The balance of vehicle and CRS protection for the older children in child restraints
Objective

Identify the balance of vehicle protection and child restraint protection enabling the optimal real world safety for the children of different sizes.

-focusing children from 4 years and above.

Major safety issues using adult restraints:
• Size and proportions
• Pelvic development
Development of belt-positioning boosters

- World first 1978
- Built-in booster 1990
- 2-stage built-in booster 2007
Protection of belt-positioning boosters


No clear evidence of difference in the safety performance of backless versus high-back boosters, based on real world data (Arbogast et al. Pediatrics 2009)

For side impacts, this could potentially be explained by that the vehicle offers the main protection, by:
• the influence of pre-braking on initial sitting postures (Stockman et al. TIP 2012)
• the influence of wide head supports on initial sitting postures (Andersson et al. AAAM 2010)
Example of sitting posture after braking event of 1g
Child kinematics at braking events, 1g

135-150cm - seat belt only

135-150cm

105-125cm

105-125cm

(Stockman et al. TIP 2012)
Sitting postures for 3-6y during riding in the rear seat

- Shoulder-to-booster back contact during an average of 45% of riding time in the seat with the large head side supports compared to 75% in the seat with the small head side supports.

- The children in the study were seated with the head in front of the front edge of the head side supports more than half the time, in both boosters.

(Andersson et al. AAAM 2010)
The backrest positions the head more forward

Child 6 yo – 123 cm, rear seat of Volvo XC70

Child 7 yo – 133 cm, rear seat of Renault Grand Espace
Potential effects of a booster seat as compared to a booster cushion

• The backrest positions the child’s head forward.
• A child is more prone to lean forward when riding in booster with pronounced head supports (due to visibility).
• During emergency braking, the child’s head will move forward 15-20cm.

- Decreased distance to potential head impact areas in case of a subsequent **frontal impact**.
- High likelihood of head passing in front of head supports in case of subsequent **side impact**.

‼ It is not evident that a backrest with head side supports offers protection for the child in real world situations and could for the **largest** children even be a hazard.
Benefits of a booster backrest

- Decreases the booster cushion length, beneficial for the smallest children.
- Helps keep the shoulder belt in position.
- Provides sleeping support.
- Helps support the child laterally.
Steering event

Booster cushion

Booster with backrest

(Bohman et al. AAAM 2011)
Shoulder belt far out on shoulder, child in high-back booster
Protection principles
Built-in booster and seat belts with pretensioner and progressive load limiter
2-stage built-in booster cushion

Encourages usage – Utilizes vehicle protection

Performance
• Seating position/belt fit
• Reduce risk of misuse
• Pretensioner and progressive seat belt load limiter
• Inflatable Curtain coverage area

Usage
• Availability/ease of use
• Acceptance from older children
• Comfort

(Jakobsson et al. ESV 2007)
Protection principles

As for an adult, a large child gains protection by having a tight connection to the vehicle.

As for an adult, a child’s head will be protected by the vehicle side structure, incl. IC.
- The sitting height of a SIDIIs (small female sized ATD) is approximately similar to a child of 130 cm using a booster raising the child 10 cm.
Comparison SIDIIs and HIII10y

SIDIIs

HIII10y using Volvo built-in booster (1st stage)

HIII10y using Volvo booster seat (similar to Britax KidPlus)

+6 cm
Comparison SIDIIIs and HIII6y

SIDIIIs

HIII6y using Volvo built-in booster (2nd stage)

HIII6y using Volvo booster seat (similar to Britax KidPlus)

HIII6y using Volvo booster cushion

HIII6y using Volvo built-in booster (1st stage)
Summary

- Children aged 4-10(-140cm) benefit from the vehicle safety systems, given they are raised in position using boosters.
- Add-on child restraints should be balanced to the in-vehicle safety design.
- The primary effect of the backrest part of the high back booster is to help position the child.
- For children approx >130cm a booster cushion (without backrest) together with the 3pt belt should be used as their primary restraint.
- For shorter children the benefit of a backrest is depending on the vehicle used and the behaviour of the child during the specific trip.
References

• Andersson M, Bohman K, Osvalder A-L. Effect of Booster Seat Design on Children's Choice of Seating Positions during Naturalistic Riding. The 54th AAAM Annual Conference, Annals of Advances in Automotive Medicine, 2010


• Jakobsson et al. The balance of vehicle and child seat protection for the older children in child restraints. 10th Int. Conf. Protection of children in cars, München, Germany, Dec 2012