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Research Paper

A REVIEW OF THE PERFORMANCE OF READING ACTIVITY BY SEATED SUBJECTS EXPOSED TO WHOLE BODY VIBRATION

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Most of the train and bus passengers would like to perform sedentary activities like reading, writing and eating etc. While commuting from one place to another. Previous studies have shown that these activities are adversely affected by the whole body vibration exposure due to the vehicle vibrations. There is no standard which defines the extent of perceived difficulty offered to a human being while performing the sedentary activities in a whole body vibration exposure. For the current review study, reading activity has been chosen as reading is the most preferable activity over the other activities while travelling. The reported studies on performance of reading activity of the seated subjects in whole body vibration exposure along the different directions and related experimental parameters are methodically reviewed to identify the ranges of perceived difficulty and performance decrement. The recommended ranges are expected to assist the improvements in various target functions in vehicle design such as seat design, suspension system etc. to optimize the ride comfort of the passengers.

Keywords: Body vibration, Ride comfort, Frequency posture

INTRODUCTION

Sedentary activities performed by the seated subjects have been widely studied under the whole body vibration. Reading activity has been most preferred by the people while travelling from one place to another by train (Bhiwapurkar *et al*., 2009, Khan and Sundström, 2004). The effect of whole body vibration on the seated subject has been quantified by the subjective and objective evaluation of the reading activity. The subjective evaluation in terms of perceived difficulty has been done on the subjective scales. The Objective evaluation of reading activity has been done with the help of time to complete the reading task and decrement in reading speed. A variety of reading sources were used in the studies such as newspaper (Bhiwapurkar *et al*., 2011), laptop (Bhiwapurkar *et al.,* 2012), plain paper (Westberg, 2000, Hancock, 2007, Bhiwapurkar *et al.,* 2010, Kumar *et al*., 2013),

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Cathode ray display (Lewis and Griffin, 1980) etc. There is no availability of any standard for the activity comfort in the trains or any other vehicle. This study is an attempt to identify the ranges of perceived discomfort in the vertical, lateral and fore-&-aft direction.

SELECTION OF DATA SETS

The reading activity performed by the seated subjects is strongly affected by the vibration parameters such as magnitude, frequency, postures etc. Wide-ranging experimental

Table 1: Experimental Conditions Employed in the Studies Reporting Reading Activity of the Seated Subjects

Author	No. of Subjects (M-Male F-Female)	Mass (kg)	Vibration Type	Direction	Levels (m/s^2 rms)	Frequency (Hz)	Posture	Measurement Reported
Lewis and griffin, 1980	10 M	NR	Sinu-soidal	Vertical	0.4, 0.8,1.2 1.6,2.0	4.0 and 11.2Hz	Erect without backrest	Percentage Reading error
Griffin and Hayward, 1994	8 M, 8F	NR	Random	Lateral and fore & aft	0.6, 0.8,1.0 and 1.25	0.5 to 10 Hz.	Upright with backrest	Words read, and subjective assesment on percentage scale
Sundstrom and Khan, 2008	24M, 24F	NR	Sinu-soidal	Lateral	0.4, 0.8 Peak	0-8 hz, 0.8, 1.25, 1.6, 2.0, 2.5, 3.15, 4.0, 5, 8.0.	Erect: With vertical Backrest and leaning over table without backrest	Subjective assesment on borg scale
Bhiwapurkar *et al*., 2010	18M	54 ± 8.7	Random	Vertical, lateral, Fore-&-aft	0.5,1, 1.5	1-10 Hz	Erect: With vertical Backrest and leaning over table without backrest	Percieved difficulty on 7 point scale
Bhiwapurkar *et al*., 2011	30M	68.9 ± 12.0	Random	Mono, dual, multi axis	0.4, 0.8 and 1.2	1-20 Hz	Erect: With vertical Backrest and leaning over table without backrest	Time required to complete the reading task and subjective rating using a Borg CR10 scale
Bhiwapurkar *et al*., 2012	30M	68.9 ± 12.0	Random	Mono, dual, multi axis	0.4, 0.8, and 1.2	1-20 Hz	Erect: With vertical Backrest and leaning over table without backrest	Time required to complete the reading task and subjective rating using Borg CR10 scale
Kumar *et al*., 2013	6 M	69.0 ± 6.1	Sinu-soidal	Fore-&-aft axis	0.6, 1.2	2, 3, 4, 5, 6, 8, 10 Hz	Erect with vertical backrest	Seven point scale

conditions were considered in the reported studies. Sinusoidal and random vibrations were generated in the laboratory environment and different level of vibration magnitude (0.5, 1.0 and 1.5 m/s^2) and frequencies. For the present study, the following conditions have been chosen to represent an environment in a train for a seated human subject: Vertical backrest posture, reading material in hands on the lap, three levels of vibration magnitude in different frequency ranges. In all the reported studies experiments have been performed on the male subjects in seated postures. Two measured responses about the reading activity have been considered: Percentage reduction in reading speed and perceived difficulty to read. The data regarding these two responses were collected from the reported studies for the chosen posture and vibration magnitude. The data reported for both sinusoidal and random vibration has been considered. In some studies,Where the vibration magnitudes do not match with those chosen for the present study, the response has been linearly interpolated to the same levels of vibration magnitude. A total of seven studies reporting the reading activity of the seated human body under whole body vibration were identified. The summary of the associated experimental conditions in the reported studies have been tabulated in the Table 1.

RESULTS AND DISCUSSION

The data regarding the percentage reduction in reading speed and perceived difficulty to read from the identified and reported studies have been selected for the vertical, lateral and fore-&-aft vibration. Figures 1 to 3 represents the percentage reduction in reading speed in the vertical, lateral and fore-&-aft whole body vibration for seated subjects. In all the

Figure 1: Percentage Reduction in Reading Speed in the Vertical Whole Body Vibration for Seated Subjects

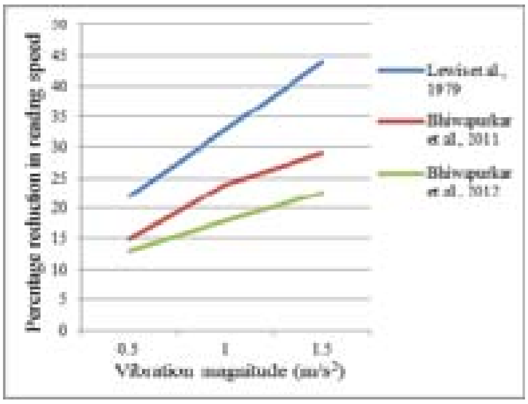


Figure 2: Percentage Reduction in Reading Speed in the Lateral Whole Body Vibration for Seated Subjects

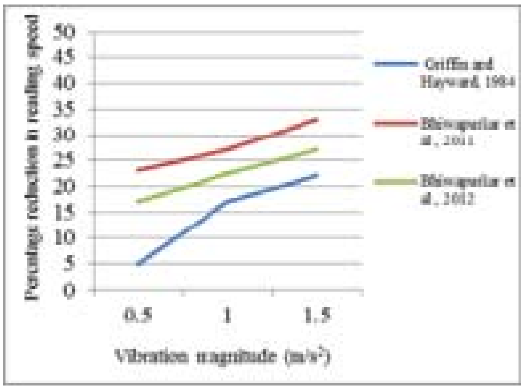
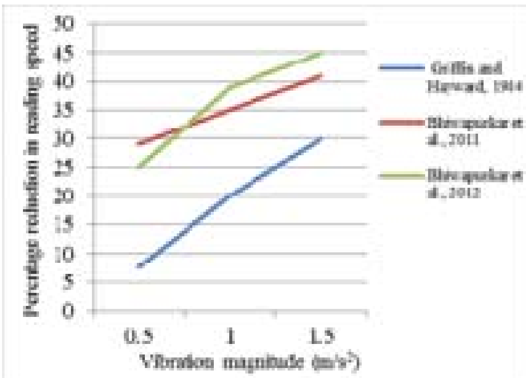


Figure 3: Percentage Reduction in Reading Speed in the fore-&-aft Body Vibration for Seated Subjects



considered studies, there is an increase in the percentage reduction with the increase in vibration magnitude of whole body vibration in all the three considered directions. Figures 4 to 6 represents the perceived difficulty to read in the vertical, lateral and fore-&-aft whole body vibration for seated subjects. In all the considered studies, there is an increase in the perceived difficulty with the increase in vibration magnitude of whole body vibration in all the three considered directions. Mean values of percentage reduction in reading speed and perceived difficulty to read has been displayed in the Figures 7 and 8 for the vertical, lateral and fore-&-aft vibrations.

Figure 4: Perceived Difficulty to Read in the Vertical Whole Body Vibration for Seated Subjects

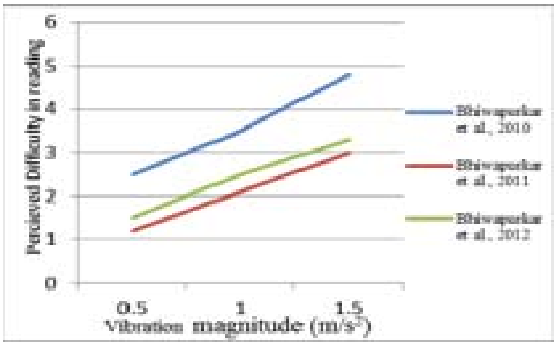


Figure 5: Perceived Difficulty to Read in the Lateral Whole Body Vibration for Seated Subjects

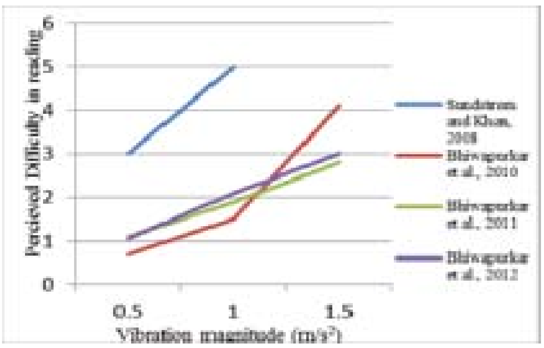


Figure 6: Perceived Difficulty to Read in the fore-&-aft Whole Body Vibration for Seated Subjects

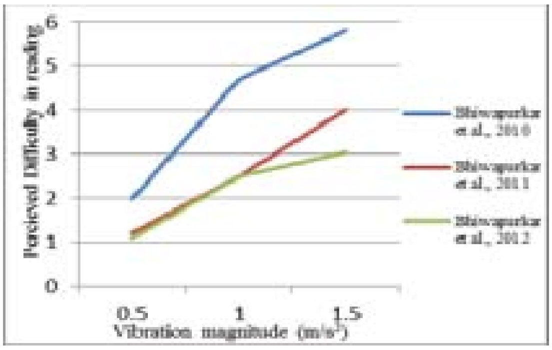


Figure 7: Mean Values of Percentage Reduction in Reading Speed in the Three Direction of Whole Body Vibration for Seated Subjects

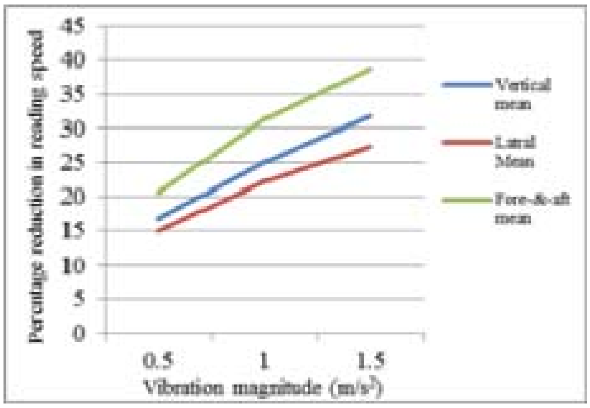
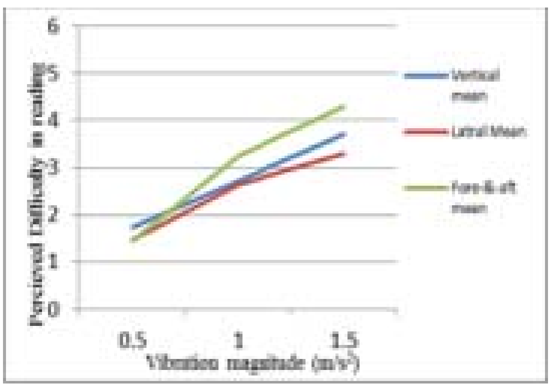


Figure 8: Mean Values of Perceived Difficulty to Read in the Three Directions of Whole Body Vibration for Seated Subjects



Percentage reduction in reading speed has been found to be more in the fore-&-aft direction of whole body vibration and less in the lateral direction. The same pattern has been observed in mean values of perceived difficulty to read except at low levels of vibration magnitude.

Mean values of percentage reduction and perceived difficulty suggest that reading activity has been found to be most affected by the fore-&-aft vibrations in the seated posture with vertical backrest and least in the lateral directions. This may be attributed to the striking of head with the vertical backrest in the fore-&-aft direction whereas backrest supports the upper body in the lateral direction of vibration. Considering that reading activity of seated subjects in a whole body vibration exposure is dependent on several issues. The reported data showed a more unevenness, -although the data were limited to similar experimental conditions involving sedentary posture, vibration amplitude, frequency ranges. Significantly larger differences could be observed when the boundaries of experimental conditions are relaxed. The present defines the mean values of measured responses for the reading activity in the seated posture with vertical backrest support. A very few studies are available, so more experimental investigations are required for the reading activity in a whole body vibration exposure which will be beneficial for the refinements of the data.

CONCULUSION

Mean values of the selected datasets were created for reading activity in the vertical, lateral and fore-&-aft whole body vibration for the seated posture. Whole body vibration levels for the exposure were considered from 0.5 to 1.5 m/s^2 rms. Mean values of percentage reduction and perceived difficulty for reading has been proposed for the vertical, lateral and fore-&-aft direction of vibration exposure. There is considerable effect of backrest in the fore-&-aft direction of vibration which causes more difficulty to perform in this particular direction compare to other directions. At the same time, vertical backrest reduces the adverse effects on the reading activity for the lateral as well as for vertical whole body vibration.

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