TINNITUS OF EARS DUE TO COMPLEX EXPOSURES

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Abstract

Two kinds of studies took place in an exposure chamber as factorial experiments yielding a total of 48 exposure combinations (study 1) and of 16 exposure combinations (study 2). The exposure combinations included whole body vibrations (along Z axis), stable broadband noises, physically and mentally loading tasks and different illumination levels. The subjects in the first study were under 25 yrs, 26-39 yrs and over 40 yrs old, whereas in the second study half of the subjects were non-smokers and half of active smokers who smoked during the experiment too. The results showed that noise, vibration, and physically loading work and their corresponding combinations influenced tinnitus sensations and temporary threshold shifts of hearing (TTS$_2$) most markedly. In general, changes in tinnitus sensations seemed to be associated with the changes in hearing thresholds: the greater the TTS$_2$ values, the greater were the means of tinnitus ratings scores.


Key words: Tinnitus — TTS$_2$ — Noise — Vibration — Physically Loading Work — Mentally Loading Work — Illumination — Smoking — Age — Combined Effects

Introduction

In many recent studies we have found that subjective ratings concerning different kinds of environmental exposure conditions are relatively reliable and correlate well with the intensity and factor combinations of environmental factors, e.g. noise, whole body vibration etc. (Manninen 1990 a,b). Correspondingly, tinnitus ratings given by the subjects could be used in many fascinating and meaningful ways as well. The word tinnitus is derived from the latin word tinnire, which means sounding or tinkle (Jackson 1983). The term is used to describe any sound that seems to originate in a person' brains or ears. In these studies we set out to examine how the intensity of tinnitus is correlated with various environment-induced exposures, with their combinations and temporary threshold shifts of hearing (TTS).

Material and methods

Experimental arrangements

These finding deal with results obtained in two studies. Both studies were realized in factorial experimental design. The first (study 1) was a 2-2-2-2-3 type factorial experiment participated by a total of 192 subjects (i.e 384 ears). The second study was a 2-2-2-2 type factorial experiment participated by a total of 80 subjects (i.e. 160 ears). The subjects were given a medical examination and physical fitness test before acceptance to actual exposure tests. All subjects were voluntary, healthy males in good physical fit. Before starting the exposure tests the subjects were familiarized with the exposure chamber system and practised for the tests during introductory visits. The operating principle and the controlling equipment of the exposure chamber system have been discussed in detail elsewhere (eg Manninen 1989).

Tinnitus ratings

The subjects were asked to rate the intensity of tinnitus on a five step scale, which is presented below:

1. Very low
2. Low
3. Rather high
4. High
5. Very high

While preparing for the tests the subjects rehearsed the ratings. In each rating the subjects were asked to propotion their sensations to the sensations they had during the control period before the test. In other words, by means of the control period the subjects...
Audiometric measurements

To establish correlations, the temporary threshold shifts of hearing were determined at 4 and 6 kHz during the both studies. Determinations were done with a pure tone audiometer two minutes after the exposures (i.e. TTS₂ values).

Study 1

During the test, subjects of different ages were exposed to combinations of physical work, psychic work, noise and vibration. The classes of physical work were 1) 2 W, and 2) 7 W. The classes of psychic work were 1) no competition for best performance and 2) competition with the choice reaction apparatus. The competition was motivated with monetary rewards and intermediary results. Noise classes were 1) no noise and 2) a 90 dBA stable broadband noise. Vibration classes were 1) no vibration and 2) a stochastic broadband whole body vibration with a frequency range of 2.8-11.2 Hz (acceleration 2.12 m/s²). Age cohorts were 1) 19-25 years, 2) 26-39 years and 3) 40-54 years. During the tests the subjects were sitting in the vibration chair. The temperature of the exposure chamber was 35°C and illumination level was 300 lux. One personal test took 1/2 hours, during which the subjects were exposed to consecutive exposures of 16 minutes. The tinnitus ratings were recorded and the TTS₂ determinations were done three times during the exposures and once after the recovery period.

Study 2

The subjects were policemen, half of them (40) were non-smokers and half (40) active smokers. During the test the subjects were exposed to combinations of illumination, noise and vibration. Noise classes were 1) a 70 dBA stable broadband noise and 2) a 90 dBA stable broadband noise. Illumination classes were 1) illumination level 0 lux; 3 cd and 2) illumination level 300 lux; 8cd. Vibration classes were 1) no vibration and 2) a stochastic broadband noise with a frequency range of 2.8-11.2 Hz (acceleration 2.12 m/s²). The temperature of the exposure chamber was 35°C. One personal test took 3 hours, and it consisted of consecutive exposures. The tinnitus ratings were recorded twice during the exposures.

Analysis of data

The results are characterized using arithmetic means and standard errors of the means by exposure combinations. To distinguish single and combined effects 4-5 way variance analyses were calculated (F ratios). The explanatory powers of the variance analysis models used were characterized with squares of the multiple correlation coefficients (R² x 100).

Results

Study 1

The results of the variance analyses showed that in the first exposure measurement noise and vibration had a significant single effect on the variation of the intensity of tinnitus (p < 0.001-0.01) and TTS₂ values at 4 and 6 kHz. Physical work, age, psychic work and noise had a significant combined effect (p < 0.001). In the second exposure measurement noise, vibration and age had a significant single effect (p < 0.001-0.01). Noise and age had a significant combined effect (p < 0.05). In addition, physical work, noise and vibration had a significant combined effect on the variation of the intensity of tinnitus (p < 0.001). Likewise, physical work, age, psychic work and noise had a significant combined effect (p < 0.001-0.05). In the third exposure measurement psychic work and noise (p < 0.001) and noise and age (p < 0.01) had a significant combined effect. In addition, physical work, psychic work and age (p < 0.001) and physical work, noise and vibration (p < 0.01) had a significant three-factor combined effect. All five factors together had very significant effects on the variation of the intensity of tinnitus and the TTS₂ values both at 4 kHz and 6 kHz (p < 0.001). During the recovery period, the variation of the intensity of tinnitus and the TTS₂ values were explained significantly by these exposure factors and their combinations. For the first measurement the variance analysis model explained 57.3 percent of the variation of the intensity of tinnitus, for the second measurement it explained 48.0 percent, for the third 47.0 percent and in the recovery measurements 58.0 percent. The corresponding percentages for the TTS₂ values at 4 and 6 kHz were 60-75. An analysis by exposure combinations, in turn, showed that the sensations of tinnitus were consistently higher the greater the number of simultaneous exposure factors. In general, the ratings of the intensity of tinnitus reflected temporary threshold shifts of hearing.

Study 2

The results of the variance analyses showed that in the first exposure measurement noise and smoking had a significant single effect on the variation of the intensity of tinnitus (p < 0.001-0.01). Noise and vibration together (p < 0.01) and vibration and illumination to-
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gether (p <0.05) had significant combined effects. Likewise, noise, illumination and smoking together had a significant combined effect (p <0.05) on the variation of the intensity of tinnitus. In the second exposure measurement noise, illumination and smoking had significant single effects on the variation of the tinnitus sensations (p <0.001-0.05). Noise and vibration together (p <0.001) and vibration and smoking together (p <0.05) had a significant combined effect on the variation of the tinnitus sensations. Likewise noise, illumination and smoking together had a significant combined effect on the variation of the tinnitus sensations (p < 0.001). The variance analysis model explained 48.0 percent of the variation of the tinnitus sensations in the first exposure measurement and 34.0 percent in the second exposure measurement. An analysis by exposure combinations showed that among non-smokers tinnitus sensations were highest when the subjects were exposed to a 90 dBA noise in complete darkness and when they were exposed to a 90 dBA noise and stochastic vibration at an illumination level of 300 lux. Among smokers the sensations of tinnitus were strongest when they were exposed to a 90 dBA noise in complete darkness. The values of the temporary hearing threshold were also relatively high due to exposures to these combinations.

Conclusions

A general conclusion that can be drawn from the results is that the variation of the tinnitus sensations are closely connected to the environmental exposure factors used and in particular to the combinations of these factors. The variations in the tinnitus values seemed to follow the variation of the TTS values. These were displayed more distinctly and unambiguously in the first study than in the second. A probable explanation for this is that in the first study the number of consecutive exposures, and hence the total exposure time, was longer than in the second. The continuous studies will be aimed at examining the correlation between the variation of the tinnitus sensations and changes of the hearing thresholds more closely. That study should also investigate the significance of some other individual background factors to these correlations and further to find out how the ratings of tinnitus and upright body sway are correlated to so-called objective balance and hearing measurements.

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