Effects of Earplugs on Catecholamine and Cortisol Excretion in Noise-Exposed Textile Workers

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Abstract: To investigate physiological and psychological effects of industrial noise, a survey was performed on 50 female workers exposed to machinery noise [93-100 dB(A)] (noise group) and 25 female workers in less-noisy environments [71-75 dB(A)] (control group) in a textile factory in Vietnam. Urine was collected for analysis of catecholamines and cortisol. The subjects were also asked to fill out a questionnaire. Each subject was examined over 2 working days. The workers in the noise group were asked to put earplugs in their ears during the working hours of the 2nd day. On the 1st day without earplugs, urinary excretion of catecholamines in the noise group were greater than those in the control group. Cortisol in urine showed a similar tendency. Differences in catecholamine excretion between the noise group and the control group decreased on the 2nd day when the earplugs were used for attenuation of noise level in the noise group. Frequency of subjective fatigue symptoms was lower on the 2nd day than that on the 1st day in the noise group, while the control group showed almost no day-difference. The results indicate that the catecholamine response to noise in workers was reduced through the use of earplugs.

Key words: Noise — Earplugs — Textile workers — Adrenaline — Noradrenaline — Cortisol — Urine — Subjective fatigue symptoms

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INTRODUCTION

Modern technical improvement of industrial machinery has considerably decreased the physical burden of work. An unfavorable side-effect of this largely favorable development has been the generation of noise. Exposure to noise not only causes hearing loss but also disturbs attention and concentration resulting in irritability and disturbance in working life.

Since sympathetic adrenomedullary and pituitary adrenocortical systems are known to be activated in various stressful situations, it is expected that noise-induced stress responses are evaluated objectively by measuring catecholamines and cortisol in plasma and urine of workers. Although experimental studies have demonstrated almost no increases in these hormones in sedentary human subjects exposed to noise, a field survey conducted by Cavatorta et al. suggested enhanced activity of sympathetic adrenomedullary function in noise-exposed workers in a glass factory. To our knowledge, few other researches have been published concerning the effects of industrial noise on secretion of stress hormones in workers. The present study was designed to evaluate psychophysiological effects of industrial noise and examined urinary excretion of catecholamines and cortisol in noise-exposed workers and control workers during working hours. To elucidate the protective effects of hearing protection devices on these functions, the examination was also performed during working hours when the workers wore earplugs.

METHODS

Seventy-five female workers in a textile factory in Hanoi, Vietnam participated in this survey. About 1,100 people worked in the textile factory and more than one half of the workers were supposed to be exposed to machinery noise during working hours. Approximately 200 weaving machines were located on one floor of the plant and produced continuous, steady-state noise during operation. The sampling time for noise measurement was 10 to 15 seconds, and the noise level measured by the sound level meter (Rion NL-01A, Tokyo) according to Vietnam National Standard (TCVN3150-79), which corresponds with Recommendation of ISO (ISO R1996 and R1999), was 93–100 dB(A) at the positions of fabric rollers and thread rollers, where the workers operate usually machines. Fifty female workers in the noisy environments (noise group, 34.7 ± 0.9 years old) and 25 female workers at less-noisy worksites (control group, 30.8 ± 1.2 years old) were randomly selected for this field survey. They were engaged in 3-shift work and working hours were 6:00–14:00 in day shift, 14:00–22:00 in evening shift and 22:00–6:00 in night shift. Each shift, in this turn, continued 2 to 4 consecutive days in one shift cycle, followed by 1 or 2 days off. The job of the noise group was operation and maintenance of weaving machines, and they had been exposed...
to the machinery noise for 5 years or more. The subjects in the control group worked in less noisy conditions [71–75 dB(A) at the 5 points examined], inspecting the textile products for quality control. For each subject, the study was performed over 2 working days of the day shift.

On Day 1, the workers were asked to void their bladders completely at 11:00. At 14:00, urine was collected. The questionnaire on subjective fatigue of ‘drowsiness and dullness’, ‘difficulty in concentration’ and ‘projection of physical disintegration’ (Japan Association of Industrial Health; translated into Vietnamese6) was filled out by the workers right after urine collection. The same procedure was done on Day 2. The workers in the noise group were instructed to put earplugs (3M, model 1110, Noise Reduction Rating = 29 dB) in their ears for attenuation of noise level during working hours. Urine samples were acidified with hydrochloric acid immediately after collection and stored at -20°C until analysis. Pulse rate in 12 subjects of the noise group was recorded using a pulsimeter (Sports tester PE-2000, Polar Electro Co., Finland) on Days 1 and 2.

Free catecholamines and cortisol in urine were analyzed by the methods described previously6. Urinary excretion rate is expressed as pmol/min/kg of body weight. Data is presented as mean ± s.e.m. Statistical significance was determined by student’s t-test or paired t-test and ANOVA. Differences of p < 0.05 are considered significant.

RESULTS

Urinary excretion of catecholamines and cortisol in noise-exposed workers with or without earplugs

Urinary excretion of catecholamines and cortisol in the noise group and the control group during the 2 working days is shown in Fig. 1. On Day 1, adrenaline, noradrenaline and dopamine excretion was significantly higher in the noise group than that in the control group. Cortisol in urine also showed a tendency to increase in the noise group compared to that in the control group. Differences in urinary excretion of these hormones between the two groups were generally suppressed on Day 2 when the noise workers wore earplugs. The hormone levels on Day 2 were also reduced compared to those on Day 1 in the noise group, whereas the levels in the control group were substantially the same between Days 1 and 2. On Day 2, however, there was still recognized a significant increase in noradrenaline excretion in the noise group compared with the control group.

Pulse rate in noise-exposed workers with or without earplugs

Mean pulse rate every 30 minutes during working hours in 12 subjects of the noise group is shown in Fig. 2. The pulse rate during the first 30 minutes on Day 1 was about 15 b/min higher than that on Day 2 when earplugs were used. Pulse rate seemed to decrease with passage of time during working hours, but the
Fig. 1. Urinary excretion of catecholamines and cortisol in noise-exposed workers with and without earplugs.

** p < 0.01, * p < 0.05 for Day 1 vs. Day 2
The difference between Day 1 without earplugs and Day 2 with earplugs was still significant in the last 30 minutes of work.

As stated above, earplugs also reduced adrenaline and noradrenaline excretion in noise-exposed workers compared to Day 1 with no earplugs. Correlation coefficient between pulse rate and catecholamine excretion for all 24 measurements was 0.546 (p < 0.01) for noradrenaline and 0.465 (p < 0.05) for adrenaline, suggesting the physiological significance of catecholamine secretion in noise-induced pulse rate increases.

Frequency of subjective fatigue symptoms in noise-exposed workers

Frequency of subjective fatigue symptoms is listed in Table 1. The frequency of ‘drowsiness and dullness’ and ‘difficulty in concentration’ in the noise group showed a significant decrease on Day 2 compared with Day 1, whereas no day-difference was observed in the control group, except for an increase in the score of ‘drowsiness & dullness’ on Day 2. There was no group difference in the occurrence of symptoms of ‘drowsiness and dullness’ and ‘difficulty in concentration’ on Day 1. The frequency of ‘projection of physical disintegration’, however, tends to be higher in the noise group than that in the control group, both on Day 1 and 2. The frequency of this symptom in the noise group was significantly lower in Day 2 than that in Day 1, whereas, in the control group, the difference between days was not significant.
Table 1. Frequency of subjective fatigue symptoms in noise-exposed workers with and without earplugs.

<table>
<thead>
<tr>
<th></th>
<th>Day 1</th>
<th>Day 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Noise group</td>
<td>Control group</td>
</tr>
<tr>
<td>Average of categories I, II, and III</td>
<td>59.1 ± 3.0</td>
<td>55.7 ± 5.2</td>
</tr>
<tr>
<td>I: Drowsiness and dullness</td>
<td>62.4 ± 3.3</td>
<td>58.8 ± 5.5</td>
</tr>
<tr>
<td>II: Difficulty in concentration</td>
<td>49.6 ± 4.1</td>
<td>54.4 ± 6.2</td>
</tr>
<tr>
<td>III: Projection of physical disintegration</td>
<td>65.2 ± 3.1</td>
<td>54.0 ± 5.3</td>
</tr>
</tbody>
</table>

Data are mean ± s.e.m. of number (%) of answer 'yes' to questions in each category (I, II, or III).

**: p < 0.01, *: p < 0.05 for Day 1 vs. Day 2

All workers in the noise group answered that earplugs were effective against the noise. However, 29 noise-exposed workers (58%) responded that the earplugs were uncomfortable because of ear pain, large size, ill-fit, and so on.

DISCUSSION

The present study demonstrated that textile workers exposed to machinery noise above 93 dB(A) showed increases in urinary excretion of noradrenaline, adrenaline, and dopamine during working hours, compared with workers in less-noisy environments. The results were almost consistent with the findings of Cavatorta et al.4 who examined catecholamine levels in serum of two groups of workers in high noise levels (> 90 dB(A)) and low noise levels (< 78 dB(A)) in a glass factory. The authors demonstrated that adrenaline and noradrenaline levels at mid-shift were greater than the levels before the shift, whereas the work-related increases in catecholamine levels were not observed in the control group. Ortiz et al.1 also reported that catecholamine excretion in the majority of workers exposed to turbine noise (105–115 dB) in an aircraft factory was increased compared with the levels under baseline conditions before work.

It is likely that experimental studies on the effects of noise in human subjects, even in the case of 100 dB(C) noise, fail to confirm noise-induced stress responses which is rather evident in experimental animals. Most of these studies have dealt with physiological functions in the subjects exposed to only noise, but not with simultaneous exposure to noise and mental work. Brandenberger et al.5 noted that noise in combination with mental tasks produced an increase in cortisol in plasma, which is compatible with the results of our recent experiments on urinary cortisol excretion. Breier et al.10 pointed out that uncontrollable noise has a greater effect on adrenaline excretion than controllable noise. In industrial fields, the workers are generally exposed to noise while performing their jobs including mental...
tasks, and they must be unable to control noise occurrence. It is assumed that industrial noise produces much more serious effects than those presumed from the results of experimental studies.

Catecholamines in blood and urine have been accepted as useful indices of sympathetic adrenomedullary system in men and animals, and generally used in physiological studies on stress\(^2\). Noise-induced increases in urinary excretion of catecholamines observed in the present survey suggest that industrial noise possibly causes enhanced activity of sympathetic adrenomedullary functions, which is probably responsible for stress-related ill health such as high blood pressure, cardiac complaints and gastric ulcers. Some researchers\(^1,12\) have pointed out relationship between noise and occurrence of hypertension in industrial workers.

To protect workers from noise-related health problems, the use of hearing protection devices has been recommended for many years. The protective effect of earplugs and earmuffs against hearing loss is well-documented\(^1,13\). Additionally, the present study demonstrates that hearing protection will reduce noise-induced stress responses. However, disadvantages of the protective devices, such as discomfort, difficulty in communicating orally, and the loss of the ability to perceive warning signals and machinery malfunctions have been reported\(^13\). The workers in the present survey also stated that earplugs were not comfortable because of ear pain, large size and ill-fit. Development of comfortable hearing protectors is necessary, as well as technical improvement for silent industrial machines.

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**REFERENCES**