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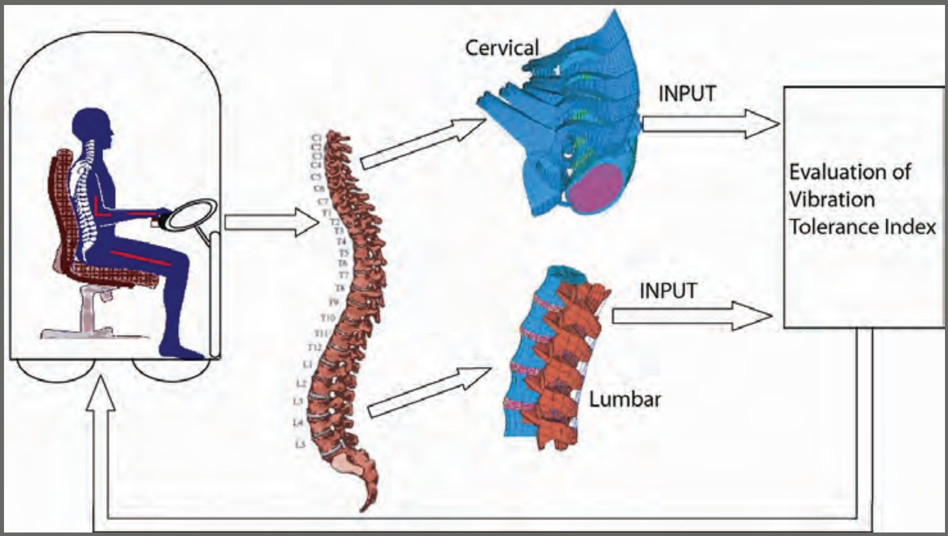

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A COMPARISON OF WHOLE-BODY VIBRATION EXPOSURES ACROSS THREE DIFFERENT TYPES OF BUS SEATS

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Introduction

Low back pain among public transit drivers is quite prevalent. U.S. Bureau of Labor Statistics data indicate a high occurrence of low back illness and injury in the transportation industry. The relationship between whole-body vibration (WBV) exposure and low back pain has been established in prior research [Troup 1998]. Using a low-floor coach bus and a standardized test route, the goal of this project was to compare and determine whether there were differences across three seat types in their ability to attenuate WBV exposures as defined in ISO 2631-1 (1997) and ISO 2631-5 (2004). By using a standardized and controlled test route, which accurately simulates on-the-job conditions, it is hoped that the analysis of these data may help direct and reduce WBV exposures and the potential for subsequent injuries and illnesses among bus operators.

Methods

Sixteen subjects were recruited for this study. After data collection (dropouts and equipment failure), complete repeated measures data were collected and analyzed from 10 subjects. Three different seats were used: (1) a Recaro Ergo M, (2) a USSC Q91 with a standard foam seat pad, and (3) the identical USSC Q91 retrofitted with a silicone foam seat pad. Subjects drove the bus for approximately 1 hr over a 65-km standardized test route. Seat order was not randomized. Vibration was measured using two triaxial accelerometers, one mounted on the seat using an accelerometer rigidly mounted in a runner seat pad and the other placed on the floor next to the seat using thin high-bond adhesive. Based on ISO 2631-5, which requires a sampling rate of at least 160 samples per second, we collected data at 640 samples per second. The standardized test route included surface streets, freeways, and a small section of road containing eight speed humps. This route was chosen to represent different types of driving, including start-and-stop driving associated with surface streets, impulsive speed hump excursions, and continuous freeway travel. The bus used in the study was a 4-year-old, empty, 12.2-m, low-floor coach bus (New Flyer Industries, Inc., Winnipeg, Manitoba, Canada). Since there are no steps to impede entrance and exit, most major metropolitan bus companies are transitioning to this type of bus.

The instrumentation developed for this study included a PDA-based portable WBV data acquisition system, which collected raw unweighted WBV data at 640 Hz, and the associated software to analyze WBV exposures, per ISO 2631-1 and 2631-5. The preliminary analysis of the data was focused on analyzing the Z-axis measurements of A_w, vibration dose value (VDV), crest factor, maximum continuous peak, and positive and negative raw peaks. Data are presented as mean and standard error with significance accepted for p-values less than 0.05.

Results

The global positioning system data indicated that there were no significant differences in bus speed across the three conditions. Table 1 shows the preliminary results of the analysis of time-weighted average (TWA) and peak data across the three different seat types and between the bus seat and floor. Relative to the vibration measured at the floor, the bus seats primarily attenuated the vibration exposures. The degree of attenuation depended on the type of measure; average measures of vibration (A_w and VDV) were attenuated to a lesser degree than impulsive measures (crest factor, maximum peak, and raw peaks). In addition, with the exception of VDV, the vibration measured on the bus floor was dependent on seat type. There were also differences across seats in the attenuation of the impulsive vibration measures (crest factor, maximum peak, and raw positive peak). In general, the Recaro seat had lower impulsive exposures, but what the data do not show (not presented) are the seat results by individual road types. On freeways, relative to floor measurements, all seats amplified the A_w exposures; over the speed humps, all seats amplified the VDV exposures.

Table 1.—Mean and standard error Z-axis vibration measures by location and seat type (n = 10)

	Seat				Floor			
	Recaro Ergo M	USSC Q91	USSC Q91 with silicone	p-value	Recaro Ergo M	USSC Q91	USSC Q91 with silicone	p-value
A_w (m/s^2)	0.39 *± 0.01*	0.39 *± 0.02*	0.39 *± 0.01*	0.98	0.43 *± 0.01*	0.42 *± 0.01*	0.44 *± 0.01*	0.04
VDV ($m/s^{1.75}$)	9.03 *± 0.23*	9.28 *± 0.46*	9.32 *± 0.43*	0.77	11.83 *± 0.46*	12.05 *± 0.44*	11.11 *± 0.20*	0.20
Crest factor	9.65 *± 0.51*	12.09 *± 0.36*	12.63 *± 0.66*	0.001	20.92 *± 1.82*	22.85 *± 1.61*	15.26 *± 0.82*	0.01
TWA peak (m/s^2)	3.61 *± 0.18*	4.60 *± 0.27*	4.78 *± 0.32*	0.005	8.99 *± 0.82*	9.45 *± 0.70*	6.69 *± 0.39*	0.04
Raw (+) peak (m/s^2)	5.44 *± 0.27*	8.26 *± 1.03*	7.33 *± 0.53*	0.03	44.58 *± 5.41*	53.72 *± 2.32*	32.05 *± 3.94*	0.01
Raw (–) peak (m/s^2)	–6.50 *± 0.33*	–6.91 *± 0.42*	–7.08 *± 0.74*	0.77	–47.88 *± 6.00*	–62.87 *± 4.87*	–34.02 *± 4.20*	0.01

Discussion

The bus seats tested in this study seem to be attenuating vibration exposures, but there are some exceptions, such as freeways (A_w) and speed humps (VDV). This indicates that the bus seats are not optimized for all road types and perhaps bus seat selection could be improved by matching or tuning the bus seat to the predominant road type on the bus route. Of particular interest is the amplification of exposures on freeways, which can predominate certain types of bus routes. Finally, the vibration measured on the bus floor was dependent on seat type. This indicates a complex interaction between the bus seat and vibration measured on the floor.

References

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