THE INFLUENCE OF LUMBAR SUPPORT ON THE SEAT-OCCUPANT INTERFACE DURING A REAR-IMPACT COLLISION: A SEAT DESIGN PERSPECTIVE

Jackie D. Zehr[a], Kayla M. Fewster[a], David C. Kingston[a], Chad E. Gooyers[ab], Jack P. Callaghan[a]

[a]*Department of Kinesiology, University of Waterloo, Waterloo, ON, Canada*
[b]*Biomechanics Group, 30 Forensic Engineering, Toronto, ON, Canada*

Introduction: Lumbar supports increase lordosis [1] and reduce discomfort [2] compared to non-supportive seating when driving. Despite these benefits during prolonged driving exposures [1,2], it is possible that altered seat back stiffness, pressure distribution, and seat geometry together with design features (e.g., bilateral seat trim) may affect the interaction between the seat and occupant during a rear-impact collision and alter injury potential. Therefore, the purpose of this investigation was to examine if and/or how the seat-occupant interface (i.e., force characteristics) changes as a function of lumbar support during a simulated rear impact motor vehicle collision.

Methods: To date, a sample of four participants (2 males, 2 females) have completed two 8 km/h laboratory-simulated rear impact collisions during separate test sessions. Randomized collisions were completed with (4 cm horizontal shell deflection) and without the addition of lumbar support to a Honda CRV seat, which contained a 10 cm bilateral trim. At a rate of 500 Hz, seat back pressure was quantified with a ferroresistive pressure-sensing system (3150, Tekscan Inc., Boston, MA), and contact area was manually determined at the time of impact prior to determination of total seat back force and pressure area. Pelvis position was recorded at 100 Hz (NDI, Certus, Waterloo, ON) and the horizontal and vertical deviation of the centre-of-force (CoF) on the seatback was transformed into the pelvis local coordinate system (LCS), which enabled a comparison to the approximate location of the L_4 spinal level (i.e., the mid-point between iliac crests). Mean differences in total force, contact area, and CoF deviation (with respect to the origin of the pelvis LCS) were assessed across support types (within-subject) and sex (between-subject) using a general linear model.

Results: The total force magnitude was, on average, equivalent to individual body weight when impacted with both lumbar support types ($p = 0.86$). However, the average area of force concentration was approximately 3.2 cm^2 and 2.9 cm^2 greater without lumbar support for men and women, respectively ($p < 0.04$). The most notable difference observed was the location of force application with respect to the origin of the pelvis LCS; without lumbar support, the CoF had a greater vertical deviation (7.3 cm) ($p = 0.03$), while the CoF was laterally deviated to a greater extent (9.2 cm) when lumbar support was applied ($p = 0.02$). The magnitude of lateral deviation was greater in men (11.4 cm) than women (6.9 cm) for both support conditions ($p = 0.04$).

Discussion and Conclusions: Lumbar supports in automobile seats likely alter the distribution of seatback forces during low-speed rear end collisions. For the average tested male occupant (78 kg), the peak anterior shear force of approximately 765 N applied at apex of the lumbar support (L_4 spinal level) exceeds the recommended Waterloo action limit of 500 N. Further, based on our findings, it is noted that the presence of a seat trim may compromise the ability of larger individuals to sit with their back flush against the seat, thereby increasing the lateral CoF deviation and inducing an off-axis moment.

References:

[1] De Carvalho & Callaghan (2012). *Applied Ergonomics* (43); p.876-882
[2] Donnelly et al. (2009). *Int J Occup Saf Ergon* (15); p.295-307