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A comparison of the performance of two advanced restraint systems in frontal impacts

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Abstract-

Objective:
The goal of the study is to compare the kinematics and dynamics of the THOR dummy in a frontal impact under the action of 2 state-of-the-art restraint systems.
Methods:
Ten frontal sled tests were performed with THOR at 2 different impact speeds (35 and 9 km/h). Two advanced restraint systems were used: a pretensioned force-limiting belt (PT+FL) and a pretensioned belt incorporating an inflatable portion (PT+BB). Dummy measurements included upper and lower neck reactions, multipoint thoracic deflection, and rib deformation. Data were acquired at 10,000 Hz. Three-dimensional motion of relevant dummy landmarks was tracked at 1,000 Hz. RESULTS are reported in a local coordinate system moving with the test buck.
Results:
Average forward displacement of the head was greater when the PT+FL belt was used (35 km/h: 376.3±16.1 mm [PT+BB] vs. 393.6±26.1 mm [PT+FL]; 9 km/h: 82.1±26.0 mm [PT+BB] vs. 98.8±0.2 mm [PT+FL]). The forward displacement of T1 was greater for the PT+FL belt at 35 km/h but smaller at 9 km/h. The forward motion of the pelvis was greater when the PT+BB was used, exhibiting a difference of 82 mm in the 9 km/h tests and 95.5 mm in the 35 km/h test. At 35 km/h, upper shoulder belt forces were similar (PT+FL: 4,756.8±116.6 N; PT+BB: 4,957.7±116.4 N). At 9 km/h, the PT+BB belt force was significantly greater than the PT+FL one. Lower neck flexion moments were higher for the PT+BB at 35 km/h but lower at 9 km/h (PT+FL: 34.2±3.5 Nm; PT+BB: 26.8±2.1 Nm). Maximum chest deflection occurred at the chest upper left region for both belts and regardless of the speed.
Conclusion:
The comparison of the performance of different restraints requires assessing occupant kinematics and dynamics from a global point of view. Even if the force acting on the chest is similar, kinematics can be substantially different. The 2 advanced belts compared here showed that while the PT+BB significantly reduced peak and resultant chest deflection, the resulting kinematics indicated an increased forward motion of the pelvis and a reduced rotation of the occupant's torso. Further research is needed to understand how these effects can influence the protection of real occupants in more realistic vehicle environments.

Index Terms- belted, crash dummies, front impact, occupant kinematics, pretensioners, seatbelt

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