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Effects of Noise Pollution on Blood Pressure, Heart Rate and Hearing Threshold in School Children

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Abstract: This study reports the association of noise pollution level with blood pressure (systolic and diastolic), heart rate and hearing threshold in school children. The schools were selected randomly as to present quiet [Seida village, 68.2-71.1 dB(A)], noisy [Nablus city, 76.5-79.4 dB(A)] and very noisy, [Tulkarem refugees camp, 82.4-85.9 dB(A)] localities. Strong positive correlation (Pearson Correlation Coefficient) were found between noise pollution level and systolic and diastolic blood pressure, heart rate and hearing threshold at different frequencies. The mean systolic and diastolic blood pressure for the two sexes are correlated positively with the noise pollution level (R = 0.521 and 0.440, respectively). The hearing threshold levels of different frequencies correlated positively with the noise pollution level (R = 0.114 to 0.267; where $p < 0.05$).

Key words: Noise pollution, blood pressure, heart rate, hearing threshold

Introduction

Noise pollution is becoming increasingly more severe in industrial countries and the cost of alleviating it in future years is expected to be insurmountable. Immediate and serious attention must be given to control this mushrooming problem, since the overall loudness of environmental noise is doubling every ten years (Chedd, 1970). This has encouraged scientists to discuss and study the effects of noise pollution on human's health and their capability intake of high or low doses of sound pressure levels as measured by decibel The Federal Occupational Safety and Health Act (OSHA), administrated by the U.S. Department of Labor, requires that specified noise exposures not be exceeded. These are guidelines for safe exposure.

Excessive noise pollution has been blamed not only for hearing damage and community annoyance but also for hypertension, fatigue, heart trouble, serum lipid, triglycerides, platelet, count, plasma viscosity, glucose and reduced motor efficiency (Lord *et al.*, 1980; Regecova and Kellerova, 1995).

Other noise pollution effects observed in humans include changes in the electrical activity of the brain, in heart and respiration rate and in gross motor activity. Other effects have been noted including changes in the size of several of the glands of endocrine system, blood pressure changes, constriction of the blood vessels, dilation of the pupil of the eye and observations of irritability, nausea, fatigue, anxiety and insomnia. Apart from these physical changes, noise can cause psychological disturbances. Interruption of sleep by noise can cause people to become irritable and resentful against the cause of noise. Speech communication can be impaired by noise masking resulting in inefficiency, a feeling of isolation and more seriously can result in accident (Webb, 1978).

A study on a group of patients from exposed to occupational noise pollution suggested that the exposition to acoustic defilement during work activity might be considered as aetiological factor for development and progression of sensorineural hearing impairment and more extensively for the occurrence of cardiovascular complication (Solerte ***et al.***, 1991).

On the basis of a survey that has been done in to compare blood pressure in deaf-mute children and children with normal hearing, it was suggested that noise exposure is associated with higher systolic and diastolic blood pressure (Wu ***et al.***, 1993).

Children attending kindergartens situated in area with traffic noise > 60 dB(A) had shown to have higher mean systolic blood pressure(SBP) and diastolic blood pressure (DBP) and lower mean heart rate than children in quiet areas (Regecova and Kellerova, 1995). An overall dose-response relationship between noise exposure levels [< 75 dB(A), 76-80 dB(A), 81-85 dB(A), > 86 dB(A)] and mean serum lipid/lipoprotein levels was also reported for younger men only (Melamed ***et al.***, 1997).

Significant association were found between noise and potential ischemic heart disease risk factors (IHD), including total triglycerides, platelet count, plasma viscosity, glucose (increase) and systolic and diastolic blood pressure (decreased) (Babisch, ***et al.***, 1993).

Noise pollution in West Bank towns and cities is increasingly becoming more evident because of the increasing number of noise sources such as markets, factories, vehicles and aircrafts (Qamhieh ***et al.***, 1993).

In a household environmental survey on exposure to noise in Palestine, it was indicated that 69.4% of households in the west Bank were seldomly exposed to noise, against 62.8% in Gaza Strip. The percentage of households that were sometimes exposed to noise were 18.5% in Gaza Strip and 14.3% in West Bank, whereas 16.9% of households in Palestinian were very often exposed to noise. The survey also showed that traffic was the most important source of noise in the Palestinian area for 54.2% of households, whereas construction work was the most important source of noise 44.0% of households in the Gaza Strip and for 24.7% in West Bank (Abdel-Raziq ***et al.***, 2000). This qualitative survey was based on a household using a special questionnaire only.

Objectives of this study

No regulations concerning noise pollution have been yet formulated in the Palestinian authority. In the West Bank, data on noise pollution and its association with auditory and non-auditory effects are lacking. Therefore, this work was aimed at investigating the effects of noise pollution in three different areas with different noise pollution levels, on hearing, blood pressure and heart rate in school children residing in these areas and compare the results with international collateral literature.

Experimental technique

The study population consisted of 480 school children (240 females and 240 males) aged 9-10 years, belonging to six schools located at three different localities. The schools in each locality were selected making sure that the people who live neighborhood of the schools are under similar socioeconomic conditions. The selected schools are located in populated areas having the same social, emotional and nutritional levels(same lifestyle). In each locality, two schools (male and female) were chosen. Eighty children were chosen randomly at each school. The three localities were; the city of Nablus (noisy), located in the center of the West Bank, with approximately 150,00 inhabitants and crowded with traffic and factories; Tulkarem refugee camp (very noisy), located one km. east of Tulkarem city, with approximately 30,00 inhabitants, situated at the Tulkarem-Nablus highway; and Seida village(quiet), located 18 km. north east of Tulkarem city, with approximately 3,000 inhabitants and represented a quiet rural area. The three locations were expected to have different noise pollution levels.

The children deemed eligible for this study were healthy and were not compelled to undergo the investigation. The children's health status was checked from medical records available in their schools. The same equipment and the same method for screening all of the participants were employed throughout this study. Data collection at schools was carried out during morning hours (7:30-13:00) under ideal meteorological conditions, during the period from January to June 1999, all throughout the study. Measurements of hearing threshold , blood pressure and heart rate were taken twice inside special room for each case while the rest of children outside the classrooms under the influence of the outdoor continues noise sources. The noise levels were measured by using the Quest model 2900 type 2 integrating and logging sound level meter. The accuracy of the meter is ±0.5 dB(A) at 25°C and its precision is 0.1 dB(A) (Anonymous, 1998). The measurement level L_{eq} are read directly by sound level meter by A-weighting. The sound level meter was placed outdoor while the children outside the classrooms to measure the noise level which exposed by the children.

The response of auditory system (threshold of hearing) was measured for each child at different frequencies (125, 250, 500, 750, 1000, 1500, 2000, 3000, 4000, 6000, 8000 Hz) by AM 232 Manual Audiometer (Diehl, 1973) with accuracy ±3%, at operating temperature 15 to 40°C. The results of each left and right ear was recorded in an audiogram form.

The systolic and diastolic blood pressure and heart rate were measured for each child by Automatic Digital Electronic Wrist Blood Pressure Monitor (Nihon Seimitsu Sokki Co., Japan model WS-300). The accuracy ± 3mmHg cuff (pressure) and ±5% of reading pulse rate with operating temperature range of +10°C to +40°C. Blood pressure and Heart rate were recorded with the children supine after five minutes bed rest. A second blood pressure reading was taken two minutes after complete deflation of the cuff and the average was recorded.

Results and Discussion

The data were analyzed using the SPSS program. Average values were expressed as group mean±standard deviation (SD). Analysis of variance (ANOVA) test was used to detect associations between dB(A) and heart rate, blood pressure and hearing threshold. In addition, a Pearson correlation factor (R) was carried out to find the strength of the correlation between noise level and the dependant variables. To know the effect of noise pollution level in dB(A) and gender on heart rate, blood pressure and hearing threshold, a multiple comparison (Univariate Analysis of Variance) was carried out. $P < 0.05$ was considered statistically significant.

Table 1: Noise pollution levels at the different locations

Area	Location	School	Sex	L_{eq}dB(A)
Quiet	Seida village	Seida boys school	Male	68.2
		Seida girls school	Female	71.1
Noisy	Nablus city	Tariq boys school	Male	76.5
		Ali girls school	Female	79.4
Very noisy	Tulkarem Refugee camp	UNRWA boys school	Male	82.4
		UNRWA girls school	Female	85.9

Table 2: Mean values of blood pressure, heart rate, hearing threshold for study population with Pearson Correlation Coefficients (PCC) and F-Test values between dB(A) level and other variables

dB(A)	Quiet		noisy		Very noisy		PCC	ANOVA	
Sex	M	F	M	F	M	F	dB	F	S
Sys.	96.41	101.80	106.81	106.81	112.60	120.26	0.521**	78.3	0
Dias	60.57	66.48	67.90	66.85	75.33	78.45	0.440**	63.7	0
H.R.	80.50	84.52	89.67	90.18	87.75	93.78	0.440**	24.5	0
125R	22.93	25.43	29.75	35.25	34.00	40.62	0.097*	60.7	0
125L	25.43	25.75	25.68	28.87	31.50	37.75	0.311**	24.5	0
250R	25.87	26.68	29.37	37.12	38.62	42.81	0.432**	50.4	0
250L	27.12	27.43	26.12	33.81	37.25	40.81	0.334**	30.6	0
500R	28.43	27.50	30.25	38.43	39.50	42.87	0.369**	36.4	0
500L	28.31	27.62	27.93	36.43	37.81	40.75	0.299**	23.2	0
750R	22.00	22.62	26.43	36.06	36.31	37.75	0.371**	49.1	0
750L	21.87	23.37	24.37	33.50	34.93	35.43	0.339**	28.6	0
1000R	20.00	20.12	22.68	33.18	35.50	38.00	0.413**	57.1	0
1000L	20.06	21.50	21.56	31.25	34.18	35.31	0.374**	35.9	0
1500R	14.43	15.68	20.12	29.00	29.25	31.18	0.389**	56.8	0
1500L	15.31	17.12	17.56	27.37	30.25	29.12	0.365**	34.7	0
2000R	12.87	13.93	16.50	24.87	27.75	31.12	0.445**	67.6	0
2000L	13.25	15.31	15.00	23.93	28.50	28.75	0.398**	43.4	0
3000R	10.06	12.68	14.43	22.50	26.75	26.37	0.402**	53.9	0
3000L	10.37	12.31	14.06	20.93	25.56	24.93	0.375**	40.9	0
4000R	9.68	12.31	13.87	22.06	26.18	26.31	0.420**	52.0	0
4000L	9.37	11.18	13.50	20.25	24.75	24.25	0.374**	42.6	0
6000R	10.25	12.25	11.81	20.31	26.06	24.87	0.392**	44.5	0
6000L	8.75	11.06	12.00	18.68	24.93	23.31	0.368**	44.3	0
8000R	11.18	12.31	10.31	18.50	25.87	24.56	0.364**	42.6	0
8000L	9.00	11.81	10.31	18.37	24.68	23.43	0.353**	75.1	0

Sys.: Systolic, Dias: Diastolic, H. R.: Heart Rate, R: Right ear, L: Left ear, *: Significant ($p<0.05$) and **: Highly Significant ($p<0.01$), M: Male, F: Female, S: Significant, PCC Pearson Correlation Coefficient, ANOVA: F-Test, Degrees of freedom = 2 for all tests

The measurements of noise pollution level L_{eq} of three different locations represented by: quiet (Seida village) [68.2-71.1 dB(A)], noisy (Nablus city) [76.5-79.4 dB(A)] and very noisy (Tulkarem refugee camp) [82.4-85.9 dB(A)] are given in Table 1.

Blood pressure (systolic and diastolic) values, heart rate and hearing threshold of right and left ears for whole study are given in Table 2.

Table 3: Mean values of diastolic blood pressure related to noise level

							95% confidence interval	
Noise level	Sex	S.E.	df	F-Test	Mean±SD (mmHg)	Sig.	Lower	Upper
Quiet	M	1.219	2	4.1	60.57±0.80	0.017	-6.23	-1.44
	F	1.219	2	4.1	66.48±0.72	0.017	-15.75	-10.96
Noisy	M	1.219	2	4.1	67.90±0.93	0.017	1.44	6.23
	F	1.219	2	4.1	66.85±0.92	0.017	-11.91	-7.12
Very noisy	M	1.219	2	4.1	75.33±1.47	0.017	1096	15.75
	F	1.219	2	4.1	78.45±1.96	0.017	7.12	11.91

S.E: Standard Error, df: Degrees of freedom , SD: Standard deviation, Sig.: Significant

Table 4: Hearing threshold before and during experienced noise exposure for the right ear

	Seida boys school R		Seida girls school R		Tariq boys school R		Ali girls school R		UNRWA boys school R		UNRWA girls school R	
Hz	B	D	B	D	B	D	B	D	B	D	B	D
125	25	30	20	25	30	60	30	35	30	50	35	50
250	30	35	20	30	30	60	35	40	30	55	35	45
500	40	40	25	30	35	60	35	50	40	55	35	45
750	35	35	25	30	30	50	35	50	35	40	30	40
1000	25	35	20	25	30	55	35	50	30	40	30	40
1500	25	20	15	20	25	55	40	50	25	35	25	25
2000	15	15	10	15	20	50	30	40	15	30	15	25
3000	10	15	10	15	20	30	30	40	15	25	15	25
4000	10	10	5	15	25	30	25	40	10	20	20	25
6000	10	20	5	20	25	25	25	35	10	25	20	25
8000	5	20	5	20	25	25	25	30	10	25	20	25

Strong positive correlation (Pearson Correlation Coefficient) were found between noise level in dB(A) and dependent variables (systolic pressure, diastolic pressure, heart rate and hearing threshold) at different frequencies. In addition, a significant effect for noise level in dB(A) on each dependent variable was detected in this study by ANOVA test (F-test) Table 2. The analysis of variance of data on diastolic blood pressure(as an example) related to the noise level in dB(A) is given in Table 3.

Comparison of the group mean blood pressure and heart rate values of children attending schools in area with different noise levels in dB(A) showed significantly higher values of systolic and diastolic blood pressure, heart rate and hearing threshold in noisy or very noisy environment than in quiet environment. The mean systolic(SBP) and diastolic (DBP) blood pressure were even significantly higher in very noisy than in noisy areas Fig. 1. High noise pollution level seems to increase the stress reaction that elevates blood pressure. This process will increase cardiac oxygen demand and causes in

increase in the heart rate. In consistent to the behavior of blood pressure, mean heart rate values for the two sexes tended to increase with increasing noise level Fig. 2. The positive correlation coefficient between the heart rate and the noise pollution level was found (R =

0.440). The data showed that the heart rate was 8 beats per minute higher at the higher noise level. Regecova and Kellerova (Regecova and Kellerova, 1995) have investigated the association between the urban traffic noise and blood pressure in pre-school children. Their measurements showed that the behaviors of mean blood pressure increase with the higher traffic noise levels. Wu in his study showed that the noise exposure is associated with higher systolic and diastolic blood pressure (Wu ***et al.***, 1993). Green ***et al.*** (Wech Allyn) study showed that industrial noise exposure is associated with higher blood pressure and heart rates in men under 45 years old, but the effect on blood pressure appears to diminish considerably with age. In addition, they have studied the association between the industrial noise exposure and heart rate. They found that the heart rate was 2.7 beats per minute higher at the higher noise level.

The hearing threshold levels of different frequencies correlated positively with the noise pollution level ($R = 0.114$ to 0.267 ; $p < 0.05$). The hearing threshold levels of left ears for different samples (males) are plotted as a function of frequency in Fig. 3.

Figure 4 shows the results of hearing threshold shifts in the right ear during experienced noise for different frequencies for male schools. Hearing threshold level of left and right ears for the different schools of the two sexes as a function of frequency in our study shows little difference between male and female, this result because of elevation of noise pollution levels in female schools than in male schools. Studies of hearing loss seem to indicate that female retain better hearing sensitivity than male under the influence of similar noise exposures (Green ***et al.***, 1991).

Figures 5 and 6 show two examples (male and female) of hearing threshold shifts in the right ears in two different locations shortly before experiencing noise pollution (pre-exposure) and during experiencing of two hours of relatively high noise pollution (post-exposure). The recorded data are shown in Table 4. For example, the shift difference in hearing threshold between pre-exposure and during experiencing relatively high noise pollution (post-exposure) was 15 dB(A). Previous studies (Harris, 1979), showed 10 dB(A) shift difference in hearing threshold between pre-exposure and post-exposure by an 18-year old man.

Apart from these physical changes, noise can cause psychological disturbances, the children become irritable and resentful against the cause of noise. In several tests it has been established that high noise levels can seriously affect productivity and efficiency and that fewer mistakes in the classes are made when noise levels are reduced. When this occurs it is a direct result of mental fatigue caused by noise which makes children to be absenteeism and disagreeable.

In this work, the behavior of the blood pressure (systolic and diastolic) for the two sexes showed a positive increase with the noise pollution level. In consistent to the behavior of blood pressure, mean heart rate values for the two sexes tended to increase with increasing noise level. The positive correlation coefficient between the heart rate and the noise pollution level was found.

The hearing threshold levels of different frequencies correlated positively with the noise pollution levels. Our study showed that the hearing threshold shifts in the right and left ears shortly before experiencing noise pollution (pre-exposure) and during experiencing of two hours of relatively high noise pollution (post-exposure).

Many things can be done to relieve the noise pollution problem in the pollutant schools. Some of these are: quieting the noise sources, putting barriers or allowing enough spaces between schools buildings and noise sources, following safety and health regulations, decreasing the number of pupils in the class room and school.

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