Effect of a Booster Seat on Reclined Small Female Vehicle Occupants During Lateral Oblique Low Acceleration Impacts

Andrew Duong, John Burns, Madeline Griffith, Valentina Graci

Introduction

Humans may become more inclined to adopt reclined seating postures as technological advancements continue to improve automated driving. However, current safety restraints are not designed for these postures, and the likelihood of submarining may be increased as reclined seating postures rotate the lumbar spine rearward. Submarining in reclined postures has been particularly prevalent in small occupants, such as the 5th percentile female occupant, as well as children. It was also found that small child occupants do not exhibit submarining during frontal impacts when seated on a belt-positioning booster (BPB) or if a pelvis restraint cushion airbag is deployed under the seat pan. However, most of this research has only been done in frontal impacts. Therefore, the goal of this study is to understand if a BPB could improve the kinematics of the 5th percentile female occupant during lateral-oblique low acceleration impacts.

Methodology

The THOR (Test Device for Human Occupant Restraint) AV 5-F anthropometric test device (ATD) was placed into a pneumatically actuated, hydraulically controlled low-acceleration crash sled (2g; Arbogast et al., 2009). The seat was rotated to 80° from the frontal to simulate a lateral-oblique impact. An on-board Optitrak Prime 13W 10-camera 3D Motion Capture system was used to record head and trunk kinematics. Motive software was used for data processing. Three GoPro cameras were used to record video footage of trials from the frontal, side, and overhead perspectives. Lateral and forward peak head and trunk displacements were extracted using MATLAB. Three seatback angles (25°, 45°, 60°) and BPB and no-BPB conditions were examined.

Results

Lateral head and trunk displacements decreased in more severe reclined seatback angles (Figure 1 a, b). Additionally, more variability in lateral head and trunk displacements was observed without a BPB. Head and trunk also showed slightly more forward displacement with greater reclined angles and no BPB, however, overall forward motion (approximately 50 mm or lower) was smaller compared to lateral.

Conclusions

These findings suggest that booster-like solutions or new seat pan designs may be beneficial for small reclined adult occupants to reduce head and trunk displacements across different seatback angles. However, considering the slight increase in forward displacement with the increased reclined seatback angle, it is plausible that submarining may emerge in acceleration pulses more severe than 2 g. Future studies with more aggressive pulses are warranted to confirm this hypothesis.