Insurance Institute for Highway Safety
Highway Loss Data Institute

Booster seat characteristics in the US market

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iihs.org

Volvo introduced the booster seat in 1978

Boosters are similar almost 40 years later

Other belt-positioning devices

travel vests

inflatable boosters

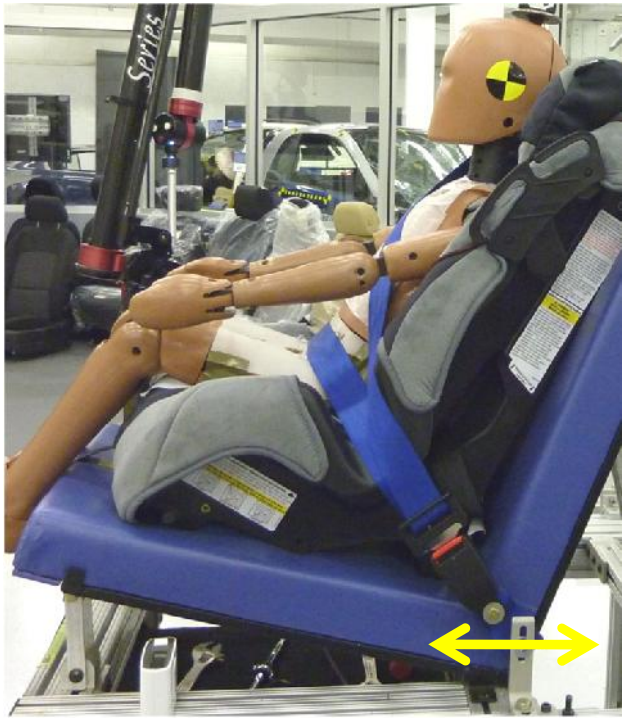
heightless
belt-positioners

What do boosters do? How do they work?

- Adapt the vehicle seat environment to fit children who have outgrown harness-equipped restraints but are too small for the vehicle seat and belts
- Elevate so the child fits the vehicle seat belts more like an adult
  - Moves the shoulder belt off the neck, reducing the likelihood of misuse
  - Steepens the lap belt angle which improves lap belt fit and engagement with the pelvis throughout a crash
  - Puts the child's head in a better position to take advantage of curtain airbags
- Shorten the seat cushion length
  - More appropriately sized for children to improve posture and decrease slouching
- Position the lap belt below the ASIS and shoulder belt mid-clavicle

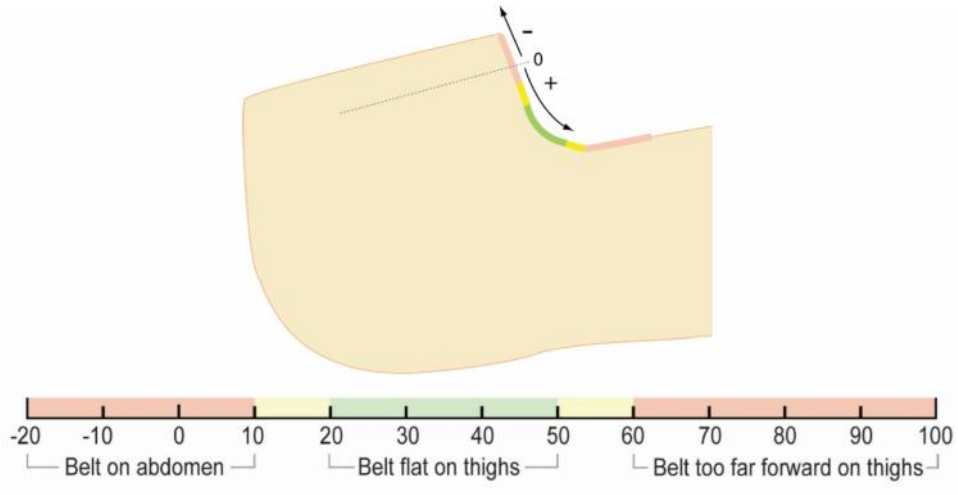
Belt fit measurement rig

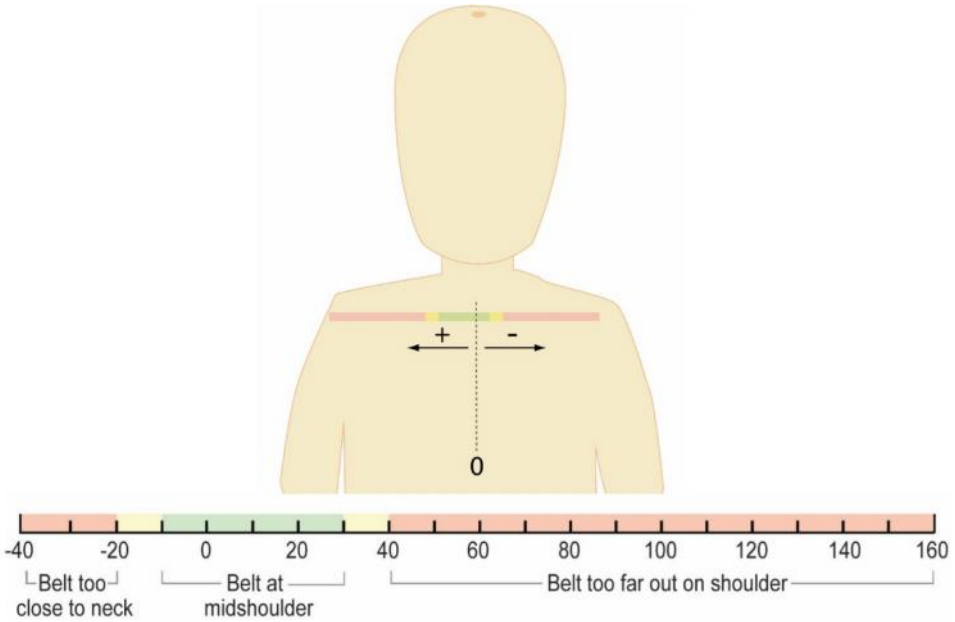
Movable anchorages to match range observed in vehicles



Static belt fit

Lap and Shoulder Belt Score





Other booster measures

- Boost height: height of dummy h-point on booster relative to no booster condition
- Head center-of-gravity position: height and fore-aft distance relative to test fixture
- Lap belt angle: angle of h-point to lap belt anchorage relative to horizontal
- Knee flexion angle: angle of lower leg relative to thigh

Types of US boosters

highback only

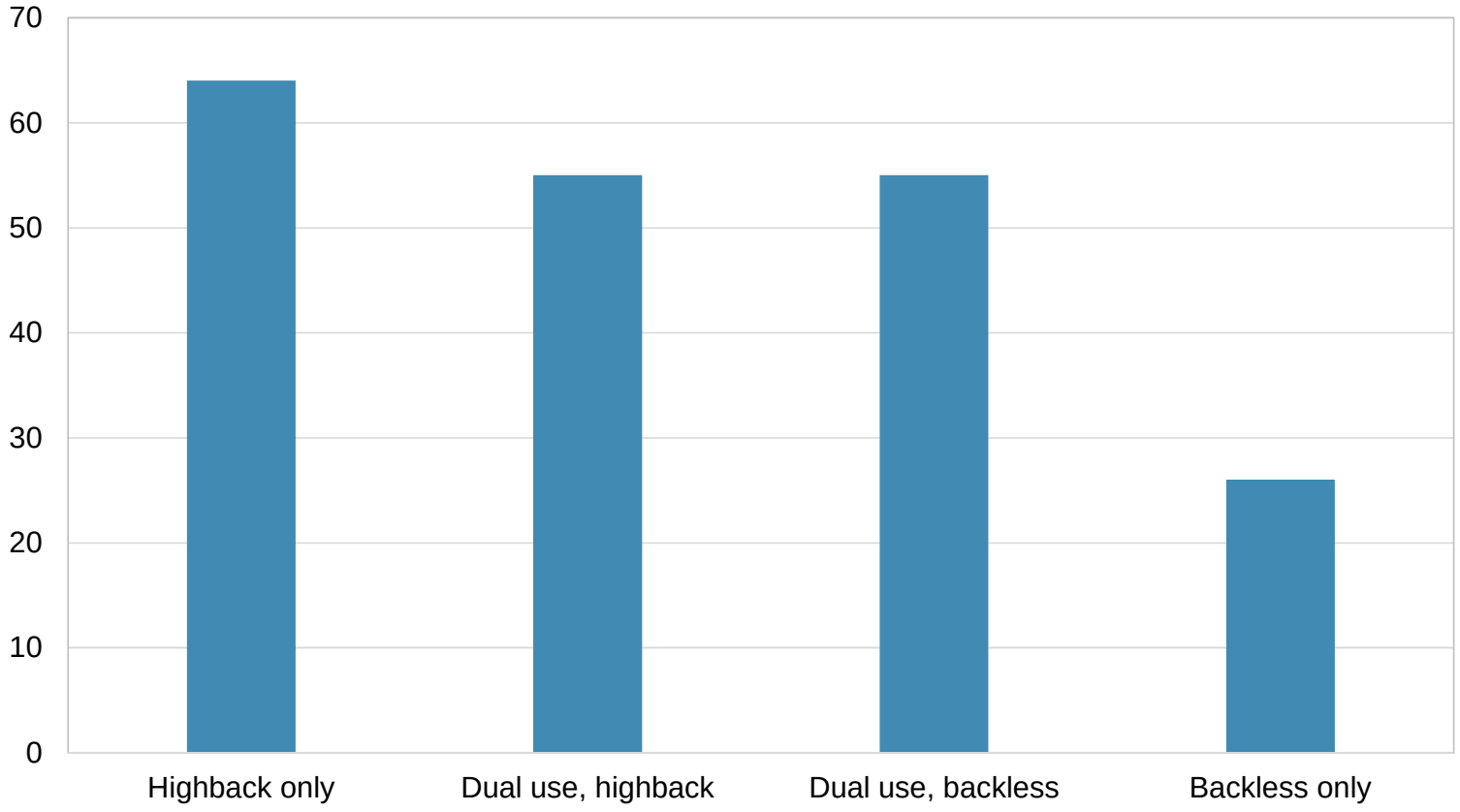
dual use,
highback mode

dual use,
backless mode

backless only

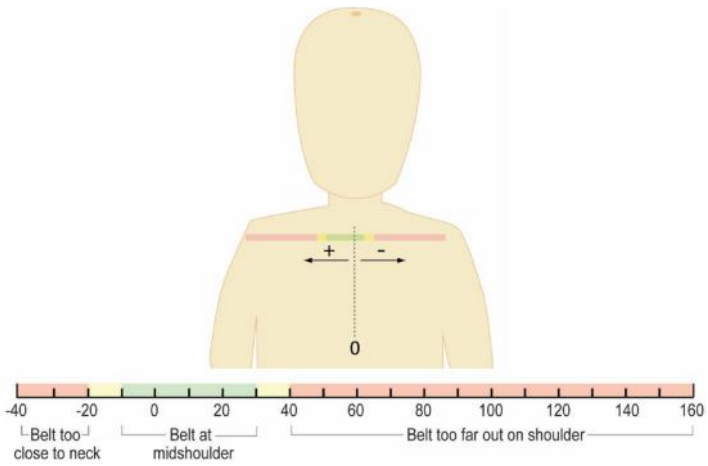
200 booster seats in the US market

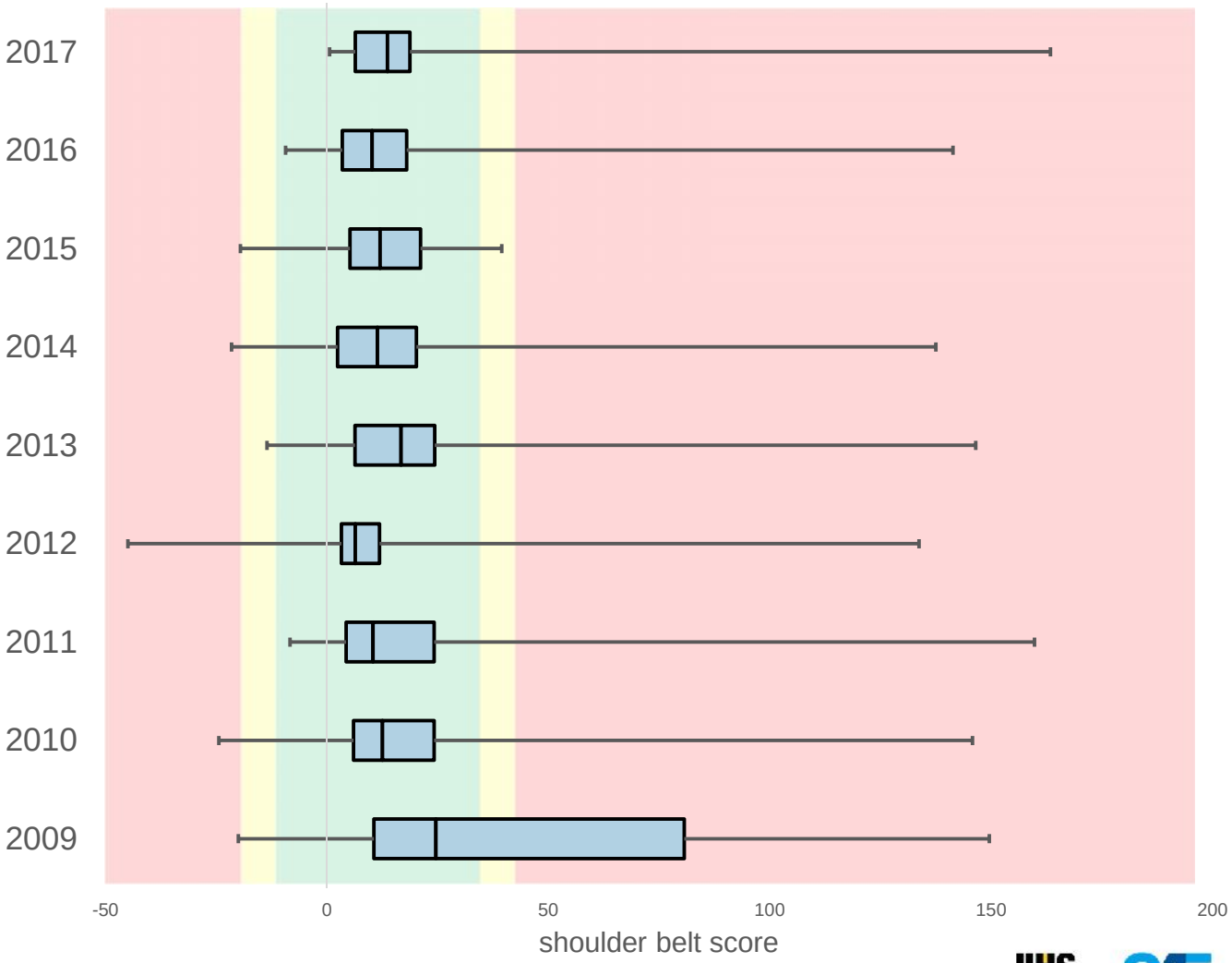
From 2011 to 2017



Shoulder belt score

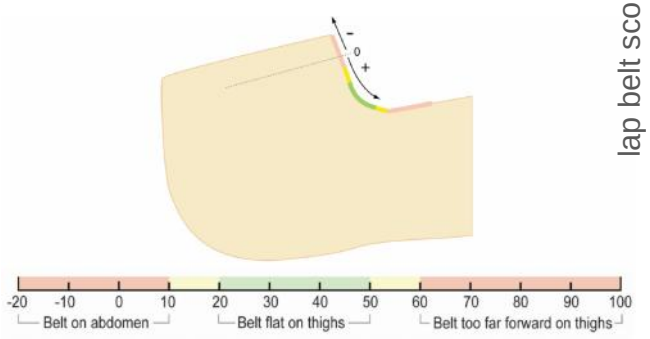
2009 to 2017

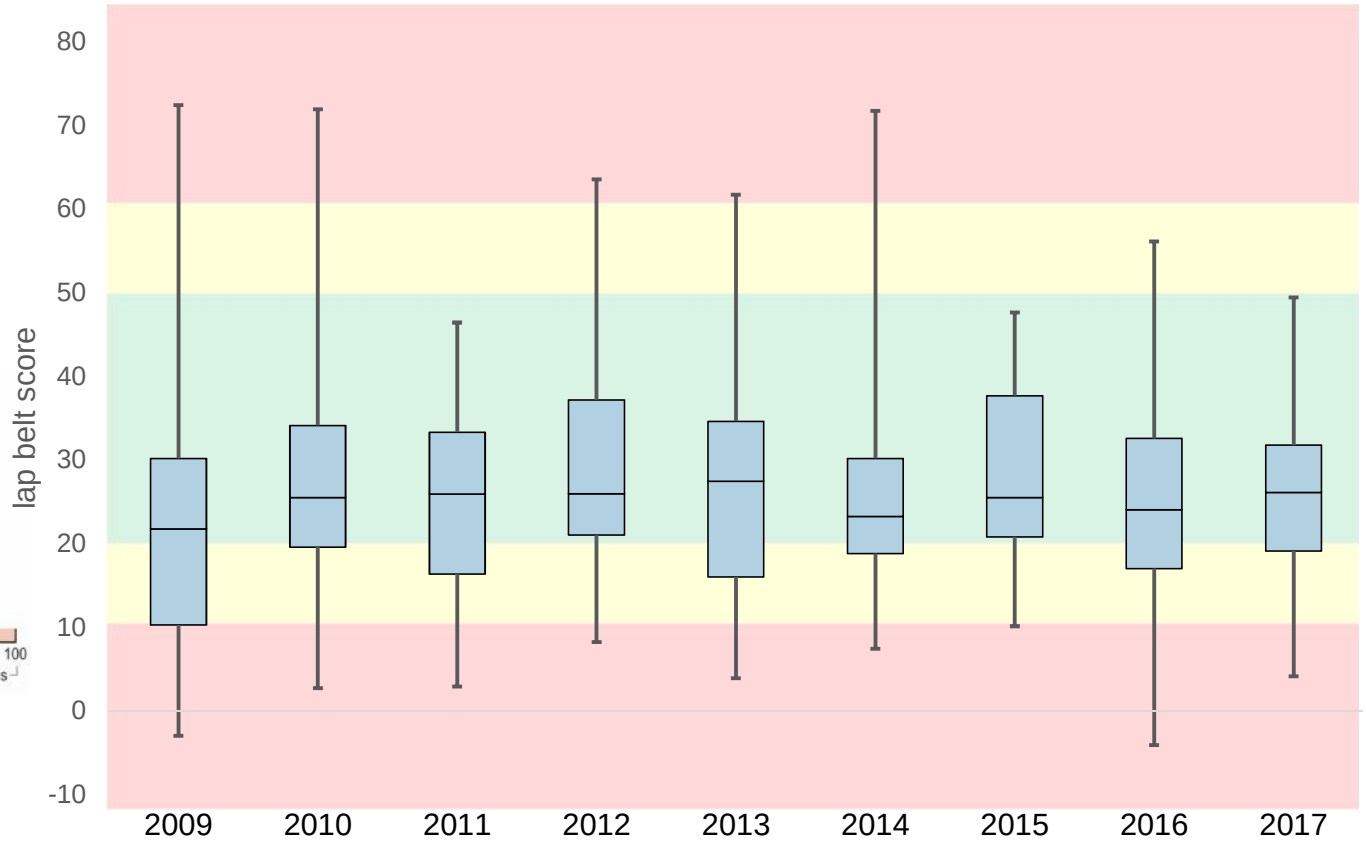




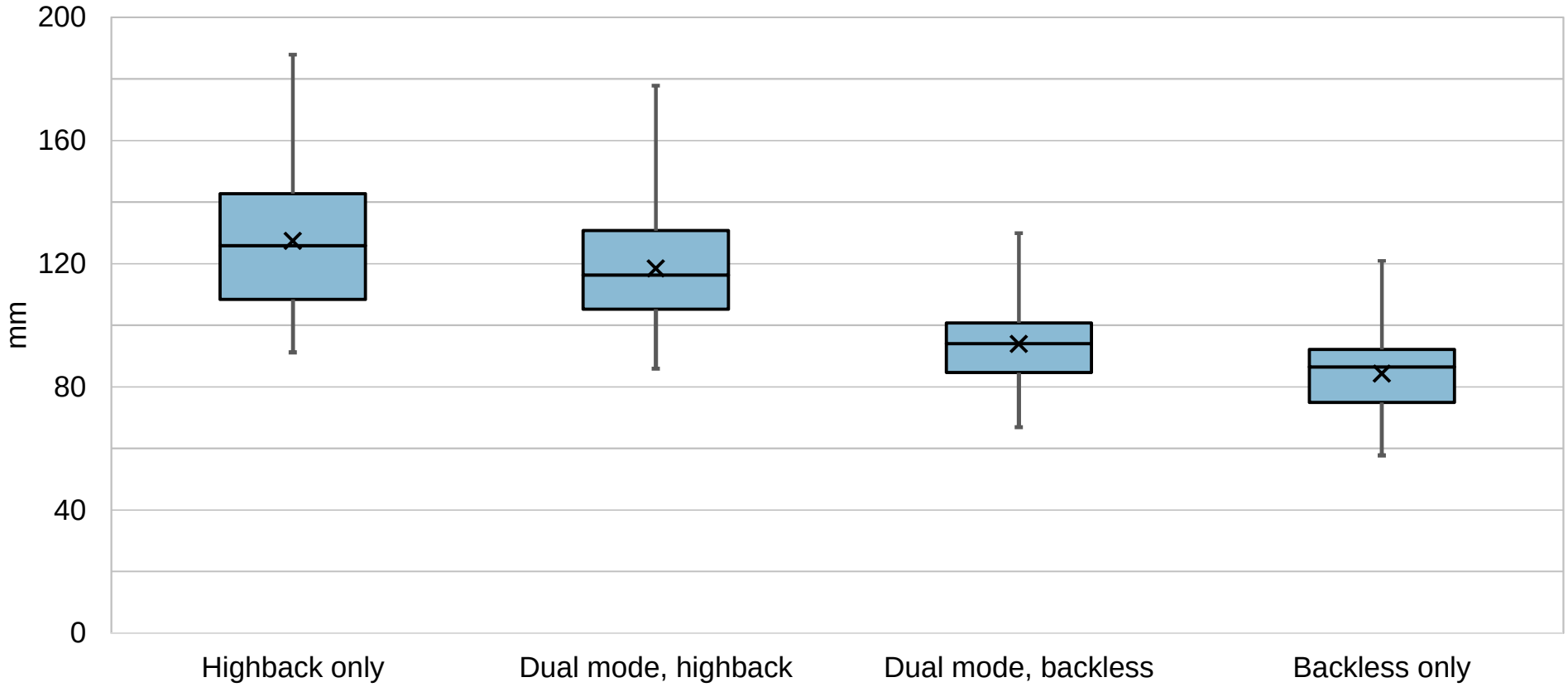
Lap belt score

2009 to 2017

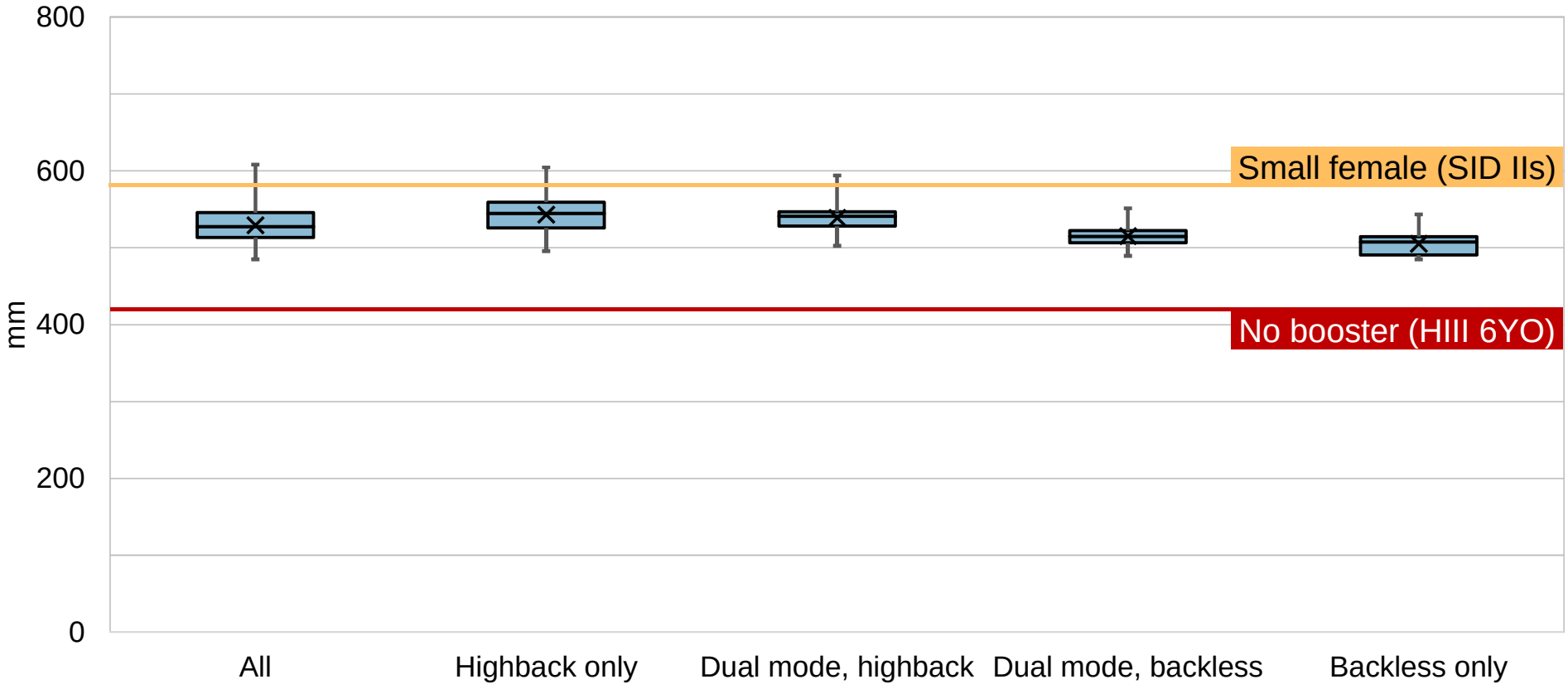




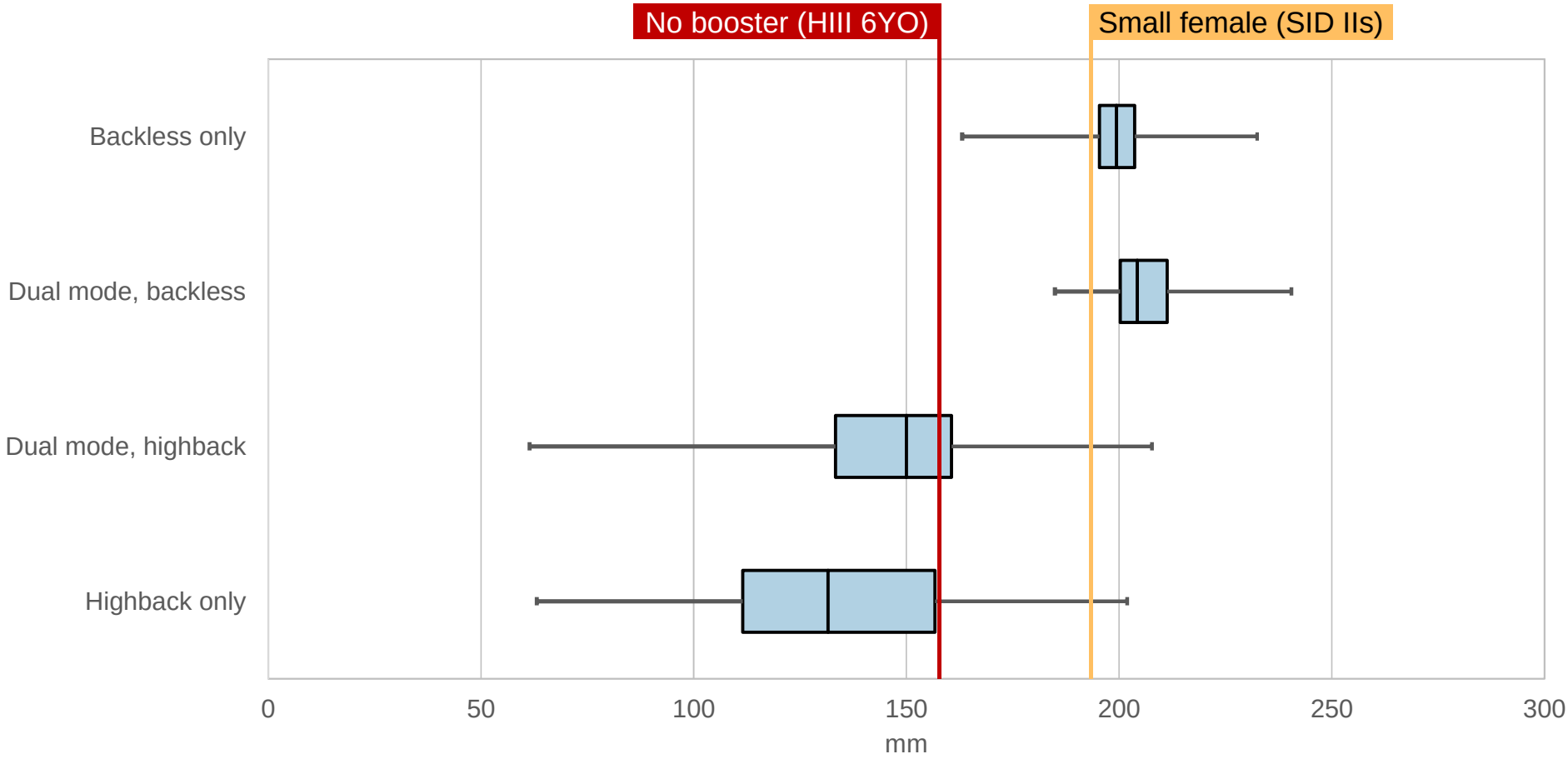
Boost height



Head center of gravity height

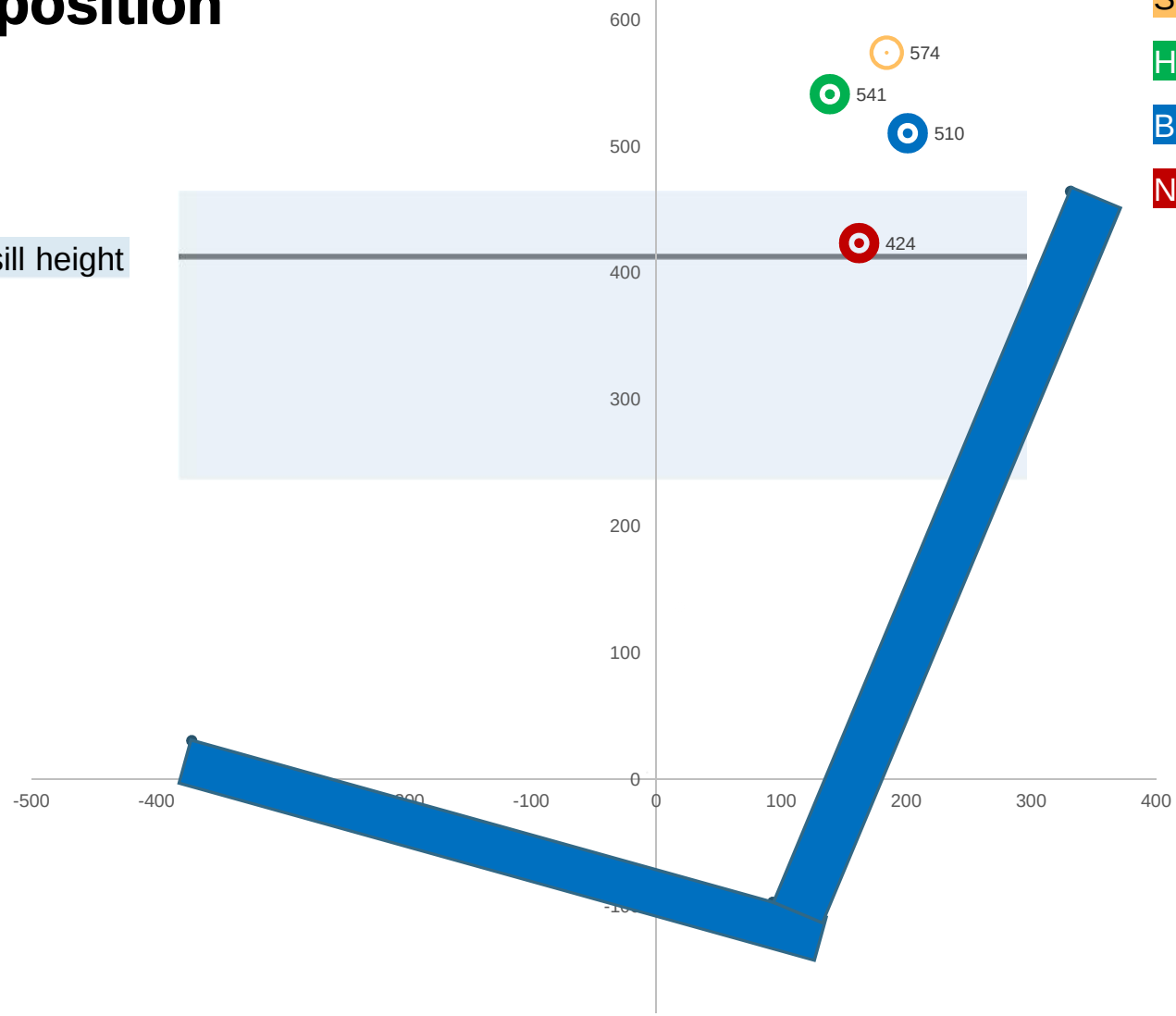


Head cg fore-aft distance



Head cg position

range of windowsill height



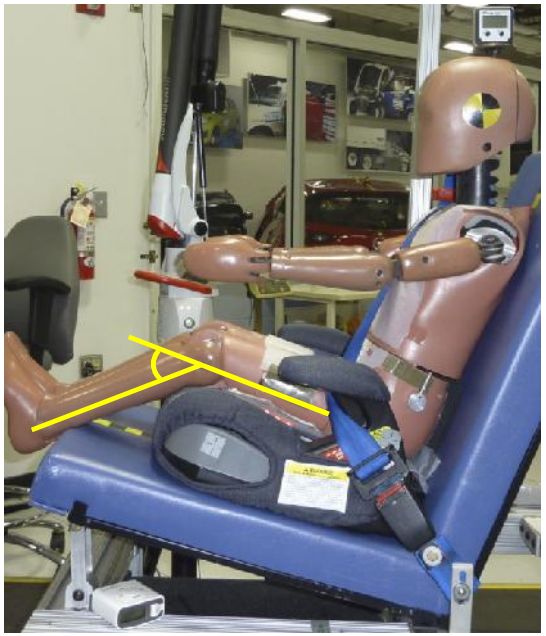
Small female (SID IIs)

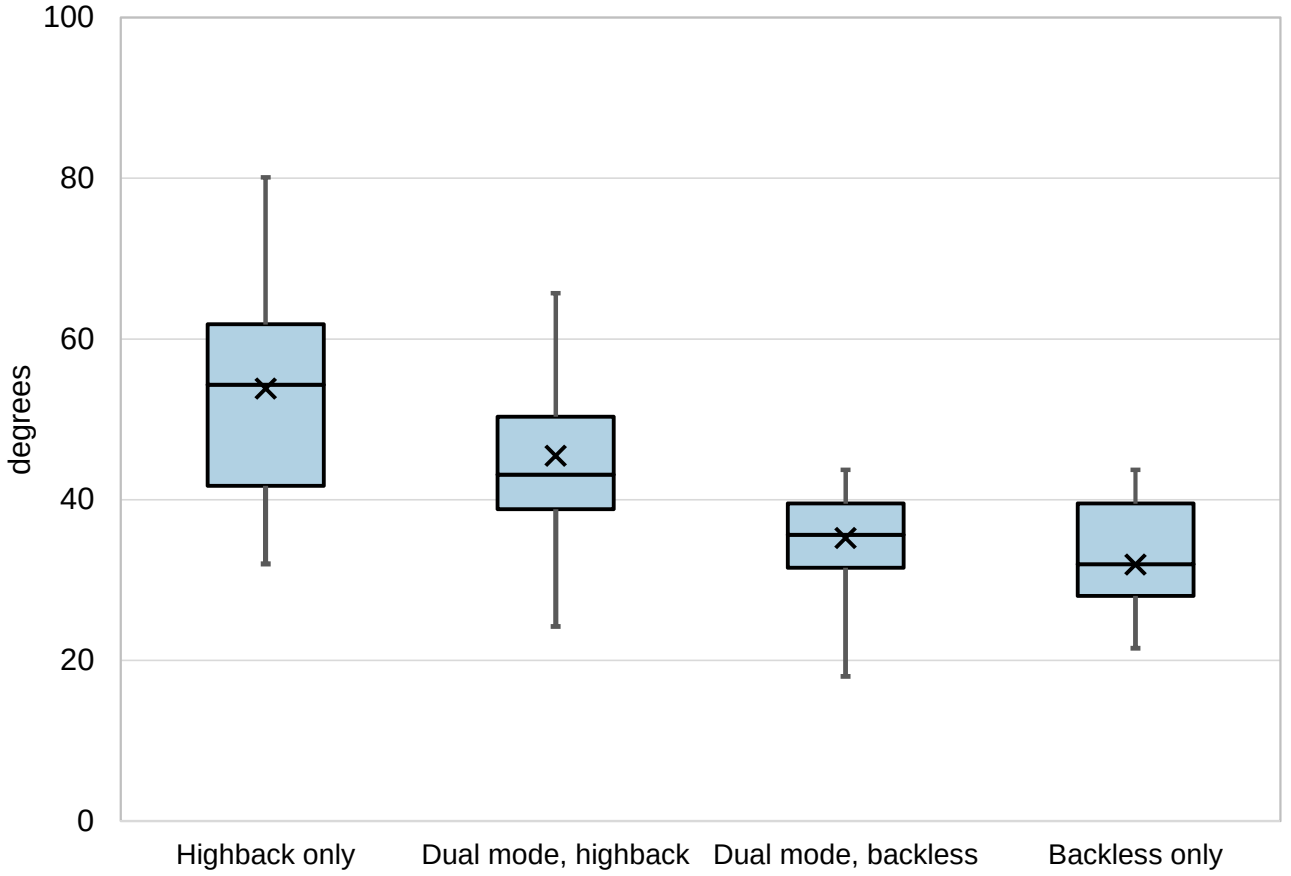
Highback booster (mean)

Backless booster (mean)

No booster (HIII 6YO)

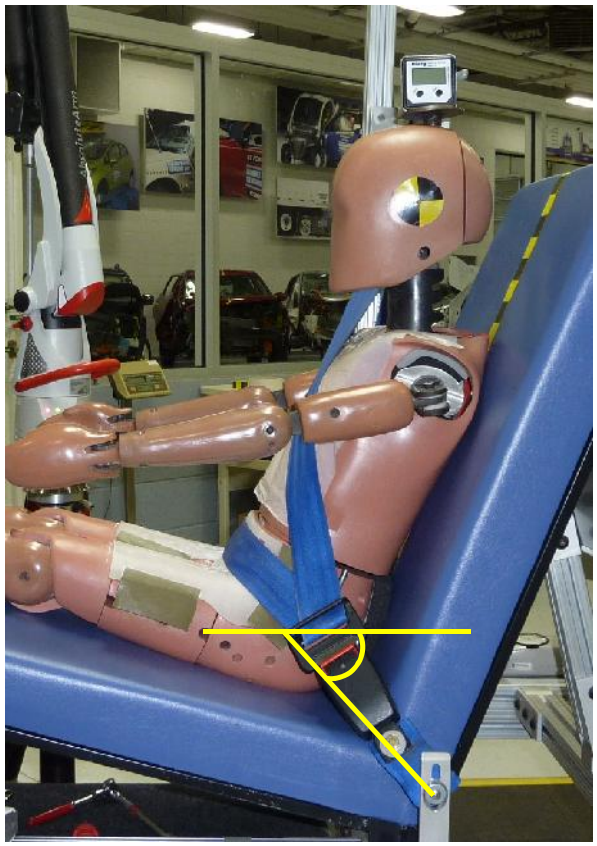
Knee flexion

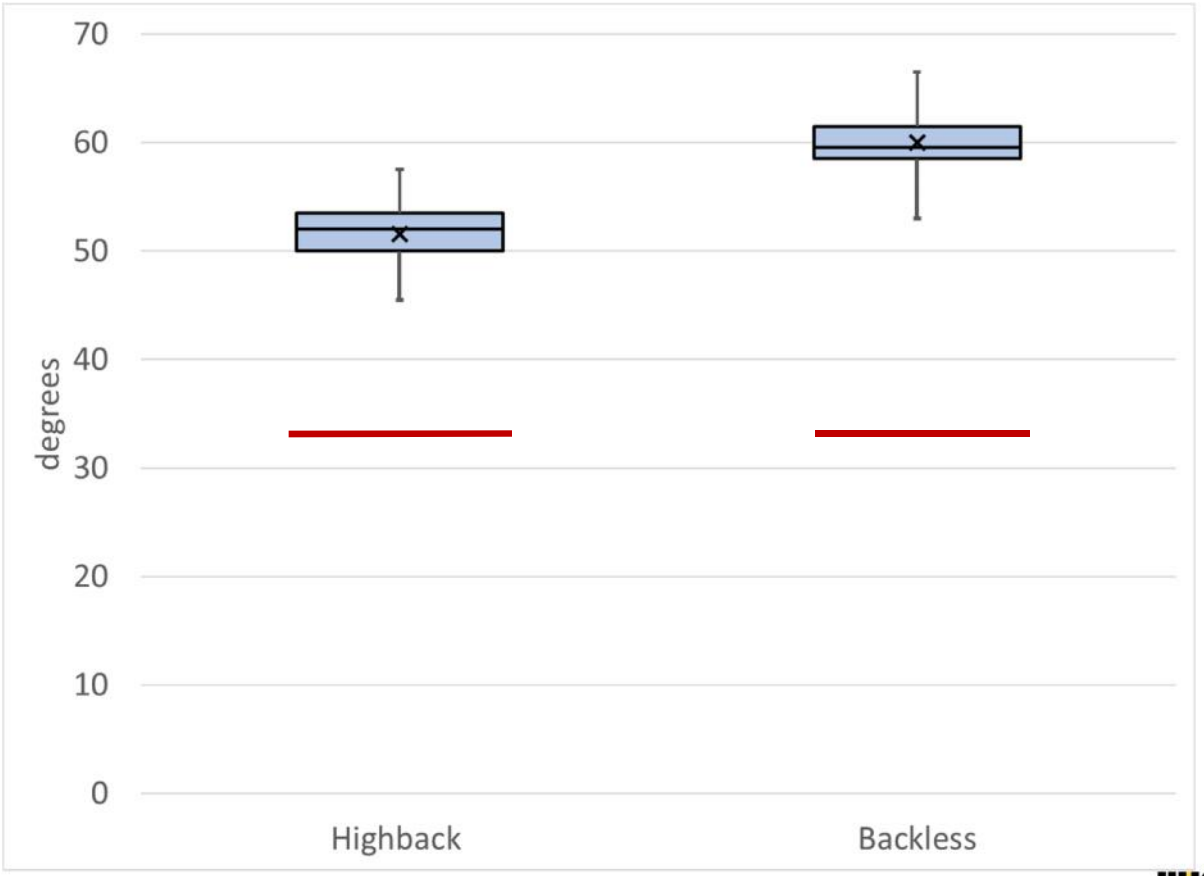




Lap belt angle (H-point to anchorage location)

Test conditions with minimum lap belt angle





Summary

- Range of static belt fit has narrowed considerably since 2009
  - Shoulder belt fit for backless boosters highly dependent on use of shoulder belt clip
- Highback boosters position the dummy higher and more forward than backless boosters
  - Dummy head positioned, on average, 31 mm higher and 62 mm more forward than backless
  - Larger knee flexion angles than backless, typically due to highback boosters positioning dummy hip position more forward, reducing seat cushion length
  - Lap belt angle (H-point to anchorage angle) steepened with all boosters but to a larger extent in backless boosters
- On average, boosters position the head 105 mm higher than no booster condition
  - Within 45 mm of the small female head height
  - On average, 120 mm higher than the average windowsill height found in NHTSA's 2012 study of rear seat geometry; 70 mm higher than the maximum windowsill height

Limitations

- This is a descriptive study to quantify the effect of booster geometry on head and pelvis position, knee flexion, and static belt fit on a standard test fixture with a standard size dummy
- Dynamic performance is governed by many more variables and cannot be inferred directly from these data

A specially designed dummy is simplifying IIHS booster evaluations. Dubbed Jasper, the dummy should make it easier for manufacturers to design seats that provide proper safety belt fit for young passengers.

IIHS began using Jasper to measure boosters during the latest round of evaluations. A total of 16 new boosters for 2017 are rated. Thirteen of them earn the highest rating of BEST BET, meaning they provide good belt fit for typical 4 to 8 year-olds in almost any car, minivan or SUV. The other three are rated Check Fit, meaning they could work for some children in some vehicles. None of the new seats are rated Not Recommended.

With the new additions, consumers can find ratings for a total of 151 boosters currently on the market, including 118 BEST BETs and nine GOOD BETs, which provide acceptable belt fit in most vehicles. Only one current seat — the Safety 1st Summit 65 — is Not Recommended and should be avoided. Four other seats rated Not Recommended were discontinued this year.

New dummy is better for the task

Vehicle safety belts are designed for adults, and the job of a booster is to make them fit a child. IIHS has been rating boosters since 2008 on their ability to provide good lap and shoulder belt fit (see *Status Report* special issue: booster seats, Oct. 1, 2008).

Up until now, the Institute has measured belt fit using a crash test dummy that

Until now, IIHS has used a crash test dummy for booster evaluations. It's expensive and not ideal for measuring belt fit. The new dummy is designed specifically for this purpose and is easier to use and cheaper to produce.

represents a 6-year-old child. That dummy, known as the Hybrid III 6 year-old, is a complex tool designed for dynamic tests.

"The Hybrid III 6 year-old is expensive and more complicated than what we need and actually isn't ideal for measuring belt fit," says IIHS Senior Research Engineer Jessica Jermakian.

"Jasper will be easier to use and cheaper to buy and obtain replacement parts for. Because it's more accessible, we hope that booster manufacturers will be able to use it in-house as part of the design process for new seats."

Booster ratings

There are 16 new models for 2017, including 13 BEST BET boosters and 3 Check Fit.

BEST BET
Chicco GoFit (backless)
Cosco Finale (highback)
Cosco Finale DX (highback)
Ekono Monterey XT (backless mode)
Ekono Monterey XT (highback mode)
Evenflo Spectrum (backless mode)
Evenflo Spectrum (highback mode)
Graco Wayz (backless mode)
Graco Wayz (highback mode)
Maxi-Cosi RodiFix (highback)
Nuna AACE (backless mode)
Nuna AACE (highback mode)
Peg-Perego Viaggio Shuttle (backless)

Check Fit
Harmony Folding Travel Booster (highback)
Kiddy Cruiser 3 (highback)
Ride Safer Delighter Booster (backless)

IIHS BEST BET BOOSTER

BEST BETs provide good belt fit for typical 4 to 8 year-olds in almost any car, minivan or SUV.

GOOD BETs provide acceptable belt fit in most cars, minivans or SUVs.

Not Recommended don't provide good belt fit and should be avoided.

Check Fit have varied results depending on child size and vehicle model.

The name "Jasper" is an acronym for Juvenile Anthropomorphic Seat-belt Position Evaluation Rig. IIHS worked with Humanetics, the maker of the Hybrid III 6 year-old, to develop Jasper, and the Michigan-based company manufactures and sells the new dummy. The 45-pound Jasper also represents a typical 6 year-old.

The Hybrid III 6 year-old has skin made of a material that can shrink over time and has moveable parts so that it moves like a human in a crash test. It also has a gap between the pelvis and the thigh that the belt can slip into. When using it for booster evaluations, a silicone shield must be placed over the gap.

In contrast, Jasper is 3D-printed out of a UV-cured liquid polymer that resists shrinkage and distortion. It has only a few moveable parts and has a seamless pelvis, so no additional lap shield is needed. The new dummy lacks arms, since they can get in the way during booster evaluations.

Another difference is that the scales for belt fit measurement are printed directly on Jasper. This way, it can be used like a ruler without the need for additional measuring tools.

Sixteen new models in 2017

IIHS strives to cover the entire U.S. booster market with its ratings. This year, manufacturers added 16 seats to their line-ups. The 16 are made up of 12 distinct models; four are rated twice because they are dual use boosters that can be used either in high-back or backless mode.

The 13 new BEST BETs (nine distinct models) range in price from about $40 for a

JASPER

Juvenile Anthropomorphic Seatbelt Position Evaluation Rig

- New device for static belt fit measurements
  - 3D printed UV-cured liquid polymer
  - Materials less prone to shrinkage and distortion
  - Shorter lead time on parts
  - Lower cost solution than Hybrid III 6 year-old
- Geometry based on the Hybrid III 6 year-old
- Lap and shoulder belt scales printed directly into the pelvis and chest
- Developed in collaboration with Humanetics

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