Influence of the Rib-deflection Measurement Method on Evaluation of Side-impact Restraint Effectiveness

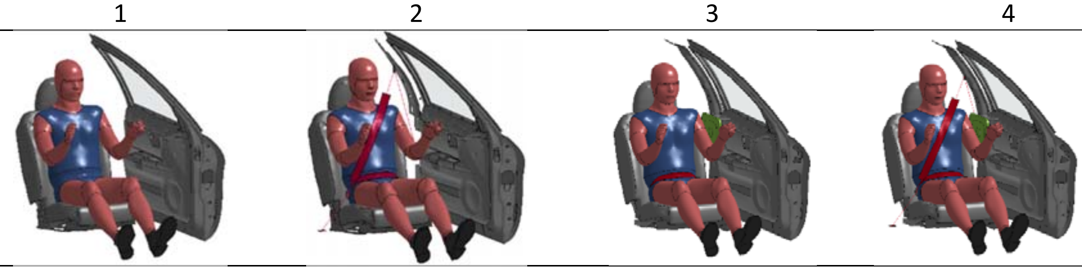
Donata Gierczycka, Skye Malcolm, Duane S. Cronin

I. INTRODUCTION

Advanced safety systems have reduced the number of road deaths in recent years, but the number of injured occupants remains significant [1]. While frontal impact scenarios are quite well addressed, side-impacts remain a challenge, and injuries to thorax are amongst the leading causes of fatalities in this impact scenario [2]. While side-impact testing and investigation with use of Anthropometric Test Devices (ATDs) have led to improved occupant protection, recent epidemiological studies demonstrated that side airbags (SAB) have not been as effective as expected in reducing thoracic injury [2-3]. Previous studies comparing human body models' (HBMs) and post-mortem human subjects' (PHMS) responses demonstrated that chest stiffness in lateral impact was dependent on location of impact [4-5], and that response to changing impact conditions was sensitive to choice of the injury metric [4]. The objective of this study was to demonstrate the effect of an occupant response measurement method on evaluating side-impact restraint effectiveness in full vehicle side-impact scenarios.

II. METHODS

An advanced HBM (Global Human Body Models Consortium (GHBMC) 50th percentile male) was coupled with a previously validated and enhanced vehicle model and Moving Deformable Barrier (MDB) model [6], subjected to a NCAP MDB side impact at 61 kph. The HBM was located in a standard driving position (Fig. 1) within the vehicle model. Four restraint settings were considered: unbelted and no SAB (SAB = side airbag), (Fig. 1.1), belted and no SAB (Fig. 1.2), unbelted with SAB (Fig. 1.3), and belted with SAB (Fig. 1.4).

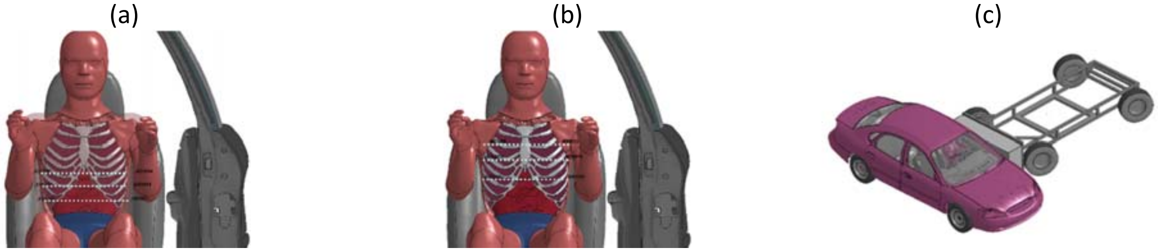


	1	2	3	4
Belt	No	**Yes**	No	**Yes**
SAB	No	No	**Yes**	**Yes**

Fig. 1. Configuration of the restraints.

Chest deflection responses were compared between different restraint configurations. Chest deflection was measured using two methods: (a) lateral deformation of upper, middle and lower chest bands, defined as in PMHS tests (Fig. 2(a)); and (b) deflections of rib 4, 6 and 8, corresponding to locations of ATD ribs (Fig. 2(b)) [7-10].

(a) (b) (c)



D. Gierczycka is a PhD candidate and D. S. Cronin (e-mail:dscronin@uwaterloo.ca; tel: 1-519-888-4567) is a Professor in the Department of Mechanical and Mechatronics Engineering, University of Waterloo, Canada. S. Malcolm is a Principal Engineer at Honda R&D Americas, Inc.

Fig. 2. Chest deflection measurement location with respect to vehicle door: (a) chest band method; (b) rib deflection method; (c) NCAP MDB test set-up.

III. INITIAL FINDINGS

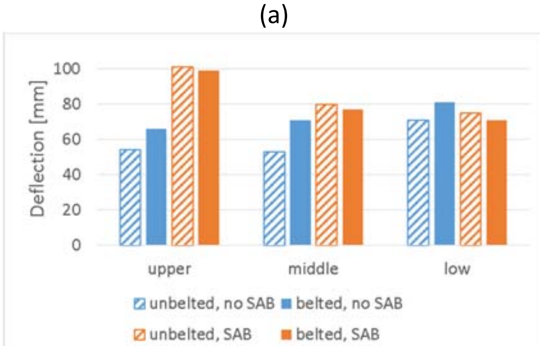
Table I summarizes the most important observations, which include comparison of belted and unbelted cases without the SAB (1-2), and belted versus unbelted cases with the SAB (3-4).

TABLE I
EFFECT OF THE RESTRAINTS DEPENDING ON THE MEASUREMENT METHOD

Compared configurations	Chest band method	Rib-deflection method
1-2 (no SAB)	Seatbelt increases chest deflection (largest increase: from 53 mm to 71 mm, +33%).	Seatbelt has no effect on chest deflection.
3-4 (w/SAB)	Seatbelt has no effect on chest deflection.	Seatbelt reduces chest deflection (largest reduction: from 61 mm to 45 mm, -26%).

Both methods demonstrated an increase in chest deflection for unbelted cases when the SAB was present (Fig. 2), while the effect of the SAB for belted cases was inconclusive. For the chest band method, the SAB increased chest-deflection values at the upper chest band, and decreased at the lower chest band (Fig. 2(a)). For the rib-deflection method, the SAB increased the chest-deflection value at the level of rib 8, and did not notably change the responses at the other levels (Fig. 2(b)).

(a)



(b)

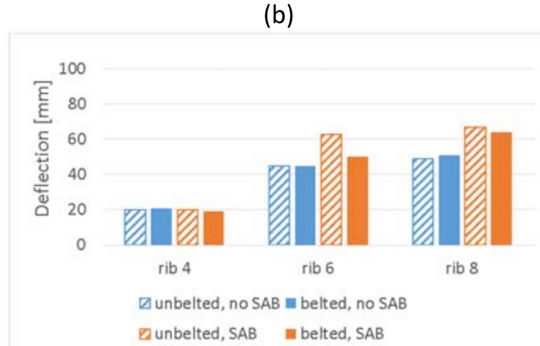


Fig. 2. Chest deflection measured using: (a) chest band method; (b) rib-deflection method at ribs 4, 6 and 8.

IV. DISCUSSION

This study extended previous observations on the importance of location and thoracic response assessment method in side-impact evaluation, extending this assessment to a full vehicle side-impact scenario. Two measurement methods demonstrated different, even contrary, effects of restraint configuration on predicted occupant chest deflection. An observed trend of the upper thorax (rib 4) being less sensitive to changing impact conditions compared to other chest levels was in agreement with [4]. The chest band method showed an increase in chest deflection for the belted case, while no effect was observed with use of the rib-deflection method. For cases with a SAB, the seatbelt was observed to reduce chest deflection when the rib-deflection method was used, while the chest band method did not identify a notable effect. The results confirm that location and choice of a measurement method are important considerations for the assessment of restraint performance in side-impact scenarios.

V. REFERENCES

[1] Schmitt, K-U, 2014.
[2] Kahane, C.J., NHTSA Report No. DOT HS 810 748, 2007.
[3] McCartt, A., TIP, 2007.
[4] Pipkorn, B., TIP, 2014.

[5] Park, G., *IRCOBI*, 2013.
[6] Watson, B., *21st Technical Conference ESV,* Paper No. 09-0016, 2009.
[7] Samaha, R.R., *17th Technical Conference ESV*, 2001.
[8] Pintar, *41st Stapp Car Crash Conference*, 1997.
[9] Yoganandan, N., *Med Eng and Physics*, 2012.
[10] Yoganandan, N., *Stapp Car Crash J*, 2012.