Correlation between Vibration Induced White Finger and Hearing Loss in Miners

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Abstract: Correlation between Vibration Induced White Finger and Hearing Loss in Miners: Szanto Cs., et al. Institute of Public Health Cluj-Napoca, Romania—In the present investigation age and duration of exposure to vibration and noise were matched with the intention to confirm the earlier reported difference in hearing threshold loss in miners with vibration-induced white finger (VWF) and those without VWF. The case-referent study comprised 264 miners without VWF and 84 miners with VWF. Out of the two groups were selected 65 pairs, having the same duration of exposure to vibration and noise (in years) and a maximal difference in age of 2 yr. The diagnosis of VWF was made after cold provocation at 10°C for 10 min, when the clinical sign appeared: whitening of the fingers. The values for acceleration of vibration and noise intensity exceeded the permissible level, when taking measurements for P-90 type pneumatic hammers used in miners. The mean hearing threshold level (HTL) was typical for hearing loss induced by noise, reaching the highest value at 6 kHz both in the case- and in the reference group. The HTL were lower in those suffering from VWF than without VWF, for all the frequencies, but significant differences exist only for 4, 6 and 8 kHz. The mean recovery rate (RR) for the skin temperature tested at the fingertips after 5, 10 and 15 min indicated significantly high values in the reference versus cases. The subjects were divided into three groups by RR of skin temperature 5 min after cold provocation. The miners having a smaller RR (<0.25) had the lowest HTL; but the subjects with a prompt RR (>0.90) had hearing thresholds significantly better at 4, 6 and 8 kHz. For the group with VWF a medium range correlation between HTL loss and duration of exposure to vibration at all frequencies was found. The same calculations for the reference group did not indicate a significant correlation. The effects of vibration in miners can appear in the hearing organ, far from the part of the body through which this risk factor enters (the hand/arm). The correlation between VWF and hearing loss is directly related to the duration of exposure.

(J Occup Health 1999; 41: 232–237)

Key words: Vibration exposure, VWF, Hearing loss, Correlation

Miners using pneumatic hammers are exposed to the risk of both vibration syndrome and noise induced hearing loss1 Iki et al.2 in their matched pair case-referent study reported that lumberjacks with a history of vibration induced white finger (VWF) had a hearing loss at 4 and 8 kHz that was about 10 dB greater than that of lumberjacks without a history of VWF, both groups were matched to the same five-year age group and their operating hours for vibrating tools were almost equal. They suggested that the extra hearing loss was based on sympathetic vasoconstriction induced by local vibration not only in fingers but also in the inner ear. This hypothesis is interesting because the increased hearing loss is developing far (hearing organ) from the hand-arm. The process of establishing an association between VWF and hearing loss must be made unconfoundable with age and exposure to noise, by simultaneously elimination.

Growing characteristics of fingertip skin temperature after cold provocation test are known to represent the digital circulatory function and are used as objective criteria for VWF in our country3–5). The present investigation is a more precise matched pair case-referent study with the intention of confirming the earlier reported association between VWF and hearing loss.

Method

The study comprised 264 miners without VWF and 84 miners with VWF who had no history of ear disease, vertigo, head injury or drugs liable to cause hearing affections. Sixty-five case-referent pairs were selected out of two groups having the same duration of exposure to vibration and noise (in years) and a maximal difference in age of 2 yr. In the audiometric examination pure tone air and the bone conduction hearing level were measured.
at frequencies of 0.5 1 2 3 4 6 and 8 kHz in 5 dB steps, in conformation of the international standard⁶, with a clinical audiometer Pracitronic type MA-30. Each subject was free from the professional noise exposure for at least 18 h before the audiometric examination. The air conduction hearing level of the left ear was analyzed. The diagnosis of VWF was based on the visualized attack after the cold provocation test. The skin temperature was measured on both hands and all fingertips, with a Klinsk (Soviet Union) type Temp 60 contact thermometer. The cold provocation test was done by immersing the hands and arms (including the elbow and without contact between the hands) in cold water at 9–9.5°C at the beginning of the test³,⁶) and not exceeding 10°C at the end of it. The duration of the test was 10 min. The subject had the upper part of the body (arms, thorax) undressed. The room temperature was 20–22°C. It is very important to mention that the miners examined worked in cold mines where the air temperature was constantly 7.5–10°C throughout the year. The water used for the pneumatic hammer had a temperature of 9–10°C, the same as that for the cold provocation test and the air temperature in the mines.

The rate of recovery of skin temperature of the third fingertip x min after immersion of the suffering or right hand, was calculated as follows: \( RR_x = (T_x - T_{end})/(T_{before} - T_{end}) \) where \( T_{before} \), \( T_{end} \) and \( T_x \) = fingertip skin temperatures before, at the end of, and x min after immersion, respectively. Duration of exposure to vibration in years was determined in detailed interviews. We calculated only the full number of years worked with vibration exposure, in the case of some factors influenced by age, were calculated after Yule-Kendall.

### Results

In our country the occupational health norms⁷), for the intermittent hand-arm vibration (3–4 h daily) permit a maximal admissible level of 15–17.5 m/sec². The values for acceleration vibration measurements reached equivalent values between 120 and 150 m/sec², exceeding the permissible levels. Our determinations have showed exceeding this level by 8–9 fold. The P-90 type Tampella pneumatic hammers used by miners, are also responsible for the high noise equivalent continuous level (the mean of 62 measurements was \( L_{eq} =96 \) dBA). The maximal equivalent noise level in a week is 90 dBA. Our determinations have shown exceeding this level a mean of 6 dBA.

Table 1 shows the miners’ mean age and duration of exposure to vibration, found in this study. Figure 1 shows the mean hearing threshold level (HTL) for the ten year age group among 348 miners. The HTL was typical for hearing loss induced by noise, reaching the lowest value at 6 kHz with close values at 4 and 8 kHz. An increase with age produced a decrease in HTL especially for high frequencies (4, 6 and 8 kHz). The HTLs for 4, 6 and 8 kHz in all age groups were significantly higher than those for the same aged general population in our country¹–³), but the hearing in miners was affected by noise and age.

In Table 1 are included the mean values for age and duration of exposure to vibration in miners with VWF (+) and without VWF (-). There was no significant difference between age and duration of exposure in these two groups.

The mean audiograms of the VWF (+) and VWF (-) groups are shown in Fig. 2. The miners in the VWF (+) group had a higher HTL at every frequency than the subjects in the VWF (-) group, but significantly higher differences for 4, 6 and 8 kHz were found.

The fingertip skin temperature of the subjects with VWF decreased from 23–27°C before immersion to 11–15°C after the test. Among those without VWF the fingertip skin temperature was higher before the cold provocation test (30–35°C) and also after the test (17–23°C).

The mean fingertip skin temperature recovery rates (RR) of both groups were calculated after 5, 10 and 15 min: VWF (+) and VWF (-) (Fig. 3). The figure shows

### Table 1. The number, mean age and duration of exposure registered for different groups formed from the total of examined miners

<table>
<thead>
<tr>
<th>No. of subjects</th>
<th>Mean age ± SD (yr)</th>
<th>Mean duration of exposure to vibration ± SD (yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of subjects examined</td>
<td>435</td>
<td>37.5 ± 6.8</td>
</tr>
<tr>
<td>Total number of subjects in the study</td>
<td>348</td>
<td>37.0 ± 6.5</td>
</tr>
<tr>
<td>Subjects with VWF [VWF (+)]</td>
<td>84</td>
<td>37.0 ± 6.3</td>
</tr>
<tr>
<td>Subjects without VWF [VWF (-)]</td>
<td>264</td>
<td>36.9 ± 6.7</td>
</tr>
<tr>
<td>Paired subjects with VWF (+)</td>
<td>65</td>
<td>37.0 ± 6.3</td>
</tr>
<tr>
<td>Paired subjects without VWF (-)</td>
<td>65</td>
<td>37.0 ± 6.3</td>
</tr>
</tbody>
</table>
Fig. 1. The mean HTL values for ten year age groups.

Fig. 2. Mean HTL values for subjects with VWF (+) and VWF (-).

Fig. 3. Mean fingertip skin temperature recovery rate (RR) after cold provocation test.
that the VWF (+) group values were significantly lower than results for the VWF (-) group.

We could not detect whether age, duration of exposure to vibration or VWF is determinative in the difference in HTL. For this reason, from the VWF (+) group and the VWF (-) group, 65 case-referent matched pair were selected with the mean age and duration of exposure shown in Table 1. Figure 4 shows the mean HTL of the cases and the reference. The cases had a more increased hearing loss than the references at every frequency, but a significantly higher difference was found only for 4, 6 and 8 kHz. The mean HTL was typical of hearing loss induced by noise, reaching the highest value at 6 kHz with close values at 4 and 8 kHz, both in the exposed group and in the reference. The HTL were lower in subjects suffering from VWF than those without VWF, for all frequencies, but significantly differences were found only 4, 6 and 8 kHz.

The recovery rate after 5, 10 and 15 min in the fingertip skin temperature test (Fig. 5), indicated significantly higher values in the reference than in the cases.

The subjects selected from the 30–39 yr age group and with a duration of exposure of 7.9 (mean value) ± 0.95 (SD) yr, were divided into three groups by the recovery rate (RR) for skin temperature 5 min after the cold provocation test (Fig. 6). The miners with a smaller RR
Fig. 6. Mean age corrected HTL values for subjects from the 30–39 age group and three fingertip skin temperature recovery rate groups after 5 min (RR5).

Table 2. The calculated simple ($r_{12}$) and partial ($r_{12,3}$) correlation coefficients for 1. -duration of exposure to vibration and 2. -HTL for different frequencies, influenced by 3. -age, for VWF (+) and VWF (-) paired subjects

<table>
<thead>
<tr>
<th>Group</th>
<th>Correlation coefficient for HTL and duration of vibration exposure ($r_{12}$), corrected for age in partial correlation ($r_{12,3}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.5 kHz</td>
</tr>
<tr>
<td>VWF (+)</td>
<td></td>
</tr>
<tr>
<td>$r_{12}$ (simple)</td>
<td>0.37**</td>
</tr>
<tr>
<td>$r_{12,3}$ (partial)</td>
<td>0.31***</td>
</tr>
<tr>
<td>VWF (-)</td>
<td></td>
</tr>
<tr>
<td>$r_{12}$</td>
<td>0.16 NS</td>
</tr>
<tr>
<td>$r_{12,3}$</td>
<td>0.05 NS</td>
</tr>
</tbody>
</table>

NS: not significant; *: p<0.001; **: p<0.01; ***: p<0.05.

(<0.25) had the highest HTL; but the subjects with an increased RR (>0.90) had auditive thresholds significantly lower at 4, 6 and 8 kHz.

In the group of cases, [VWF (+)] values for the simple ($r_{12}$) and partial ($r_{12,3}$) correlation coefficients indicate a correlation between (1) duration of exposure to vibration and (2) HTL for different frequencies, influenced by (3) age (Table 2). The same calculations for the reference group [VWF (-)] did not indicate a significant correlation.

Discussion

Among the vibration hazards caused by using vibrating tools, the occurrence of various symptoms, such as vibration induced white finger (VWF), damage to peripheral nerves, deformities and abnormalities of the bones and joints, numbness in the hands or arms, and excessive muscle fatigue are well known. Some authors have reported that the hand/arm vibration syndrome involves the central nervous system. This involvement has been hotly debated, special reference being made to autonomic nervous disorders.

The effect of local vibration on the autonomic nervous system found by Iki et al. indicates that there is also an association between VWF and hearing loss at high frequencies and that there is also a relationship between hearing loss and fingertip skin temperature. The present study has similar results but also findings indicating a correlation between duration of exposure to vibration (in years) of miners with VWF and observed hearing loss. Therefore the circulatory disturbance in miners with vibration syndrome is correlated with an additional hearing threshold shift. The cause of this increased loss is not known.

One possible cause of the association is the activated sympathetic nervous system effect. One may suggest that a high sympathetic tone plays a role in the production of increased hearing impairments. As another possible mechanism to explain the hearing involvement it has been proposed that thromboembolic events produce ischemic changes in the inner ear. This hypothesis is interesting because the increased hearing loss is developing far from the part of the body in contact with vibration (hand/arm).
The effect of vibrations in miners produced increased hearing loss, but develops far from the part of the body in contact with the risk factor (hand/arm). It is possible, and we also demonstrate it in this study, that there is a correlation between HTL with extra hearing loss and duration of exposure to vibration (in years), in miners.

References