Characterizing Impact Vibration for Rat Tail Vibration Exposure Experiments

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INTRODUCTION

Vibration-induced finger disorders are major components of hand-arm vibration syndrome. The frequency weighting specified in the current standard for the risk assessment of the hand-transmitted vibration exposure emphasizes the risk of injury associated with exposures to vibration frequencies at less than 50 Hz, with the highest weighting value occurring at 12.5 Hz[1]. The validity of this weighting for assessing vibration-induced finger disorders is questionable. Whether and how high-frequency vibrations affect development of the disorders remains an important issue for further studies. It is also unclear whether the rms acceleration adopted in the current standard is a good vibration measure for assessing the risk of shock or impact vibration exposure, and if the biodynamic response of the fingers is closely associated with finger disorders. A new testing platform that uses a riveting hammer to produce impact vibration has been recently developed so that the rat-tail model of vibration-induced injury can be used to investigate the above issues. The objectives of this study are to characterize the impact vibration input to the platform and that transmitted to the tail.

METHODS

As shown in Fig. 1, the rat tail impact testing platform is a riveting hammer vertically fixed on a stand with the rivet set replaced with a bell-shaped steel plate on which the rat tail is positioned during the experiment. Two bungee cords are used as fasteners to provide a load on the platform. The riveting hammer is driven using compressed air, and a pressure regulator controls the input pressure. A scanning laser vibrometer was used to scan five measurement points spread across the platform, glove materials or rat tails. The measurement at each location lasted 10 seconds, and the vibration up to 21.75 kHz was measured. The study variables included applied load, air pressure, measurement location, and platform conditions (air or gel gloved and ungloved). As a random factor, four rats were used in this study. Three trials were performed for each treatment. The time history of the velocity signal from the laser vibrometer in each trial was recoded using a data acquisition system. From the recorded data, three typical vibration measures (peak accelerations, weighted and unweighted rms accelerations) were quantified for characterizing the impact vibration.

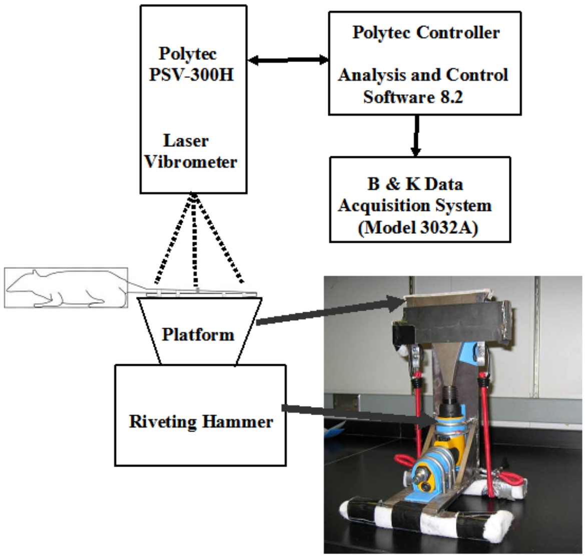

Fig.1 Rat tail impact testing platform

RESULTS AND DISCUSSIONS

Fig. 2 shows typical examples of the acceleration time histories measured at the middle location of the platform in three of the six platform treatments, which were filtered at a cut-off frequency of 1,500 Hz. Peak accelerations on the bare platform (P) were much higher than the rest. Both air glove materials (AG) and gel glove materials (GG) reduced the peaks significantly. The rat tails on the platform (RTP) also absorbed high frequency vibrations and reduced the peaks. Peaks measured from the rat tail on the air glove material (RTAG) were around 500 m/s^2 and were around 300 m/s^2 on the gel glove material (RTGG). Judging purely by the peak accelerations, one would conclude that the impact vibration from the bare platform should cause more severe health effects than that from the glove materials-cushioned platform, especially with the gel glove material.

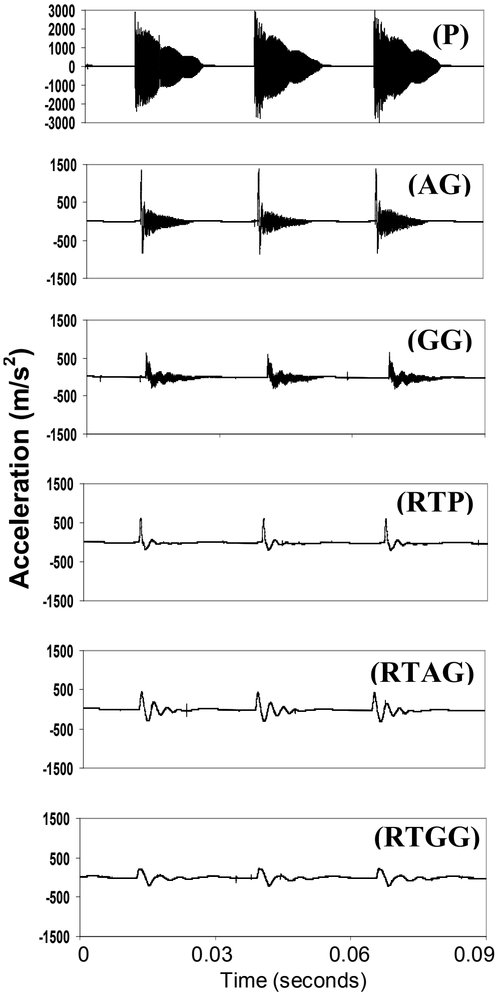

Fig.2 Typical examples of the accelerations

However, the effects of the glove materials and rat tail on the rms acceleration (integrated from 6.3 to 1,250 Hz in the one-third octave bands) are the opposite: the unweighted and weighted rms accelerations under these conditions were either similar to or greater than those on the bare platform, as shown in Table 1. This is because the glove materials and/or rat tail amplified a portion of the vibration components below 1,250 Hz, although they effectively attenuated high frequency peaks. Based on the ISO risk assessment, results from this study indicate that anti-vibration gloves do not help isolate impact vibration and may make it worse.

Table 1 Peaks, Unweighted and Weighted rms Accelerations (m/s^2) with Coefficients of Variation (CV)

	Peaks		Unweighted rms		Weighted rms	
Treatments	Average	CV	Average	CV	Average	CV
P	3010	0.10	82.46	0.03	6.99	0.01
AG	1168	0.14	97.41	0.07	6.9	0.02
GG	492	0.31	81.37	0.08	7.51	0.05
RTP	548	0.25	88.35	0.14	8.52	0.05
RTAG	462	0.14	104.03	0.09	9.1	0.04
RTGG	271	0.13	82.4	0.07	9.84	0.05

This rat tail impact test platform, together with the glove materials, can be used to study the mechanisms of the impact vibration-induced disorders, to examine the validity of the frequency weighting, and to explore alternative vibration measures.

REFERENCES

1. ISO 5349-1, 2001: Mechanical vibration -- measurement and evaluation of human exposure to hand-transmitted vibration -- part 1: General requirements. Geneva, Switzerland: International Organization for Standardization.