

## Review

# Noise and Health—Sleep Disturbance in Adults

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**Abstract: Noise and Health—Sleep Disturbance in Adults: Tomoyuki KAWADA, Department of Hygiene and Public Health, Nippon Medical School—**Factors modifying the effect of environmental noise on sleep include sex, age, susceptibility, personality and the health status, including past and present history of disease. **Objective:** The effects of noise on sleep and habituation of sleep to noise were summarized. **Results and conclusions:** 1) The effect of noise on sleep is associated with physical changes, such as changes in heart rate, blood flow volume, breathing and the immune and neurocirculatory systems. During sleep, specific changes in these indicators are noted during different sleep stages. There are individual and sex differences, and it is important to understand the effects of noise on sleep considering several related factors. 2) Habituation to noise is also an important phenomenon that must be addressed while considering the effects of noise on sleep. Habituation is dependent on the type and sound level of the noise. In occupational fields, shift work and job stress should be considered to determine the association between noise and sleep, which is important to retaining a good quality of working life. (J Occup Health 2011; 53: 413–416)

**Key words:** Adult, Noise, Sleep Disturbance, Review

Noise is one of the most disturbing environmental hazards in the world, originating from a wide variety of sources such as road, rail or air traffic, and industrial plants. Noise pollution is an important public nuisance caused mainly by road traffic and is an important cause of sleep disturbances<sup>1)</sup>.

Noise pollution is currently on the increase, as observed by the increasing number of complaints from the general population. The adverse health effects of community noise include hearing impairment, interference with speech communication, sleep disturbances, psychological and

performance effects and subjective feeling of annoyance<sup>2)</sup>. In occupational fields, the effect of noise on health is related to hearing loss<sup>3, 4)</sup>, and cardiovascular risk from occupational noise exposure is also considered<sup>5)</sup>. The effect of occupational noise on health was also been considered in combination with shift work<sup>6, 7)</sup>. The effect of occupational noise on sleep has seldom been reported in the past decade<sup>8)</sup>, and habituation of sleep to noise has been recognized.

Good sleep is fundamental for good physiological and mental health<sup>9)</sup>. Difficulty in falling asleep, intermittent wakefulness, light sleep, difficulty in going back to sleep and early morning waking are the main indicators to determine the level of sleep disturbance. Some of the factors that influence the effects of noise on sleep are subjective sensitivity, sex, age, health status, frequency of complaints and socioeconomic status<sup>10–13)</sup>. Sleep disturbances have also been shown to be related to the risk of cardiovascular events<sup>14)</sup>. The effects of noise on sleep may lead to stimulation of the sympathetic nervous system, with release of adrenaline, noradrenaline and cortisol<sup>15)</sup>. Individual differences are observed in the neuroendocrinological response to noise. The reported existence of a significant relationship between the arousal sound level and personality or subjective sensitivity to noise could explain these differences<sup>16, 17)</sup>. These changes might also be related to subjective illnesses and chronic diseases.

The peak level, differences between the peak and background levels, equivalent level (*Leq*), intermittency, duration, frequency of tone and meaning of noise are all related to sleep, and the intermittent high peaks of noise have more adverse effects on sleep than other factors<sup>18–20)</sup>. However, comparison of results is sometimes difficult because of the lack of standardization of noise exposure. A precise description of noise characteristics and an appropriate experimental design are recommended.

Laboratory experiments and field surveys are the two major approaches employed to determine the effects of noise on sleep. Field surveys are important to evaluate the practical environmental settings for sleep<sup>21, 22)</sup>. The greatest advantage of field research lies in the fact that

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since noise is a common environmental hazard, it is a simple approach to explore the effects of noise in everyday life. The disadvantage is that noise is ordinarily measured outdoors, and it is difficult to measure the level of the noise indoors, to which the residents are actually exposed. On the other hand, laboratory experiments allow both strict control of the sound level and objective evaluation of noise-induced sleep disturbances by polysomnography (PSG). It, however, represents an unusual situation for the respondents. The parameters analyzed by the two methods sometimes show large discrepancies, and respondents are more likely to be awakened from sleep in the laboratory setting than at home in response to the same sound pressure level<sup>23</sup>. On the other hand, the high level of annoyance found among respondents from noisy areas may be a factor underlying the sleep disturbances, besides other psychological and behavioral effects of noise.

Aircraft noise is concentrated around airports<sup>24-26</sup>, although the population at risk is relatively localized as compared with that exposed to road traffic noise. Horne *et al.* reported on the severity of sleep disturbance in the inhabitants around four UK airports and showed a significant association among the results of polysomnography, actigram-measured awakening and subjective surveys of sleep disturbances. However, there was no significant association between sleep disturbance and sound levels less than 82 dBA<sup>25</sup>. Field surveys of the effects of aircraft noise on sleep sometimes show controversial results. The definition of sleep disturbance varies, and multidimensional evaluation of sleep is, therefore, recommended.

Noise level in the room is important to evaluate sleep disturbances for the establishment of governmental policies. The environmental noise level is not directly related to the exposure level inside the home. Insulation techniques to protect against noise exposure are important to ensure good sleep. Exposure to noise in the daytime makes subsequent sleep worse<sup>27</sup>. The mechanism underlying the adverse effects of noise exposure before sleep on subsequent sleep is still unclear.

In this review, the author mainly reviewed the effects of road traffic noise on sleep.

### Habituation of Sleep to Noise

Habituation is an important factor influencing the effects of noise on sleep. Although some investigators claim exposure to road traffic noise does not result in habituation, recent studies have provided some evidence that it does occur. In these studies, habituation could be observed when subjective sleep parameters were taken into account; however, little or no evidence could be found based on polysomnographic, including EEG, sleep parameters<sup>28</sup>.

A precise review of the habituation of sleep to noise was reported previously<sup>29</sup>, and only limited additional information has been reported in the last decade.

Habituation may vary in individuals based on interindividual variations in the sensitivity to noise.

### Effects of Noise on REM Sleep

Poorer sleep quality and tiredness after sleep, which are important late effects of noise, have been reported previously<sup>30</sup>. They can be explained by the changes in the sleep stages, such as shortening of deep sleep and the rapid eye movement (REM) phase and prolongation of shallow sleep and the awake state<sup>31, 32</sup>. Poorer sleep quality and irritability in the morning have been reported in residents exposed to traffic noise or low frequency noise<sup>19</sup>. In addition, the duration of REM sleep in all-night sleep was decreased by noise exposure both in the experimental room setting and in a field study<sup>33, 34</sup>.

The stability of REM sleep against noise is partly explained by the fact that middle ear muscle activity increases during the REM stage. For example, the increase in the percentage of emerging middle ear muscle spikes is 0.3% during non-REM sleep, whereas that during REM sleep is 2.1% (unpublished data). Namely, the masking effect of noise by middle ear muscle activity, mediated by the REM sleep controlling nucleus in the pons, may minimize the effects of noise on sleep.

### Classification of Sleep Parameters and Insomnia Caused by Noise Exposure

Sleep can be evaluated by both subjective and objective parameters. There are many self-assessment tools for sleep, as it can be perceived from multiple dimensions<sup>35</sup>. Subjective sleep evaluation by self-assessment is conducted using two different approaches, global and elemental evaluations. Both evaluations are relatively perceived by subjects, and the latter evaluation is used to define insomnia. Not only physiological sleep parameters, but also subjective evaluation of sleep is important while examining the effects of noise on sleep.

Exposure to traffic noise during sleep also appears to be related to insomnia, and Kageyama *et al.* showed that the prevalence of insomnia was highest among inhabitants living closest to busy highways<sup>36</sup>. Jakovljevic *et al.* reported that sleep disturbances were significantly more frequent in urban populations exposed to traffic noise above 65 Leq dBA than in respondents living in quieter areas<sup>20</sup>. Personality, subjective noise sensitivity and noise annoyance were found to have a significant modifying effect on this relationship. Longitudinal studies conducted among urban residents of Gothenburg who were exposed to daytime traffic noise higher than 71.8 Leq dBA also showed greater difficulty in falling asleep, poorer sleep quality and a greater degree of tiredness after sleep (control noise level under 56 Leq dBA)<sup>30</sup>.

It must be noted with caution that the prevalence of sleep disturbance is related to not only the characteristics of the noise, but also the sensitivity of the subjects who

are exposed to the noise. The characteristics of the subjects in this context may be divided into physiological, psychological and social characteristics. In order to exclusively evaluate the prevalence of noise-related sleep disturbances and evaluate insomnia, corrections must be employed for many related environmental factors<sup>14, 37–39</sup>.

### Perspective of Noise, Sleep, and Health as a Conclusion

In the past, many studies have reported about the effects of noise on sleep. Sleep disturbance has been classified into delay of sleep onset or awakening from sleep in the middle of the night or early morning. Besides causing awakening, noise also makes the stages of sleep shallower, reducing the feeling of rejuvenation after sleep. The specifications of noise, such as the loudness, duration and pattern of change, is very important in clarifying the effects of noise on sleep. For example, intermittent noise has more adverse effects than continuous noise. The number of peaks affects the sleep to a greater degree than the average sound level expressed by the “equivalent sound level” (*Leq*). Furthermore, exposure to noise during sleep worsens the performance of subjects on the following day. Therefore, the effects of noise on sleep must be evaluated comprehensively using many indicators, including those measured during sleep, those measured a short time after sleep and those measured a long time after sleep. In occupational fields, the author recommends conduct of a survey on the association between noise and health with special emphasis on shift work, job stress and physical problems including sleep apnea and metabolic syndromes. Sleep is a fundamental and indispensable lifestyle factor, and good sleep definitely improves quality of working life.

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