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EFFECTS OF DIFFERENT TYPES OF INDUSTRIAL NOISE ON HEARING

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تأثير الضوضاء على سمع العاملين في المصانع

الخلاصة :

تمت مقارنة التأثير الحاصل على السمع بسبب الضوضاء النبضية مع التأثير الحاصل بسبب الضوضاء المستمرة والمختلطة . حيث تم مقارنة ثلاث مجموعات من العاملين المعرضين للضوضاء (مجموعة معرضة لضوضاء نبضية ومجموعة معرضة لضوضاء مستمرة ومجموعة معرضة لضوضاء مختلطة) . جرت مقارنة بين المجموعات المتعرضة للضوضاء فيما بينها وكذلك بينها وبين مجموعة السيطرة . دلت نتائج الدراسة على أن الضوضاء النبضية أحدثت اعلى انحراف في عتبة السمع للترددات ٤ ر ٦ كيلوهيرتز في الاذن اليسرى في حين الضوضاء المستمرة أحدثت أعلى إنحراف في عتبة السمع في الترددات ٦ كيلوهيرتز للاذنيين . أما الضوضاء المختلطة فقد أحدثت اعلى انحراف في عتبة السمع في الترددات ٦ كيلوهيرتز في الاذن اليسرى و ٤ كيلوهيرتز في الاذن اليمنى .
ان مجموعة السيطرة أحدثت اعلى انحراف في عتبة السمع في الترددات ٦ ر ٨ كيلوهيرتز في الاذن اليسرى .
أستنتج من هذه الدراسة ان الضوضاء النبضية اكثر ضرراً على سمع العاملين من الضوضاء المستمرة أو المختلطة وأن الانحراف في عتبة السمع كان في الترددات ٤ ر ٦ كيلوهيرتز.

SUMMARY:

Hearing loss induced by impulse noise was compared with that induced by continuous or mixed types of noise. Three industrial groups of workers exposed to these three types of noise were studied together with a control group. Results showed that impulse group had the highest threshold level values (TLVs) at 6 kHz (27.1 dB) and 4 kHz (26.2 dB) in the left ear. Continuous group had the

highest TLVs at 6 kHz; the values were 17.1 dB in left ear and 16.8 in right ear. Mixed group had the highest TLVs at 6 kHz in left ear (20.7 dB) and at 4 kHz in right ear (19.8 dB).

Control group had highest TLVs at 8 kHz (10.3 dB) and 6 kHz (8.8 dB) in left ear. Impulse group had the highest TLVs, while the control group had the lowest values. We concluded that exposure to impulse noise is more harmful to hearing and causes more serious hearing loss than continuous or mixed noise, and that the regions mostly affected are at 4 and 6 kHz.

INTRODUCTION:

Noise is one of the well known hazards of work, and the relationship between industrial noise exposure and hearing loss is well established [1,2]. Industrial noise may be continuous or impulse, or of mixed types[3]. Damage risk criteria (DRC) for continuous noise are well established[4], but it is uncertain that the established criteria are also valid for exposure to impulse noise[5]. The most common way to describe the auditory effect of noise exposure is by the threshold shift which may be temporary or permanent[6]. Auditory threshold is defined as the sound pressure level at which persons with normal hearing begin to respond[1].

Some authors[7,8] found that the cumulative effects of long duration (10 to 15 years) exposure to high level of continuous industrial noise seems to raise TLVs at 4 kHz. Noise-induced hearing loss (NIHL) is (after presbycusis) the most common form of hearing loss in the United States which accounts for around 5 million americans[9]. In finland NIHL comprises about half the verified cases of occupational diseases, if occupational skin diseases are excluded[10]. To our knowledge in our country neither data concerning the number of workers exposed to noise nor the number of workers suffering from NIHL are available.

The aim of this work is to perform a comparative study of the effect of three types of industrial noise (continuous, impulse and mixed) on hearing in relation to the severity of their effects on audiometric frequencies.

MATERIALS AND METHODS:

The study included 350 subjects divided into four groups as follows:

1- Group one (G.1): exposed to impulse noise.
2- Group two (G.2): exposed to continuous noise.

3- Group three (G.3): exposed to mixed noise.
4- Group four (G.4): not exposed to industrial noise (control group).

These groups were selected from a total of 608 volunteers working in the State Enterprise for Electrical Industries, after completing a questionnaire form (appendix 1) and clinical examination of the ears.

Table 1 shows the mean and standard deviation of ages and period of exposure of subjects in the four groups studied.

Table 1- Age and duration of exposure of subjects.

Group	Age (years) Mean ± S.D.	Duration of exposure (years) Mean ± S.D.
G.1	35.5 ± 11.9	6.1 ± 6.2
G.2	33.1 ± 11.4	8.4 ± 7.0
G.3	34.9 ± 10.8	6.5 ± 7.3
G.4	32.2 ± 9.9	No exposure

Noise Surveys:

The noise surveys were carried out to obtain the intensity and frequency characteristics. Noise measurements were made with precision sound level meter (Band K type 2209) fitted with a Third Octave Filter set (Band K type 1616) and a 1/2 inch condenser microphone (B and K type 4165). The procedure followed for the survey conformed with the recommended International Electrotechnical Committee (IEC) standard 651 type 1 (Irnp.) and American National Standard Institute (ANSI) S 1.4-1971 type 1[11].

Assessment of duration of exposure was made from analysis of questionnaire forms. Measures of daily exposure of some workers were collected using Noise Dose Meter (B and K type 4424)[12].

Measurements of hearing threshold level value (TLV):

Hearing threshold levels were measured using an automated recording audiometer (B and K type 1800), at frequencies of 0.5, 1,2,3,4,6 and 8 kHz in 5dB step for both ears. Audiometer was calibrated according to the International Standardization Organization, (ISOR 389 and ANSIS 3.6-1969) using an artificial ear (B and K type 4152). The ambient noise in the tesing room was well below the permissible levels for International Standards (ANSIS 3.1-1960, R 1970). Measurements of hearing threshold levels were taken immediately before shift. None of workers in all groups had been exposed to noise for at least

16 hours prior to test.

Statistical analysis:

Data analysis was carried out in the National Electronic Computering Center. Data from the left and right ears were analysed separately using students t-test.

RESULTS:

Table 2 shows the results of noise surveys of the working environment. Fig. 1 shows frequency analysis of noise in the working environment.

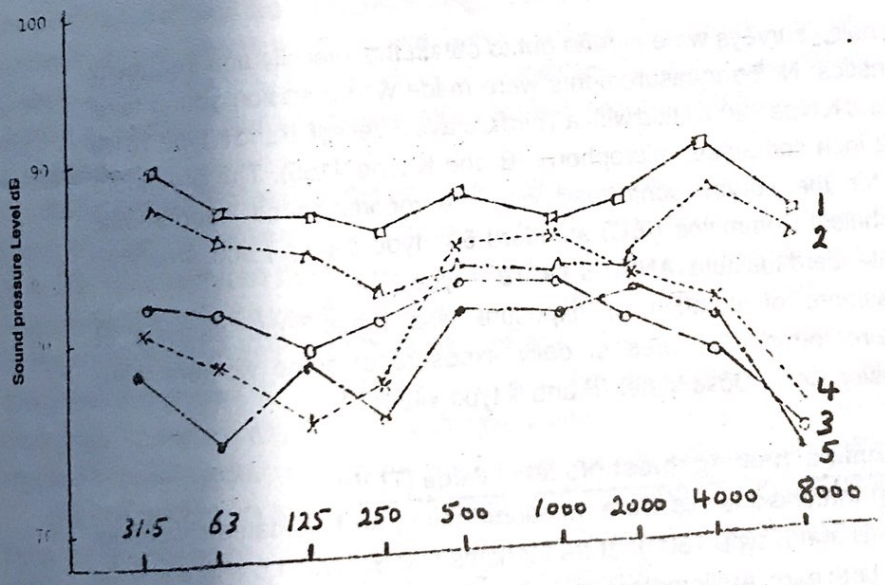

Fig. 1 One-third octave-band frequency spectrum of noise in
1. Welding workshop 2. Pressures workshop.
3. Motor workshop, 4. Carpentry unit. 5. Fan Factory.

Table 2. Summary of Noise Profile in the working environment.

Type of noise	Workshops occupation	Average A-weighted dB (A)	Average Peak levels (peak-hold) dB (A)	Estimated Leq (Dosemeter)
Impulse	Pressors	96	109	107
	Transfor-mance	97	111	106
	Carpentry	96	98	100
Contin-uous	Fanfactory	90	94	96
Mixed	Motor factory	95	105	96

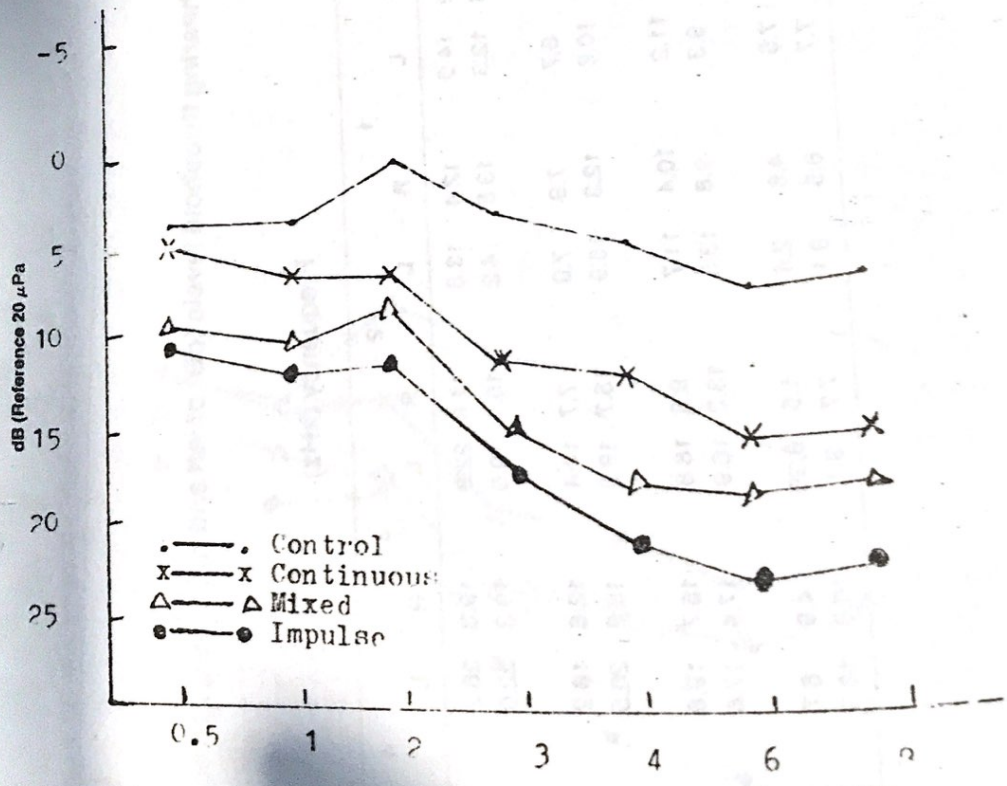

Fig. 2 Average hearing threshold level of right ear of the four main groups

Table 3. Average and S.D. of hearing threshold levels (dB) of left and right ears at frequencies of 0.5-8 kHz of the 4 groups.

group		Frequency (kHz)														
		0.5		1		2		3		4		6		8		
		L	R	L	R	L	R	L	R	L	R	L	R	L	R	
G.1 Impulse	Mean	12.0	10.4	14.0	12.4	13.6	11.8	22.3	19.3	26.2	22.6	27.1	24.1	24.7	23.3	
	S.D	11.2	15.6	12.3	13.5	14.2	15.1	19.0	19.3	22.0	21.5	19.8	21.8	22.3	22.6	
G.2 Continuous	Mean	7.1	5.5	8.7	7.9	7.0	7.7	14.4	12.6	16.2	12.8	17.1	16.8	16.5	16.2	
	S.D	9.1	10.5	10.8	12.3	16.9	15.7	19.0	18.2	20.5	20.4	22.3	21.6	22.4	23.2	
G.3 Mixed	Mean	9.7	9.3	11.2	10.4	11.7	9.3	18.8	15.7	19.6	19.8	20.7	19.2	18.0	18	
	S.D	7.9	9.5	9.3	9.8	13.5	13.2	16.9	17.4	17.6	20.9	17.9	17.7	19.6	20	
G.4 Control	Mean	7.2	4.3	7.5	4.8	2.4	1.5	6.39	4.9	6.7	5.8	9.8	8.8	10.3	8.0	
	S.D	7.1	7.9	7.7	6.5	8.1	7.7	9.1	10.8	10.6	11.9	10.2	12.2	13.3	12.4	

Table 3 gives average hearing threshold level values (TLVs) and standard deviation (S.D) of left ear (LE) and right ear (R.E) of the four groups. It appears that G.1 has highest TLVs at 6 and 4 kHz in LE, the values are 27.1 dB and 26.2 dB respectively. G.2 has highest TLVs at 6 kHz in both ears (BE), the values being 17.1 dB in LE and 16.8 dB in RE.

G.3 shows TLVs as follows: in LE, TLVs are highest at 6 kHz, (20.7 dB) and in RE, TLVs are highest at 4 kHz (19.8 dB). G.4 (Control group) has highest TLVs at 6 and 8 kHz in LE, the values being 9.8 dB 10.3 dB, respectively.

Fig. 2 and 3 show the audiograms of right and left ears of the four groups.

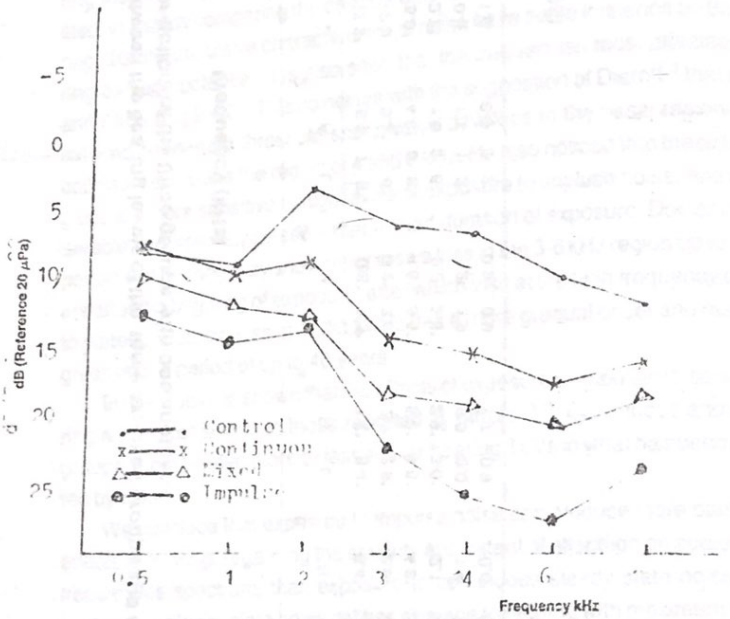

Fig. 3 Average hearing threshold level of left ear of the four main groups

Table 4. Summary of t-test comparisons between the hea ing levels of the three exposed groups and control group as well as the inter-action of the three groups with one another.

Frequency (kHz)

			0.5		1		2		3		4		6		8	
			L	R	L	R	L	R	L	R	L	R	L	R	L	R
G.1	VS	G.4	3.9*	4.3*	4.7*	5.3*	7.2*	6.3*	7.8*	6.8*	8.3*	7.1*	8.4*	6.4*	5.9*	6.2*
G.2	VS	G.4	0.1	0.8	0.8	2.0	2.3	3.3*	3.6*	3.2*	3.8*	2.7	2.8*	2.9*	2.1	2.8*
G.3	VS	G.4	2.0	3.4*	2.6*	4.2*	5.3*	4.6*	5.8*	4.6*	5.6*	5.2*	4.8*	4.2*	2.9*	4.1*
G.1	VS	G.2	2.9*	2.4	2.7*	2.1	2.7*	1.6	2.6*	2.2	2.8*	2.9*	3.0*	2.1	2.3	1.9
G.1	VS	G.3	1.4	0.6	1.5	1.0	0.8	1.1	1.2	1.2	1.9	0.8	2.0	1.4	1.9	1.2
G.2	VS	G.3	1.5	1.9	1.3	1.1	1.6	0.5	1.2	0.9	0.9	1.7	0.9	0.6	0.4	0.6

* Indicates statistical significance at 5% ($P < 0.05$).

The differences between the groups are shown in Table 4, G.1 has higher TLVs at all frequencies than G.4 ($P < 0.05$). G.2 has higher TLVs at 2 and 8 kHz in RE, and at 3,4 and 6 kHz in BE than G.4 ($P < 0.05$). G.3 has higher TLVs at all frequencies in BE than G.4 ($P < 0.05$), with the exception of that at 0.5 kHz in LE where is no significant difference at this frequency ($P > 0.05$). G.1 has higher TLVs at 0.5, 1,2 and 6 kHz in LE, and at 4 kHz in BE, than G.2 ($P < 0.05$). There is no significant difference between G.1 and G.3 as well as between G.2 and G.3 ($P > 0.05$).

DISCUSSION:

Hearing measurements indicate that impulse noise is more harmful to hearing than other types of noise (continuous or mixed). Evans and Ming[3] suggested, in a study comparing the effect of different types of noise exposure on hearing, that the impulsive characteristics of noise have some influence on the hearing damage potential. It is also seen that the frequencies most affected are 4 and 6 kHz (Fig 2 & 3). This coincides with the suggestion of Dieroff[13] that noise-induced permanent threshold shift always develops in the basal region of the cochlea, i.e. around the region of 4 and 6 kHz. He also noticed that these two regions are more sensitive to high levels of exposure to impluse noise, and considerable damage may be seen after a short duration of exposure. Dobie[9] has reported that hearing may show progressive loss in the 3-6 kHz region up to 15 years after the begining of exposure, after which loss at the high frequency begins to plateau. Hearing loss at 1 and 2 kHz has a more gradual onset and may progress over a period of up to 40 years.

In this study it is shown that the effects of exposure to impulse noise on hearing are almost similar to those reported by others[1,3,13]. Continuous and mixed groups seem to have more or less similar hearing TLVs to what has been reported by Dobie[9].

We conclude that exposure to impulse noise can produce more damaging effects to hearing, regarding the severity and extent of affecttion on audiometric frequencies spectrum, than exposure to continuous steady state noise. Also continuous-steady state noise causes damage to hearing with maximum loss at 6 kHz in our series. The hearing damage is less pronounced than impulse noise.

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Appendix 1

Questions used in Hearing Questionnaire

1- No.
2- Occupation
3- Age (years)
4- Sex
5- Time at main job
6- Duration of work (months)
7- Complete working day
8- Use of ear protectors
9- Have you ever worked in a noisy job, other than present?
10- Which?
11- Duration of work (months)
12- Complete working day
13- Use of ear protectors
14- Do you have other job, after shift, in which you may be exposed to loud noise.
15- How many hours?
16- Do you use ear protectors
17- Have you been exposed to loud noise since leaving the workplace (yesterday)?
18- How many hours passed since exposure?
19- For how long the exposure lasts (in seconds)?
20- Have you a hobby expose you to loud noise?
21- Nature of this hobby (shooting, music).
22- How many times you experience this hobby in the year.
23- How many years you experienced this hobby.
24- How is your hearing at present?
25- Do you experience one of the followings:
    a- Heat injury b: Pain in the ear c. Discharge from the ear
26- Do you take medication for long time or drugs for the ear?
27- What is the kind of medication?
28- Is there any deaf in your family?
29- Do you have a hearing aid?
30- Clinical examination of the ears
31- Rinne's test
32- Weber's test
33- Audio metric testing