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COMBINED EFFECT OF HAND-ARM VIBRATION AND NOISE ON TEMPORARY HEARING THRESHOLD SHIFT

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INTRODUCTION

Workers operating vibrating tools are exposed to both hand-arm vibration and noise. Previous studies indicated greater noise-induced hearing loss among operators with vibration-induced white finger (VWF) than those without VWF (Pyykko et al. 1981; Iki et al. 1985; Miyakita et al. 1987a; Sakakibara and Yamada 1987). These findings have suggested that simultaneous exposure to hand-arm vibration and noise might contribute to greater hearing loss. The aim of the present study was to experimentally investigate whether simultaneous exposure to hand-arm vibration and noise causes combined effect on temporary threshold shift (TTS) of hearing among healthy subjects.

MATERIALS AND METHODS

Subjects were nineteen healthy volunteers (fourteen males and five females) aged 25.7 (SD=7.7) years (range from 20 to 40). They had no ear diseases affecting hearing, and had not been occupationally exposed to vibration and noise.

Subjects were exposed to vibration (30 m/sec2 root mean square, 60 Hz), noise (90 dB(A), white noise), or both. Each experiment was conducted in random order at intervals of more than 24 hours to avoid the effect of the previous one. Subjects sat on a chair and put the right hand on the plate of a vibrator, while wearing headphones connected to an audiometer. Then, vibration produced by a vibrator (EMIC E-1011A) was applied to the right hand, and noise generated by an audiometer (MAICO Model MA22) was applied to the right ear via headphones. Exposure to vibration and/or noise lasted for three minutes, which was repeated five times with one-min intermission.

Hearing thresholds of the right ear at 4 kHz were measured with the same audiometer used to generate noise. The measurements were made two min before the first exposure, in each one-min intermission between exposures, and one, two, three and five min after the last (fifth) exposure. In each one-min intermission, the measurement started 10 sec after cessation of exposure and finished within 30 sec. These measurements were conducted by the same examiner. The background noise in the experiment room was less than 45 dB(A), when a vibrator was working nearby. Since subjects wore headphones throughout the experiments, such background noise would not affect the present results.

TTSs of hearing were calculated by subtracting the threshold before the first exposure from that obtained in intermissions and after the last exposure. TTSs in exposure to vibration, noise or both were statistically compared using Wilcoxon matched-pairs signed-rank test.

RESULTS

Table 1. Temporary hearing threshold shift (dB) in exposure to hand-arm vibration (30 m/sec2, 60 Hz), noise (90 dB(A), white noise), or both (n=19)

	Vibration mean (s.d.)	Noise mean (s.d.)	Both mean (s.d.)
1st 3-min exposure	0	7.1 (4.2)	9.7 (4.2)*
2nd 3-min exposure	0.3 (1.2)	10.3 (4.9)	14.0 (4.9)**
3rd 3-min exposure	0	12.9 (5.4)	15.8 (5.3)*
4th 3-min exposure	0	13.4 (5.3)	16.8 (5.6)**
5th 3-min exposure	0	15.5 (6.4)	19.0 (4.9)**
1 min after exposure	0	12.4 (5.9)	15.0 (5.0)*
2 min after exposure	0	10.5 (6.0)	12.1 (4.2)
3 min after exposure	0	8.2 (5.3)	9.7 (4.9)
5 min after exposure	0	6.6 (4.7)	7.6 (5.6)

*p<0.05, **p<0.01, compared between exposure to noise and both

As shown in Table 1, vibration exposure generated almost no TTSs. However, noise exposure and combined exposure caused significant increases in TTSs. TTSs in combined exposure were significantly greater even compared with those in noise exposure ($p<0.05$ or 0.01). At the fifth exposure, TTS in combined exposure was greater by 3.5 dB on average than that in noise exposure.

DISCUSSION

In the present study, exposure to hand-arm vibration generated almost no TTSs of hearing, while combined exposure to vibration and noise caused significant increases in TTSs. Additionally, TTSs in the combined exposure were significantly greater even compared with those in noise exposure. Thus, the present findings demonstrated the combined effects of hand-arm vibration and noise on hearing, although exposure to vibration alone did not affect the hearing.

There is only one experimental study about combined effects of hand-arm vibration and noise on hearing. But the study could not clearly show the combined effects, though TTSs of hearing tended to be greater in combined exposure than in noise exposure (Miyakita et al. 1987b). In the experiment subjects were exposed to vibration and noise by operating a chain saw, which might contribute to its failure. On the other hand, the present study positively demonstrated the combined effect on hearing.

Although the exact mechanism of noise-induced hearing loss is not clear, recent studies suggest the contribution of reduction of cochlear blood flow to noise-induced hearing loss. It is demonstrated that noise exposure reduces cochlear blood flow (Dengerink et al. 1984; Thorne and Nutall 1987; Okamoto et al. 1990; Scheibe et al. 1993). And that significantly reduced cochlear blood flow is observed in noise-induced hearing loss than in normal hearing (Hillerdal et al. 1987; Thorne and Nuttall 1987). It is also shown that cervical sympathectomy diminishes TTS of hearing in response to noise (Borg 1982; Hildesheimer et al. 1991). Considering these findings, noise might reduce cochlear blood flow through the sympathetic nervous system and contribute to noise-induced hearing loss. Combined exposure to vibration and noise is known to induce higher sympathetic activity than exposure to each of noise or vibration (Okada et al. 1991; Harada et al. 1993), which might lead to greater reduction of cochlear blood flow, and then greater TTS of hearing.

However, it is also shown that exposure to vibration alone activates the sympathetic nervous system, though not as much as the combined exposure (Sakakibara etal. 1990; Okada et al. 1991; Harada et al. 1993). Since exposure to vibration alone produced almost no TTS of hearing, vibration exposure under study might activate the sympathetic nervous system too weakly to generate TTS. It is, hence, considered that noise exposure is essential for noise-induced hearing loss, while hand-arm vibration enhances the effect of noise on hearing.

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