Estimate of the Percent Reduction of the Workers Hearing Loss by Doing a Training Intervention Based on BASNEF Pattern

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If we want to provide the efficient training intervention to increase the duration of using hearing protection devices (HPDs) by workers, we need a tool that can estimate the person’s hearing threshold taking into account noise exposure level, age, and work history, and compare them with audiometry to find out the percent reduction of workers hearing loss.

First, the workers noise exposure level was determined according to ISO 9612, then 4000 Hz audiometry was done to find age and work history. On basis of ISO 1999 the hearing threshold was estimated and if the hearing protection device was not used continuously and correctly, the hearing protection device’s actual performance was reduced adjusted with person’s audiometry. After training intervention, the estimate was done again and was compared with the adjusted audiometry.

According to ISO 1999 standard estimation results, the percent reduction of the workers hearing loss level was 6.48 dB in intervention group. This level remained unchanged in control group. The mean score of hearing threshold estimation (standard ISO 1999) was statistically more significant than mean score of hearing threshold (p-value ≤ 0.001). The results show not significant change in control group due to lack of changing of noise exposure level.

In regards to the results of hearing threshold estimation based on ISO 1999 and comparing with workers audiometry, it can be seen that BASNEF training intervention increases the duration of using the HPDs and it could be effective in reducing hearing threshold related to noise.

Keywords: hearing loss; hearing protective devices; ISO 1999; BASNEF.

1. Introduction

Noise is one of the most common causes of hearing loss in the industries, and noise induced hearing loss (NIHL) is one of the most commonly reported occupational diseases (Lie et al., 2016). In a study conducted on workers exposed to non-permissible noises, it was found that these sounds lead to decreased job perfor-
mance and safety of people, interfere in conversation, fatigue and stress, and the using of hearing protective devices (HPDs) reduces these effects (Morata et al., 2005). In various studies, the relationship between the hearing Standard Threshold Shift (STS) with the time of using HPDs in each ear has been proved (Melamed et al., 1996; Rabinowitz, 2000; Toppila, 2000; Ologe et al., 2005; Pourabdiyan et al., 2009). Occupational hearing loss due to noise is completely preventable and using the hearing protection devices is one of the noise exposure control methods (Choobine, Amirzadeh, 2003). The last way of controlling noise is using HPDs (Monazzam et al., 2016). Obviously, if the hearing protection device is not used continuously and correctly, the hearing protection device’s actual performance will be reduced, for example, according to Fig. 1, if a HPD with an Noise Reduction Rate (NRR) of 20 dB is not worn for just 15 minute in an 8 hours’ work shift, its effective NRR is reduced by 5 dB (time Corrected NRR would be only 20 dB) (Else, 1973; Berger, 1983).

Knowing the duration of using the hearing protection device is surely affective on hearing protection programme (Williams, 2009). Therefore, needs for a comprehensive review is essential. According to the Occupational Health and Safety (OHS) Act, all employers are required to provide employees with proper PPE as required by the Act and monitor the employees’ use of PPE ((OHS) October 2011, revised June 2014). The important thing is how the employer trains workers (3071 2002). If workers are just familiar with how to use the HPD and being forced into using it (by motivation and punishment); the question arises whether the workers willingly use their HPDs appropriately and all the time when they are exposed to encounter the unallowable noise. According to studies, the training program is considered as a prevention strategy on occupational health and safety learn that enhances workers use of PPE (Cohen et al., 1998; Ologe et al., 2005). Education and training can be used as a method to increase of compliance (Hon et al., 2008; Gershon et al., 2009; Verbeek et al., 2016). Insufficient training on the correct techniques of the HPDs usage, and lack of motivation have been reported as the other causes of irregular use of the HPDs in the workplace with dangerous level of noise (Ologe et al., 2005). Educational theories and models can help researchers to pay attention to the most suitable areas for changing behaviour (Saghafi pour et al., 2017). One of the useful models in health education is beliefs, attitudes, subjective norms and enabling factors (BASNEF) model (Salehi et al., 2004). This model focuses on the impact of knowledge and attitude on behaviour, and is assisted by other factors such as enabling factors and subjective norms. The aim of this study was to evaluate the effectiveness of BASNEF training course on increasing the time that workers use HPDs, using the method of estimating the reduction of prevalence of hearing loss based on ISO 1999:2013 method: “Acoustics – Estimation of noise-induced hearing loss, International Organization for Standardization (ISO)” (ISO 1999:2013). The ISO published the relationship between noise exposure and noise induced permanent threshold shift (NIPTS) that allows to compare hearing status of subjects of different age and noise exposure (ISO 1999:2013). The ISO 1999 model uses four parameters: gender, age, duration of employment and noise exposure level (ISO 1999:2013).

2. Methodology

In this cross-sectional study, the research population includes workers in the tile industry based on this Eq. (1) \(a = 95\%, \, P = 80\%, \, Z = 1.96\)

\[
n = \left(\frac{Z_{1-\alpha} + Z_{1-\beta}}{d}\right)^2. \tag{1}
\]

A total of 100 workers (50 in intervention and 50 in control group) were selected from employees of these units as the sample group. Inclusion criteria were exposure to occupational noise, at least 1 year of exposure to noise and no history of ear diseases, no co-exposure to noise and chemical materials. Exclusion criteria included the history of head injury or otologic surgery and family history of hearing loss. First, the noise exposure of workers was determined according to the dosimetry based on standard
No. ISO 9612 (MONAZZAM ESMAEILPOUR et al., 2017; ISO 9612:2009). In the next stage, the demographic information like age and experience were collected. For determining the threshold, audiometry test for each of the cases and controls were carried out, and after collecting the information of the audiogram, hearing threshold level (HTL) was recorded at a frequency of 4000 Hz. To estimate the HTL associated with age and noise, ISO 1999:2013 method was used. So that first hearing threshold level associated with age (HTLA) was calculated in accordance with the ISO 1999:2013 method (Table 1) for each employee according to their age and at the frequency of 4000 Hz (ISO 1999:2013).

Table 1. HTLA from ISO-1999 (2013), Table A.3 (database A).

<table>
<thead>
<tr>
<th>Frequency [Hz]</th>
<th>Age [year]</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>30  40  50  60</td>
</tr>
<tr>
<td>1000</td>
<td>1   2   4   6</td>
</tr>
<tr>
<td>2000</td>
<td>1   2   3   7</td>
</tr>
<tr>
<td>3000</td>
<td>2   6   12  20</td>
</tr>
<tr>
<td>4000</td>
<td>2   8   16  28</td>
</tr>
<tr>
<td>6000</td>
<td>3   9   18  32</td>
</tr>
<tr>
<td>8000</td>
<td>3   11  23  39</td>
</tr>
</tbody>
</table>

At the next stage, the noise-induced permanent threshold shift (NIPTS) was calculated in accordance with the ISO 1999:2013 method (Table 2) for each employee according to the duration of noise exposure (work experience) for frequencies (4000 Hz) (ISO 1999:2013). Also to get the level of noise exposure, the ISO 9612 standard, was used according to the duration of using the HPD.

Table 2. NIPTS from ISO-1999 (2013), Table D.1 and D.2.

<table>
<thead>
<tr>
<th>Exposure time [year]</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEX, 8hr [dB]</td>
<td>90</td>
<td>85</td>
<td>85</td>
<td>90</td>
</tr>
<tr>
<td>500</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2000</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>3000</td>
<td>8</td>
<td>3</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>4000</td>
<td>11</td>
<td>5</td>
<td>13</td>
<td>6</td>
</tr>
<tr>
<td>6000</td>
<td>7</td>
<td>3</td>
<td>8</td>
<td>3</td>
</tr>
</tbody>
</table>

The calculations of the age-related hearing threshold level (HTLA) were taken into reference population (database A) and the mean values of the change of the noise threshold constant (NIPTS) according to ISO 1999 (Eq. (2)). In the next stage, by using the Eq. (2) the hearing threshold level associated with age and noise (HTLAN) was estimated for each of the individuals in two groups in the frequency of 4000 Hz

\[
\text{HTLAN} = \text{HTLA} + \text{NIPTS} - \frac{\text{HTLA} \cdot \text{NIPTS}}{120} \quad [\text{dB}] \quad (2)
\]

HTLAN is the hearing threshold level, associated with age and noise, expressed in decibels [dB]; HTLA is the hearing threshold level, associated with age, expressed in decibels [dB]; NIPTS is the actual or potential noise-induced permanent threshold shift (PTS), expressed in decibels [dB].

The expression \((\text{HTLA} \cdot \text{NIPTS})/120\) starts to modify the result significantly only when HTLA + NIPTS is greater than 40 dB. Finally, with regard to age, work experience and exposure to noise, the threshold of hearing (audiometry) of each person in the frequency 4000 Hz was compared with ISO 1999:2013 method for validation. The difference \((\Delta)\) between actual individual measured HTL \((\text{HTL}_m)\) and standard HTL \((\text{HTL}_s)\) in the population of the same age and noise exposure is a measurement describing the state of the auditory system of a given person. The delta is expressed by subtracting \(\text{HTL}_s\) from \(\text{HTL}_m\).

\[
\Delta = \text{HTL}_m - \text{HTL}_s \quad [\text{dB}]. \quad (3)
\]

After the intervention, to assess the reduction of prevalence of hearing loss in the intervention group, the estimation is run again based on the age and work experience of people by considering reduced exposure to noise based on the standard; then we compare it with audiometric test results to estimate the effect of using HPDs in hearing loss. Educational intervention was performed in six sessions (practical-theoretical), each held once a week for 30 to 45 minutes (six weeks long) (KHAN et al., 2018). Also, additional educational training such as texting, face to face training in the workplace and design of posters were done. All classes were held based on the BASNEF model in terms of knowledge, personal attitude and enabling factors; behavioural intention, planning, and design performance with appropriate training methods (lectures, practical displays, videos, providing pamphlets). The workers of control group have not received any training in this study. In this study, the BASNEF intervention was used to increase workers’ awareness about the sound and change their attitude towards the use of HPDs and provide the enabling factors such as knowledge about harmful noise and HPDs and access to them, as well as involving the occupational physician and head of the unit, so that workers who are exposed to excessive noise use protection headset throughout their shift. Data related to estimating the level of HTL using SPSS 19 was compared before and after intervention using UNIANOVA procedure. The \(\chi^2\) testing was again used to look for a difference in diversity scores between the HTL\(_m\) and HTL\(_s\) groups. The standard
criterion for statistical significance for all tests was set at a $p = 0.05$.

3. Results

The study involved 100 workers in tile industry, 50 cases and 50 controls, aged 21–50 years, (mean 30.30 ± 4.27 years). Duration of exposure to noise ranged from 1 to 18 years (mean 10.12 ± 2.96 years).

The results of measuring noise exposure of workers in conformance with ISO 9612 and the time of using the HPDs are presented in Table 3. According to Table 3, it is obvious that before the intervention the time of using HPDs in both groups was 0.5 hour, and the noise exposure was 89 dBA. Also, after the intervention the time of using HPDs was increased in intervention group, the noise exposure was 80 dBA, and for the control group that had not received treatment the same amount of time spent on the HPD was found as 89 dBA (Table 4).

In order to estimate the threshold of the hearing before increased duration of use of the HPD in the intervention and control groups, HTLAN for both groups is presented in Table 4.

The results show that according to audiometric measures, HTL at the frequency of 4000 Hz was obtained about 21.20 dB for the intervention group and 20.30 dB for the control group (Table 3). In order to estimate HTL after increased duration of HPD use in the intervention and control groups, HTLAN for both groups is shown in Table 4. The Daily Exposure Measurement (LEX, 8h) was modified to use HPDs according to the previous study (Monazzam Esmaeipour et al., 2017).

After reducing exposure to noise, HTL estimation results (standard and adjust) were about 14.72 dB and 19.30 dB for the intervention and control groups, respectively. To compare the two groups HTL in the frequency of 4000 Hz was used and its results are presented in Table 5.

Results in Table 5 show that the average score of estimating the threshold of hearing (standard unit) in the intervention group was statistically significant compared to the mean threshold of hearing (audio-
occupational physician was asked to train workers in


to explain the importance of education to workers. The


previous years and explain the loss of hearing progress to


neural guards, that can be achieved with proper plan-


ning. Since estimation of hearing threshold using


BASNEF educational intervention was carried out in


short time, longer duration study in future is recom-


mended.

5. Conclusion

The results showed that increasing the using dura-


tion of hearing protection device had significant effect


on increasing the performance of protective devices.


Also as the duration of using the hearing protection
device increases, hearing threshold shift remains con-


stant. All of these positive results were achieved by


BASNEF training intervention.

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terms the harmful noise side effects and occupational
defauness steps. Health professionals were also asked to

teach the types of HPDs, how to use them properly and
testing them in terms of being fit, and maintenance and

cleaning of headsets. One of the workers (colleagues)


that almost entirely used the HPDs was asked to speak


of the advantages of the HPD. Also, the enabling fac-
tors such as time, cost, training facilities and access to


HPDs, that is another component of BASNEF model,


helped us in the training. The four parameters of BAS-


NEF model (knowledge, attitude, influential individu-


als, enabling factors) lead to behavioural intention and


finally behaviour, i.e. using the HPDs in a full time


manner. Since estimation of hearing threshold using


BASNEF educational intervention was carried out in
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