Pediatric response to oblique loading in aircraft seats with standard and inflatable seat belts

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Context: The Federal Aviation Administration (FAA) recommends that all children ride in a size-appropriate child restraint system (CRS) while onboard aircraft. As aircraft seating evolves to accommodate the safety and comfort needs of the adult population, all such changes should be evaluated to determine their impact on the pediatric population. Sparse data exists to ensure satisfactory performance of CRS in aircraft crashes. Currently, FAA operational policies do not allow CRS installation in aircraft seats which do not face directly forward and also require that inflatable seat belts are deactivated before CRS installation. More data from dynamic crash tests in these scenarios could influence a change in the FAA policy to better accommodate families traveling with children.

Broad Objective: The long-term objective is to inform the policies and regulations of the FAA regarding CRS use on aircraft with obliquely oriented passenger seats and/or inflatable seat belts. Positive outcomes could allow the FAA to better accommodate families traveling with children in CRS.

Specific Aims: The specific aims of the study are to simulate realistic aircraft seating scenarios for children of multiple ages using multiple restraint methods to:

1. Determine any differences in pediatric occupant response between aircraft seats oriented at 30° vs. 45° offset from the aircraft centerline.
2. Identify the dynamic response of CRS installed in aircraft seats with standard lap belts vs. deactivated inflatable lap belts.

Methods: Sled testing was completed at the FAA's Civil Aerospace Medical Institute in Oklahoma City. All tests were conducted on a representative rigid couch oriented 45° from the aircraft centerline. Tests were conducted with a 16 g, 44 feet per second triangular pulse (14 CFR Part 25.562). A one-year-old (Q1) and Hybrid III 3-year-old (HIII 3YO) were used to represent pediatric occupants. The ATDs were restrained in a rear-facing CRS (Q1), forward-facing CRS (HIII 3YO) or no CRS (lap belt only; HIII 3YO). Some trials included the addition of a side wall or arm rest fixture to determine the likelihood of head contact with these common aircraft structures. Standard ATD injury metrics were evaluated.

Results: No head strikes occurred during the 30° impact trials, but the 45° impact trials resulted in head strikes in several conditions. Head strikes were most severe for the "No CRS" conditions when the head struck the top of the armrest. Head strikes occurred for all "No CRS" trials at 45° and also the forward-facing CRS trials with a wall at 45°. The rear-facing CRS performed well in all conditions. Most injury metrics responded to the principal direction of force as expected. Acceleration and loading in the x-direction were higher for the 30° trials while the same metrics in the y-direction were higher for the 45° trials. The deactivated inflatable belt was too thick to route through the rear-facing CRS base, so these CRS were tested without the base. Despite these initial installation difficulties, the deactivated inflatable belt appears to perform similarly to the standard belt once installed.

Conclusions: Head strikes occurred more often against adjacent structures when the impact angle was directed 45° from the aircraft centerline as opposed to 30°. The use of a CRS reduced several injury criteria, especially rear-facing CRS.