Effect of Comfort Accessories on the Frontal Crash Performance of Seat Belt Restraints: Considerations for Older Occupants

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I. INTRODUCTION

Aging results in changes to body shape, body composition and posture as well as an increased sensitivity to pressure pain compared to younger people [1-2]. Previous studies have found that around one quarter of older drivers use aftermarket accessories in their vehicle in an attempt to improve their comfort and driving position [3-4]. It is not known whether such comfort accessories influence the effectiveness of the vehicle restraint systems in a crash. Of particular concern is the decreased biomechanical tolerance of the elderly due to age-related changes in bone morphology and bone density as well as the reduced ability to recover from injury [5]. A previous study showed that 47% of drivers aged over 64 years who died in a frontal crash sustained a fatal chest injury highlighting the vulnerability of older occupants to thorax injury compared to younger drivers who sustained fatal chest injuries in only 24% of cases [6]. As the proportion of older people in the population rises in developed countries, consideration of elderly vehicle occupants is a critical issue in injury prevention. The aim of this study is to examine the effect of comfort accessories on seat belt restraint systems in simulated frontal crashes.

II. METHODS

Frontal sled tests were conducted using a series of front seats from a 2002-2007 model common Australian passenger car. Lap/sash seatbelt inertia reel components (Hemco Industries Pty Ltd, Ballarat, VIC, Australia) were affixed to the sled table with the D-ring mounted in the approximate location as in the subject vehicle. The simulated frontal crash severity was at 32 *g*, 43 km/h. A Hybrid III 5th percentile female anthropometric test device was seated without any comfort accessory for a baseline test, followed by three comfort accessories, pictured in Figure 1. Dummy instrumentation included three orthogonally arranged linear accelerometers at the head centre of gravity and in the chest, a six-axis load cell at the upper neck and a rotational potentiometer measuring sternal deflection. Two high-speed cameras sampling at 1 kHz captured the deceleration event, with a lateral view used to track the trajectory of the dummy head centre of gravity and the knee at the knee bolt. The initial angle made between the lap belt and the vertical on the lateral view was also recorded. Head acceleration data were used to calculate the Head Injury Criterion (HIC_{15}) and neck force and moments were used to calculate the Neck Injury Criterion (N_{ij}) with critical intercept values for the Hybrid III 5th percentile female.

Fig. 1. Tested comfort accessories: Seat wedge cushion (left), swivel seat cushion (centre), padded seat cover (right).

III. INITIAL FINDINGS

The sit-on-top accessories reduced the initial lap belt angle compared to the baseline seated position. For the dummy responses, HIC_{15}, N_{ij} and peak chest acceleration were reduced for the seat wedge and swivel seat cushion sled tests compared to the baseline test. For the padded seat cover, N_{ij} was reduced while HIC_{15} and peak chest acceleration increased. The sternal deflection increased for all sit-on-top aftermarket accessories tested. The relative head and knee trajectories for the baseline and accessory sled tests are shown in Figure 2. The initial positions indicate the ATD head centre of gravity and knee were positioned approximately 25 mm higher on the seat wedge and swivel seat cushions compared to the baseline test. Sled tests performed with the aftermarket comfort accessories increased both the head and knee excursions of the dummy compared to the baseline test.

TABLE I

INITIAL LAP BELT ANGLE AND DUMMY RESPONSES FOR THE FRONTAL SLED TESTS.

Test condition	Initial lap belt angle (°)	HIC_{15}	N_{ij}	Peak chest acceleration (g)	Sternal deflection (mm)
Baseline (no accessory)	24.5	694.7	0.589	89.3	30.1
Seat wedge cushion	17.9	618.5	0.540	82.1	47.0
Swivel seat cushion	16.0	492.9	0.500	82.7	45.1
Padded seat cover	22.4	735.0	0.572	92.6	37.2

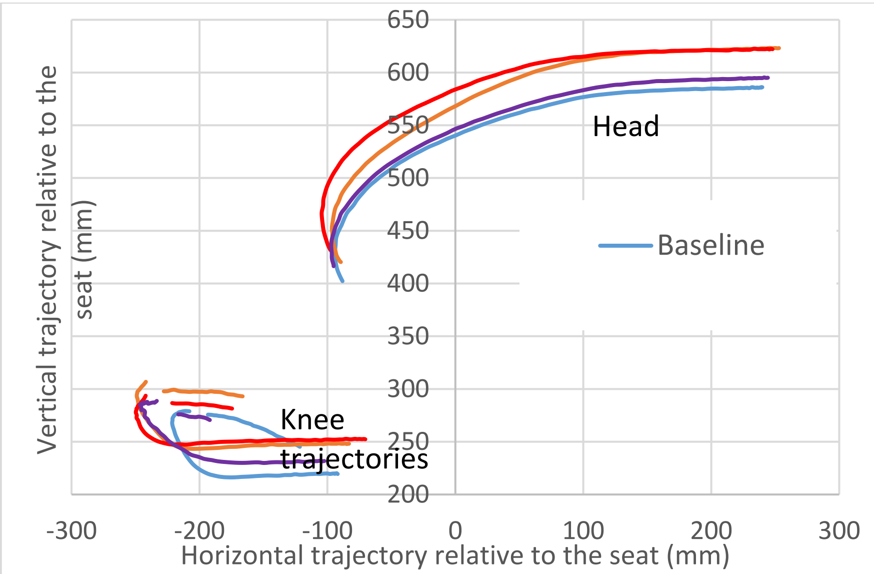

Fig. 2. Relative trajectories of the dummy head and knee during the frontal sled tests in a baseline test and with the sit-on-top aftermarket comfort accessories.

IV. DISCUSSION

The initial results of this study indicate the potential for changes to the frontal crash performance of the lap/sash seatbelt restraint due to inclusion of aftermarket comfort accessories. Increased sternal deflection that occurred due to the sit-on-top accessories is a concern for older occupants who may be particularly vulnerable to thorax injuries. The increased knee trajectories indicate that the comfort accessories introduce slack into the lap portion of the restraint which allows greater knee excursion compared to the standard driving position. We have also tested lumbar support accessories and analysis is continuing.

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VI. REFERENCES

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