STUDY OF NOISE, HEARING IMPAIRMENT AND HYPERTENSION IN EGYPT

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This study included 295 workers of Assiut Generation Station (Upper Egypt). Two hundred and twenty-one of the workers were exposed to different levels of noise (80 to 107 dBA) and the remaining 74 were used as a control group. There were no significant differences in risk factors viz age, duration of work, body mass index, weight, height, smoking, and previous work as determined by a questionnaire. The relationship between occupational exposure to noise, the degree of hearing loss and hypertension was determined. The results showed that there were statistically significant differences between the average hearing threshold levels of the two groups ($P<0.01$) which were more in those workers exposed to noise than in the control group. The mean systolic and diastolic blood pressures were also statistically significantly different in the two groups ($P<0.001$) and they were positively correlated ($P<0.001$) to the percentage of impairment of the whole body at 4 and 6 kHz, and hearing disability at 0.5, 1, 2, and 3 kHz. Stepwise multiple regression analysis revealed that age, noise level and body weight could each be used as a predictor of hypertension. A predictive formula was derived between the amount of hearing loss and blood pressure in the subjects exposed to occupational noise. *Ann Saudi Med 1994;14(4):307-311.*

Noise can be a health hazard in two main ways: it can damage hearing and it can affect various body systems. The auditory effects of noise have been documented and evidence has been accumulated regarding the cardiovascular effects of noise.[1] Noise was recognized by the World Health Organization (WHO) in 1983[2] as one of a number of possible exogenous factors in the pathogenesis of essential hypertension. Von Eiff et al.[3] found a significant increase in the incidence of hypertension among people living and working in proximity to aircraft and automobile traffic.

The correlation between the degree of hearing impairment and elevation of systolic and diastolic blood pressure has not yet been established. Early screening surveys[4] on middle age population could not find such correlation, while a recent study[5] found a statistically significant positive correlation between the two variables among retired metal workers who had been exposed to noise -84 dBA- for 30 years or longer.

The aim of this work was to investigate the relationship between elevation of hearing threshold and blood pressure (systolic and diastolic) among subjects exposed to various noise levels; and at the same time considering the effect of other variables such as duration of exposure and age on such relationship.

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Material and Methods

This study was conducted in Assiut Electricity Generation Station (EGS) in Assiut, Egypt. A) Subjects: 221 employees exposed to noise in the station were the study subjects. None of the employees was excluded unless he had severe deafness resulting from a known cause other than noise or suffered from hypertension (pressure more than or equal to 160/95 mm/Hg) or there was a history of antihypertensive medication prior to work in the station.

A control group (74 employees) was chosen from the administrative departments with the same criteria as the exposed group, but they were not working in the noisy environment. B) Equipment: 1) single channel audiometer calibrated to ANSI (1946) for hearing threshold determination (Harison audiometer); 2) noise level meter (Simpson 890) for field noise level measurements; 3) clinical otoscope for ear examination and a mercury sphygmomanometer for blood pressure measurement. Hypertension was defined as greater than or equal to 160/95 mm/Hg or having a history of antihypertensive medication; and 4) a balance and a height scale were used for recording weight in kg and measuring height in cm. C) Methods: 1) a preliminary visit was made to the station and the purpose of the study explained to the administration. The appropriate site was selected for conduction of the various examinations so that audiometric evaluation could be completed in an environment free from noise interference; 2) a questionnaire encompassing various elements relating to occupational exposure to noise, blood pressure and ear disease was completed by all the subjects partaking in the study; 3) noise level in different departments of the station was measured with the help of the station's industrial hygiene personnel and was found to range from 80 to 105 dBA; 4) blood pressure was measured while the participant was in the sitting position, using the right arm. After a 10 minute rest period, the blood pressure was determined three times within five minutes and the procedure was repeated 15 minutes later. The first and fifth Kortakoff sounds were recorded for each subject;[6] 5) weight in kg and height in cm were determined, then the body mass index (BMI) was calculated (weight in kg^2, height in meters) (Quetlet index); 6) otoscopic examination of the external ear (auricle, meatus and presence of wax), middle ear (mastoid process, drum appearance, mobility and perforation) together with nose and throat examination to include major pathologies; 7) audiological examination: Calibration of the audiometer was done at the Audiology and Speech Unit in Assiut University Hospital. On examination, the subject was seated facing the examiner, without being able to see the controls. The test was performed prior to the start of the shift so that at least 16 hours had passed since the last exposure to overcome temporary threshold shift effect; D) Statistical Analysis: 1) hearing loss was calculated for each ear separately as the amount of threshold shift above the standard audiometric zero, and the average hearing loss of both ears was calculated; 2) the amount of hearing disability and percentage of impairment of the entire body were calculated from tables of ANSI 1969, which were reaffirmed in 1973. In this study, grading of impairment was adopted as follows: a) normal threshold = average threshold < 25 dB; b) mild impairment = average threshold between 25 to 40 dB; c) moderate impairment = average threshold between 41 to 60 dB, d) severe impairment = average threshold between 61 and 80 dB; and e) profound impairment = average threshold more than 80 dB. Hearing impairment was defined as the average hearing threshold for the better ear at 500, 1000 and 2000 Hz (WHO);[7] and 3) proper tests of significance were used where indicated.

Results

Analysis of the completed questionnaire revealed that there was no statistically significant difference between the study and control subjects. The two groups were comparable in their smoking habits, duration of employment and history of hypertension. Noise level measurement in different departments showed that the filters, turbines and boiler departments exceeded the standard Threshold Limit Value (90 dBA) as set by the American Conference of Governmental Industrial Hygienists (ACGIH), while in the control area, it was less than 50 dBA.

The mean hearing threshold for the two groups is shown in Table 1. There was a statistically significant difference at all test frequencies (except at 2 kHz) in the right ear as well as the composite values of both ears. For the left ear, the difference was only significant at frequencies of 0.25

TABLE 1. *Mean hearing threshold in employees at Assiut Electricity Generation Station.*

Hearing Threshold		250	500	1000	2000	3000	4000	6000	8000
Right Ear									
Exposed	Mean	25.7	26.3	21.3	34.5	36.4	41.0	41.3	33.2
	SD	9.7	8.9	8.5	10.2	11.2	14.5	15.7	15.6
Control	Mean	21.2	22.2	17.8	32.8	32.7	34.9	36.4	37.8
	SD	10.1	10.3	9.7	9.3	9.5	12.2	12.9	17.2
t-Test	t	3.3	3.1	2.8	1.4	2.8	3.6	2.7	2.0
	P	***	**	**	NS	**	***	**	*
Left Ear									
Exposed	Mean	24.2	26.5	20.3	34.1	35.7	39.5	41.4	33.0
	SD	9.8	10.3	10.2	11.6	12.3	15.4	18.1	14.1
Control	Mean	20.5	22.8	17.4	33.0	33.4	36.2	38.0	39.8
	SD	11.0	10.8	11.5	10.4	12.1	16.6	18.2	20.9
t-Test	t	2.5	2.5	1.9	0.7	1.4	1.5	1.4	2.6
	P	*	*	NS	NS	NS	NS	NS	*
Binaural									
Exposed	Mean	24.9	26.5	20.8	34.3	36.1	40.3	41.3	33.1
	SD	8.6	10.3	8.4	9.6	10.6	13.7	15.4	14.1
Control	Mean	20.9	22.5	17.6	32.9	33.0	35.6	37.2	38.8
	SD	9.8	10.0	9.9	9.0	10.1	13.5	14.8	18.0
t-Test	t	3.2	3.0	2.5	1.1	2.2	2.6	2.0	2.5
	P	**	**	*	NS	*	**	*	*

NS=not significant; *=$P<0.05$; **=$P<0.01$; ***=$P<0.001$; t= Student's test statistic; *P*= probability value.

and 8 kHz. The table also shows that the highest hearing threshold values were for the 6 kHz frequency in the exposed group.

Exposed employees showed a greater hearing loss of the sensorineural type than the control, which was of statistical significance ($P<0.01$). On the other hand, in terms of hearing disability and percentage impairment of the entire body, there was a statistically significant difference ($P<0.05$) between the two groups.

In relation to age and duration at work, it was found that there was a gradual elevation of hearing threshold in both groups. The mean hearing threshold for frequencies 4, 6 and 8 kHz was directly proportionate to the duration of work for the exposed group only. The results were less consistent for the control group. The percentage hearing disability as well as the percentage impairment of the entire body was greater for the employees exposed to higher noise levels.

Statistically significant correlation was found between hearing threshold at 4, 6 and 8 kHz and age, duration of work ($P<0.01$) and noise level ($P<0.05$) (Table 2). It was also worth noting that the highest correlation and significance values were with 4 kHz threshold and each of these three variables. There was also a positive correlation ($P<0.01$) between these variables considered for monaural and binaural threshold.

With regard to hypertension, exposed employees showed a twofold prevalence as compared to the control (8.6% versus 4.1%).

Measurements of blood pressure showed a statistically significant difference ($P<0.001$) for both the systolic and diastolic pressures between the two groups. It was also found that the mean systolic and diastolic pressure increases as a function of age, duration of work and noise level, weight, body mass index and duration of smoking (Table 2). In addition, both were found to significantly and positively correlate ($P<0.001$) with the degree of hearing disability as well as the percentage impairment of the entire body.

Stepwise multiple regression analysis was used to determine those variables affecting our subjects' blood pressure. Age, noise level, and body weight (in order) can be used as predictors of high blood pressure (both systolic and diastolic).

A relationship was derived between the amount of hearing loss (impairment) and hypertension in the exposed study employees in this industrial environment in such a way that the amount of either can be quantitated knowing the other. The following equations were calculated: (A) - for 4 kHz: systolic blood pressure=108.765924+0.361071 x hearing impairment; diastolic blood pressure=74.688077+ 0.244720 x hearing impairment; (B) - for 6 kHz: systolic blood pressure=109.006667+0.344459 x hearing impairment; diastolic blood pressure=74.688077+0.237073 x hearing impairment; (C) - for 8 kHz: systolic blood pressure=114.292351+0.248023 x hearing impairment; diastolic blood pressure=79.189359+0.145612 x hearing impairment.

Discussion

The insignificant difference between the exposed and the control group of employees in relation to variables considered as risk factors for hearing loss and hypertension, e.g., age, weight, height, body mass index, smoking habits and duration of work, implies that any difference in hearing loss and hypertension between these two groups will be due to noise exposure.

The increase in hearing threshold and diminished hearing ability and the binaural statistically significant difference in hearing threshold level of the exposed employees can be attributed only to noise exposure. It is the only hearing risk factor in which the exposed employees differed from the control group. This is consistent with the findings reported by WHO and Dobie.[7,8]

The maximum impairment of hearing for both ears (binaural) was at 6 kHz frequency followed by 4 kHz (which is approximately of the same degree of loss as 6 kHz). This agrees with Taylor et al.[9] who showed that the first and most severely affected frequency is 4 kHz, but

TABLE 2. *Correlation of blood pressure with various risk factors and with hearing impairment, % hearing disability and precent whole body impairment.*

		Systolic	(*P*)	Diastolic	(*P*)
Risk Factors					
Age		0.3620	(<0.001)	0.3725	(<0.001)
Height		0.0721	(NS)	0.0651	(NS)
Weight		0.2352	(<0.001)	0.2439	(<0.001)
Body Mass Index		0.2069	(<0.001)	0.2177	(<0.001)
Duration of Smoking		0.2237	(<0.01)	0.2062	(<0.001)
Duration of Employment		0.3331	(<0.001)	0.3520	(<0.001)
Noise level (dBA)		0.2196	(<0.001)	0.2058	(<0.001)
Hearing Impairment					
(4000 Hz)	Rt Ear	0.2721	(<0.001)	0.2826	(<0.001)
	Lt Ear	0.2255	(<0.001)	0.2041	(<0.001)
	Binaural	0.2686	(<0.001)	0.2618	(<0.001)
(6000 Hz)	Rt Ear	0.2679	(<0.001)	0.2795	(<0.001)
	Lt Ear	0.2563	(<0.001)	0.2415	(<0.001)
	Binaural	0.2849	(<0.001)	0.2818	(<0.001)
(8000 Hz)	Rt Ear	0.2571	(<0.001)	0.2401	(<0.001)
	Lt Ear	0.1250	(<0.05)	0.0884	(NS)
	Binaural	0.2057	(<0.001)	0.1738	(<0.01)
% Hearing Disability					
Rt Ear		0.2039	(<0.001)	0.2280	(<0.001)
Lt Ear		0.2191	(<0.001)	0.1981	(<0.001)
Binaural		0.2190	(<0.001)	0.2192	(<0.001)
% Impairment of whole body		0.2200	(<0.001)	0.2185	(<0.001)

6 kHz is affected nearly as much at early stages. Schneider et al.[10] and Al-Nasser et al.[11] discovered that the maximum impairment of hearing was at 6 kHz. On the other hand, the classical 4 kHz notch was described by many other investigators such as Bilger and Schilling.[12,13]

However, hearing threshold of the exposed subjects at 8 kHz was much better than at 4 kHz and 6 kHz as reported by Makhlouf et al.[14] Mild bilateral hearing impairment was the most common degree of impairment that agrees with the findings of Al-Nasser et al.[11]

In both the exposed and control groups, the mean hearing threshold increased with age advancement and the difference was statistically significant. This can be explained by the additive effects of presbycusis and noise exposure. There was a significant positive correlation between the duration of exposure and the mean hearing threshold level at 4, 6 and 8 kHz, as well as between the duration of exposure and hearing disability (at 0.5, 1, 2, and 3 kHz). This agrees with Oleru et al.[15] who concluded that the duration of employment was the only significant contributor to threshold elevation. Other investigators such as Al-Nasser et al. and Makhlouf et al.[11,14] also reported similar findings.

Hearing impairment at 4, 6 and 8 kHz was found to correlate positively with noise level, whether for one or both ears. This was in agreement with that reported by Ward.[16] With regard to the prevalence of hypertension in exposed employees, Strazynski et al.,[17] in their study on textile employees, reported a prevalence of 8.3% in these employees, which is very close to the prevalence recorded in this study. In 1987, Chang discovered that the relative risk of hypertension among employees exposed to over 85 dBA was 2.38, indicating that noise-exposed employees are at an increased risk of high blood pressure.[18] On correlating hypertension and hearing impairment, it was found that both systolic and diastolic blood pressures were highly correlated with the amount of impairment at 4 kHz and 6 kHz. Jhonson and Hansson[19] and Lennart et al.[20] reported similar correlation between noise-induced auditory impairment and systolic and diastolic blood pressure. Delin[21] did not find this association between hearing impairment and the mean systolic and diastolic blood pressure. At interview, men who had been working a long time in their jobs showed that the degree of stress may be more important than the level of noise. Talbott et al.[6] found that there was no difference in diastolic or systolic blood pressure in 197 metal fabrication employees exposed for at least 10 years to 89 dBA or greater compared to their control group.

In this study, in both groups, higher frequency hearing loss was strongly associated with high blood pressure.

To determine the risk factors of hypertension, it was found that the mean systolic and diastolic pressure in both the exposed and the control group increased significantly with age after the age of 35, which was similarly reported by Conner et al.[22] Kavoussi,[23] on studying 465 employees occupationally exposed to noise, showed that hypertension was significantly more prevalent among men between the ages of 55 and 64 years.

It was also found in this study that the duration of exposure to noise correlated positively with hypertension and the incidence of the latter increased with increasing years on the job. This also agrees with that reported by Kavoussi and Parvizpoor.[23,24]

Kortkov et al.[1] showed that when length of service exceeds 10 years, the noise dose increment of 1 dB corresponds to the hypertension frequency increment of 2%.

Blood pressure (systolic and diastolic) was also found to be highly and significantly correlated with body mass index, which is in agreement with that reported by many investigators.[6,17,21,22] The predictive equations derived from this study could be used to define damage risk criteria of noise on the cardiovascular system other than criteria used for hearing.

In conclusion, the above discussed results indicate the following: 1. There is a definite noise hazard in Assiut Electricity Generation Station in at least three departments. 2. Hearing threshold elevation due to noise exposure is positively and significantly correlated with age, duration of work and noise level. 3. Employees exposed to high noise levels are more prone to hypertension than their control peers. 4. Hypertension identification among employees and measures of control should be seriously considered in addition to hearing conservation programs. A successful control of noise will help in reducing the prevalence of hypertension both quantitatively and qualitatively.

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