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OBJECTIVES: The objective of this study was to present, compare, and discuss the kinematic response of children and child anthropomorphic test devices (ATDs) during emergency braking events in different restraint configurations in a passenger vehicle.

METHODS: A driving study was conducted on a closed-circuit test track comprising 16 children aged 4 to 12 years old and the Q3, Hybrid III (HIII) 3-year-old, 6-year-old, and 10-year-old ATDs restrained on the right rear seat of a modern passenger vehicle. The children were exposed to one braking event in each of the 2 restraint systems and the ATDs were exposed to 2 braking events in each restraint system. All events had a deceleration of 1.0 g. Short children (stature 107-123 cm) and the Q3, HIII 3-year-old, and 6-year-old were restrained on booster cushions as well as high-back booster seats. Tall children (stature 135-150 cm) and HIII 10-year-old were restrained on booster cushions or restrained by 3-point belts directly on the car seat. Vehicle data were collected and synchronized with video data. Forward trajectories for the forehead and external auditory canal (ear) were determined as well as head rotation and shoulder belt force.

RESULTS: A total of 40 trials were analyzed. Child volunteers had greater maximum forward displacement of the head and greater head rotation compared to the ATDs. The average maximum displacement for children ranged from 165 to 210 mm and 155 to 195 mm for the forehead and ear target, respectively. Corresponding values for the ATDs were 55 to 165 mm and 50 to 160 mm. The change in head angle was greater for short children than for tall children. Shoulder belt force was within the same range for short children when restrained on booster cushions or high-back booster seats. For tall children, the shoulder belt force was greater when restrained on booster cushions compared to being restrained by seat belts directly on the car seat.

CONCLUSIONS: The forward displacement was within the same range for all children regardless of stature and restraint system. However, the maximum forward position depended on the initial seated posture and shoulder belt position on the shoulder. Differences could also be seen in the curvature of the neck and spine. Short children exhibited a greater flexion motion of the head, whereas a more upright posture at maximum forward position was exhibited by the tall children. The ATDs displayed less forward displacement compared to the children.