AVERAGE AND IMPULSIVE WHOLE BODY VIBRATION EXPOSURES IN METROPOLITAN BUS DRIVERS

Ploger, J., Johnson, P. Department of Environmental and Occupational Health Sciences, University of Washington, Seattle, WA, USA

Aims

Research has shown an association between exposure to Whole Body Vibration (WBV) and high rates of low back disorders. Impulsive WBV exposures have been recognized as a risk factor for low back injury and new guidelines have been published for their measurement and assessment (ISO 2631-5, 2004). We developed hardware and software systems to measure time weighted average (TWA) and impulsive WBV exposures from a tri-axial seat pad accelerometer and the Z-axis of an accelerometer mounted on the bus floor. Our aims were: (1) to characterize tri-axial WBV exposures by simultaneously collecting traditional TWA (per ISO 2631-1-1997) and raw, continuous impulsive WBV exposure data (per ISO 2631-5-2004), and (2) to characterize potential TWA and impulsive WBV exposure determinants, such as the type of street (city versus freeway) and driver weight (thin, average, obese), (3) to determine the attenuation of the vibration exposure by the bus seat (floor versus seat) and (4) to compare bus WBV exposures to car exposures when the vehicles were driven over the same route.

Methods

A seatpad ICP accelerometer was used to collect tri-axial WBV exposures from the driver/seat interface and from the Z-axis of an accelerometer mounted to the bus floor under the seat. Using Personal Digital Assistant (PDA) with a 16 bit data acquisition card, we continuously collected the four channels of WBV data at 640 Hz. Global Positioning System (GPS) data was also collected simultaneously via the serial port of the PDA in order to identify the location, speed and type of road the bus was on. Fifteen Seattle Metro bus drivers each drove a 40' (13.3 m) unloaded King County Metro coach bus with an adjustable height seat. The test route was 40 miles (65 km) and required 1 hour to complete. A subset of 5 drivers drove a car over the same route. The route included two different street segments and two different freeway segments and one segment consisting of road with 10 speed humps.

Results

We found significant differences ($p < 0.001$) between the three road types (street, freeway and speed humps) for all TWA measures in all three axes: the weighted r.m.s acceleration (A_w), Crest Factor and vibration dose value (VDV), as well as for the impulsive static compression doses (S_{ed}'s). For A_w in the Z-axis, only the freeway exceeded the ISO 2631-1-1997 action limit (0.5 m/s^2 for an 8 hour exposure), while for all three road types the VDV values exceeded the EU action limit (9.1 $m/s^{1.75}$ for an 8 hour exposure). Also, the ISO 2631-5-2004 vibration doses (S_{ed}'s) for all three road types were in the potential moderate to high hazard zone (above 0.5MPa). When comparing outbound and inbound segments of the streets and freeways, there were even significant differences between the two segments. Bus driver weight did not have a significant effect on exposures; however, vibration exposure tended to increase as driver weight decreased. Car exposures at the seat were significantly less ($p<0.05$) than buses for every measure: A_{wz}, VDV_z, z-axis daily acceleration dose (D_{zd}), maximum r.m.s. weighted peak and the maximum raw peak. Somewhat surprisingly, the bus seats amplified the exposures of VDV_z, D_{zd} and maximum weighted peaks ($p<0.05$) whereas the car seats attenuated the exposures of A_{wz}, VDV_z and the maximum raw peak as compared with the floor.

Conclusions

With this system, we were able to characterize TWA and impulsive exposures for three road types and two vehicle types. The TWA, VDV and impulsive S_{ed} measures demonstrated similar moderate risk outcomes for all three road types, indicating that some drivers may be exposed to moderate risks when driving selected routes (rough city streets and old, worn freeways). The seat and suspension systems of the car performed significantly better than the bus, with the bus seat amplifying many of the low frequency, non-impulsive WBV exposure measures. This data collection system may ultimately be used to develop administrative (alter speed and/or route of bus, vary type of routes) and/or engineering controls (identify and trigger the need for street repair) in order to reduce high WBV exposures.