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

UNIVERSITY OF WATERLOO

Jackie D. Zehr [1], Kayla M. Fewster [1], David C. Kingston [1], Chad E. Gooyers [1,2], Jack P. Callaghan [1]

[1] Department of Kinesiology, University of Waterloo, Waterloo, Ontario, Canada
[2] Biomechanics Group, 30 Forensic Engineering, Toronto, Ontario, Canada

CALLAGHAN SPINE BIOMECHANICS UNIVERSITY of WATERLOO

INTRODUCTION

- Lumbar supports can increase lordosis [1] and reduce discomfort [2] compared to non-supportive seating when driving (**Fig. 1**).
- During a rear impact collision, the effect of non(supportive) seating on pain and injury potential is less understood.

Figure 1. Lumbar posture during non-supportive (left) and supportive (right) driving.

- **The objective of this study was to examine how lumbar support influences the the seat-occupant interface during a simulated rear impact collision.**

METHODS

11 men (26.4 ± 3.7 yrs; 81.0 ± 12.2 kg; 1.77 ± 0.04 m) and 11 women (25.0 ± 3.3 yrs; 71.1 ± 11.1 kg; 1.69 ± 0.04 m) participated. Two rear impact collisions ($\Delta V \approx 8$ km/h) were simulated with a custom sled-track unit (**Fig. 2**): one **without lumbar support** and one with mechanical **lumbar support** (horizontal apex deflection = 4 cm). Seat back pressure was recorded together with pelvis kinematics. These data were used to quantify the **Seatback Reaction Force**, **Force Concentration Area**, and **Deviation from the L_4 Spinal Level**. A *posteriori* analysis was conducted to examine how the total seatback reaction force was partitioned amongst the lumbar spine motion segments.

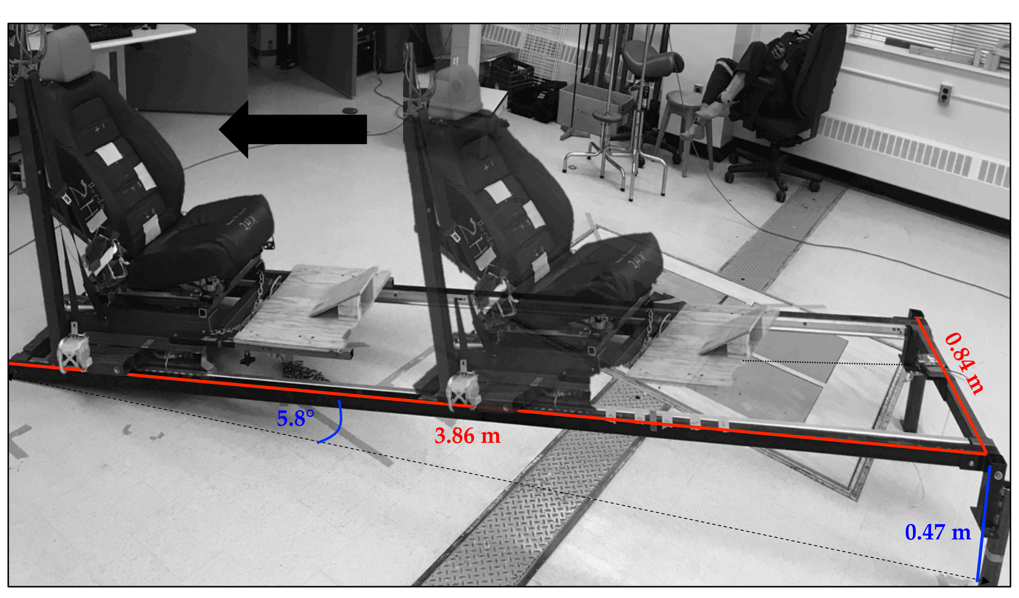

Figure 2. The sled-tack unit. Participants were belted to the rear-facing Honda CR-V driver's seat (2017 Model: 10 cm bilateral side bolsters; 50 cm seat pan depth; 30 cm seatback height; vertically adjustable head restraint; seat reclination = 27°) and sat upright with a 110° knee angle. The impact was facilitated by the sled platform accelerating rearward under gravity and simultaneously striking four springs mounted to the track base. The total platform mass was standardized to 113.4 kg (i.e., 250 lbs) and all impact parameters were measured with a triaxial accelerometer (377, ADXL, Analog Devices, Norwood, MA).

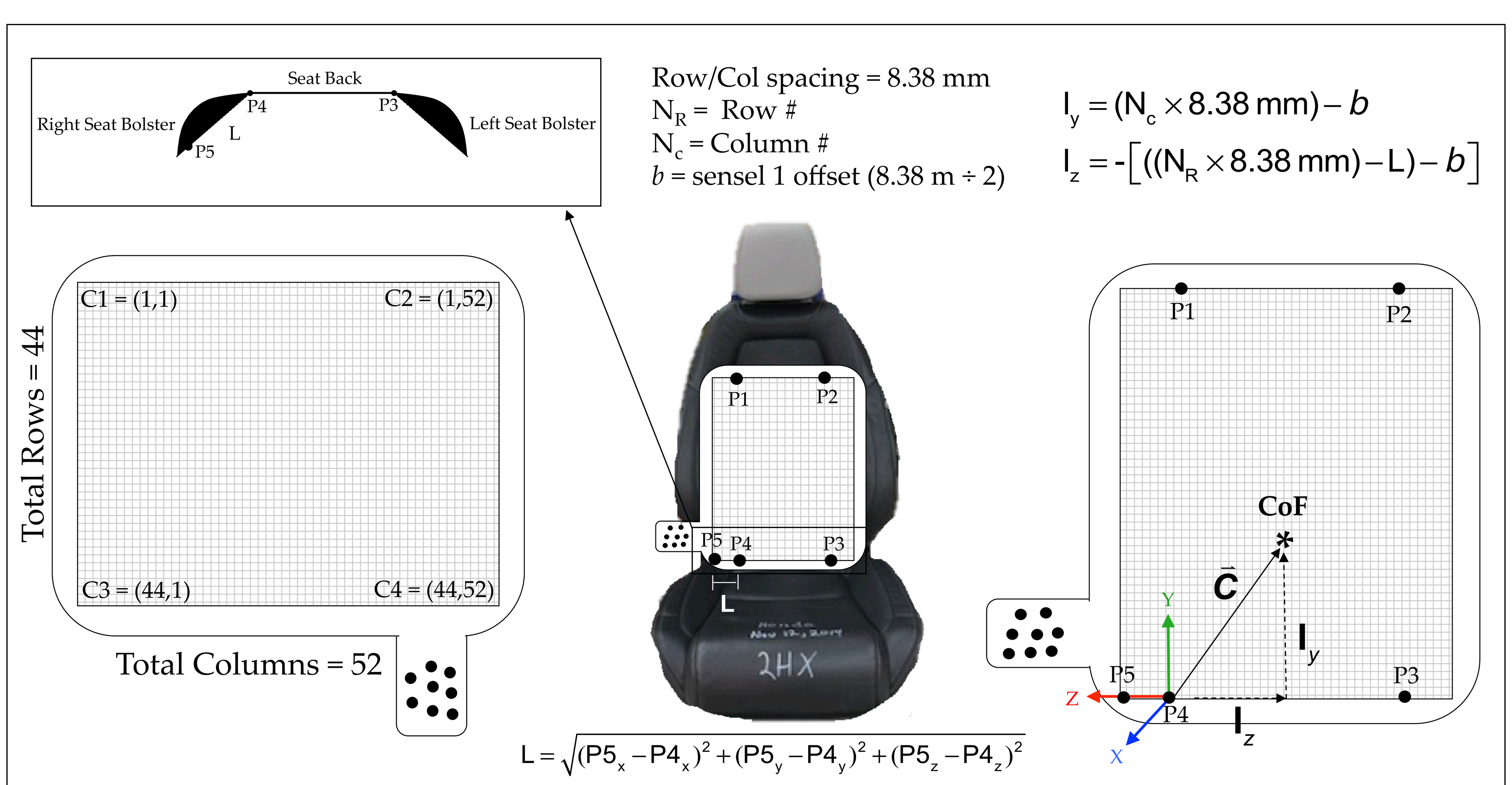

Figure 3. A schematic of the pressure sensing system (left). Positioning of the pressure mat on the seatback, quantification of row offset (L), and digitized points (P1-5) (centre). Derivation of center-of-force coordinates (CoF) with respect to the mat local coordinate system (LCS), which was originated at P4 (right).

Partitioning The Seat Back Reaction Force

The spinous processes of the L_1 to S_1 vertebrae were palpated and marked. The position of the 6 spinous processes (i.e., L_1 - S_1) in global space were then transformed into the mat-fixed LCS (**Fig. 3**), which permitted the identification of pressure sensing elements that were vertically aligned with each lumbar motion segment (**Fig. 5**).

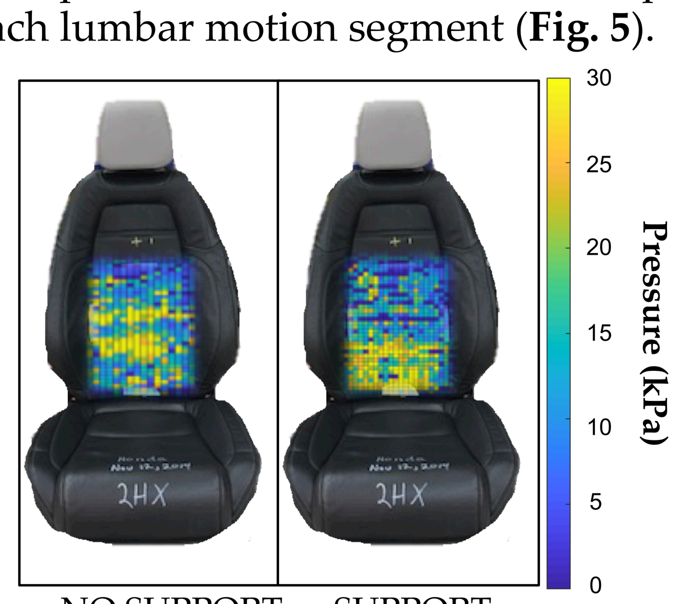

Figure 4. Seatback pressure output at the moment of impact during a rear end collision with and without the application of lumbar support.

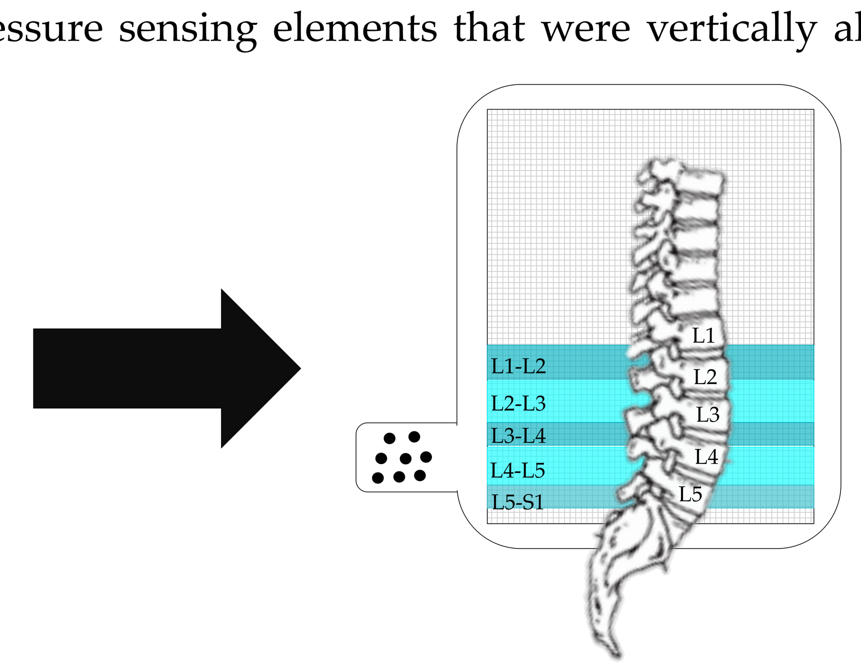

Figure 5. A sagittal view of the spine overlying an anterior view of the pressure mat. Forces including and between the identified column numbers were extracted and represented the anterior shear force applied to each lumbar motion segment.

RESULTS

Table 1. Mean (SD) impact parameters.

		SUPPORT	NO SUPPORT	*p*
Δ Velocity	km/h	7.74 (0.35)	7.58 (0.25)	0.060
Peak Acceleration	G	4.76 (0.28)	4.74 (0.30)	0.826

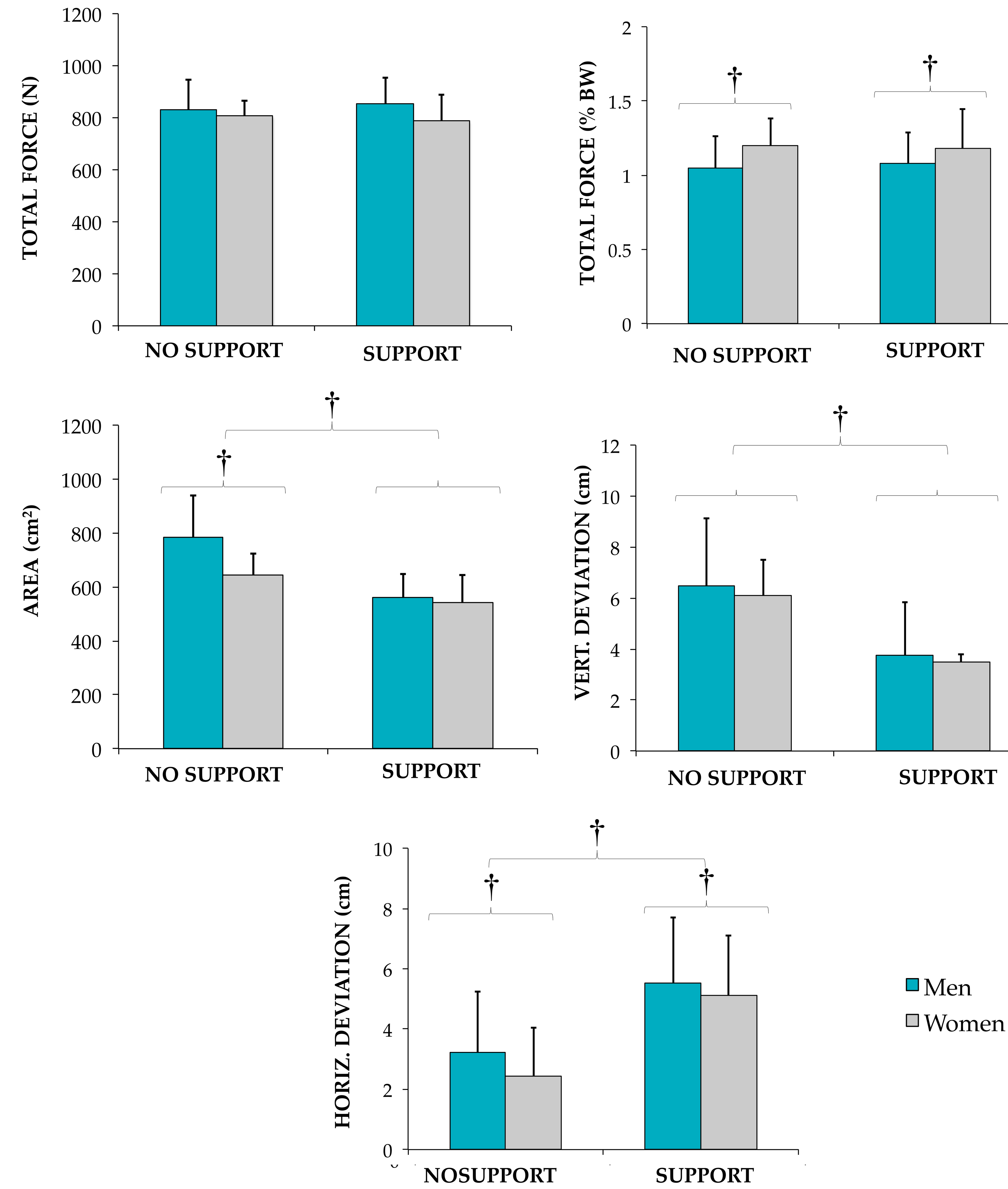

Figure 6. Each plot represents the mean of the respective dependent variable during simulated rear impact collisions with and without lumbar support. Where applicable statistical significance is indicated ($p < 0.05$) and error bars represent one standard deviation.

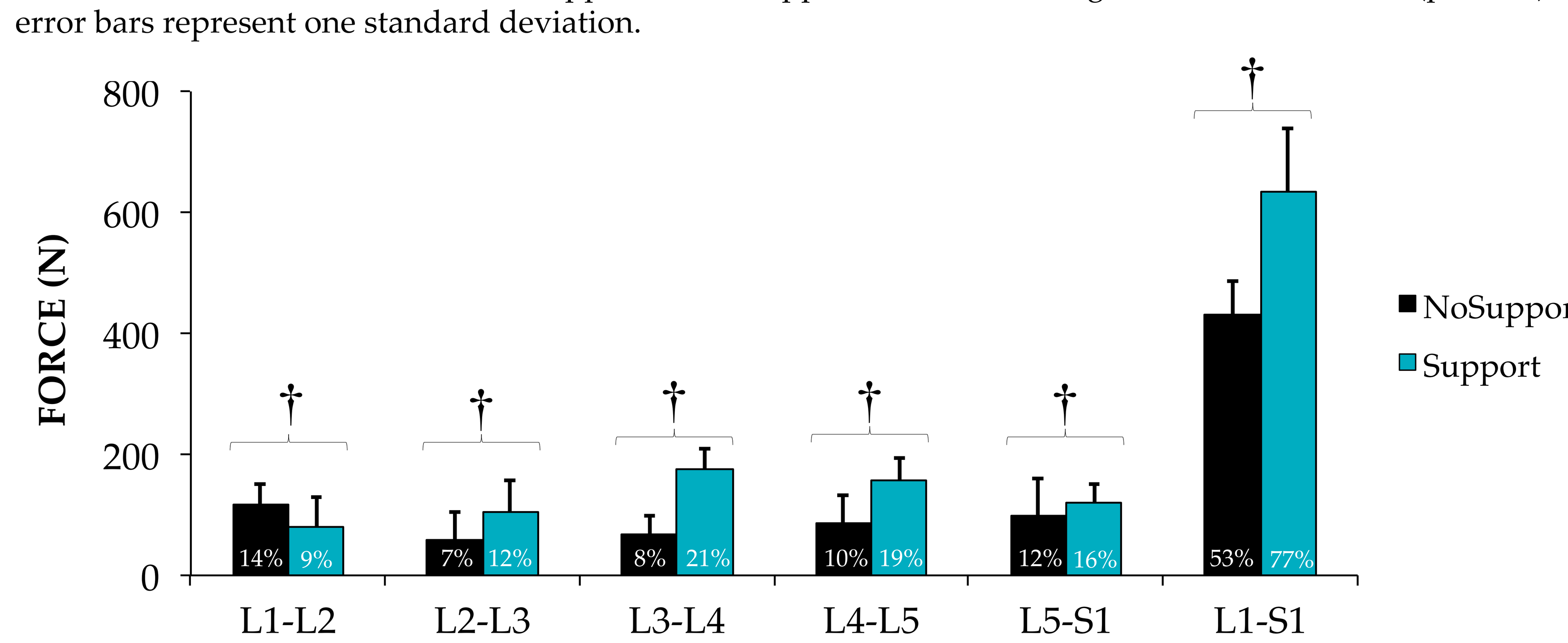

Figure 7. The total seatback force applied to the lumbar motion segments. Where applicable statistical significance is indicated ($p < 0.05$) and error bars represent one standard deviation. Values within each bar represent the percentage of the total shear reaction force for both of the tested support conditions.

DISCUSSION

Our findings suggest that lumbar supports can alter how and where the seatback force is applied to the lumbar spine (**Fig. 6**). As such, **a measure of stress may more accurately characterize localized loading responses**. Despite the lumbar spine bearing a **larger load when support is applied**, each motion segment is subjected to an **external shear force of less than 200 N** (**Fig. 7**). This is ≈ 5 times less than the ultimate shear limit (1000 N) [3]. Therefore, the exact injury mechanisms of low-back pain resulting from low-speed rear impact collisions remain unclear and may require further analyses of the internal loading environment.

REFERENCES

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