Frequency Weighting for the Evaluation of Human Response to Low-Frequency Noise based on the Physiological Evidence of the Vestibular System

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ABSTRACT

Several studies were found regarding adverse health effects due to low-frequency noise emitted by industrial machines including wind turbines. However, the causal chain between low-frequency noise and health effects still remains unclear. Meanwhile, from the physiological viewpoint, low-frequency noise stimulate hair cells in the vestibular system, which could cause dizziness, vertigo, headache and nausea. The stimulating process is different from the hearing process in the cochlea, which implies that the A-weighting is not appropriate for evaluating the risk of low-frequency noise and that an alternative method is required. In this study, we developed a frequency weighting for low-frequency noise based on existing physiological evidences of the vestibular system and a psychological experiment on vibration and/or pressure perceptions. The obtained frequency weighting showed steep peak around 40−80Hz, which was distinctly different from A-weighting. We also derived the dose-response relationship between the weighted sound pressure level and the perception of vibration and/or pressure which may be caused in the vestibular system.

INCIDENT OCCURRED IN JAPAN ABOUT 40 YEARS AGO

In Japan, there was an incident due to low-frequency noise along an elevated motorway 40 years ago, where more than half of residences complain of headache or dizziness like wind turbine syndrome. Figure 1 shows the relationships between the prevalence rate and distance from the motorway.

At that time, psychological laboratory experiences were conducted to obtain the relationship between low frequency noise and perceptions. The results revealed that subjects perceived vibration and/or pressure due to low-frequency noise around 40−80Hz, which would not be caused in the cochlea but in the vestibular system.

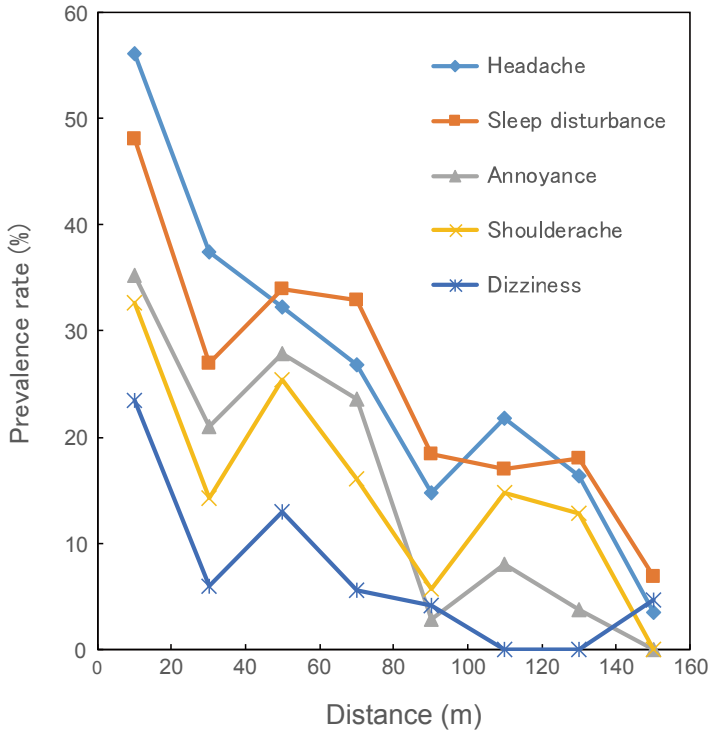

Figure 1: Complaints due to low frequency noise along an elevated motorway in Japan [1].

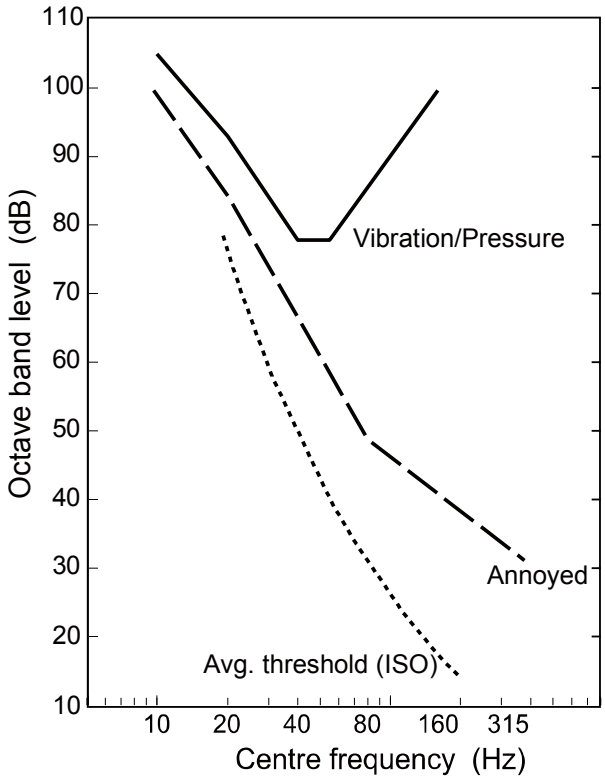

Figure 2: Experimental results of perceptions of low frequency noise [2].
The solid line and the broken line show the median of the subjects' primary response.

METHOD AND RESULTS

In this study, the results of the laboratory experiences conducted 40 years ago were re-analysed statistically, since Figure 2 shows the median values only. From the raw data of the experiences, dose-response relationship between the perception rate and sound pressure level was obtained at each octave band. Physiological approach was also done with a simple mathematical model of inner ear.

The obtained frequency weighting showed steep peak around 40−80Hz, which was distinctly different from A-weighting. The perception of vibration and/or pressure would cause sleep disturbance more frequently than the perception of sound in the cochlea. Moreover, strong or prolonged stimuli to vestibular system could cause disequilibrium, e.g. wind turbine syndrome. The proposed frequency weighting should be examined in epidemiological studies to obtain the dose-response relationships with environmental sleep disorder and disequilibrium due to low-frequency noise.

REFERENCES

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