



FRONT-ROW SEATBACK CONTACT FOR PAEDIATRIC OCCUPANTS SEATED IN REARWARD-FACING INFANT CHILD RESTRAINT SYSTEMS DURING FRONTAL CRASHES

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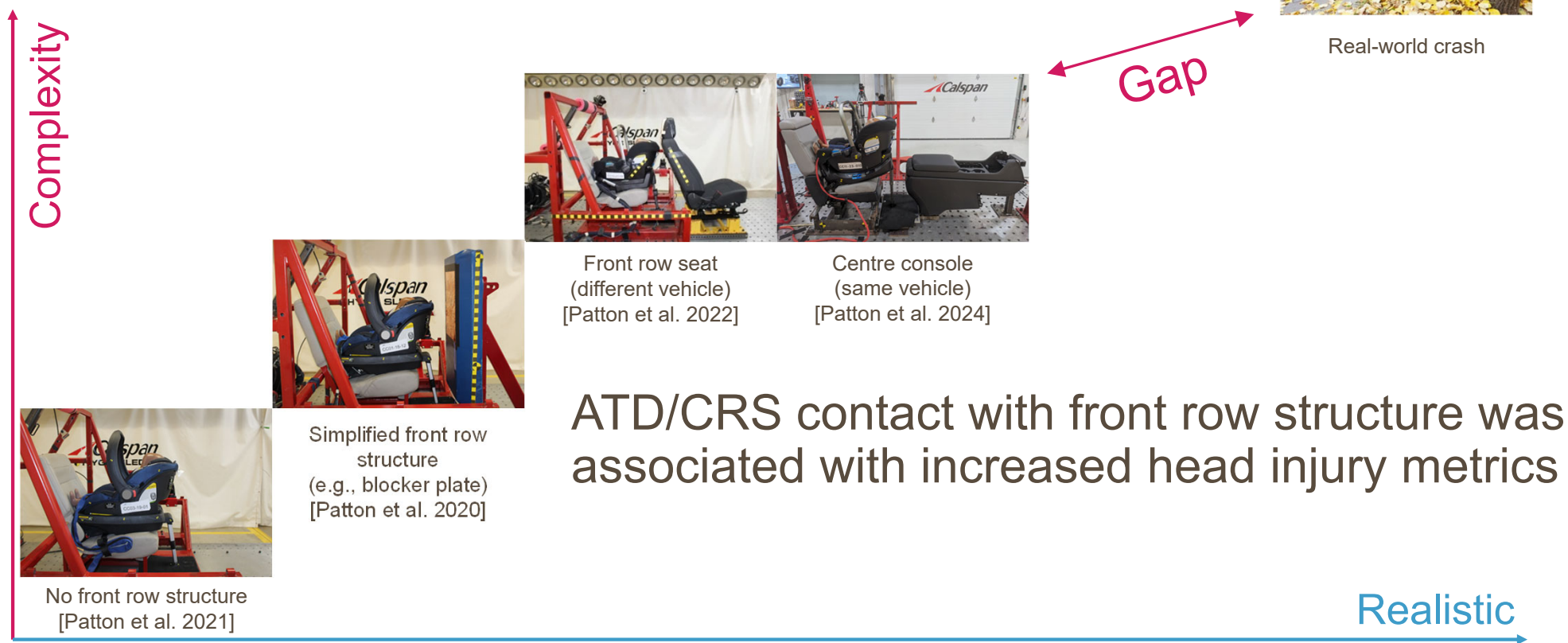
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BACKGROUND

- Correctly used CRS is associated with a substantial reduction of injury/mortality risks
(Elliot et al. 2006; Kozhumam et al. 2025)
- Epidemiologic data suggests that toddlers are safer when restrained rearward-facing
(McMurray et al. 2018; Anderson et al. 2023)
- Efforts are ongoing to ensure CRSs are evaluated in realistic scenarios where the potential exists for interaction with other interior vehicle components

APPROACHES



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Complexity



No front row structure
[Patton et al. 2021]



Simplified front row structure
(e.g., blocker plate)
[Patton et al. 2020]



Front row seat
(different vehicle)
[Patton et al. 2022]



Centre console
(same vehicle)
[Patton et al. 2024]



Full-scale vehicle



Real-world crash

Realistic

AIMS

For frontal impact full-vehicle crash tests:

- (1) To evaluate rearward-facing CRS and/or ATD head contact with the front-row seatback
- (2) To categorize the contribution to the peak linear acceleration of the ATD head

METHODS

- Subset Transport Canada full-vehicle crash database
 - Full-frontal rigid barrier at 56 km/h
- 19 vehicle crash tests
 - Model years: 2011-2024
 - Types: SUV, sedan, hatch, pickup truck, minivan
 - Sizes: subcompact, compact, midsize, large
 - Range of front-row seat track positions
- 33 rearward-facing CRS installations
 - Model years: 2015-2024
 - Attachment: base (lower anchors, seatbelt), no base, baseless, support leg
 - ATD: CRABI-12, CRABI-18, Q1.5 ATD



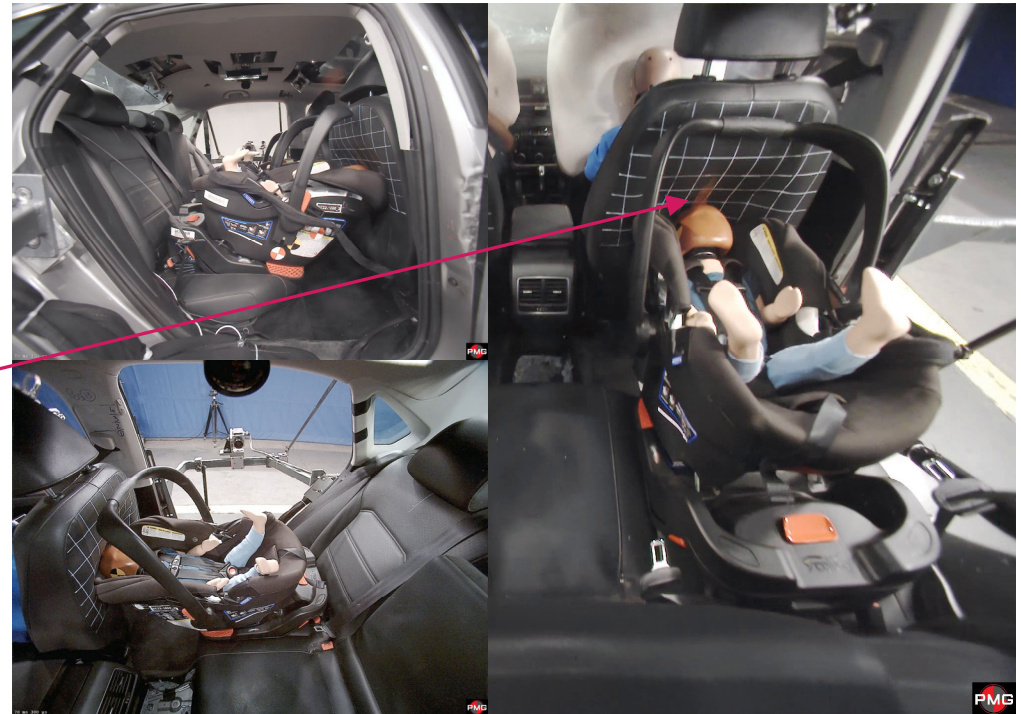
METHODS

- Video analysis of multiple synchronised high-speed camera views to identify timing



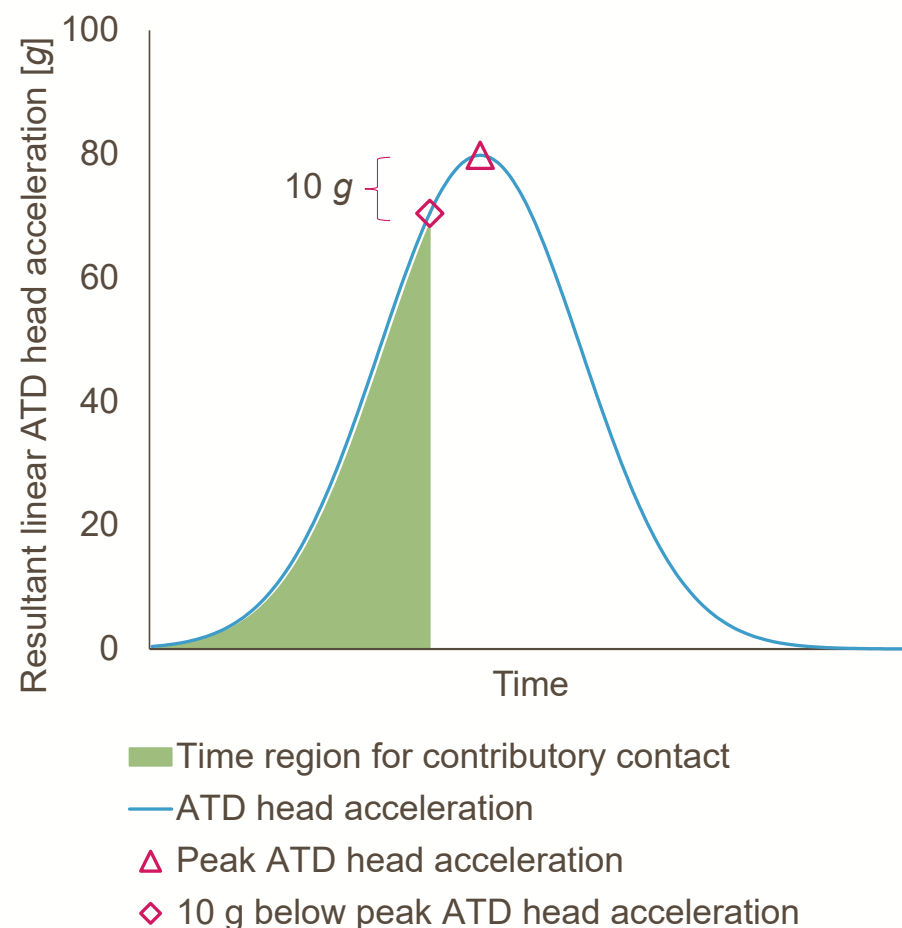
METHODS

- Video analysis of multiple synchronised high-speed camera views to identify timing
 - CRS contact
 - ATD head contact
 - Transfer paint for some cases



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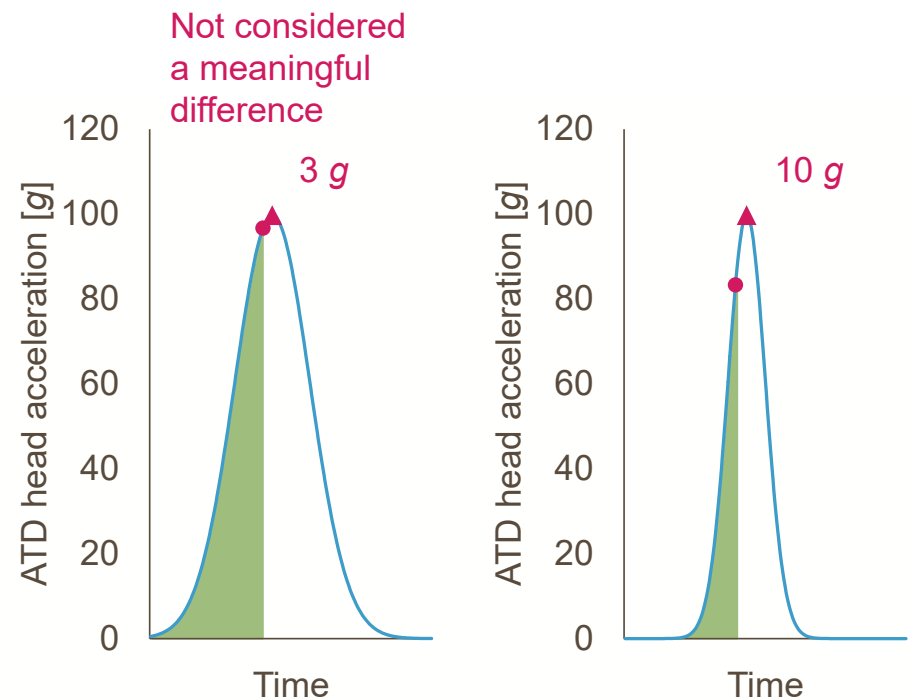
- Video analysis of multiple synchronised high-speed camera views to identify timing
 - CRS contact
 - ATD head contact
 - Transfer point for some cases
- Extracted time history of resultant head acceleration and HIC15
- Defined “contributory contact” as occurring 10 g before peak
 - Likely that the head contact contributed to the peak values



METHODS

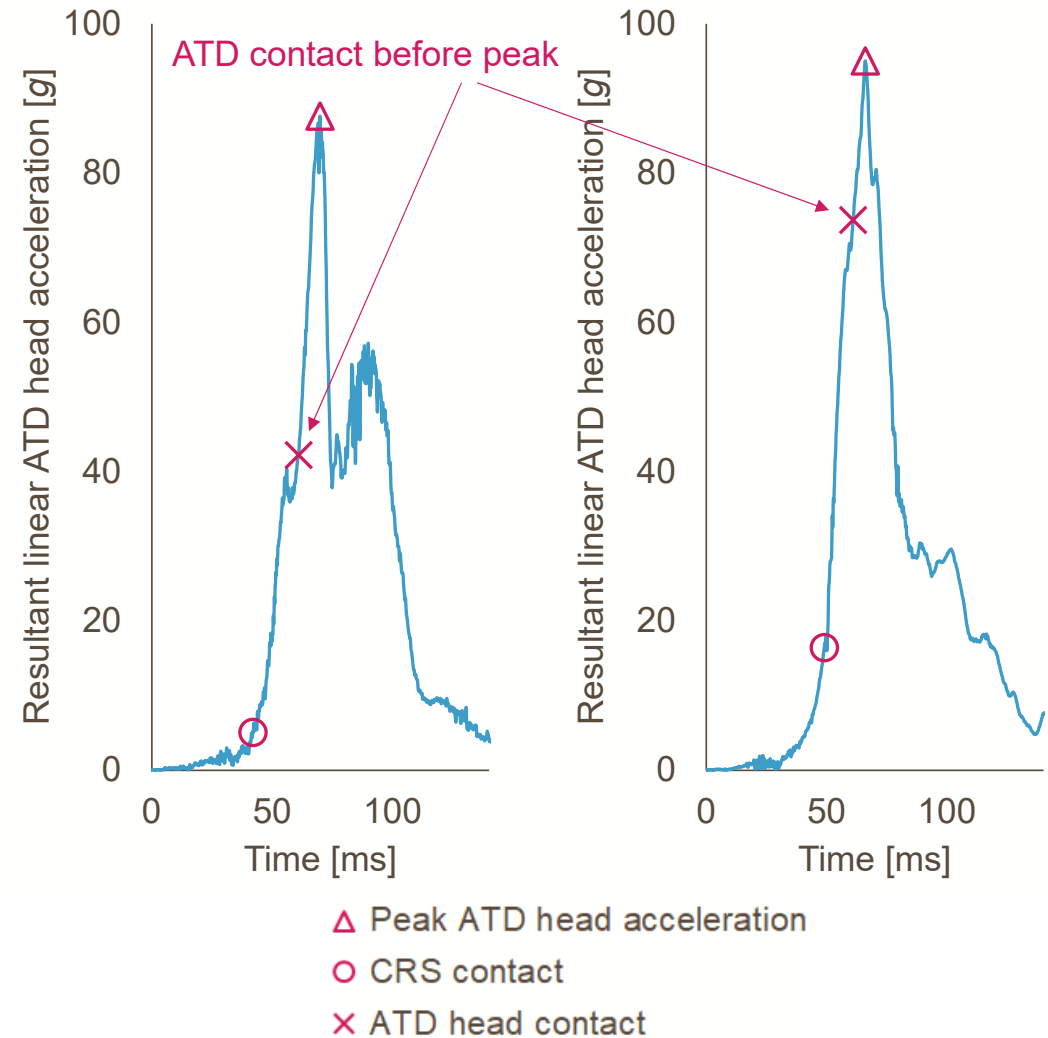
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- Other options considered
 - Percentage of peak (e.g. 90%)
 - Time before peak (e.g. 5 ms)



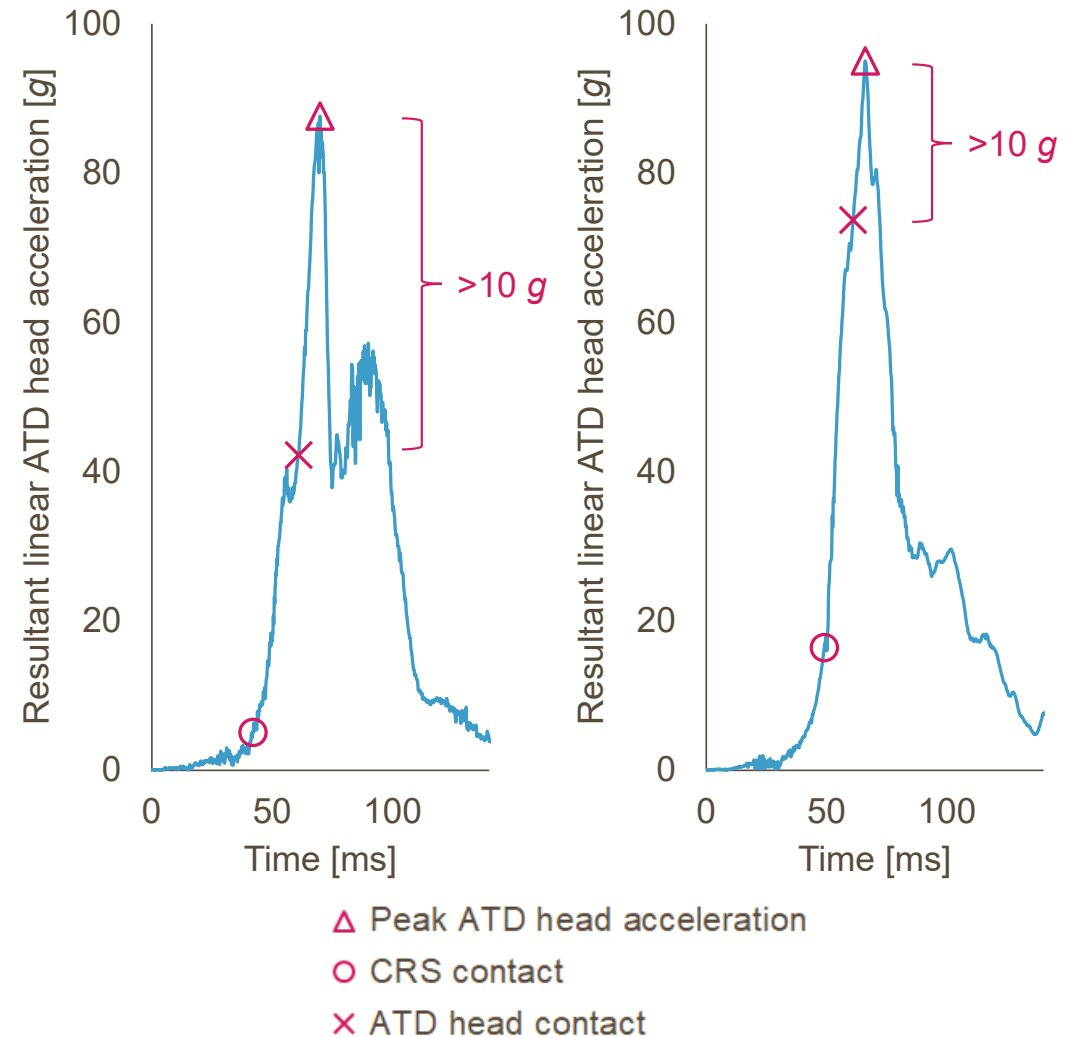
METHODS

- Contributory ATD contact
 - ATD contact before peak



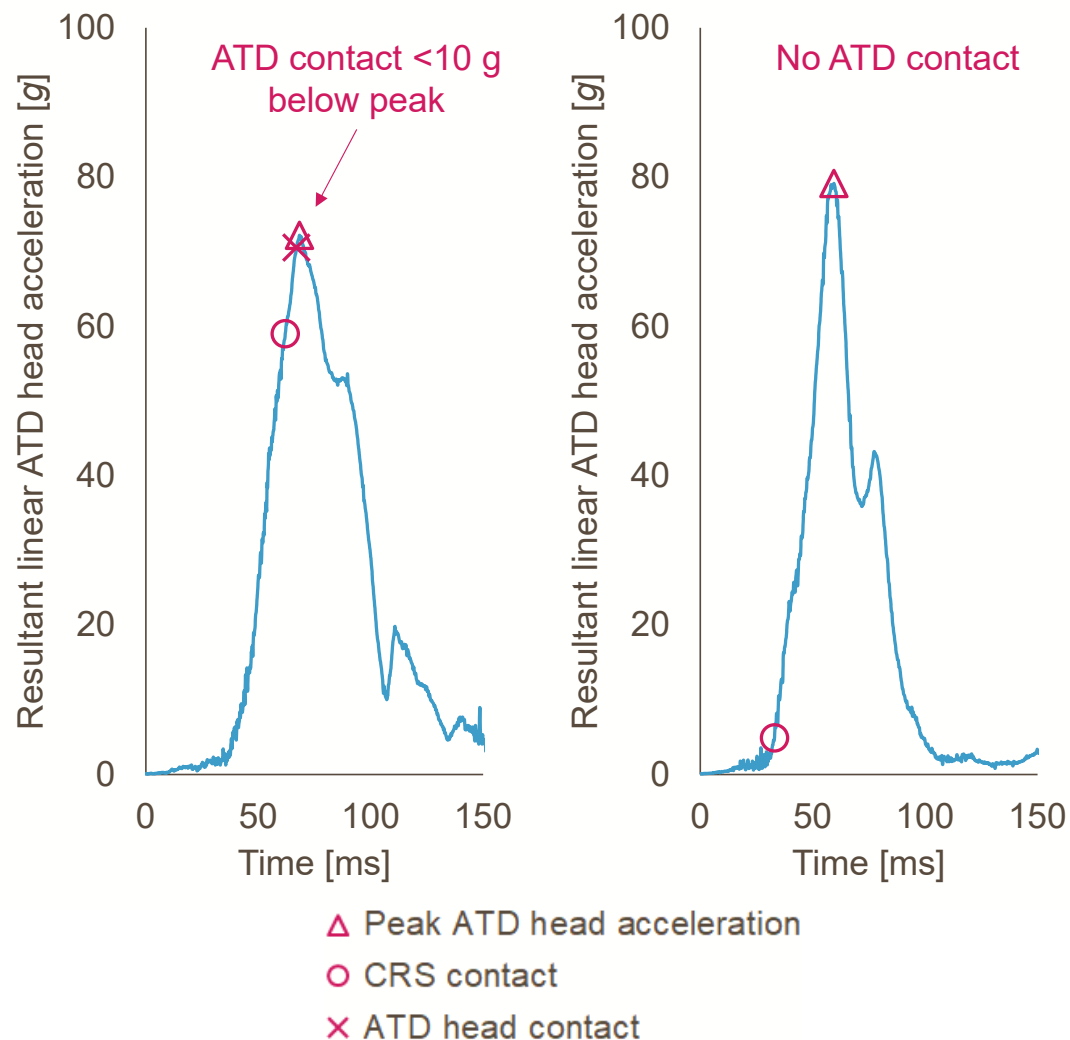
METHODS

- Contributory ATD contact
 - ATD contact before peak
 - ATD contact >10 g below peak



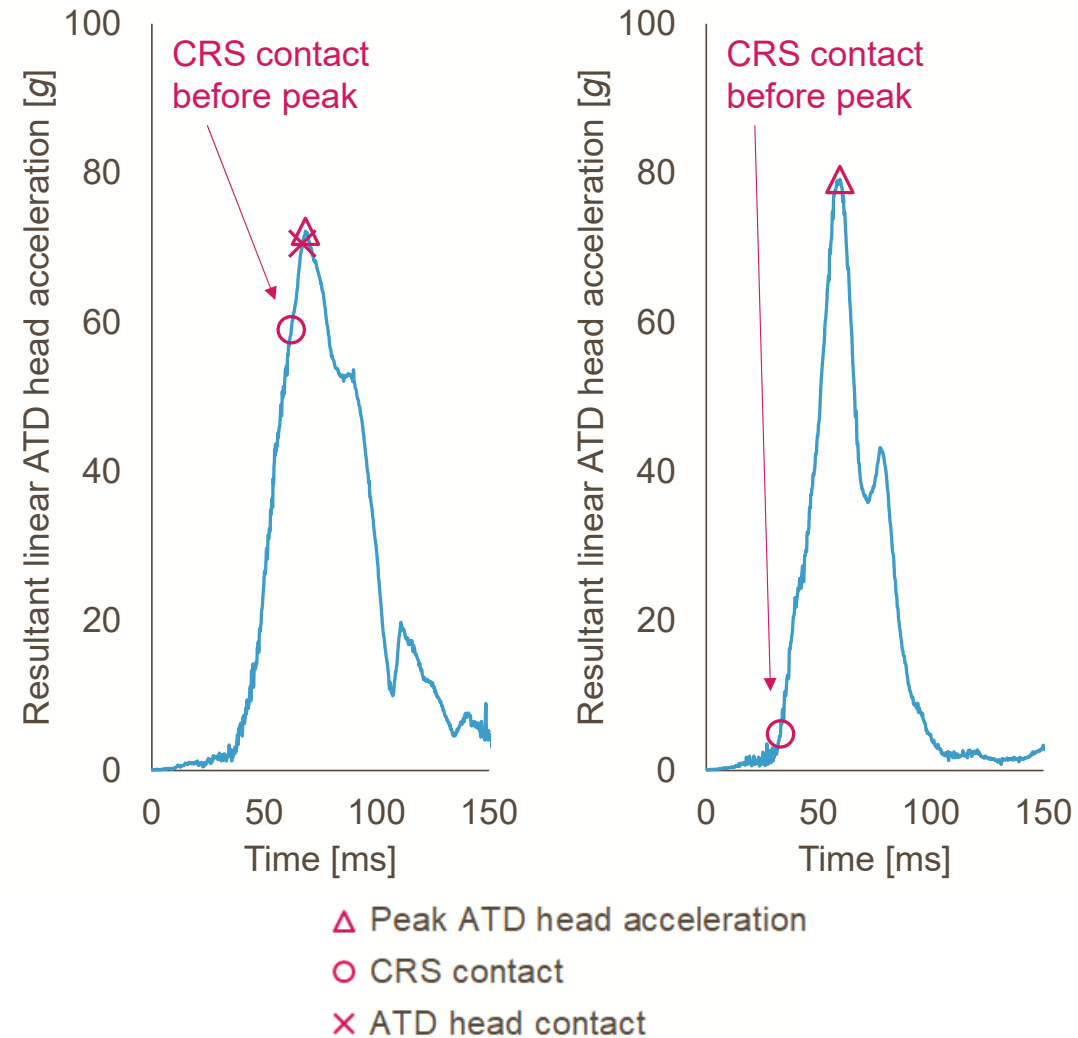
METHODS

- Contributory ATD contact
 - ATD contact before peak
 - ATD contact >10 g below peak
- Contributory CRS contact
 - No contributory ATD contact



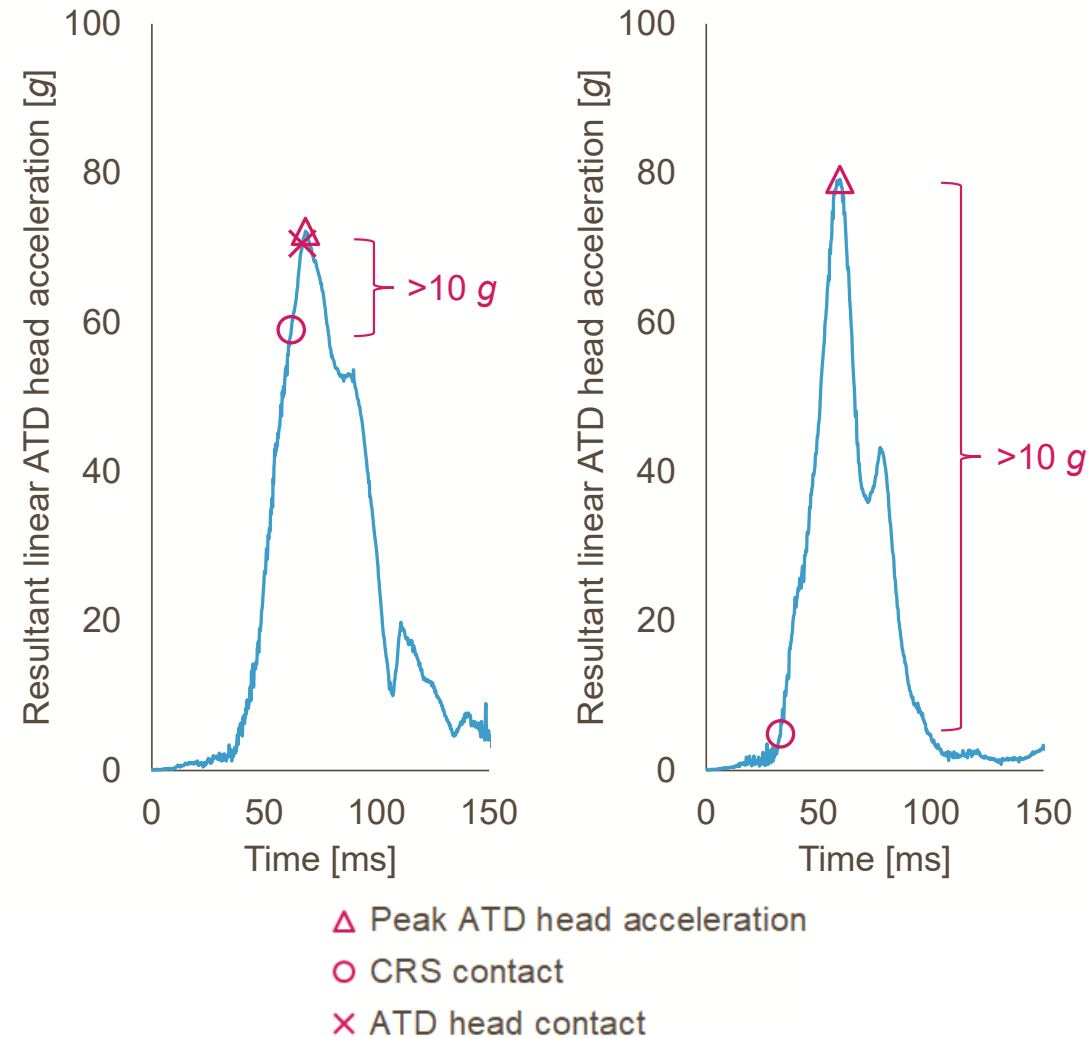
METHODS

- Contributory ATD contact
 - ATD contact before peak
 - ATD contact >10 g below peak
- Contributory CRS contact
 - No contributory ATD contact
 - CRS contact before peak



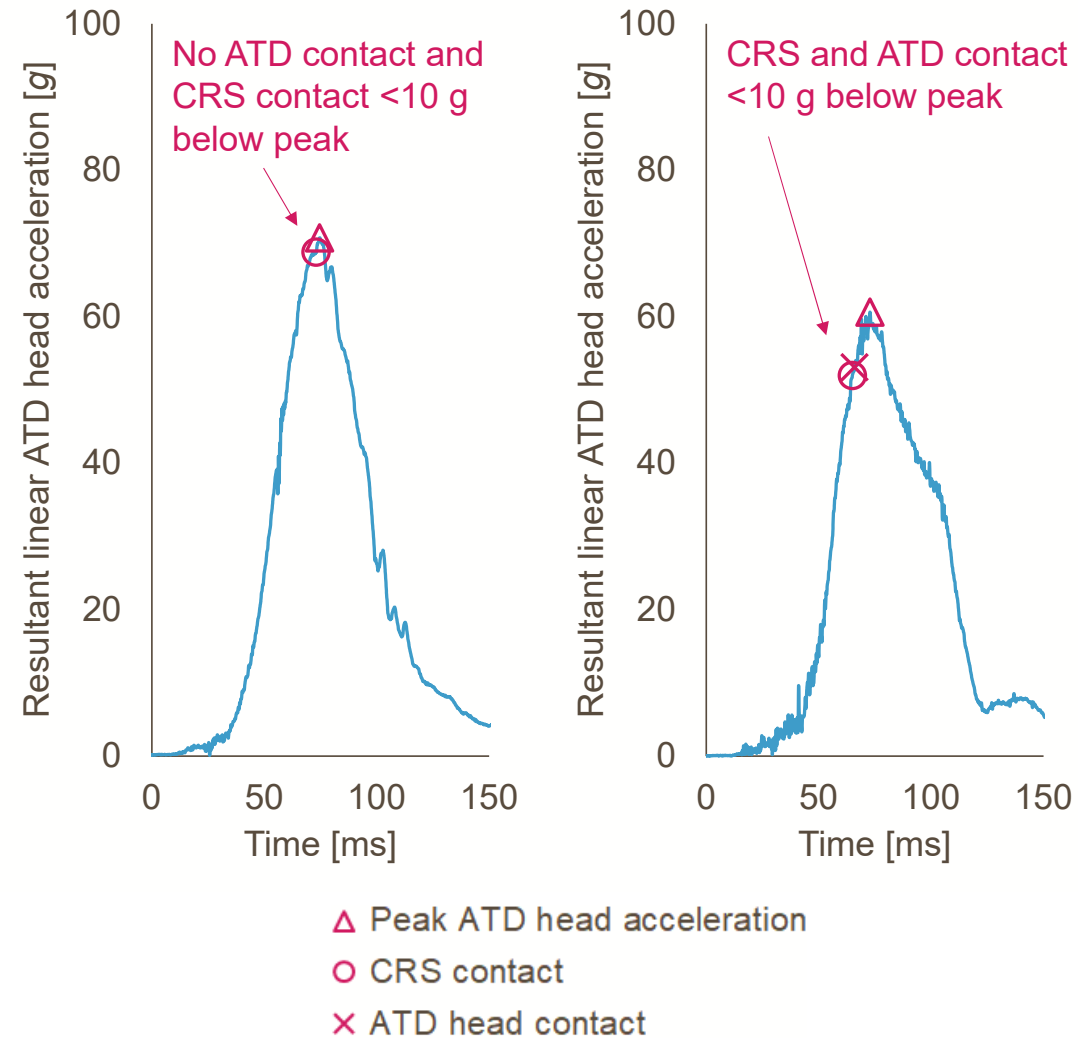
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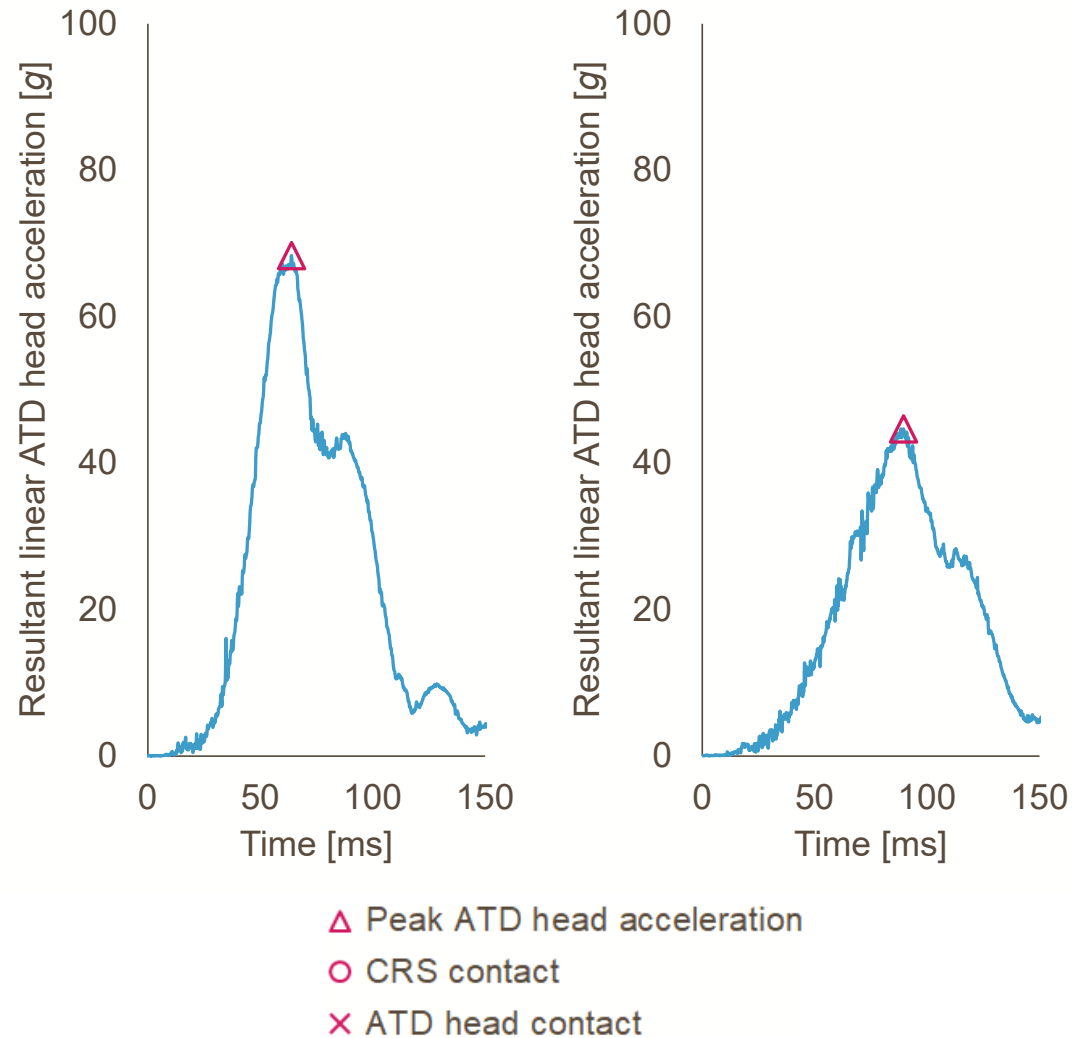
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- Contributory ATD contact
 - ATD contact before peak
 - ATD contact >10 g below peak
- Contributory CRS contact
 - No contributory ATD contact
 - CRS contact before peak
 - CRS contact >10 g below peak
- No contributory contact
 - ATD and/or CRS contact but not contributory



METHODS

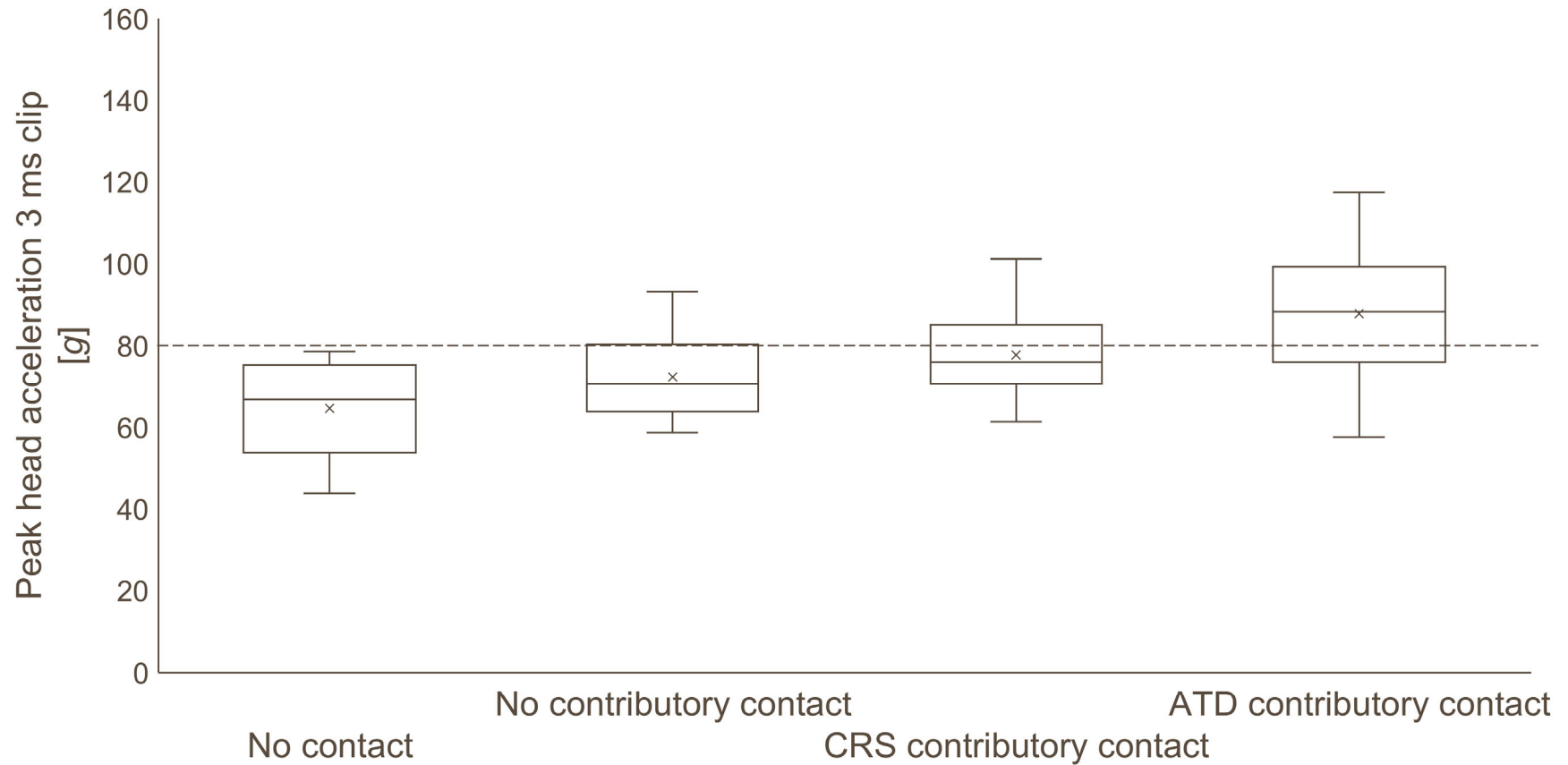
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- No contributory contact
 - ATD and/or CRS contact but not contributory
- No contact



RESULTS

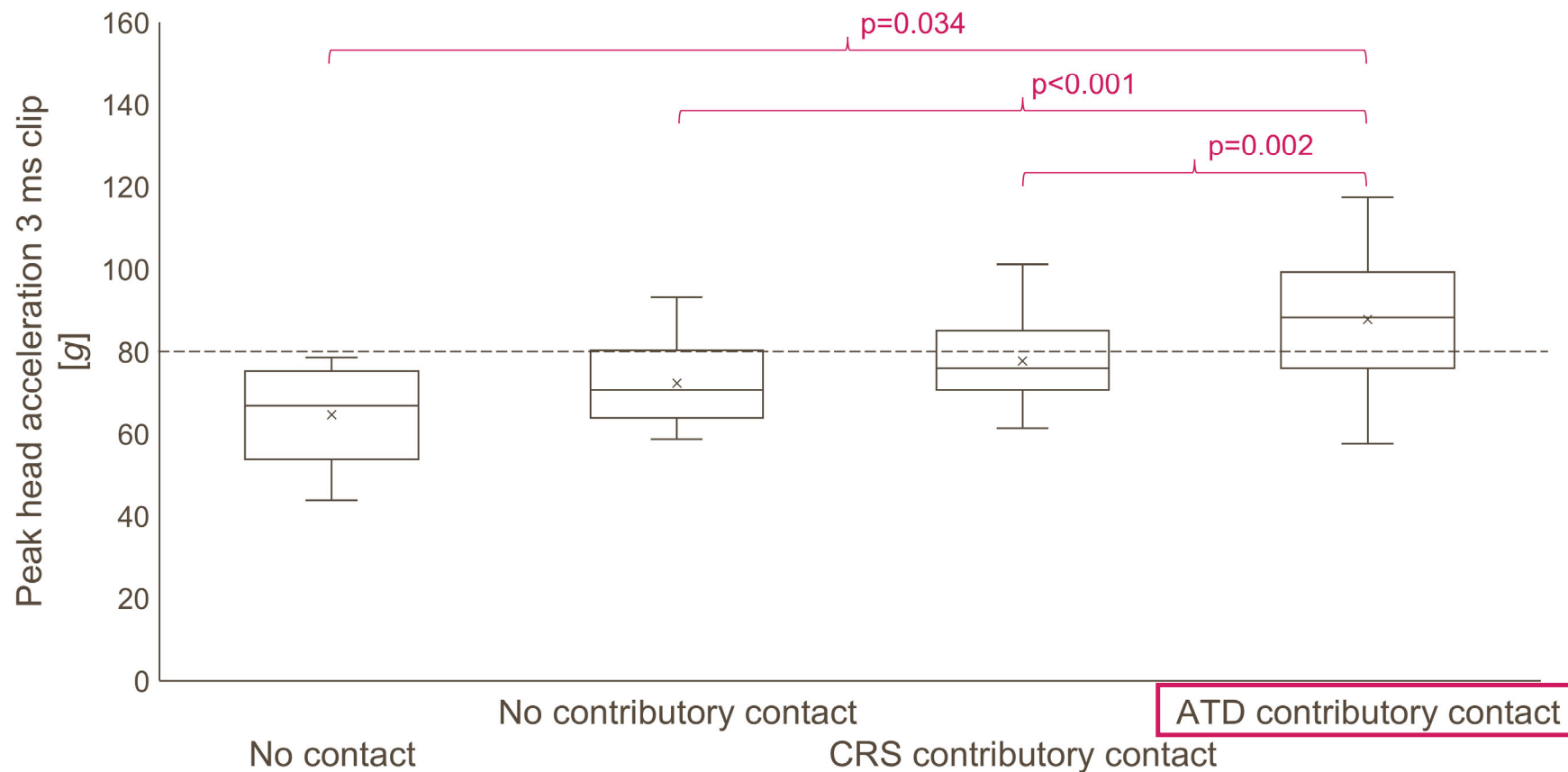
- 7 had no contact
- 9 had no contributory contact
- 11 had contributory CRS contact but no ATD head contact
- 6 had ATD contributory contact with the front-row seatback

RESULTS - LINEAR MIXED EFFECT MODELS



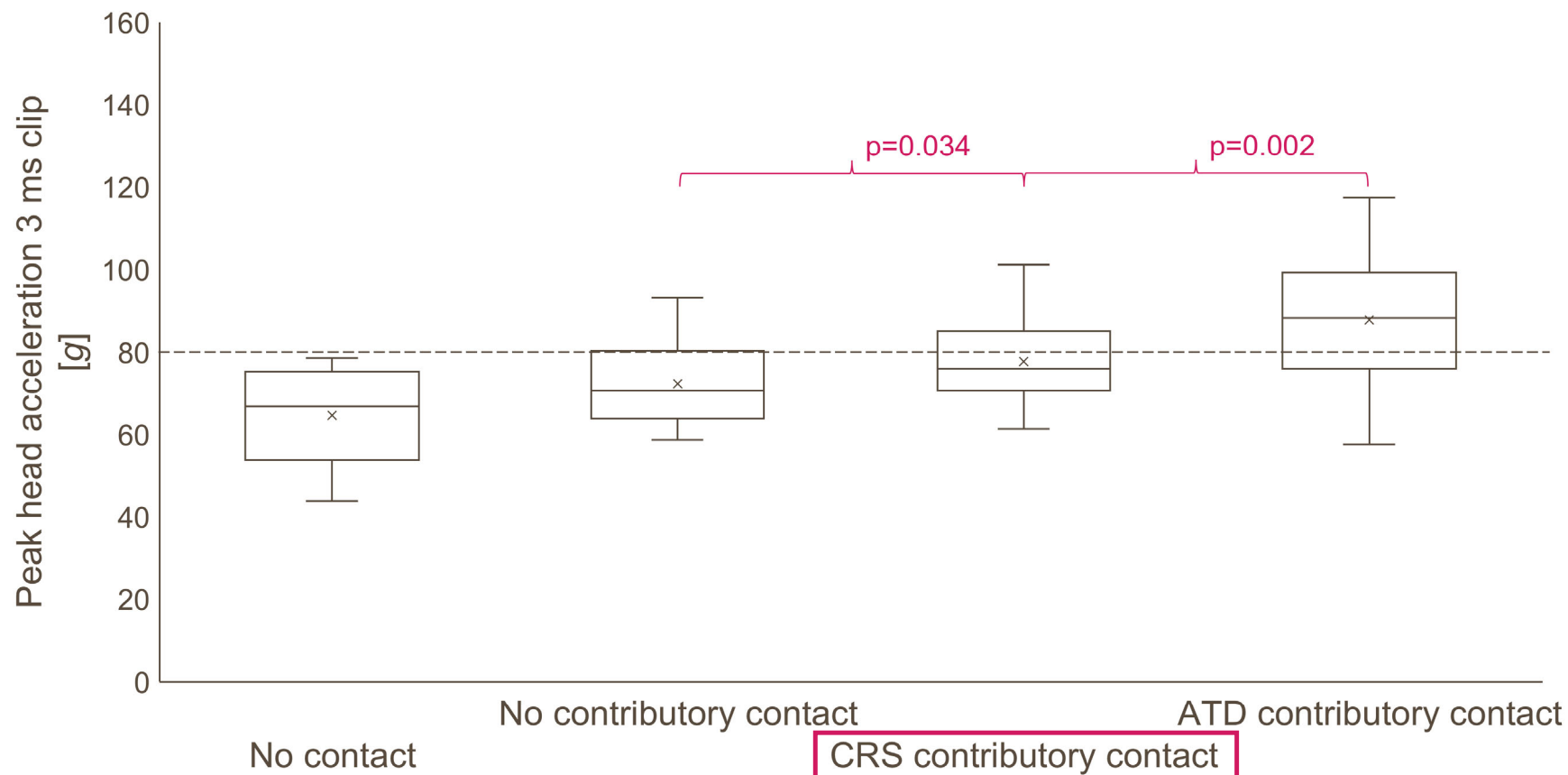
RESULTS

Controlling for vehicle and attachment

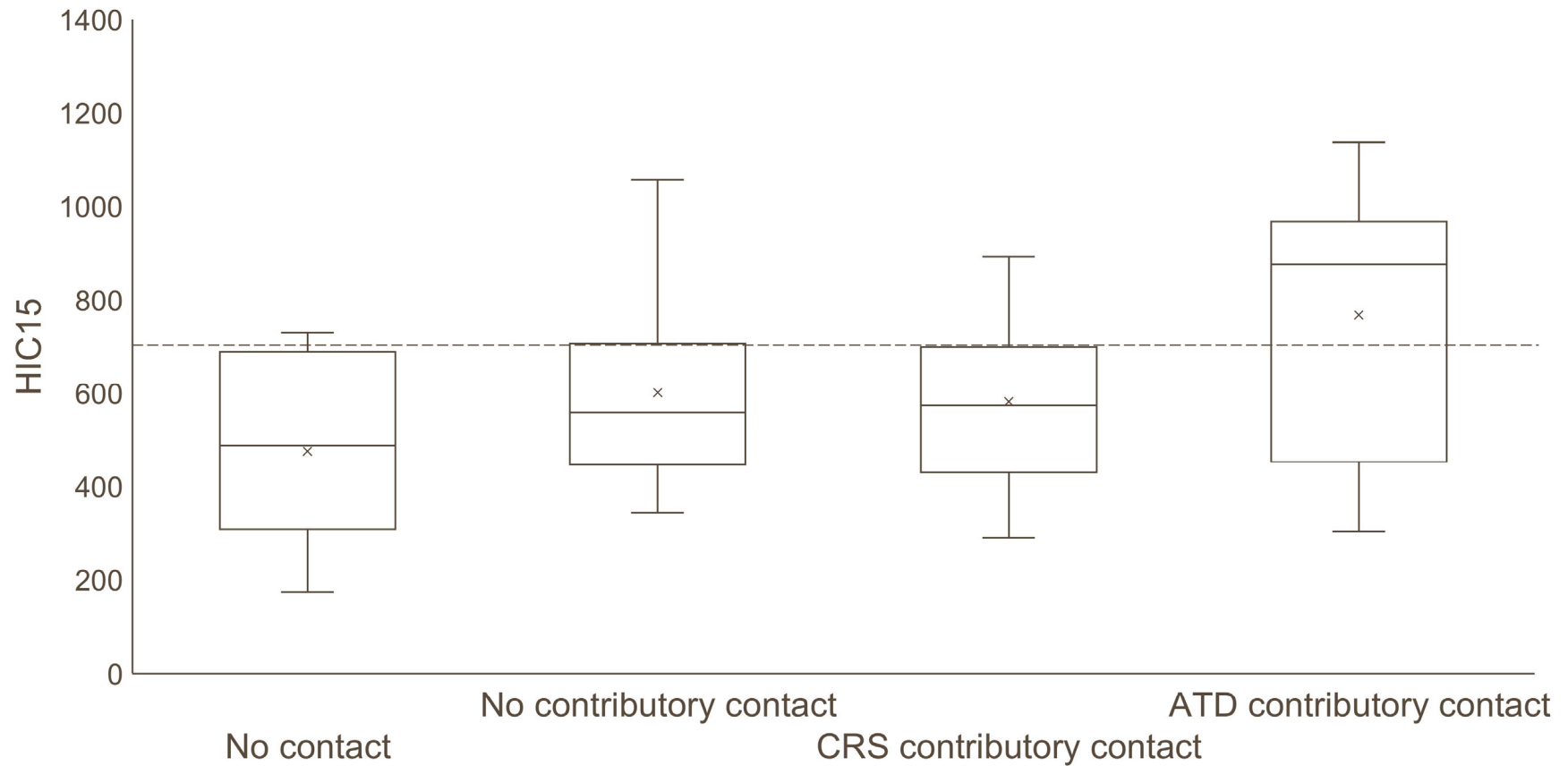


RESULTS

Controlling for vehicle and attachment

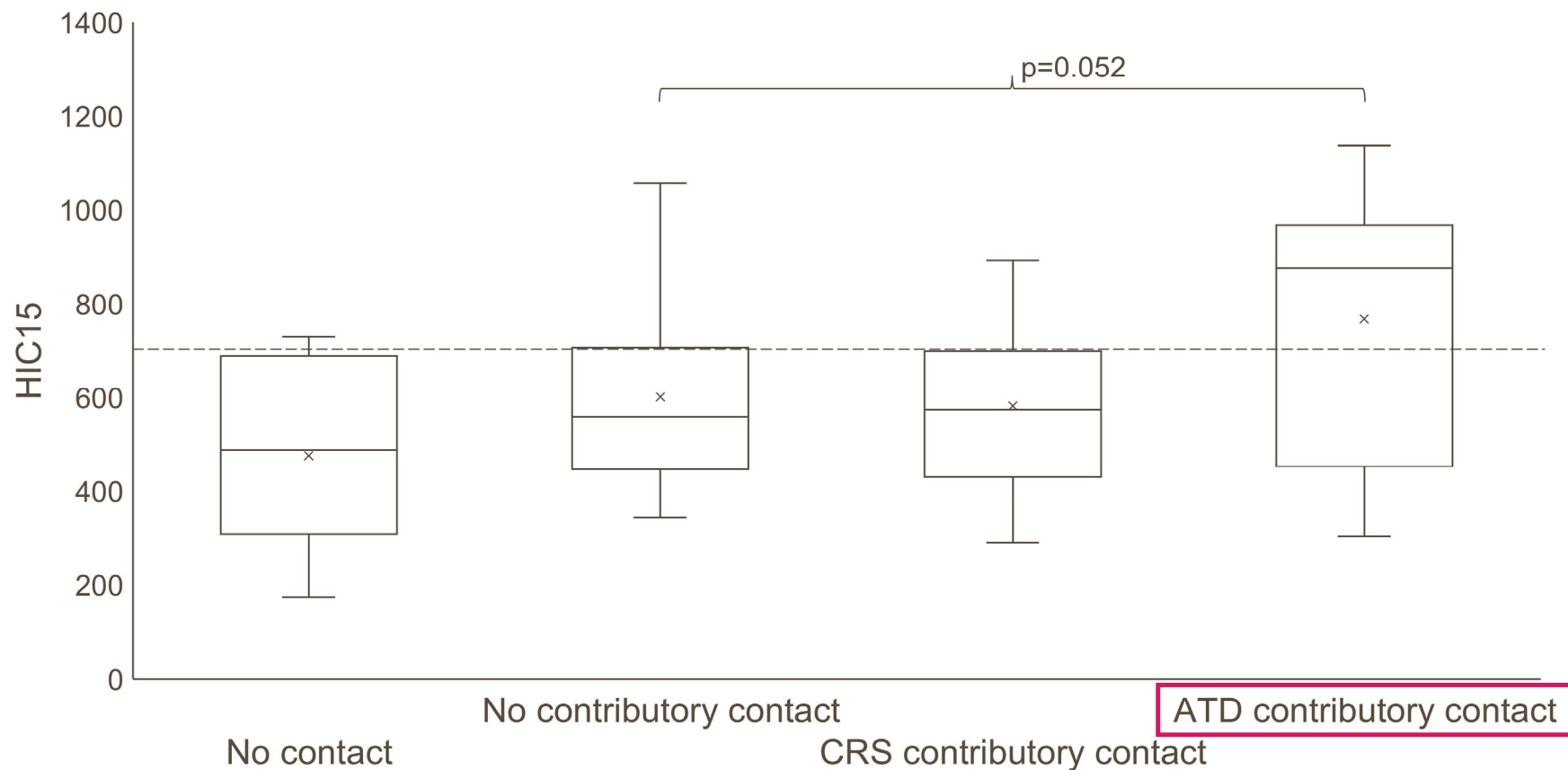


RESULTS



RESULTS

Controlling for vehicle and attachment



CHARACTERIZING SEATBACK LOADING CONDITIONS 16 CRS ACROSS 8 VEHICLE TESTS

- Two exemplar cases of **contributory ATD head contact**

5.9 m/s 75 mm below top of SB



8.9 m/s 150 mm below top of SB



LIMITATIONS

- Timing of ATD and/or CRS contact with the front-row seatback was visually observed from the high-speed video
 - Multiple angles
 - Transfer paint from ATD head
- Contributory contact defined as $>10\text{ g}$ below peak acceleration
 - Meaningful increase in peak linear acceleration of the head
 - Issues with time- or percentage-based criteria
- Single crash type (full frontal rigid barrier at 56 km/h)
 - Limits generalisability
- Small sample size
 - Expensive
 - Currently developing validated FE models to evaluate variables parametrically

SUMMARY

- Contributory contact of the ATD and/or CRS head with the front-row seatback was found to be associated with increased head injury risk
 - Significant for PLA3, but not HIC15
 - Acceleration pulse shapes detected by PLA3 but attenuated by HIC15
- ATD → energy management of front-row seatbacks
 - Currently investigating using FE simulations
- CRS → energy management of CRS head restraints
 - Currently investigating using impact tests

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