# Comparison of the 6YO ATD kinematics restrained in Booster CRSs – Sled Experiments in frontal, oblique and side impacts

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Motor vehicle crashes persist as the leading cause of death for all children over age 3 years (CDC 2006). Worldwide, road traffic was the second leading cause of death or injury among 5-14 year olds in 2012 (WHO, 2013). In the US, for every day in 2012, an average of five children 14 years and younger were killed and 568 were injured in motor vehicle crashes (NHTSA, 2013). For protection of children in crashes, belt restraints are provided at all seating positions for children who are anthropometrically large enough to fit the adult seat belt (typically above age 8 to 10 years).

There has been ample evidence from real world crashes that belt-positioning booster seats reduce injury risk. Durbin et al. (2003) published the first real-world study to quantify the benefit of booster seats over seat belts for the young school age child. Using the Partners for Child Passenger Safety (PCPS) database, they estimated the odds of injury after adjusting for child, crash, driver and vehicle characteristics were 59% lower for 4-7 year olds in belt-positioning booster seats than 3-point seat belts. There are primarily two types of belt positioning booster seats, high back and backless or low back that raise the child up so that the lap and shoulder belts fit properly. The lap belt should fit low across the child's hips or upper thighs and the shoulder belt should cross the center of the child's shoulder and chest. Emerging in the market is a third category – heightless booster seats – which do not provide a raised seating surface but rather route the belt such that the child is seated essentially on a surface that is similar to the vehicle seat but has proper belt fit.

In this sled study, a Q6 6YO ATD was tested using six different child seats in seven seating conditions. There were three principal directions of force: 0°, 30°, and 80°; full on frontal impact is 0° while almost side impact is 80°. High-speed cameras were placed all around the testing bench to capture dummy kinematic. The videos collected were then prepared in Meta, a post processor, to trace the kinematic of the heads, shoulders (chest), elbows, and knees. Because the cameras were only capable of capturing in 2D, usually two separate views (overhead and side views) are necessary to re-create the kinematic in 3D. MATLAB and Excel were used to convert units, adjust for sled's movement, scale videos size, and overlay tracings. Body angle vs. time and maximum excursions were extracted and compared.

The resulting data suggests that different types of child seats and PDOF do, in fact, affect excursions differently. The high back seats, especially its Best Bet, have the longest forward head excursions in 0° and 80°. During the 0° tests, the back of the HBB Best Bet pushed the head forward which could be the reason to it having the longest forward head excursion. The new Heightless type of seat has shorter downward head excursions in all three angles compared to the majority of the other seats but has no particular trend in forward head excursion. The Inflatable seat produced excursions that are along the line of some of the high back boosters. Some general trends could, however, be concluded. Low back boosters tend to produce shorter head excursions while high back boosters do the opposite. The data for dummy body angles also supports the irregularity of the Inflatable and Heightless seats. Low back and high back seats have similar body angles vs. time. However, the angles of Inflatable and Heightless seats shows similar trend to that of the no CRS condition. This begs the question of whether or not these Inflatable and Heightless seats are protecting children properly. It can be concluded that low backs and high backs are the safest out of all these seats with an exception of high backs tend to produce longer head excursions. Further research is necessary to draw any firm conclusion on the effectiveness of the new seat types.