

Characterizing In-vivo Exposures of the Lumbar Spine During Simulated Low-Speed Rear Impact Collisions

Kayla M. Fewster¹, Daniel Viggiani¹, Chad E. Gooyers^{1,2}, Robert J. Parkinson^{1,2}, Jack P. Callaghan¹

¹Department of Kinesiology, University of Waterloo, Waterloo, ON

²-30- Forensic Engineering., Toronto, ON, Canada

Epidemiological research suggests that up to 50% of individuals involved in low speed rear impact collisions report an acute onset of low back pain [1]. However, most research has focused on the risk of neck injury and not on injury to the lumbar spine. Specifically, there are few studies involving human volunteers conducted to directly address the risk of low back injury in low velocity rear impacts. Simulated collisions involving post-mortem human surrogates and anthropomorphic test devices have been conducted and provide valuable insight into loading dynamics, however such testing is inherently limited due to the inability of these tests to account for muscle activation.

Numerous human volunteer studies have been conducted at various collision severities to determine the muscle activation responses and thresholds associated with symptom reporting in the cervical spine. Previous investigations have demonstrated lower angular head accelerations and smaller head retractions when bracing the neck for a rear-end collision [2]. In low-speed frontal collisions, bracing reduced forward excursion of the knees, hips, elbows, shoulders, and head [3]. Overall, it has been demonstrated that developing muscle tension can change an occupant's initial posture, subsequent joint kinematics and resultant biomechanical response during a motor vehicle collision [3,4]. Therefore, the objective of this study was to expand the work done on the cervical spine by exploring muscle activations and lumbar accelerations in response to unanticipated and braced simulated rear-end collisions.

Twenty-two low severity dynamic sled tests were performed on eleven human volunteers (average $\Delta v = 4.05$ km/h). Each volunteer was exposed to one unanticipated (relaxed) and one braced impact. Tri-axial accelerometers monitored accelerations of the sled and low back. A total of fourteen channels of surface electromyography were used to monitor individual bilateral trunk and neck muscle activity. Peak lumbar linear accelerations, peak muscle activation following impact, and peak muscle activation delay times were examined.

Bracing for impact reduced peak lumbar linear acceleration in the initial rearward impact phase of the occupant's motion by an average of 15%. Bracing did not affect peak lumbar linear acceleration during the forward rebound phase. The only muscles with peak activations exceeding 10% MVC during the unanticipated impact were the thoracic erector spine and sternocleidomastoid.

Results indicate that even during unanticipated rear-end collision, the peak activation of muscles in the lumbar spine are of low magnitudes. Based on our observations, it can be concluded that muscle activation likely has minimal contribution to the bone-on-bone forces that are experienced in the intervertebral joints in the lumbar spine during low speed rear impact collisions. These findings may allow the use of simplified joint models in estimating injury risk and support the application of cadaveric and ATD testing in understanding the source of low back complaints associated with rear-end collisions.

References:

[1] Fast et al. (2002) *Am. J. Phys. Med. Rehab.* 81, 645–650; [2] Siegmund et al. (2003) *Spine* 28, 671–679; [3] Beeman et al. (2011) *Ann. Biomed. Eng.* 39, 2998–3010 [4] Kemper et al. (2014) *Traf. Inj. Preven.* (2014)15, S141–S150