

Kinematics and belt loads of the pelvis of reclined female Post Mortem Human subjects in frontal impacts

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Abstract-

Objective

This study examined the response of Post Mortem Human Subjects (PMHS) in reclined postures in frontal impacts. It aims to evaluate (1) the effect of initial lap belt position on pelvis kinematics during repeated low-speed impacts; and (2) pelvis injury outcomes and kinematics during high-speed impacts.

Methods

Two 50th-percentile female PMHS were exposed to six frontal impacts (three per subject). Each PMHS underwent two low-speed, non-injurious events (nominal delta-v: 10 km/h) followed by one high-speed, injurious test (nominal delta-v: 40 km/h). A CT scan was performed immediately after the two low-speed tests to confirm the absence of injury. All tests represented nominally frontal impacts. Occupants were seated on a semi-rigid seat (seat pan angle: 15°, reclined seatback angle: 45°) and restrained by a three-point seat belt system equipped with a crash locking tongue, three pretensioners (2.5 kN) and three load limiters (approximately 4 kN at the shoulder belt and 5.5 kN bilaterally at the lap belt). The shoulder belt pretensioner was activated only in the high-speed tests. In the two low-speed trials, the lap belt was first positioned immediately inferior to the Anterior Superior Iliac Spines (ASIS) and then further inferiorly on the lap of the subject to assess sensitivity to initial belt placement. Kinematics were recorded using 6-DX sensors and VICON marker clusters. A detailed autopsy was performed after the tests. Recruitment and handling of PMHS were reviewed and approved by the relevant Ethics Committee

Results

CT performed after the low-speed tests confirmed the absence of injury under the tested conditions. Submarining was not observed in any test, regardless of the delta-v. The pelvis of the PMHS rotated rearward, and the peak rotation magnitude was similar between subjects (4 deg and 6 deg, in the low-speed and high-speed tests respectively). The second PMHS peak pelvis rotation occurred after that of the first PMHS, regardless of test speed. This delay was attributed to the greater anterior adipose tissue of PMHS2 compared to PMHS1. Shoulder belt forces were comparable between the subjects, while the lap belt force experienced by PMHS2 was larger due to the subject's greater body mass. PMHS1 sustained a pelvic fracture and lumbar spine injuries. Both PMHS sustained multiple rib fractures and lower cervical spine injuries.

Conclusions

Lap-belt pretensioning appeared to reduce the influence of initial lap-belt position in both subjects, provided that the belt was initially routed inferior to the ASIS.

Greater anterior pelvic soft-tissue thickness in PMHS2 delayed effective lap-belt engagement with the pelvis but did not substantially alter the magnitude of rearward pelvic rotation. No submarining was identified based on video review, belt force histories, and pelvic kinematics.

Index Terms- Post Mortem Human Subject tests; female occupants; reclined positions; submarining; pelvic kinematics

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