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Objective and subjective responses of seated subjects while reading Hindi newspaper under multi axis whole-body vibration

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ABSTRACT

Train passengers often read newspapers while traveling. Vibration is one of the key factors that may occasionally inhibit this activity. An experimental study was, therefore, conducted to investigate the extent of interference perceived in reading task by seated subjects in two postures under random vibration. 30 healthy male subjects were exposed to vibration magnitudes of 0.4, 0.8 and 1.2 m/s^2 in mono, dual and multi axis in the low frequency range 1–20 Hz. The task required subjects to read a given paragraph of Hindi national newspaper, in two seated postures (lap posture with backrest support and table posture with leaning over the table). The reading performance was evaluated by both degradation in performance in terms of time required to complete the task and subjective rating using Borg CR10 scale. Both the methods of reading performance evaluation exhibit progressive increase with an increase in vibration magnitude for both the subject postures in all the direction of vibration and are found to be higher in lateral and vertical direction among mono axes. The effects of multi axis vibration on perceived difficulty have been found to be similar to dual axes vibration and greater than mono axes vibration; however degradation in reading performance in multi axis vibration was also found to be similar to that for lateral direction. A comparison of the effect of postures by both evaluation methods revealed that the reading performance was adversely affected for table posture in all direction of vibration, however for lap posture, only the *X*-axis vibration effect was more severe.

Relevance to industry: Available ride comfort standards for vehicles do not include the effects of vibrations on passenger activities. Assessment of activity discomfort would be useful for vehicle design optimization to facilitate activity comfort.

1. Introduction

In a moving vehicle, any handheld material such as a newspaper is subject to vibration. The human visual system may also be affected by vibrations. Such a situation may arise when a person reads a newspaper in a moving train. Reading small characters on the newspaper in dynamic conditions is not as effortless as in static conditions.

The reading of handheld material, such as a newspaper, in a vibrating environment may require quite an effort owing to a combination of head and hand motions. The displacement of the eye is often greatest in the range 2–5 Hz and so it is around these frequencies that reading difficulty is likely to be greatest (Griffin, 2003). When reading a newspaper on a train, the motion of the arms may result in the motion of the paper being different in magnitude and phase from the motions of both the seat and the head of the observer. The dominant axis of motion of the newspaper may be different from the dominant axis of motion of the person (Griffin and Hayward, 1994).

A literature review shows that a considerable amount of vibration studies were found in military applications (Wollstrom, 2000). However, only a few studies have shown that vibrations are disturbing a significant number of passengers on performing activities like reading, writing, sketching and drinking (Corbridge and Griffin, 1991; Griffin and Hayward, 1994; Sundström and Khan, 2008; Bhiwapurkar et al., 2010a). Whole-body vibration has been shown to affect both reading speed and reading accuracy in many studies (Lewis and Griffin, 1978; Moseley and Griffin, 1986; Griffin, 2003). Lewis and Griffin (1980) found a degradation of reading performance during exposure to fore-and-aft (*x*-axis) vibration at frequencies between 5.6 and 11 Hz, while reading of leading articles from a national newspaper. However, the effect was

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