

MECHANISMS OF WHIPLASH INJURY PREVENTION ATTRIBUTABLE TO VOLVO WHIPS SEAT



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INTRODUCTION

In attempt to reduce whiplash injuries, manufacturers have incorporated active injury prevention systems in newer automobiles, such as the Whiplash Protection System (WHIPS) introduced by Volvo in 1998. Epidemiological studies have indicated potential benefits of WHIPS in reducing neck injury risk between 21 to 47%, as compared to conventional seats. The majority of the previous biomechanical studies were manufacturer-sponsored or contain limited data.

Objective. Investigate whiplash injury prevention mechanisms attributable to WHIPS using simulated rear crashes of a Human Model of the Neck (HUMON).

METHODS

HUMON (Human Model of the Neck: Fig 1A). The model consisted of a neck specimen (n=6) mounted to the torso of BioRID II and carrying an anthropometric head stabilized with muscle force replication. HUMON was seated and secured in the drivers seat of a 2005 Volvo XC90 minivan with WHIPS on a sled.

WHIPS (Whiplash Protection System: Figs 1B,C). WHIPS was activated by HUMON's momentum pressing into the seatback during the crash, causing rearward translation and extension of the seatback relative to the seat base and plastic deformation of the bi-lateral energy-absorbing elements (Fig 2A) and return springs (Fig 2B).

Protocol. Rear crashes (9.9, 12.0, and 13.3 g) were simulated and motions of the head, neck, torso, pelvis, sled, seatback, and WHIPS were monitored. The energy-absorbing components were replaced following each crash (Figs 2A,B). Single factor, repeated measures ANOVA and Bonferonni post-hoc tests (P<0.05) were performed to determine significant increases in spinal motion peaks during the crash above physiologic limits.

METHODS



Fig 1A) HUMON.

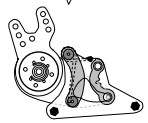


Fig 1B) WHIPS unactivated.

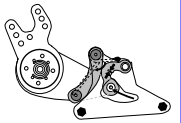


Fig 1C) WHIPS activated.

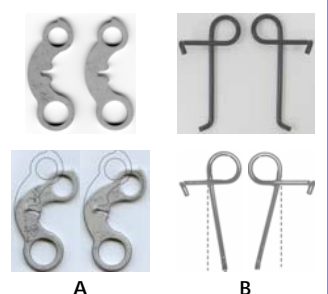


Fig 2) Representative pre- and post-crash: A) energy-absorbing elements and B) return springs.

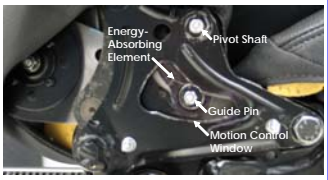


Fig 3) Representative WHIPS post-crash position.

RESULTS

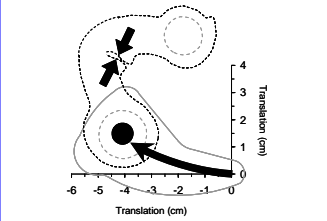


Fig 4) Average WHIPS and seatback motions at 75 ms.

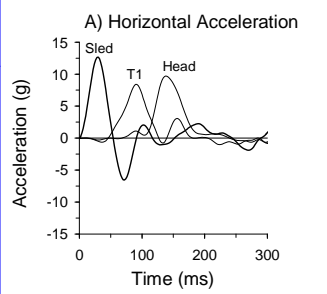


Fig 5) Representative: A) horizontal accelerations and B) C7/T1 rotation. Grey shading represents physiologic motions.

RESULTS & DISCUSSION

- Absorption of crash energy occurred during the initial 75 ms (Fig 4).
- WHIPS motion consisted of simultaneous:
 - rearward and downward translations and extension of the seatback (Fig 4);
 - deformation of the bi-lateral WHIPS energy-absorbing elements (Figs 2A,B); and
 - reduction in distance between the head and head restraint.
- A 42% reduction in peak T1 horizontal acceleration, on average, as compared to sled acceleration, demonstrated the energy-absorbing capacity of WHIPS (Fig 5A: representative data).
- Average peak C7/T1 rotations significantly exceeded physiologic limits during the 13.3 g crash (Fig 5B: representative data).

CONCLUSIONS

- The present study provided insight into the crash-dynamics of the occupant, seatback, and WHIPS. These data may be useful for refining future seat designs to reduce whiplash injuries.
- Lower cervical spine injuries due to excessive motion may occur prior to or during contact of the head with the head restraint, even in the presence of WHIPS.
- Future whiplash injury prevention systems will most likely integrate beneficial design features, such as active head restraint and energy-absorbing seat, with more advanced features, such as accident avoidance technology.

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