

1. Title: Mechanisms of whiplash injury prevention attributable to energy-absorbing seat

2. Author information

a. Primary Author:

Ming Xiao, Ph.D.
Postdoctoral Associate
Biomechanics Research Laboratory
Department of Orthopaedics and Rehabilitation Yale University School of Medicine
333 Cedar St.
P.O. Box 208071
New Haven CT 06520-8071, USA.
Phone: (203) 785-4052
Fax: (203) 785-7069
e-mail: ming.xiao@yale.edu

i. Academic department and institution where research was completed: Biomechanics Research Laboratory, Department of Orthopaedics and Rehabilitation, Yale University School of Medicine.
ii. Degree program: PhD, Biomedical Engineering, University of Delaware
iii. Advisor: Paul Ivancic, PhD (Yale Univ); Jill Higginson, PhD (Univ of Delaware) iv. PhD graduation date: May, 2009

b. Additional Authors

Paul Ivancic, PhD

3. Abstract

Objectives. The objectives were to investigate whiplash injury prevention mechanisms attributable to the energy-absorbing seat using simulated rear crashes of a Human Model of the Neck (HUMON).

Outline of the problem. Epidemiological studies have indicated potential benefits of Volvo's Whiplash Protection System (WHIPS) for reducing neck injury risk. The majority of the previous biomechanical studies were manufacturer-sponsored or contain limited data.

Methodology. HUMON consisted of a neck specimen mounted to the torso of BioRID II and carrying a custom anthropometric head stabilized with muscle force replication. HUMON was seated and secured in a 2005 Volvo XC90 minivan seat, which included WHIPS and a fixed head restraint. 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. Significant increases ($P < 0.05$) in the spinal motion peaks relative to physiologic limits were determined.

Data. Average peak C7/T1 rotations significantly exceeded physiologic limits during the 13.3 g crash. The cervical spine maintained its S-shaped curvature throughout the duration of contact of the head with the head restraint. A 42% reduction in peak T1 horizontal acceleration, as compared to sled acceleration, was observed due to WHIPS. Plastic deformation of the bi-lateral WHIPS energy-absorbing elements was observed following each crash.

Summary. Seatback motion due to WHIPS has been previously described as occurring in two potentially overlapping phases: rearward seatback translation followed by extension. Our results demonstrated that the two WHIPS motion phases overlapped with simultaneous: rearward and downward translations and extension of the seatback; deformation of the bi-lateral WHIPS energy-absorbing elements; and reduction in distance between the head and head restraint. 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.