Original Article

Effects of Occupational Noise Exposure on Hearing Status, Blood Lipid and Hypertension Levels in Workers of a Fireclay Mine

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Abstract

Background: Noise is one of the most pervasive hazards in industrial settings. This retrospective study was carried out to assess the effects of noise exposure on hearing status, blood lipids and blood pressure of employees of a local fireclay mine.

Methods: Two hundred and forty male workers were studied. Data on audiometric measurements, blood lipids and blood pressure were derived from the workers' medical records and analyzed. Furthermore, area noise measurements were performed. Data were analyzed using SPSS version 16.0.

Results: Workers were exposed to a mean noise level of 91±15 dB. The means of triglyceride (TG), total cholesterol (TC), systolic and diastolic blood pressure (SBP and DBP) were within the normal range for the first three years of the study. However, a slight, non-significant increase in TG level was noted in 2010. Most of the participants (63.6%) suffered from moderate hearing loss (HL). About 23.6% and 12.7% of the employees had developed severe and mild HL, respectively. A statistically significant difference was noted in the number of workers with high-frequency noise-induced HL. Furthermore, a statistically significant association was found between the mean of high-frequency HL and log-transformed TG values in 2009 and 2010.

Conclusions: High frequency HL could be used as a biomarker for identifying workers exposed to excessive noise levels. High-frequency HL developed over a 4-year exposure to noise was associated with hypertriglyceridemia. Implementing a hearing conservation program seems to be mandatory to prevent further increases in the number of workers who are already in the severe HL group.

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Introduction

About 30 million workers are at risk of irreversible hearing loss (HL) because of exposure to hazardous levels of noise.[1] The American National Institute of Occupational Safety and Health (NIOSH) has introduced HL as one of the top-priority areas for research in the 21st century.[2] Noise endangers human health in direct and indirect ways, with both psychological effects, such as annoyance, sleep disturbances and interference with speech communication, and physiological effects including noise-induced HL (NIHL) which can occur due to excessive noise exposures.[3-8] NIHL is defined as bilateral sensorineural HL that is maximal at 3 to 6 kHz frequencies. It develops slowly following long time exposure to hazardous, either continuous or intermittent, noise levels. The first sign of NIHL is audiometric notch at these frequencies with recovery at 8000 Hz.[9]

In addition to NIHL, exposure to noise can cause non-auditory physiological effects such as altering serum lipid profile, hypertension, cardiovascular diseases and myocardial infarction.[3, 8, 10-12] Higher levels of total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), triglyceride (TG) and blood pressure (BP) among subjects exposed to environmental or industrial noise have been reported.[8, 10, 11, 13, 14] The association between NIHL and TG and TC levels is controversial. Some studies have shown an increased risk of NIHL in subjects with higher cholesterol levels[14] and others have not found such a relationship.[10, 15] It is interesting, however, that better hearing thresholds have been reported in subjects with higher serum cholesterol levels.[16]

Despite the relationship between hypertension and repeated long time exposure to environmental (road traffic and aircraft) noise, the association between occupational noise exposure at levels above TLV-TWA (85 dBA) and hypertension is controversial. Some studies have suggested such an association as sustained blood pressure elevation[17, 18] or as a higher risk of hypertension.[19] On the other hand some other studies have not shown any significant interaction.[20]

During the past decade, the possible association between occupational noise exposure and high-frequency HL has been reported in many epidemiological studies.[8] However, to date, few studies have used high-frequency HL as an indicator of noise exposure to investigate the risk of its adverse outcomes such as hyperlipidemia, hypertriglyceridemia, and hypertension. The objectives of the present study were to assess the possible effects of excessive noise exposure on hearing status, blood lipid level and blood pressure of employees of a local fireclay mine over a 4 year period based on their medical records of their annual medical examinations.

Materials and Methods

Subject and Study Design

This retrospective study was carried out at a fireclay mine in Fars, Iran. Two hundred and forty male workers occupationally exposed to noise were studied. Data of audiometric measurements, blood lipid levels and blood pressure from 2007 to 2010 were derived from the workers' medical records. For each worker, a brief questionnaire containing information regarding demographic variables, ethnicity, exposure to intense noise in recreational activities such as listening to loud music and/or hunting, military service, history of metabolic disorders such as diabetes and congenital hyperlipidemia, and using potentially ototoxic medications was filled out according to the database of the plant.

Subjects with current and/or history of exposure to excessive noise from non-occupational activities, those with a history of metabolic disorders, those aged over 50 years, and those who used potentially ototoxic medications were excluded from the study.

Measurement of Study Variables

Audiometric Measurement

Hearing status of the left and right ears at 0.5, 1, 2, 3, 4, 6 and 8 kHz frequencies was assessed by a qualified audiologist using a MEVOX- ASB15 audiometer. The pure tone audiometry process was conducted after at least a 12-hour noise free period. Since the notch at 4 or 6 kHz in the audiogram is an indicator of NIHL, workers with bilateral hearing threshold above 25dB in 4 kHz and 6 kHz frequencies were considered to suffer from HL. The workers were divided into 3 groups based on their average HL levels at these frequencies: severe HL group (average HL≥25 dB), moderate HL group (average HL between 25 dB and 15 dB), and mild HL group (average HL≤15 dB).[21]

Blood Pressure and Lipid Measurements

The standing height and weight of each worker were measured in his normal working clothes but barefoot. Then, body mass index (BMI) was computed and taken into account to adjust for weight and height influence on BP and blood lipids. Adults were considered as "overweight" when BMI ranged from 25 to 29.9 kg/m^2, and "obese" when BMI was greater than 30 kg/m^2. Subjects were requested to fast for 14 hours before blood samples were taken for analysis. Systolic and diastolic BP was assessed by a physician using a mercury sphygmomanometer. Before the test, the subjects rested for about 15 minutes and then BP was measured in sitting position with the left arm kept at the heart level. The values of 90 mmHg and 140 mmHg were considered as normal for diastolic and systolic BP, respectively.[22]

TC and TG were measured by a digital spectrophotometer with microprocessor (APEL, PD-303S). The desirable values for these parameters were 200 mg/dl for TC and less than 150 mg/dl for TG.

Statistical Analyses

Data were analyzed using SPSS, version 16.0 on a personal computer. In all the statistical comparisons, P<0.05 was considered significant.

Results

Of the 240 noise-exposed workers included in this study, 20 workers did not meet the requirements of the study and were excluded. Descriptive characteristics of the remained subjects are presented in Table 1. The mean noise exposure level was 91±15 dB. The trends of four year exposure to noise and frequency of abnormal findings are shown in Table 2. The means of TG, TC, SBP and DBP were within the normal range for the first three years of the study.

However, a slight, non-significant increase in TG level was noted in 2010. Furthermore, no statistically significant changes were found in the means of TG, TC, SBP, DBP and NIHL over the study period.

However, a statistically significant association was found in the number of workers with high-frequency NIHL during the 4-year exposure period. Table 3 illustrates descriptive characteristics, blood lipid levels, and BPs for the three study groups. As shown, most of the participants (63.6%) fell into the moderate HL group, 23.6% in the severe and 12.7% in the mild HL groups; the means of TC, TG and BPs were normal in all groups. Additionally, no significant differences were noted among these groups as far as TC, TG and BPs levels were concerned. Table 4 shows the association between HL at 4 and 6 kHz frequencies and log-transformed TG levels. Multiple linear regression analysis, including variables of age, weight and height in the model, showed that after adjusting for these confounders, there was a statistically significant association between the mean of HL at 4 and 6 kHz frequencies and log-transformed TG values in 2009 and 2010.

Discussion

This study aimed to assess the possible effects of occupational noise exposure on hearing status, blood lipid and blood pressure using bilaterally HL at 4 and 6 kHz frequencies as a surrogate indicator of occupational noise exposure. In the present study, the

Table 1: Demographic variables of the workers (n=220)

Variable	Mean±SD	Min	Max
Age (yr)	38±6.4	28	50
Height (cm)	168.5±7.2	150	195
Weight (kg)	65.6±10.6	44	98
Body Mass Index (kg/m^2)	23.1±3.4	16.1	34

Table 2: Four-year trends (mean±SD) and frequencies (%) of abnormal levels of blood lipid levels, blood pressure and HL in the workers

	TG (mg/dL)*		TC (mg/dL)*		DBP* (mmHg)		SBP*†(mmHg)		Hi-frequency HL *	
	Mean±SD	N(%)	Mean±SD	N(%)	Mean±SD	N(%)	Mean±SD	N(%)	Mean±SD	N(%)
2007	148±92	45(20.5)	175±36	51(23.5)	75.5±7	4(1.8)	116±11	3(1.4)	21.6±8	39(18)
2008	150±94	44(20)	180±38	57(26)	-	-	-	-	21.7±9.2	42(19)
2009	150±110	42(19.1)	181±38	61(27.7)	-	-	-	-	24.3±8	61(28)
2010	160±100	50(23)	176±40	60(27.3)	73±7.7	5(2.2)	113±10	4(1.8)	20.8±9	66(30)

*No statistically significant differences were noted among mean values (P<0.05); †Data on blood pressure were only available for 2 years (2007 and 2010).

Table 3: Descriptive characteristics, blood lipid level and blood pressure (mean±SD) in the three study groups in 2010 (n=220)

Characteristics	HL groups*			P value
	Severe (n=52)	Moderate (n=140)	Mild (n=28)	
Height (cm)	166±6	168±7	169±7	>0.05
BMI (Kg/m^2)	22.9±3	23.1±3	23.1±4	>0.05
TC (mg/dL)	173±42	178±41	178±34	>0.05
TG (mg/dL)	146±75	169±106	148±65	>0.05
SBP (mmHg)	115±11	113±9	111.10	>0.05
DBP (mmHg)	78±9	73±11	75±8	>0.05
SBP>90 mmHg N (%)	4 (7.6)	2 (1.4)	1 (3.5)	>0.05
DBP>140 mmHg N (%)	3 (5.7)	4 (2.8)	2 (7.1)	>0.05

*HL in 4 and 6 kHz frequencies

Table 4: Association between NIHL at 4 and 6 kHz frequencies and log-transformed TG levels

Variables	Regression coefficient (β)	P value [a]
TG 2009	1.0	0.02
TG 2010	2.2	0.02

[a]Multiple Linear Regression Analysis

means of TG, TC and BP levels in the subjects were within the normal range (Table 2). Likewise, when the subjects were categorized based on the severity of their HL, the means of these parameters, even in the severe HL group, were still within the normal range and no statistically significant differences were noted among the groups regarding these variables. However, after adjusting for age, height and weight, multiple linear regression analysis revealed a statistically significant association between the mean of HL at 4 and 6 kHz frequencies and log-transformed TG values in 2009 and 2010 (Table 4). These findings are in accordance with those of other authors.[10, 18, 23] For instance, Chang et al. in a case-control study of workers exposed to noise over one-year period did not observe any significant association between hypercholesterolemia and HL.[10] Similarly, Susuki et al. did not find such an association between TC levels and HL.[18] Similar findings have been reported by others.[15, 23, 24] Conversely, some authors have reported significant relationships between HL and BPs and hypercholesterolemia.[8, 14, 25, 26] A sustained elevation of BP[17, 18, 25, 27] or a higher risk of hypertension[19, 28] has been reported in subjects occupationally exposed to noise. Chang et al. in a study on effects of occupational noise exposure on BP in 20 automobile workers found both transient and sustained effects of occupational noise exposure on workers' SBP.[27] In another study, Chang et al. have studied the chronic effects of noise exposure on hypertension in 790 aircraft-manufacturing workers and found that a mean hearing threshold exceeding 15 dB at 4 kHz or 6 kHz bilaterally was associated with an increased risk of hypertension.[8] Similarly, Sbihi et al. in a cohort study of 10872 sawmill workers have reported a positive association between the risk of hypertension and noise exposure above 85 dB.[28]

In the present study, we did not find a statistically significant relationship between high-frequency HL and the means of BPs even after adjusting for age, height and weight.

Our findings are in agreement with conclusions of Chang et al.[8] and Mehrdad et al.[22] who have found a significant relationship between hypertriglyceridemia and NIHL after adjusting for confounding variables. Similar conclusions have been reported in animal studies.[28] However, some studies have not observed such a relationship.[16]

The discrepancies in the association between HL and the levels of TG, TC and BPs in different studies may be explained by the fact that workers in occupational settings differ as far as demographic characteristics, levels of noise exposure, duration of exposure, and the use of personal protective equipment (PPE) are concerned.[8, 29] The levels of TG, TC and BPs can also be affected by some other factors such as nutrition, physical activities, smoking, lifestyle and job features such as stresses and shift work. Furthermore, exposure to occupational noise is a well-known risk factor for HL, which can even protect workers against noise-related non-auditory effects such as hypertension and alterations in serum lipid profile.[28] Additionally, the risk of HL may be increased because of hypertension.[30] Therefore, one should interprete the interrelationship between HL and hypertension tentatively.

Due to the inherent limitations of retrospective studies, our study could not establish a causal relationship between high-frequency HL and TG levels. However, despite its limitation, the study has provided circumstantial evidence in favor of it because:

1. Subjects with current and/or history of exposure to excessive noise in non-occupational activities, those with history of metabolic disorders, those aged over 50 years (possibly suffering from presbycusis), and those who used potentially ototoxic medications were excluded from the study.

2. Noise was the only workplace hazardous agent known to induce HL.

3. Changes in audiometric pattern and blood lipids were studied over time, as cumulative exposure to noise increased, and were compared with the base line values in the first year of study.

4. Using multiple linear regression analysis, the role of confounders such as age, weight and height was controlled.

Conclusions

Our findings suggest that exposure to noise in fireclay mines may result in hypertriglyceridemia, which exposes the workers at a greater risk of HL. Additionally, the number of workers with high-frequency HL increase annually. Therefore, interventional programs and protecting measures such as engineering control measures, safe work practice, administrative controls, and use of personal protective equipment are recommended, in order of priority, to reduce the workers' exposure to noise and protect them from developing more severe consequences.

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Conflict of interest: None declared

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