Noise-induced hearing loss is a common occupational disease among workers exposed to noise in the workplace. According to the results of a regular health checkup in Japan in 2004, some 8.4% of the one million people who took the test had hearing loss of ≥20 dB on a hearing test at 4,000 Hz. The Japanese Ministry of Health, Labour and Welfare formulated “Guidelines for Noise Control” (No. 546, October 1, 2002) and has promoted hearing protection in workers exposed to noise at work. Wearing noise protection devices is an important measure that individuals can take to prevent noise-induced hearing loss. Two major issues in the prevention of hearing loss with noise protection devices are to increase the wearing rate of those devices in the workplace and to make sure they are used in an effective way. In Japan, even after workers receive noise protection education, little effect is reported in terms of an increased usage rate of noise protectors\(^1,\)\(^2\). Recently, Ariyoshi (2007) reported that the rate of wearing earplugs was 57% among noise-exposed workers\(^3\). Similar findings are also reported in other countries\(^4,\)\(^5\). With regard to the proper use, Ito \textit{et al.} (1994) reported that in many cases earplugs were improperly used\(^6\). Miyauchi \textit{et al.} (2000) reported that 29% of workers did not wear the earplugs correctly\(^7\). Toivonen \textit{et al.} (2002) also showed that 28% of subjects in an untrained group wore ear plugs improperly\(^8\). More training is reportedly required to wear earplugs properly than to wear earmuff\(^9\).

To encourage workers to wear hearing protection devices properly, some earlier studies suggest that it may be effective to educate them to understand the importance of properly wearing such devices by quantitatively show-

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**A Trail of Individual Education for Hearing Protection with an Instrument that Measures the Noise Attenuation Effect of Wearing Earplugs**

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Received February 11, 2008 and accepted April 18, 2008

Abstract: The aim of this study was to investigate the effect of individual training of workers, using an instrument to quantitatively evaluate the noise attenuation gained with the use of earplugs, on the efforts to promote the use of hearing protection devices. The subjects were 68 male workers exposed to noise of above 80 dBA at an electronic parts manufacturer in Japan. They received group instruction on the prevention of noise-induced hearing loss, and individual education on the effect of the proper use of earplugs. The individual education was done with the use of an instrument that measures the noise attenuation effect of wearing earplugs. After the training, the prevalence of the regular use of hearing protectors increased. Among workers in loud working environments, it increased from 46% to 66% over two months after the training. The percentage of workers who obtained a sufficient noise attenuation effect of ≥25 dB in both ears with the proper use of earplugs also increased, from 46% before the training to 72% immediately afterward. These effects were still observed about two months after the intervention. The results suggest that the present individual training may be an effective means to increase both the usage rate and the proper use of hearing protection devices, perhaps because it deepens individuals’ understanding of the effect of the proper use of such devices.

Key words: Noise, Hearing loss, Hearing protection device, Education
ing the noise attenuation effect of the use of earplugs\textsuperscript{7, 8, 10}. If workers understand the level of the noise attenuation of wearing earplugs, it may raise their awareness of wearing earplugs. Hence, in the present study, we conducted group instruction on the prevention of noise-induced hearing loss, plus individual training using an instrument to quantitatively evaluate the noise attenuation gained with the use of earplugs, and then investigated the effect on both the usage rate and the proper use of hearing protection devices over about two months after the intervention.

The present study targeted all 76 male workers (mean age 35.5 (SD; 9.1) yr) exposed to noise of more than $L_{Aeq}$\textsuperscript{8} 80 dB (equivalent continuous A-weighted sound pressure level) in the workplaces of an electrical equipment parts manufacturing plant in Aichi Prefecture, Japan. Of them, 68 male workers (mean age 35.5 (9.6) yr) consented to participate in this study, which had been approved by the ethics committee of the Nagoya University School of Medicine. Their job duties were assembly and machining (31 participants; 46%), operating a molding press (26 participants; 38%), and other jobs (11 participants; 16%). In a hearing test conducted in August 2004, no one was diagnosed with noise-induced hearing loss.

In May 2004, the 68 subjects received group instruction on the prevention of noise-induced hearing loss for about two hours. Before the group education, a pre-education questionnaire survey was conducted on the status of earplug use. In June, individual instruction was given to each worker, using an instrument (earplug checker AG-20A, Rion Co., Ltd.) to measure the actual noise attenuation effect from using earplugs. In August, a post-education questionnaire survey was conducted, and the noise attenuation effect was measured again using the earplug checker to confirm whether earplugs were being worn properly.

A self-administered questionnaire survey was conducted twice in May before the group education and in August after the group and individual education. The questionnaire included items on age, smoking status, alcohol consumption, past and present ear disease, exposure to noise outside work such as shooting guns, subjective symptoms such as difficulty in hearing and ringing in the ear, work content, noise in the work environment, use of earplugs, and frequency of earplug replacement.

The earplug checker measurements were conducted three times: before and just after the individual training in June, and again in August. In the earplug checker measurements, firstly headphones were fitted over the naked ears, and the “start test” button (without earplugs) was pressed. The subject continuously pressed the “response” button as long as he could hear the test sound (pure tone at 2,000 Hz with interruption period of 0.5 s) from internal speakers in the headphones, and released the button when he could no longer hear the sound. Secondly, the headphones were placed over the ears of subjects who wore earplugs (conforming to JIS T8161 EP1), the “start test” button (with earplugs) was pressed, and the hearing threshold was measured. After the measurements were completed, the difference in hearing thresholds with and without earplugs was automatically calculated for the right and left ears, and expressed as the earplug noise attenuation value. The measurements were made by a trained examiner in a quiet room with background noise of less than $L_{Aeq}$ 45 dB, using a sound level meter (NA-29, Rion Co., Ltd.). They were conducted more than one and a half hours after cessation of exposure to noise at work.

The earplug usage rate and the frequency of earplug use before and after education were compared using the Wilcoxon matched-pairs signed-rank test. The mean noise attenuation values in the earplug checker measurements were analyzed using a paired $t$-test to compare the values before the individual training in June with those just after the education and at the time of the August measurements. The McNemar test was used in comparing the proper wearing rate (above 25 dB of noise attenuation). All statistical analyses were made using the JMP 6.0 (SAS Institute).

As shown in Table 1, the number of people who almost always used earplugs increased from 38 (56%) in May before the group instruction to 43 (63%) in August after the training, while the number of people who almost never used earplugs had decreased from 13 (19%) to 6 (9%) in this period ($p<0.01$). Among the 35 subjects who

![Table 1. Frequency of earplug use before and after noise protection training by subjective noise level in workplace](image_url)

<table>
<thead>
<tr>
<th>Subjective noise level in workplace</th>
<th>Before training (in May)</th>
<th>After training (in August)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total (n=68)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Almost always use</td>
<td>38 (56)</td>
<td>43 (63)$^b$</td>
</tr>
<tr>
<td>Sometimes use</td>
<td>17 (25)</td>
<td>19 (28)</td>
</tr>
<tr>
<td>Almost never use</td>
<td>13 (19)</td>
<td>6 (9)</td>
</tr>
</tbody>
</table>

$p<0.05$, $^b p<0.01$; Wilcoxon matched-paired signed-rank test between before and after training.
responded “conversation possible by speaking loudly” for the subjective noise level in the workplace, the number of people who almost always used earplugs had increased from 16 (46%) to 23 (66%) over the period ($p<0.05$). The reasons why the six people almost never used earplugs in the August survey were that they needed to hear sounds carefully when making dies and when adjusting machinery.

The noise attenuation value measured in June using the earplug checker significantly improved from 25.2 (SD 9.0) dB to 29.6 (5.8) dB for the right ear ($p<0.001$), and from 25.4 (8.2) dB to 29.8 (6.0) dB for the left ear ($p<0.001$), before and just after the individual training (Table 2). Improved values were also observed in the August measurement: 28.7 (7.7) dB for the right ear ($p<0.01$) and 28.3 (7.1) dB for the left ear ($p<0.01$), compared with the value before the training in June.

A sufficient noise attenuation effect of ≥25 dB was encountered in 57% of right ears, 56% of left ears, and 46% of both ears before the individual education in June (Table 3). Immediately after the training, sufficient noise attenuation effect was found in 80% or more of either the right ($p<0.001$) or left ear ($p<0.001$), and in 72% of both ears ($p<0.001$). Compared with the pre-education measurements in June, the August measurements showed that noise attenuation of ≥25 dB was seen in 74% of the left ears and 62% of both ears ($p<0.05$), but there was no significant difference in the right ear (71%).

Table 2. Noise attenuation value (dB) measured with the earplug checker before and after individual training on the proper way of wearing earplugs

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Right ear mean (SD)</th>
<th>Left ear mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before training (in June)</td>
<td>25.2 (9.0)</td>
<td>25.4 (8.2)</td>
</tr>
<tr>
<td>Just after training (in June)</td>
<td>29.6 (5.8)</td>
<td>29.8 (6.0)</td>
</tr>
<tr>
<td>After training (in August)</td>
<td>28.7 (7.7)</td>
<td>28.3 (7.1)</td>
</tr>
</tbody>
</table>

*p<0.001, b p<0.01; paired t-test compared with value before June training. n=68.

Table 3. Number of subjects who achieved a sufficient noise attenuation effect of ≥25 dB or more before and after individual training on the proper way of wearing earplugs

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Right ear n (%)</th>
<th>Left ear n (%)</th>
<th>Both ears n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before training (in June)</td>
<td>39 (57)</td>
<td>38 (56)</td>
<td>31 (46)</td>
</tr>
<tr>
<td>Just after training (in June)</td>
<td>57 (84)</td>
<td>55 (81)</td>
<td>49 (72)</td>
</tr>
<tr>
<td>After training (in August)</td>
<td>48 (71)</td>
<td>50 (74)</td>
<td>42 (62)</td>
</tr>
</tbody>
</table>

*p<0.001, b p<0.05; Wilcoxon matched-paired signed-rank test compared with number before June training. n=68.

Of the 62 subjects who used earplugs in the August survey, 39 (63%) had changed the way they wore earplugs after the individual training (Table 4). They had a relatively poor noise attenuation value in earplug checker measurements before the training, and a significantly improved noise attenuation value immediately after the training in June ($p<0.001$) and at the time of the survey in August ($p<0.01$). The 23 subjects who did not change had rather good noise attenuation values even before the training, and there was no significant difference in noise attenuation value over the study period.

The present intervention to promote the use of hearing protection devices resulted in an increase in the regular earplug usage rate from 56% to 63%, and a decrease in the non-use rate from 19% to 9% over about two months after individual training. Greater improvements in the earplug usage rate (46% to 66%) were shown in noisy workplaces where workers could only converse by speaking loudly. The rate of proper earplug use, judged from a sufficient noise attenuation effect of ≥25 dB in both ears, had improved from 46% of workers before the training in June to 72% immediately after the training and to 62% two months after the training. Thus, the present individual noise protection training using an earplug checker was shown to be effective in increasing both the wearing rate and the proper use of hearing protection devices.

In the individual training, an instrument (earplug checker AG-20A) was used to measure the noise attenuation effect of wearing earplugs. Miyachi et al. (2000) used an earplug checker to train workers on the proper use of earplugs, and reported that this training was effective among 17 workers7). Similarly, using an apparatus of the same kind, Toivonen et al. (2002) showed that the noise attenuation attained with the use of earplugs was improved by training in the proper insertion of earplugs8). Williams (2005) and Joseph (2007) reported similar findings10, 11). Earplug checkers and similar instruments can
show the level of noise attenuation from wearing earplugs, so which helps people to understand the effect of wearing earplugs. The interventions in these earlier reports were originally intended to teach proper earplug use as experimental trials with few subjects. The present study, conducted as a field study, suggested that the individual training with such instruments can be practically effective in increasing both the usage rate and the proper use of hearing protection devices.

The present study was conducted with a small number of subjects \((n=68)\) in a workplace with a noise level of above \(L_{A,eq} 80\) dB, which is a relatively low noise environment. The evaluation of the training was done over a short period of about two months, because of subject transfers to other positions in the plant. Finally, a control group without the individual training was not established. Further studies are needed to determine whether the entire effect seen in this study can be attributed to the present training.

References


