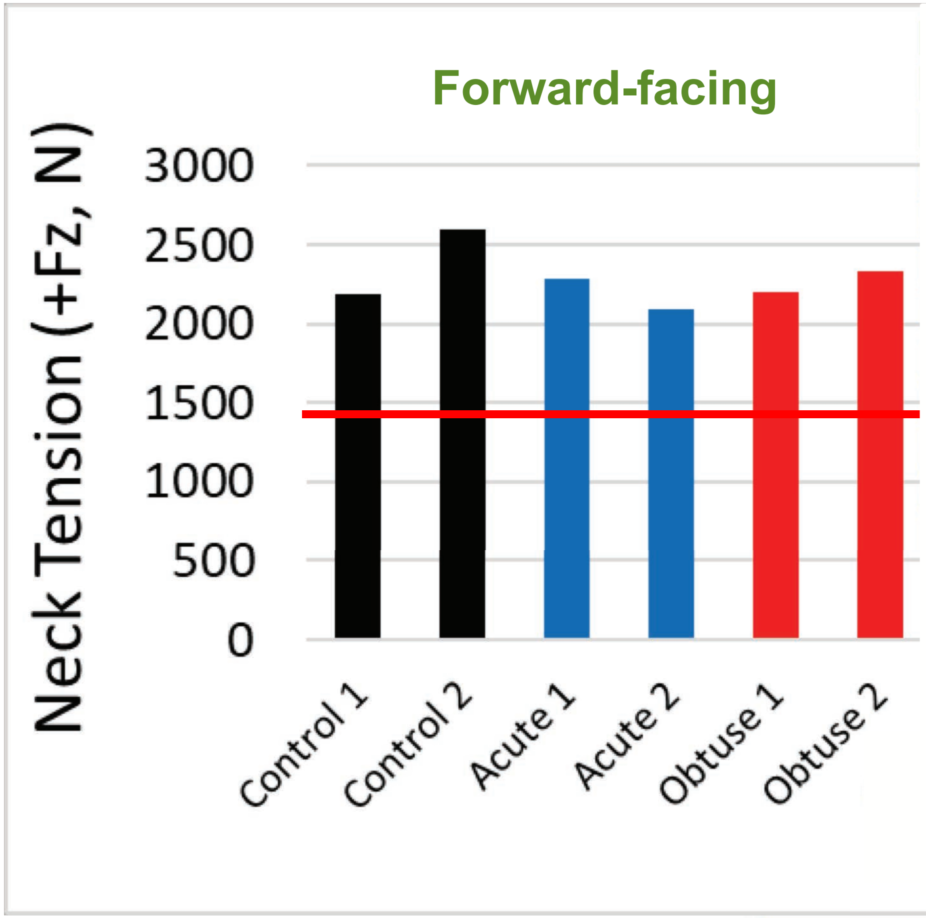


RESULTS – Neck Tension

IARV: 1430 (Mertz et al., 2016)



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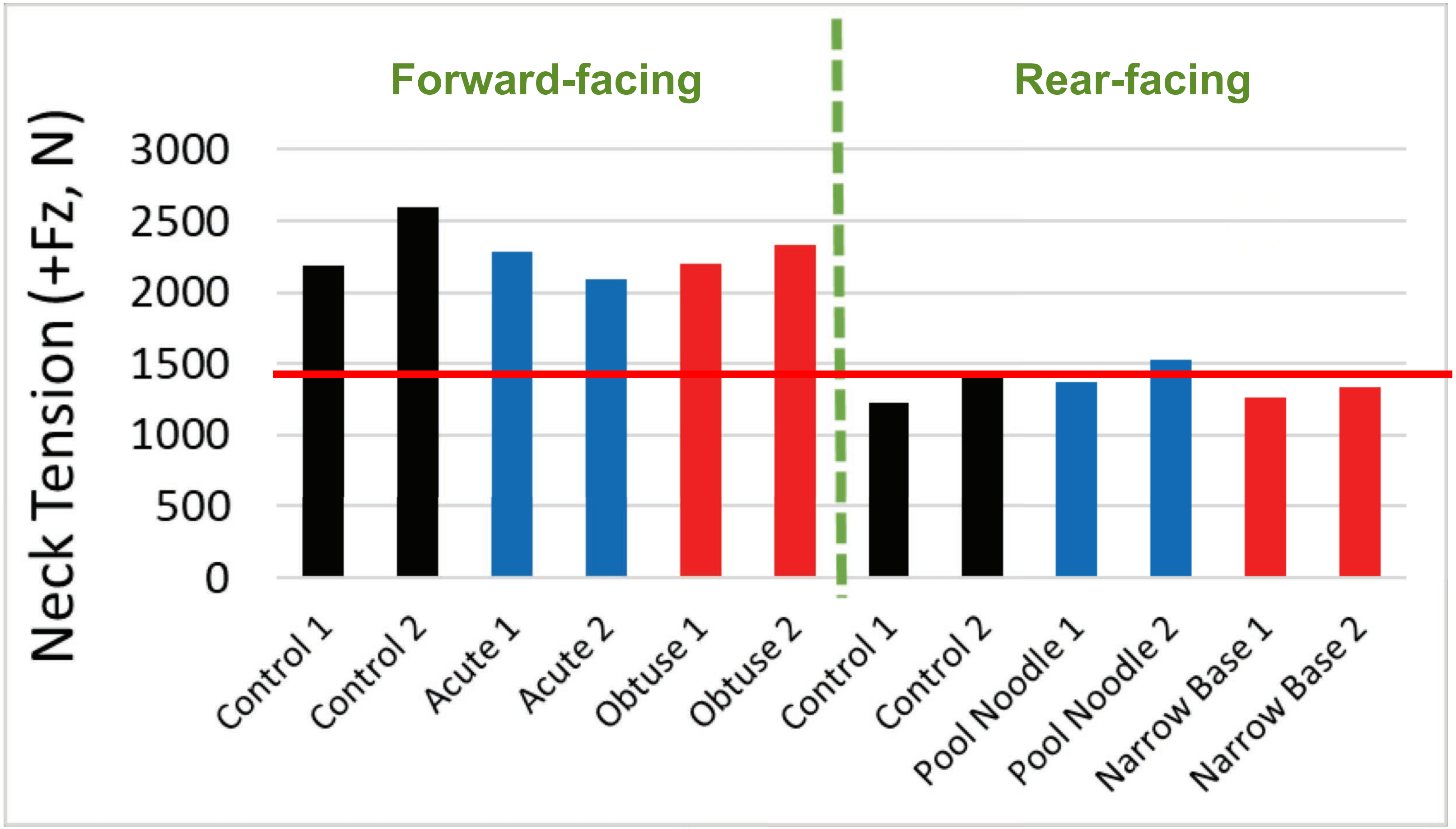
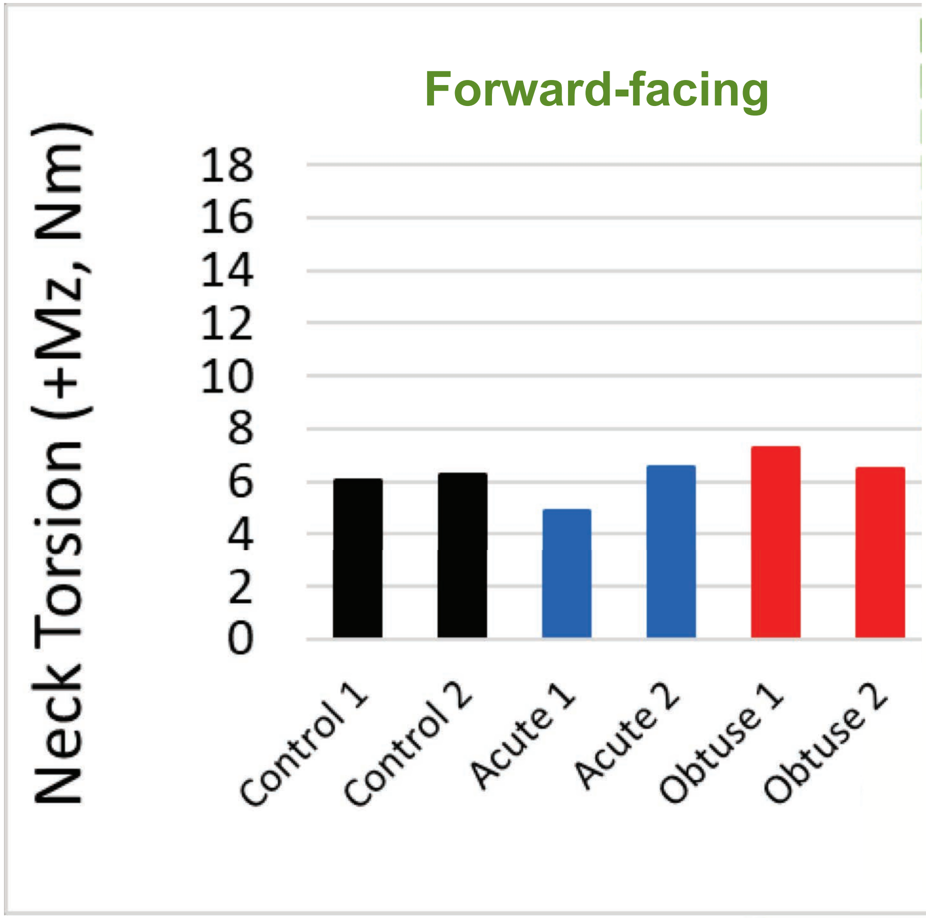


RESULTS – Neck Torsion

IARV: 21 (Mertz et al., 2016)



RESULTS – Neck Torsion

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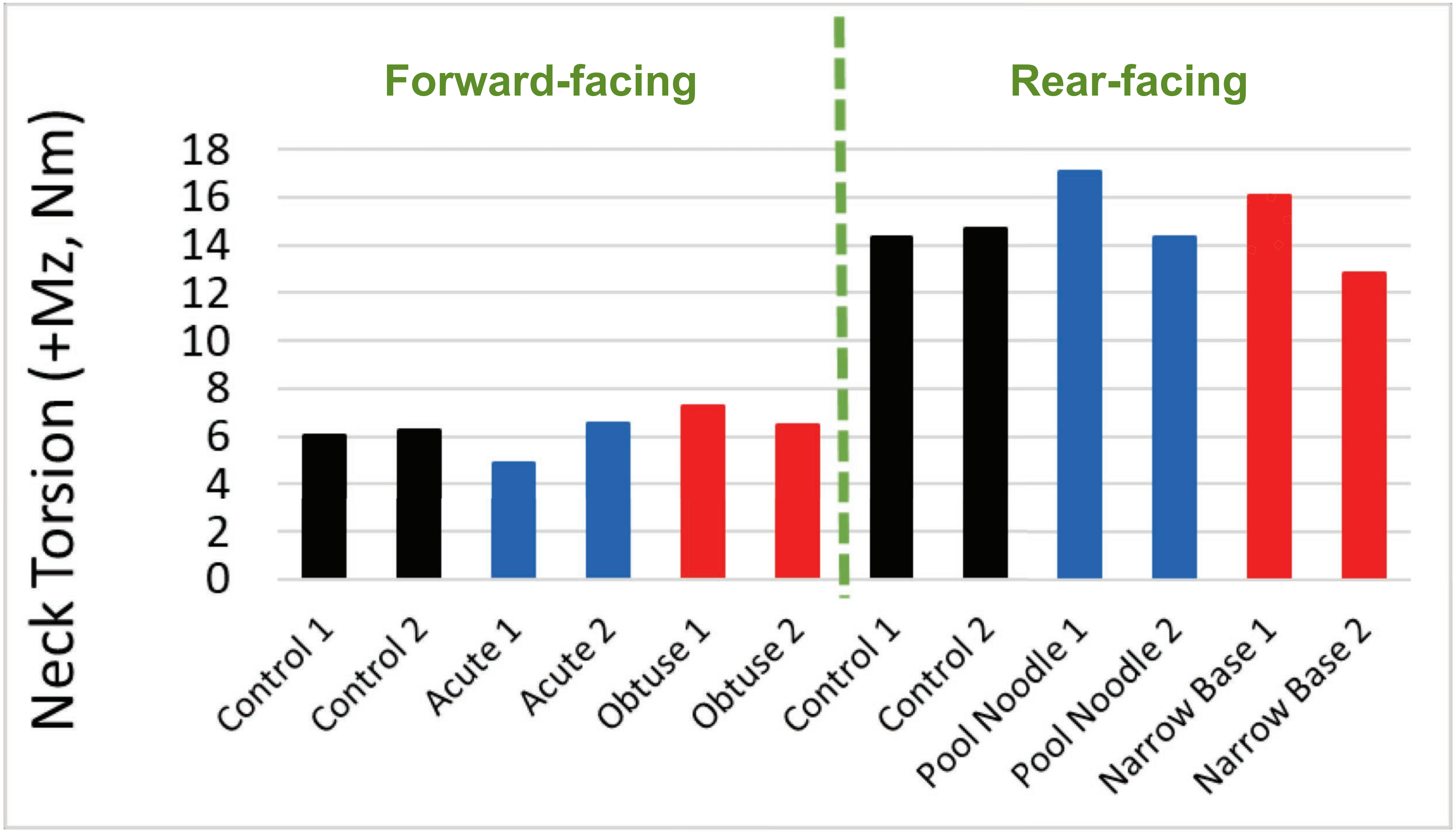
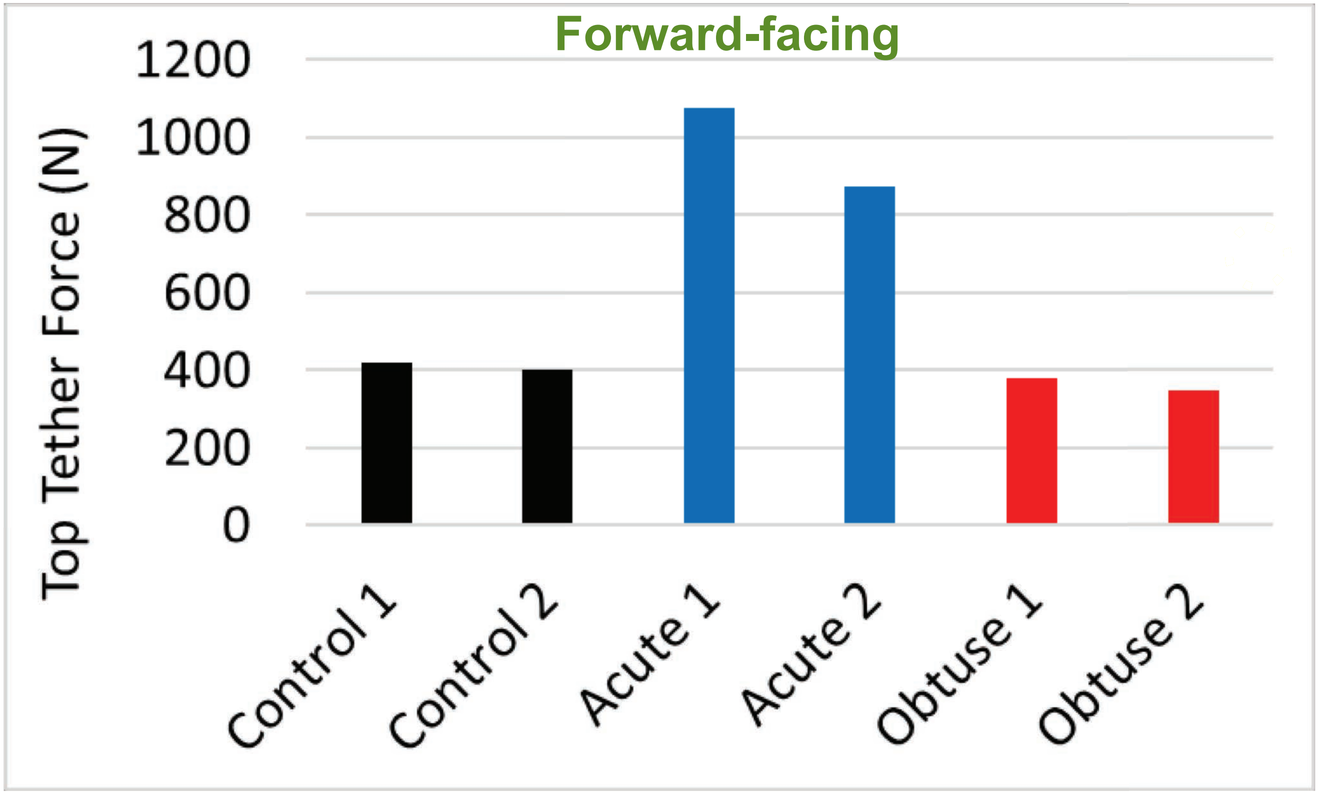


RESULTS – Top Tether Load



LIMITATIONS

- Small sample size
  - Two CRS models
  - One vehicle seat
  - One size of ATD
  - One sled input condition
  - All LATCH installations
- All tight installations
  - Loose installations are common in real world
- Biofidelity of ATD

CONCLUSIONS

- Overall: **No major differences with the non-ideal fits**
- RF: Narrow base condition showed slightly higher injury metrics, although the magnitude of differences may not be significant.
- FF: Acute vehicle seat condition resulted in higher top tether loads
  - No evidence of corresponding increase in upper neck loads
  - This condition had lowest HIC15 values
- RF vs FF: HIC15, Chest resultant acceleration, and neck tension were **lower for all RF conditions compared to FF**.
  - However, neck torsion was higher for RF

ACKNOWLEDGEMENTS

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EFFECTS OF ADJACENT SEAT POSITIONS ON CRS PERFORMANCE IN SIDE IMPACTS

PI: Julie Mansfield, MS
Co-I: Yun Seok Kang, PhD
Mentors: Consumer Reports, GM, Graco, Lear, Toyota, Julie Kleinert, Uwe Meissner

Children's Hospital of Philadelphia RESEARCH INSTITUTE | THE OHIO STATE UNIVERSITY WEXNER MEDICAL CENTER

BACKGROUND

- Vehicle interiors are becoming more adaptable to meet modern families' needs.
  - Seats can be stowed, removed, folded, etc.
- Interaction of CRS with adjacent vehicle seats is not well studied.

2018 Ford Expedition (Brandonford.com)

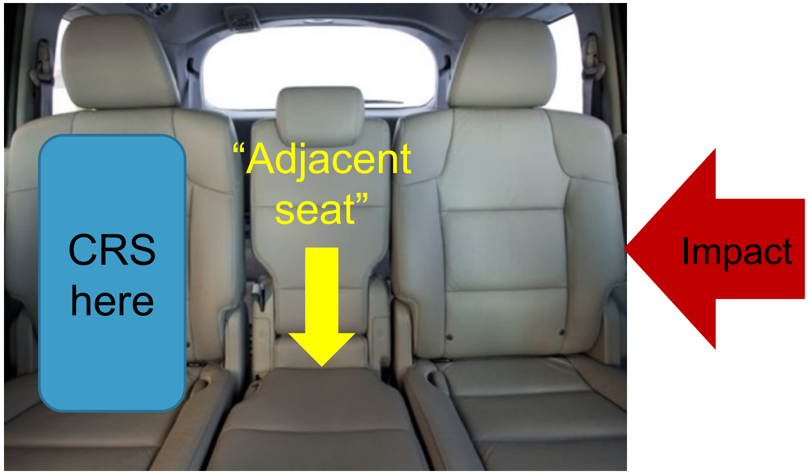
2019 Lincoln Navigator (Lincoln.com)

OBJECTIVES & SPECIFIC AIMS

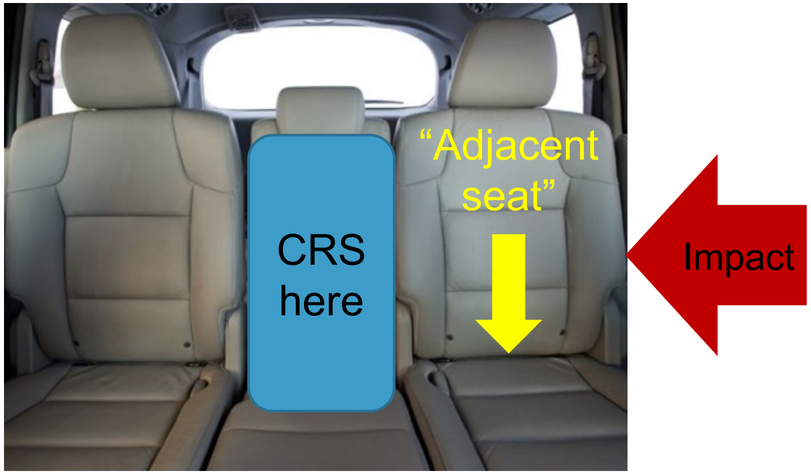
- The broad objective is to support the safe use of CRS in vehicles with adaptable interiors.
  1. Discuss with mentors to identify common seating configurations which may play a role in CRS performance in side impacts.
  2. Perform dynamic sled tests to define the performance outcomes of CRS in these conditions.
  3. Produce researched backed guidelines to support the safe use of CRS in vehicles with adaptable seating configurations.

METHODS: TERMINOLOGY

"CRS Outboard"



"CRS Center"



VEHICLE SEATS: HONDA ODYSSEY

METHODS: SLED BUCK

CRS & ATDS

Rear-facing:
Evenflo Triumph LX

Forward-facing:
Safety 1st Alpha Elite 65

Booster:
Evenflo Big Kid LX,
High back mode

CRS & ATDS

Q3s

HIII 6yo

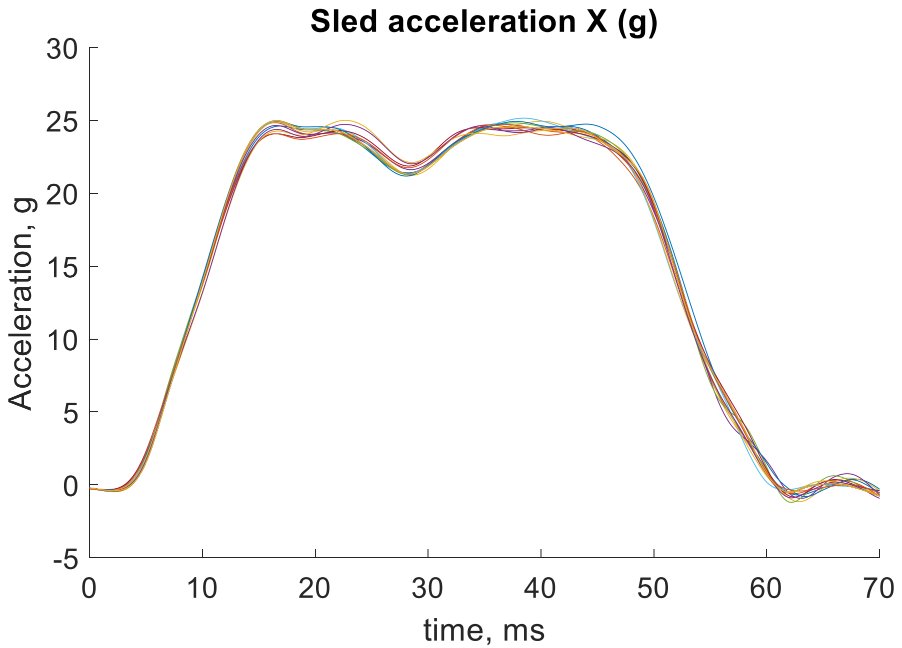
Rear-facing:
Evenflo Triumph LX

Forward-facing:
Safety 1st Alpha Elite 65

Booster:
Evenflo Big Kid LX,
High back mode

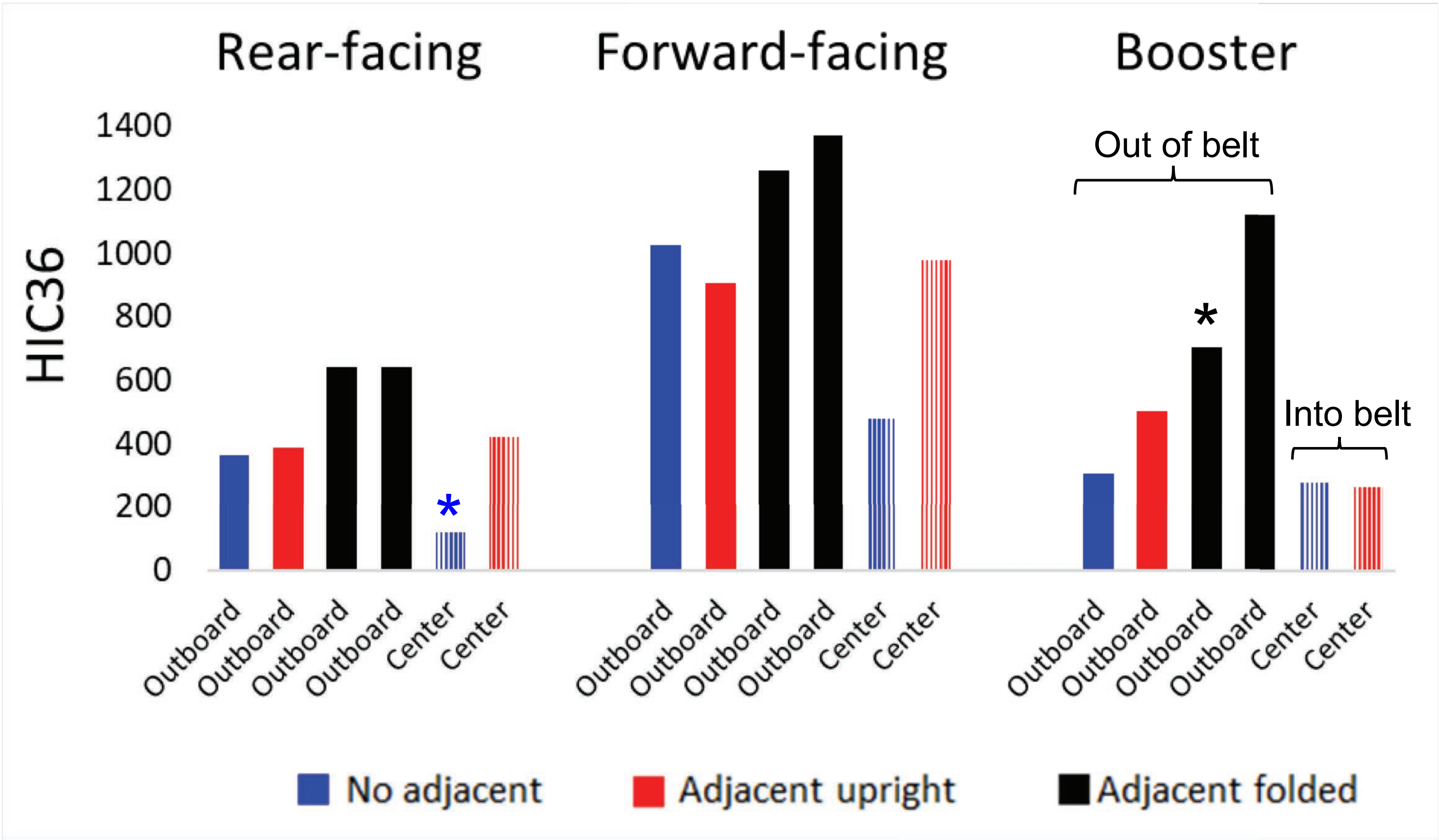
SLED PULSE

- Proposed sled pulse: FMVSS 213 side impact scaled to 35 kph (21.8 mph)
  - Same as our current tests and Hauschild et al.



IARV: 1000 (FMVSS 213)

RESULTS

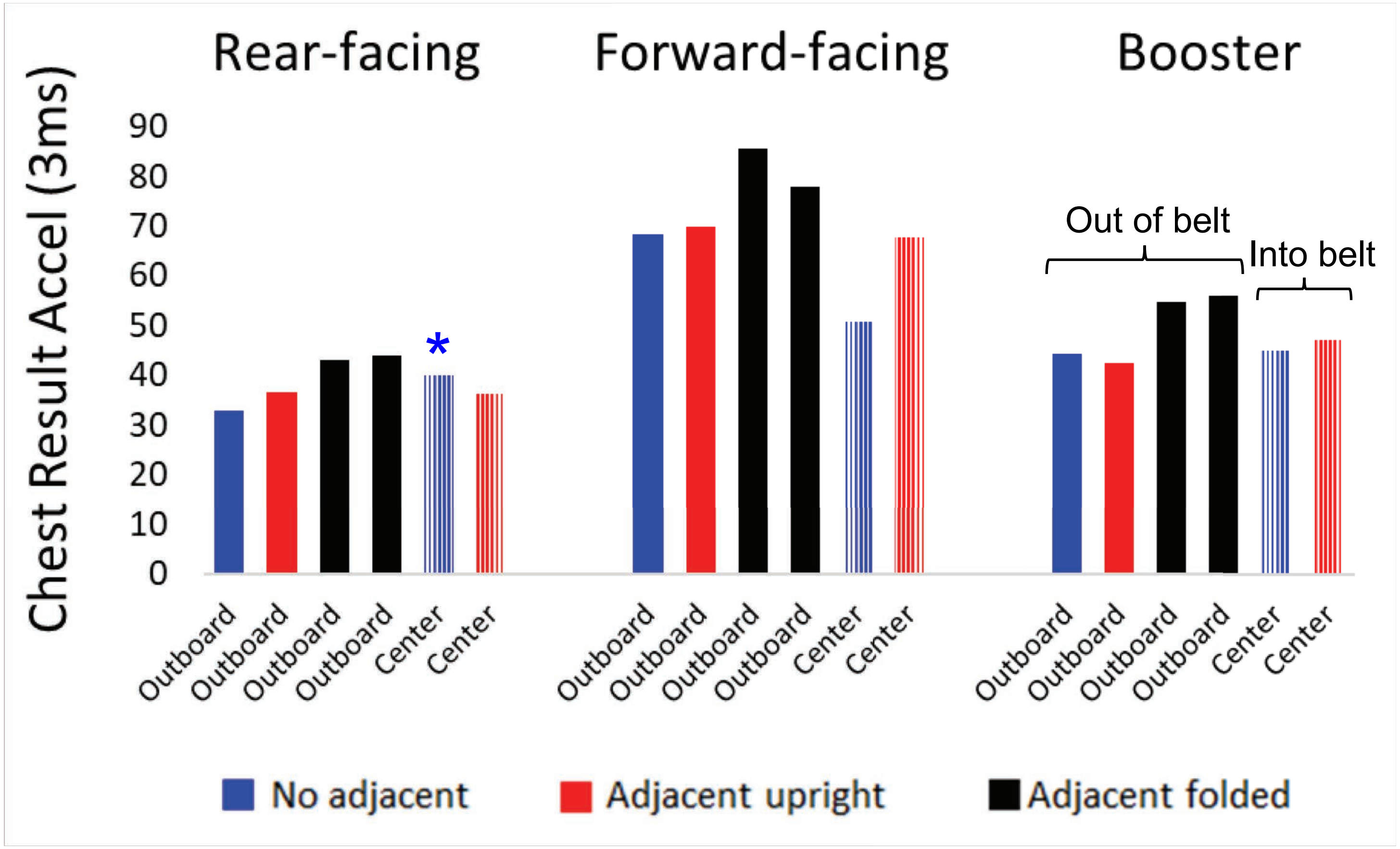


*LATCH released

*Head struck cables

IARV: 60 g (FMVSS 213)

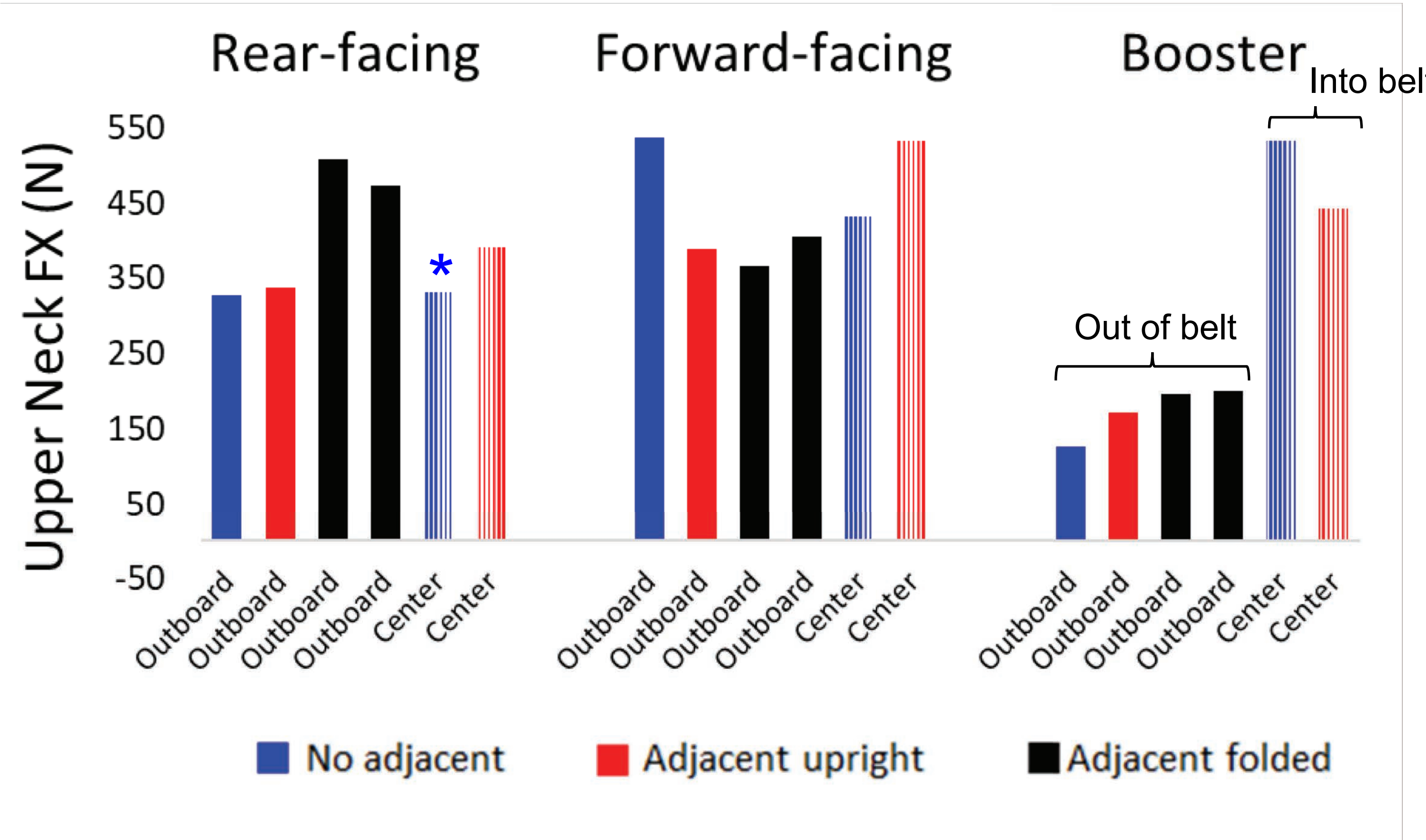
RESULTS



*LATCH released

IARV: 1070 N (3yo)
1410 N (6yo)
[Mertz et al. 2016]

RESULTS



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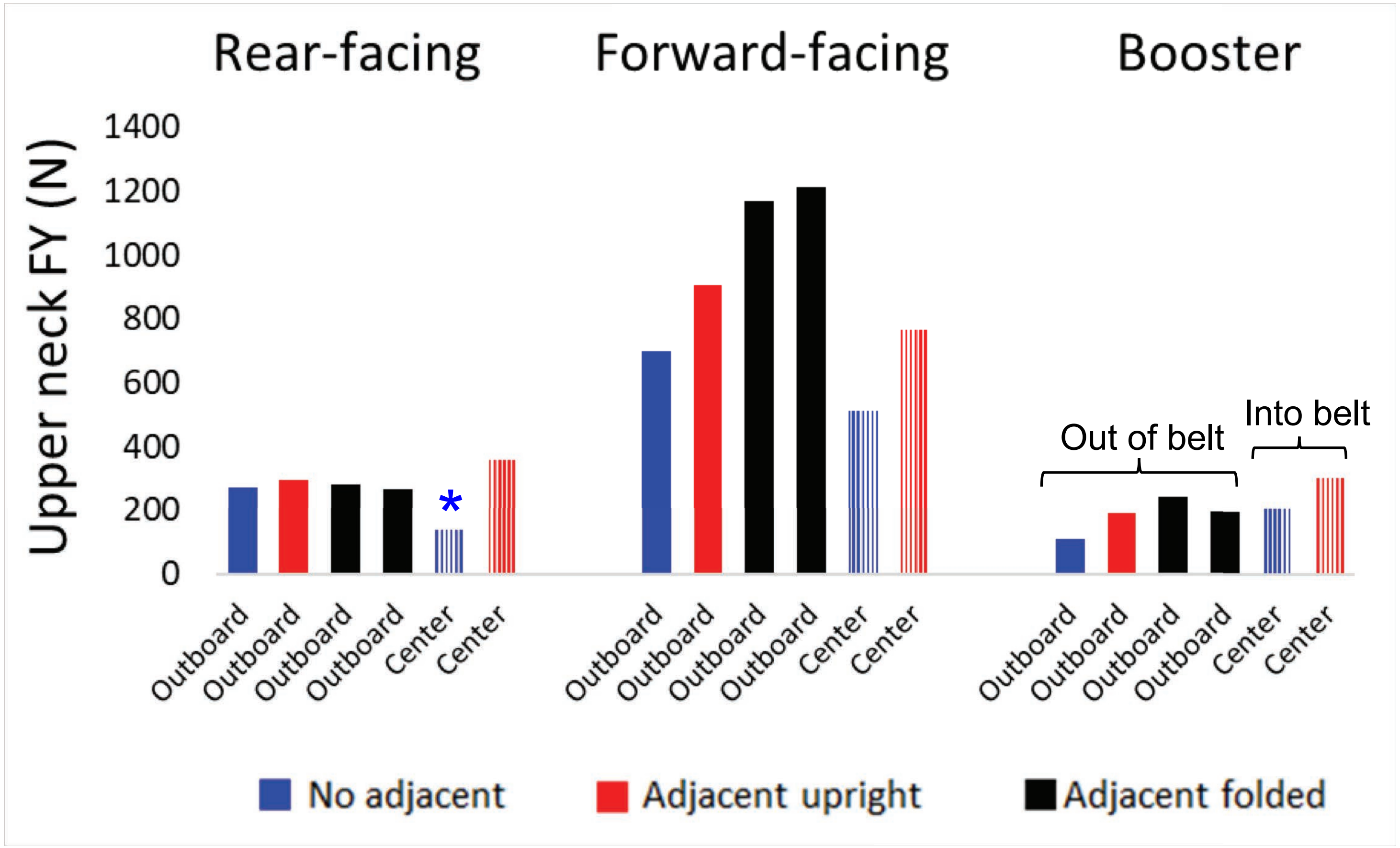
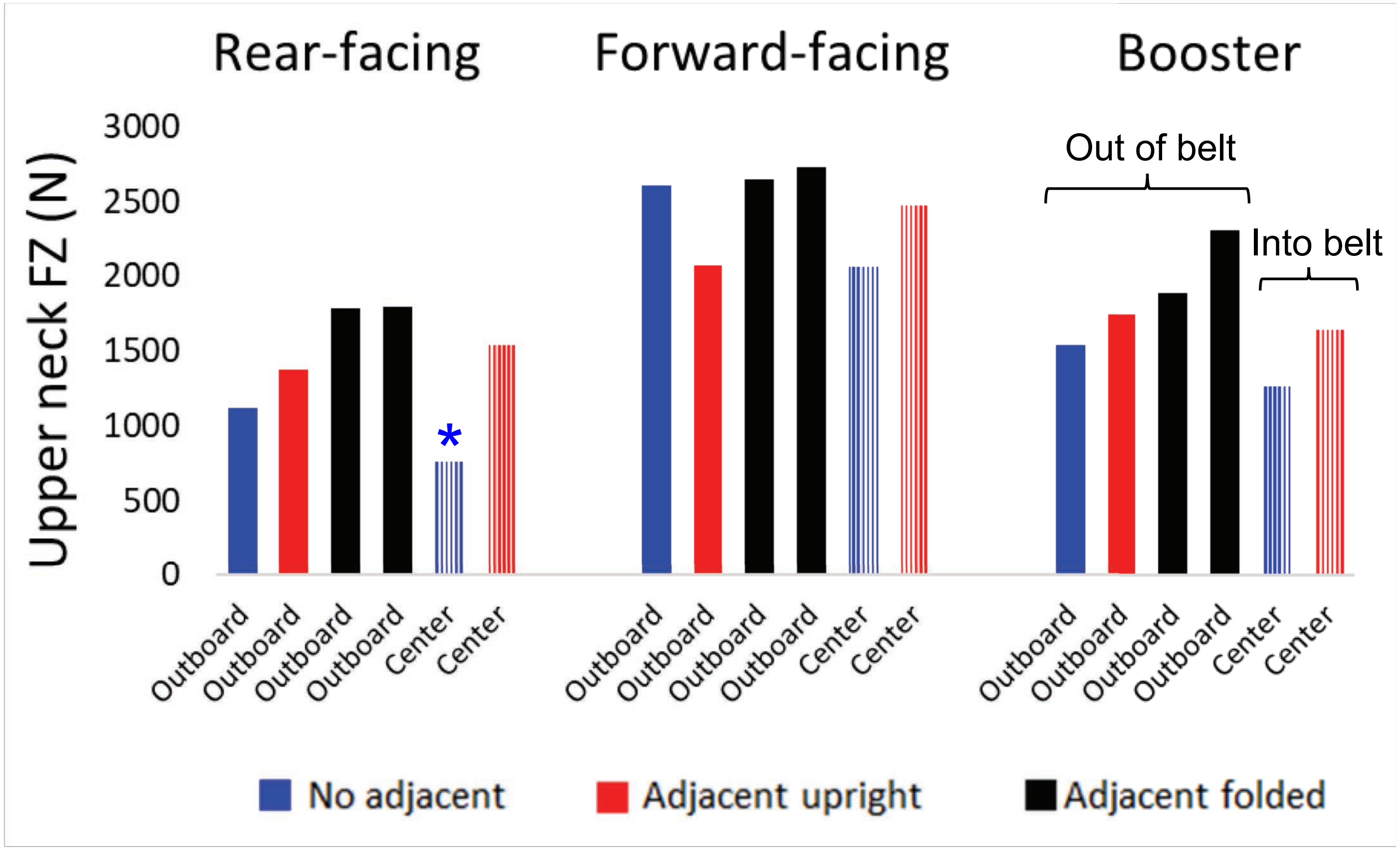


*LATCH released

IARV: 1430 N (3yo)
1890 N (6yo)
[Mertz et al. 2016]

RESULTS



*LATCH released

CONCLUSIONS

- Narrow center seat alone does not control lateral motion of CRS well.
  - RF released - Possibly affected by shape of lower anchor
  - FF - Aided by top tether, possibly higher belt path
  - Booster - Excessive motion when ATD moved into belt. Out-of-belt motion may be more severe.
  - Adjacent outboard seat appears to help limit motion
- CRS "side overhang" specifications might be warranted.
  - Overhang magnitudes for RF CRS and booster were 2.8 cm and 3.8 cm, respectively, on each side.
- Adjacent folded seat limits lateral excursion with trade-off of increasing accelerations/neck loads.

LIMITATIONS

- No intruding door in test environment
  - Head excursions extreme enough for door contact from center seat?
    - Booster head excursions > 51.4 cm (Hauschild et al. 2015)
  - Side curtain airbag influence?
- RF CRS installed with LATCH, booster installed with seat belt only
  - Other installation methods?
  - Investigating booster LATCH installations this year!
- Vehicle seats impacted 2-3 times

ACKNOWLEDGMENTS

- Honda R&D Americas, Inc.
  - Hosting sled testing
  - Vehicle seats
  - Hybrid III 6yo
  - General guidance
- TS Tech Americas, Inc.
  - Vehicle seats and sled fixture
- NHTSA VRTC
  - Q3s
- CChIPS mentors

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