June 2 to 4, 2009, Montréal, Canada
4th International Conference on Whole Body Vibration Injuries

Discomfort measure in multiple-axis whole-body vibration

Salam Rahmatalla, Civil and Environmental Engineering Department, Center for Computer-Aided Design,4121 Seamans Center for Engineering, The University of Iowa, Iowa City, Iowa, USA, salam-rahmatalla@uiowa.edu.

Rosalind Smith, Center for Computer-Aided Design, The University of Iowa, 330 S. Madison, Iowa City, IA, rosalind-smith@uiowa.edu.

Ting Xia; Center for Computer Aided-Design, The University of Iowa, 330 S. Madison, Iowa City, IA, txia@engineering.uiowa.edu.

Michael Contratto, Caterpillar Inc., Peoria, Illinois, USA, Contratto_Michael_S@cat.com.

Introduction

Studies on human response to whole-body vibration agree on the complexity of defining measures for discomfort [1]. Traditionally, in single-axis WBV, a subject's discomfort is measured subjectively using verbal or paper-based techniques. Additionally, most of these studies focused on the lumber region of the spine as a major source of discomfort. In multiple-axis WBV, where the frequency and the magnitude of the acceleration are randomly changing, the accuracy of the subjective scales becomes questionable as the subjects have a hard time rating their perception. Furthermore, with the development in seat design, the relative motion in the lumbar area has been minimized, but more motion has been transferred to the neck area, which could be a new source of discomfort.

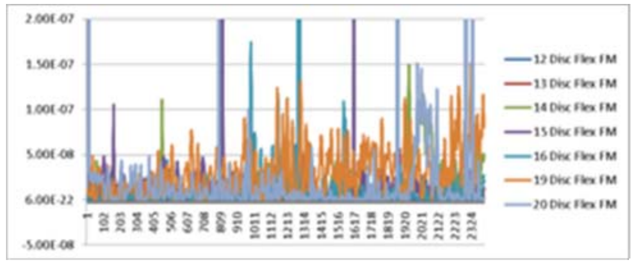
In any design process, researchers normally check the situations where large relative body motion occurs and try to avoid these regions in the design. In this work, we propose an objective discomfort function for the neck flexion-extension and lateral motion, which is useful for capturing discomfort level in multiple-axis WBV with random motion that contains large-body motion. The proposed function [2] has been tested and validated on seated subjects inside a non-vibration environment. Under the current investigation, the proposed discomfort function has also shown good results when used in comparing the relative discomfort for different control configurations.

Methods

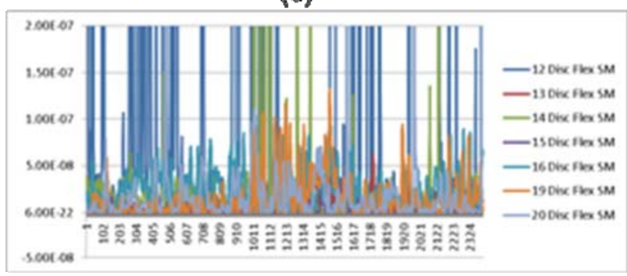
Seven healthy subjects were tested in a whole-body environment using a ride file (60 seconds) from a heavy construction machine, the Cat D10 dozer. A six-degree-of-freedom Servotest (Sears's seating facility, Davenport, IA, USA) hydraulic motion platform was used in the testing. Eight 0.3 megapixels Vicon SV cameras were used in tracking the motion; accelerometers were attached to the head and the torso areas; and surface electromyography (EMG) of the cervical erector spinea, sternocleidomastoid, upper trapezius, biceps brachii, and triceps brachii were collected using the Delsys system. A seat with three-arm support configurations was used in this study: steering wheel (ST), seat-mounted (SM), and floor-mounted (FM). An objective discomfort measure for the neck was calculated and used to compare the discomfort level between the three configurations. The subjects were asked about their perception of each configuration.

Results

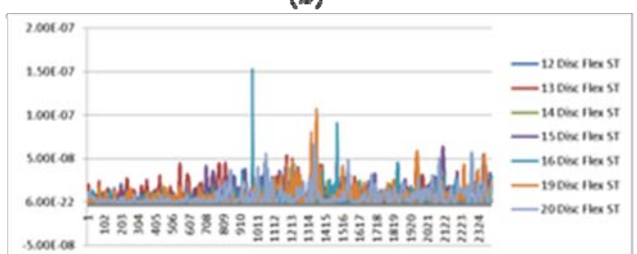
Figures (a), (b), and (c) show the discomfort level for the seven subjects, for = neck flexion-extension, and for the FM, SM, and ST configurations. The discomfort activity goes up and down during the motion with sudden peaks with maximum activity for the SM, followed by the FM and ST. Similar behaviours have been shown for the neck lateral discomfort. The results show that the discomfort value increased significantly when the joint reached its extreme-uncomfortable position and that the discomfort was higher for SM and FM than for ST positions. Meanwhile, when the subjects were asked about their perceptions of vibration and which seat was better, they gave contradicting answers. The results on five muscle activities [3] have shown that SM configuration has the lowest muscle activities, followed by FM and ST.



(a)



(b)



(c)

Conclusions

While any biomechanical objective measure for discomfort should contain the motion and the muscle activation, for situations where the muscle activation is relatively low and the relative motion is large, as in the case for random large motion multiple-axis WBV, the discomfort measure may be calculated by considering the motion only.

References

[1] Boileau, P.E., Rakheja, S., Politis, H., Boutin, J., “Assessment of operators’ exposure to multi-axis whole-body-vibration environment of Montreal subway cars,” International Conference on Whole-Body Vibration Injuries, June 7-9, Nancy, France, 2005.

[2] Yang, J., Marler T., Rahmatalla, S., “Validation development for predicted posture,” paper no. 2007-01-2467, Tranactions Journal of Passenger Cars-Electronic and Electrical Systems, 2007.

[3] Frey Law, L., Rahmatalla, S., Wilder, D., Grosland, N., Xia, T., Hunstad, T., Contratto, M., Kopp, G., “Arm and shoulder muscle activity are greater with steering wheel vs. Seat-mounted controls,” 1st American conference on Human Vibration, West Virginia, June 507, 2006.