The Motion Characteristics of Child Occupants on the Child Restraint System in Autonomous Emergency Braking

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Abstract

In a car impact circumstance, child occupants have more risk than adults because of their small body size and weight. Child restraint systems (CRS) have been utilized for their safety, and this system showed the effect of significantly descending injury occurrences possibility when used as the designed purpose. However, there is an insufficient study on occupants' motion characteristics and CRS systems' effectiveness before the collision (e.g. autonomous emergency braking (AEB)). This study was performed to identify the effectiveness of the CRS for child occupants' safety in AEB.

The child occupants have used three types of anthropomorphic test devices (ATD): Q3, Q6, Q10. The AEB was simulated with a step-function waveform acceleration to 0.8 g with the sled test platform. Conditions of the five-point harness for the Q3 dummy and Q6 dummy were divided tight and slack. For the Q10 dummy, a five-point harness is not required to restraint the dummy, so we applied a three-point belt. A three-dimensional motion capture system with 16 infrared cameras was used to measure occupant excursion with a sampling rate of 200 Hz (T-20s; Vicon Motion Systems Ltd., Oxford, UK). The excursions of body parts were measured with the virtual central markers that were determined by the following actual reflective markers: three at the head, five at the torso, four at the arms, and six at the legs.

Compared with the Q3 and Q6 dummy type, maximum frontal head excursions and neck rotation were increased significantly in the Q10 dummy by 2-fold and 1.5-fold, respectively (Q3's maximum head excursion: 50.5mm, Q10's maximum head excursion: 108.7mm; Q3's maximum neck rotation: 10.1 degrees, Q10's maximum neck rotation: 15.2 degrees). Furthermore, frontal head excursion and neck rotation were significantly increased in slacked belt conditions by 2-fold than tight belt conditions (Q3's maximum head excursion: 50.5 (tight), 103.2 (slacked); Q6's maximum head excursion: 53.3 (tight), 126.9 (slacked); Q3's maximum neck rotation: 10.1 (tight), 22.3 (slacked); Q6's maximum neck rotation: 9.0 (tight), 25.2 (slacked)).

These results may mean that CRS should be ameliorated to decrease child occupant's neck rotation. Additionally, we found the submarining motion that exacerbated the increase of neck rotation in the slacked belt conditions. Our research could construct quantitative data on child occupant's motion characteristics before the collision and would be contributed that establishing the standard for applying CRS to different ages' child occupants. This study provides valuable insights in improving risks to the child occupants in CRS before braking and/or collision and developing the active safety system to tension the seat belt of CRS.