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Original Article

Effect of Exposure to Occupational Noise and Shift Working on Blood Pressure in Rubber Manufacturing Company Workers

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Abstract: This study aimed to assess the relationship between shift working and occupational exposure to noise with blood pressure (BP). The study was carried out in a rubber manufacturing company in 2010. Demographic, medical and occupational information for carrying out the study were collected through direct interview. All 331 under study workers were divided into four groups according to work shift and noise exposure severity, from non-noise exposed day time workers (Group1) to noise exposed shift workers (Group 4). Finally, systolic and diastolic blood pressure levels were compared among these four groups. The results of this study showed that there was a significant difference between average systolic and diastolic BP and hypertension (HTN) frequency in the four groups (p<0.05). The highest rate of HTN and mean systolic and diastolic BP were observed among shift workers who were exposed to noise higher than permissible limit (Group 4). Also the results of logistic regression analysis showed that there was a significant relationship between simultaneous exposures to noise more than the permitted limit and shift work with HTN (p<0.05). The results of our study showed that shift working and simultaneous exposure to noise have an additive effect on occurrence of HTN. It is recommended that during periodic physical examinations of noise exposed shift workers, assessment of the cardiovascular system and BP should be done as well as the auditory system.

Key words: Occupational, Noise, Shift work, Hypertension, Blood pressure

Introduction

Hypertension (HTN) is relatively common among workers and is considered as one of the main health hazards[1)]. HTN is an important risk factor for cardiovascular diseases. Some factors such as age and gender (non-modifiable factors) and also, nutrition, smoking and occupational exposures (modifiable factors) are the main identified factors which can affect HTN occurrence[2)]. Shift work and workplace noise are occupational factors which probably affect blood pressure[3)]. Noise is considered as one of the most important occupational risk factors at work places. It seems workers exposure to noise is an unavoidable exposure in industrial communities. The National Institute

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of Occupational Safety and Health (NIOSH) has estimated that 14% of workers are exposed to noise higher than permissible limit[4].

Generally, biologic effects of noise are divided into two categories: auditory and non-auditory effects. The relationship between exposure to noise and hearing loss has been proven by previous studies[5]. Nowadays, studies are mostly focused on non-auditory effects including the effect of noise exposure on blood pressure (BP)[6, 7]. In industry-based studies, relationship between long-term occupational noise exposure and cardiovascular disorders such as myocardial infarction, coronary artery disease, and HTN has been observed[5, 7–10]. The results of some other studies among workers have shown the relationship between occupational noise exposure and increase in BP[11–13]. But the mechanism of this relationship is not clear. One of the possible mechanisms is peripheral vasoconstriction due to noise exposure. The study of Tomei *et al.* in 2000 showed that mean systolic and diastolic BP of workers exposed to noise was significantly higher than the control group[8]. Also, the study of Abbate *et al.* in 2002 showed that there was an unremarkably significant relationship between noise exposure and systolic BP and a highly significant relationship between noise exposure and diastolic BP[14]. However, no significant relationship was seen between noise exposure and increase in BP in some studies[15–17]. Regarding fast industrialization of societies and increase in production and productivity, applying shift work schedule in industry is unavoidable and its trend is increasing[18]. According to the International Labor Organization's statistics, about 15–30% of workforces in developing countries are shift workers[19]. In previous studies, association of shift work (i. e., working outside of daytime work) with increased risk of cardiovascular diseases has been reported[20–22]. Based on different studies, circadian rhythm disorder (stress due to sleeping disorder, etc.), social stress and behavioral factors (increase in smoking, malnutrition, …) have been cited as possible reasons of the relationship between shift work and cardiovascular diseases[20–23].

There is controversy in previous studies about the relationship between HTN and shift work. However, most of them have proved this relationship. In various studies the relationship between BP and shift work has been confirmed[1, 24]. However, some studies have not confirmed this hypothesis[25, 26].

In Nagaya *et al*. study the frequency of HTN was significantly higher among shift workers compared to day time shift workers[27]. The study of Sakata *et al*. in 2003 showed that the risk of developing HTN was 1.1 times more common in shift workers compared to day time shift workers. Based on a 14-yr historical cohort study, BP of shift workers had significant increase compared to day time shift workers[28]. In a longitudinal study carried out by Morikawa *et al*., HTN occurrence was associated with shift working among young workers[29]. However, in the retrospective cohort study of Yadegarfar and Mcnamee carried out on 1,567 English shift workers and day time shift workers, no significant relationship between BP and shift working was observed[30]. Also, in a historical cohort study carried out between 1982 and 2003, there was no significant relationship between HTN and shift working[25]. In most industries shift working and simultaneous noise exposure are considered as inseparable parts of working conditions. The independent effects of noise and shift work on BP have been largely studied and confirmed in previous studies, but combined effect of noise exposure and shift work on BP is still equivocal. In this study, we have assessed simultaneous effects of shift work and noise exposure on BP among rubber manufacturing company workers.

Subjects and Methods

Study population

This study was conducted in a major rubber manufacturing company in Yazd (a central province in Iran) in 2010. All workers of the tire manufacturing company who had experienced the working conditions for more than 1 yr were included in the study. Since there were no female workers in this factory, all the individuals under study were men. For all studied individuals, the required information such as demographic data, medical and occupational records were obtained through direct interview and recorded in questionnaires designed for the study. The data in the questionnaire included: age, work duration in current job, nature of job, regular exercise, cigarette smoking, alcohol consumption, tea consumption, history of salt in diet, work schedule, history of systemic diseases, history of family disease, drug history, second or previous occupation, and personal habits. In this study, regular exercise was defined by at least 30 min of exercise with a frequency of three or more times per week[4]. Responses to the question on cigarette smoking were categorized into smokers and nonsmokers (including ex-smokers)[4]. Responses to the question on nature of job were categorized into 3 groups of machine assisted, manual and supervisory[31]. Responses to the question on dietary salt were categorized into 3 groups of low, moderate and high.

Subjects who had been diagnosed with hypertension or known chronic illnesses such as diabetes mellitus, cardiovascular diseases and cerebrovascular diseases during pre-employment medical examinations were excluded. Subjects were excluded if they had been exposed to loud noise or if they had been working as a shift worker in previous or second job. Also subjects were excluded if they had been changing working schedules (shift-working to daytime-working or vice versa). Finally, workers with hearing protection devices usage were excluded.

In this study, 15 subjects were excluded due to change in work schedule and also based on pre-employment medical examinations, 5, 6 and 5 subjects were excluded due to diabetes, HTN, and cardiovascular diseases respectively. Besides, seven subjects were excluded because of non-cooperation. Finally, 43 workers were excluded because of hearing protection devices usage.

The rubber manufacturing process is divided into five departments that perform special operations including: compounding and mixing, component preparation, tire building, curing and inspection and finishing. Rubber manufacturing company has different units including banbury, curing, calendar, extruder, etc. The units of the factory were divided into two groups regarding occupational noise intensity including higher than permissible limit (≥ 85 dBA), like curing unit and lower than permissible limit (< 85 dBA), like banbury unit. Also, job schedule type was divided into shift work and day work.

Finally, after considering the exclusion criteria, 76 day time workers were exposed to noise lower than 85 dB (Group 1), 88 shift workers were exposed to noise lower than 85 dB (Group 2), 72 day time workers were exposed to noise higher than 85 dB (Group 3), and 95 shift workers were exposed to noise higher than 85 dB (Group 4) were compared with each other regarding mean systolic and diastolic BP and also frequency of HTN.

All workers participated voluntarily in this study and signed informed consent form (written consent was obtained in Persian). This study was approved by the Ethics Committee of Tehran University of Medical Sciences.

Individual height and body weight were measured for all workers. Body mass index (BMI) was calculated as body weight (kg) divided by the square of the height (m^2).

Also, for each subject, we measured fasting blood sugar (FBS) and lipid profile [cholesterol, HDL (High density lipoprotein), LDL (Low density lipoprotein) and triglyceride] in fasting condition. The time of blood sampling was between 08:00 and 9:00 h in this study.

Work schedule and evaluation of exposure to noise

Noise monitoring was done by a team of occupational hygienists working in the Health and Safety Executive (HSE) unit of the factory. Sound pressure was measured using a CEL-440 sound level meter (CASELLA, USA). Sound level meter was fixed on to stand and noise levels were observed and also recorded continuously during eight working hours. Noise monitoring was repeated through one week (six working days). Noise levels were recorded by Leq (equivalent continuous noise level) measurements. The instrument's range of determination is between 20 dB (A) and 140 dB (A). In order to determine noise exposures in each location, a set of job titles were determined after workplace surveying by a team of occupational hygienists. All measurements of eight-hour time weighted averages based on environmental noise sampling for each job title, by individual location, that provided a mean noise exposure level for each job title. Therefore, each understudy worker was assigned a particular level of noise exposure in his working location.

The sound level meter, which was placed in 120 various stations, detected noise levels ranging from 72–100 dBA. Mean noise intensity for Groups 1 and 2 was 81.8 dB (72–83.4) and for Groups 3 and 4 was 92.3 dB (87–99).

Job schedule type was divided into shift work and day work. Shift work and day work were measured by asking the respondents to rate which of the following categories described their current work schedule: fixed day shift (7:00 am–3:00 pm), two-shift schedule (7:00 am–3:00 pm and 3:00 pm–11:00 pm OR 3:00 pm–11:00 pm and 11:00 pm–7:00 am), fixed evening shift (3:00 pm–11:00 pm) and rotating shift (any variation of other shifts). In this factory most of the workers had fixed daytime or fixed evening and also rotating shift and the numbers of workers in two-shift schedule were limited. The first category was considered day work, and the other categories were considered shift work[32].

Outcome data

The time of blood pressure measurement was between 07:00 and 8:00 h throughout the study period, and measurement within 30 min after a meal or heavy physical activity or cigarette smoking was avoided. The measurement was taken with each subject sitting on a chair after at least five minutes of rest. Systolic and diastolic blood pressures were measured twice, using a 10 to 12 cm × 40 cm cuff of a standard mercury sphygmomanometer in the morning just before work started. The average of the two readings for both systolic and diastolic pressures was recorded for

data analysis. We defined hypertensive subjects as those who reported that their doctors had diagnosed hypertension or those who had a mean value of resting systolic blood pressure (SBP) ≥140 mmHg or a mean value of resting diastolic blood pressure (DBP) ≥90 mmHg.

Statistical analysis

Mean, standard deviation (SD) and range of quantitative variables were calculated. The ANOVA and *t*-test were used to compare these variables among the groups. The χ^2 was used to compare the qualitative variables. Logistic regression analysis was used to eliminate the confounding variables and test the correlation between shift work and exposure to noise with hypertension. Linear regression analysis was used to compare blood pressure levels (SBP and DSP) between these four groups. Biological interaction between two variables was calculated using the synergic index (SI) score based on the ratio of the combined effects to the sum of the separate effects of two variables according to Rothman and Greenland[33]. An SI score=1 indicates a departure from an additive effect between two variables. A significant SI score above 1 indicates that synergy exists between two variables. We analyzed how the shift work and noise alone or in combination were associated with hypertension. *p* values less than 0.05 were considered statistically significant. The results of statistical analysis are expressed as odds ratio (OR) with 95% confidence intervals (95%CI). All the mentioned calculations were performed using SPSS version 11 software.

Results

In this study, the researchers studied 331 workers employed in a rubber manufacturing company of which 76 subjects (23.0%) were day time workers and were exposed to noise lower than permissible limit (Group 1), 88 subjects (26.6%) were shift workers and were exposed to noise lower than permissible limit (Group 2), 72 subjects (21.8%) were day time workers and were exposed to noise higher than permissible limit (Group 3) and 95 subjects (28.7%) were shift workers and were exposed to noise higher than permissible limit (Group 4).

Average age of all subjects was 38.95 (19–55) yr. Mean work experience of the all subjects of the study was 10.75 yr (1–28). Their mean body mass index (BMI) was 25.31 kg/m^2(15.90–36.75). Fifty-four workers (16.3%) were smokers and 277 (83.7%) were non-smokers. 55.3% (183 subjects) were shift workers and 148 subjects (44.7%) were day time workers. Mean systolic and diastolic BPs among all subjects of the study were 115.08 (90–170) and 76.34 (50–100.50) mmHg, respectively. Among all studied workers, 52 (15.7%) were suffering from HTN.

Table 1 shows comparisons of demographic characteristics and risk factors of HTN in the four understudy groups. As it is understood from the results of Table 1, there was no significant difference among the groups in terms of age, work experience, BMI, smoking, exercise, occupational activity, tea and salt consumption, and family history of HTN ($p>0.05$). Also no significant difference was seen among workers regarding their blood profiles ($p>0.05$) (Table 2). Table 3 shows comparison of prevalence of hypertension and mean systolic and also diastolic blood pressure in four under study groups based on adjusted and unadjusted analysis.

There was significant difference among 4 groups regarding mean systolic and diastolic BPs and HTN frequency ($p<0.05$). The highest frequency of HTN and mean systolic and diastolic BPs were seen in shift workers who were exposed to noise higher than permissible limit (Group 4).

For more accurate assessment of relationship between simultaneous exposure to noise and shift working with HTN and also in order to adjust confounding factors, the logistic regression analysis was used. To perform the analysis, HTN was considered as dependent variable in two groups: those who were suffering and those who were not suffering from HTN. Also independent variables included exposure to noise, shift working, salt consumption, exercise, family history of HTN, age, BMI, working experience and smoking habit (Table 3). The results of this analysis indicated that even after adjusting confounding variables, there was a significant relationship between simultaneous exposure to occupational noise and shift working with HTN ($p<0.05$). The adjusted odds ratio of HTN compared to reference group (group1 workers) increased from 3.61 times in group2 workers and 4.81 times in group3 workers to 7.98 times in workers of group4. Table 4 shows the comparison of hypertension prevalence among understudy groups regarding to hypertension risk factors. Based on Table 4 in four understudy groups, the prevalence of hypertension may be increased regarding to old age, high levels of working experience, cigarette smoking, high salt diets and also non regular exercise.

The estimated synergism index was approximately equal 1 (SI=1.087) (95%CI=1.006–4.708). It shows that exposed to noise and shift work had additive effect on blood pressure.

Table 1. Demographic characteristics and risk factors of hypertension of the study groups

Variable	Exposure groups				*p*-value
	Group 1 (n=76)	Group 2 (n=88)	Group3 (n=72)	Group4 (n=95)	
Age (yr) Mean (SD)	40.2 (4.5)	38.5 (7.2)	39.0 (6.3)	37.8 (6.7)	0.066
Work of duration (yr) Mean (SD)	11.6 (3.1)	10.7 (4.5)	10.5 (3.4)	10.0 (4.5)	0.073
Body mass index (kg/m^2) Mean (SD)	25.6 (3.5)	25.7 (4.1)	24.6 (3.2)	25.2 (3.6)	0.186
Smoking Yes (%)	12 (15.7)	15 (17.0)	11 (15.3)	16 (16.8)	0.996
Nature of job N (%)					0.963
Machine assisted	42 (55.3)	50 (56.8)	41 (56.9)	54 (56.8)	
Manual	22 (28.9)	25 (28.4)	20 (27.8)	26 (27.4)	
Supervisory	12 (15.8)	13 (14.8)	11 (15.3)	15 (15.8)	
Tea consumption Yes (%)	47 (61.8)	55 (62.5)	46 (63.8)	59 (62.1)	0.201
Dietary salt N (%)					0.712
Low	25 (32.8)	29 (32.9)	23 (31.9)	30 (31.6)	
Moderate	34 (44.7)	40 (46.6)	33 (45.8)	43 (45.2)	
High	17 (22.3)	19 (21.5)	16 (22.3)	22 (23.2)	
Regular exercise Yes (%)	15 (19.7)	14 (15.9)	13 (18.0)	18 (18.9)	0.652
Family history of hypertension Yes (%)	5 (6.6)	6 (6.8)	5 (6.9)	7 (7.3)	0.834

Table 2. Characteristic of blood profiles of the study groups

Measurements		Exposure groups				*p*-value
		Group 1	Group 2	Group3	Group4	
Fast blood sugar (mg/dl)	Mean (SD)	84.8 (14.9)	84.9 (16.9)	87.9 (14.7)	86.7 (16.3)	0.534
Cholesterol (mg/dl)	Mean (SD)	205.7 (39.7)	209.5 (30.5)	207.3 (40.5)	209.9 (37.0)	0.801
Triglyceride (mg/dl)	Mean (SD)	181.6 (67.4)	187.3 (84.6)	176.9 (66.8)	181.0 (75.3)	0.754
LDL (mg/dl)	Mean (SD)	124.3 (10.3)	125.1 (7.3)	122.8 (6.5)	125.1 (6.7)	0.313
HDL (mg/dl)	Mean (SD)	40.2 (5.4)	38.9 (5.1)	39.1 (5.2)	38.8 (5.2)	0.268

Discussion

The results of our study showed that shift working and simultaneous noise exposure have an additive effect on occurrence of HTN. In the current study, shift working and exposure to noise higher than permissible limit, either alone or together, were associated with increase in prevalence of HTN. HTN risks in Group 4, Group 3 and Group No. 2 were in order 7.98, 4.81, and 3.61 times more than the risk in Group 1. Although the risk of HTN in simultaneous noise exposure was more than isolated noise exposure and shift working, combination of these two occupational factors did not have a synergistic effect on HTN (SI=1.08).

In Lee *et al*.'s study on workers of a metal manufacturing company in Busan, a significant relationship between chronic noise exposure and increase in systolic BP was seen[4]. In this study, after adjusting confounding factors, mean systolic BP of office workers exposed to noise less than 60 dB was 1.7, 2.5 and 3.8 mmHg less than workers exposed to alternating noise, workers exposed to 60–85 dB noise, and workers exposed to noise more than 85 dB, respectively. But only the difference between the first and last groups was statistically significant. Although diastolic BP had increased along with increase in noise exposure, no significant difference was seen while comparing mean diastolic BP among the four groups.

Chang *et al.*'s study on workers of a car manufacturing factory indicated that occupational noise exposure can facilitate HTN progression[6]. However in study of Hessel and Sluis-Cremer, there was no significant relationship between BP and noise exposure[34]. In Fogari *et al*.'s study

Table 3. Comparison of prevalence of hypertension and mean systolic & diastolic blood pressure (SBP & DBP) in studied groups

Outcome	Hypertension							
Exposure groups	N	%	Crude OR	95%CI	Crude *p*-value	Adjusted[1] OR	95%CI	Adjusted[1] *p*-value
Group 1 (n=76)	4	5.2	1.00	–	–	1.00	–	–
Group 2 (n=88)	12	13.6	2.84	1.12–9.21	0.023	3.61	1.07–10.18	0.038
Group 3 (n=72)	14	19.4	4.29	1.65–13.43	0.007	4.81	1.41–13.25	0.011
Group 4 (n=95)	22	23.4	5.26	1.81–15.52	0.001	7.98	3.26–22.56	0.001

Outcome	SBP (Systolic blood pressure)				
Exposure groups	Mean (mmHg)	Crude *p*-value	Mean difference (mmHg)	95%CI	Adjusted [2] *p*-value
Group 1 (n=76)	111.40	–	0	–	–
Group 2 (n=88)	112.59	0.045	1.05	0.19–1.92	0.048
Group 3 (n=72)	114.92	0.033	3.65	0.31–6.98	0.030
Group 4 (n=95)	119.31	0.001	7.67	4.11–11.17	0.001

Outcome	DBP (Diastolic blood pressure)				
Exposure groups	Mean (mmHg)	Crude *p*-value	Mean difference (mmHg)	95%CI	Adjusted [2] *p*-value
Group 1 (n=76)	74.21	–	0	–	–
Group 2 (n=88)	75.29	0.045	1.07	0.35–2.46	0.047
Group 3 (n=72)	76.72	0.035	2.55	0.54–5.29	0.031
Group 4 (n=95)	78.15	0.003	4.11	1.91–6.32	0.001

1−Adjusting for age, work of duration, body mass index, smoking, dietary salt, regular exercise and family history of hypertension using logistic regression analysis. 2−Adjusting for age, work of duration, body mass index, smoking, dietary salt, regular exercise and family history of hypertension using linear regression analysis.

on 476 workers with normal BP, there was no significant relationship between BP and noise exposure[7].

It is assumed that noise apply its health effects via stress, since noise often raises stress in different roots[13]. Stress increases blood pressure levels and heart rates resulting from sympathetic nervous system activation[35]. One plausible biological mechanism of hypertension caused by noise exposure is sympatheticotonia-induced endothelial lesion[6]. It is of interest to study the early changes in vascular properties because reduced arterial compliance and distensibility leads to increased systolic blood pressure, left ventricular hypertrophy, and acceleration of arteriosclerosis[6].

In our study, mean systolic and diastolic BPs in shift workers exposed to noise lower than permissible limit was significantly higher than day time workers exposed to noise lower than permissible limit. In this regard, the results of our study were compatible with some previous studies[27, 31, 36].

The results of a study carried out by Nazri *et al*. on 148 workers of semi-conductor industry indicated that prevalence of HTN among shift workers (22.4%) was significantly higher than day time workers (4.2%) ($p<0.001$)[34]. Also, the results of Oishi *et al*. study indicated that shift working is considered as a risk factor of HTN progression. The odds ratio of HTN among shift workers was 1.23 times more than day time workers (95%CI =1.05–1.44)[24]. However, no significant association was seen between shift work and HTN in Sfreddo *et al*.'s study[26] which was performed on 493 nursing staff and Hublin *et al*.'s study[25] which was done during 22 yr of follow-up.

An increased susceptibility of shift workers to develop hypertension can be explained by the fact that shift work triggers the effects of other lifestyle-related factors, such as disruption of circadian rhythms, stress, and behavior modification. Behavior modification includes increase in smoking, unhealthy diet, and decrease in physical activity[31].

This study may have some limitations. First, a cross-sectional design may restrict causal relationship, therefore it is recommended to conduct longitudinal studies to evaluate this relationship. One of our study restrictions is using noise monitoring instead of individual noise dosimetric study for all understudy workers. Also, the exact

Table 4. Comparison of hypertension prevalence among understudy groups regarding to hypertension risk factors

Variable	OR	95%CI	*p* value	Variable	OR	95%CI	*p* value
Age (≤ 40 yr)				Age (> 40 yr)			
Group 1	1.00	–	–	Group 1	1.00	–	–
Group 2	2.23	1.13–5.62	0.035	Group 2	3.70	1.24–7.26	0.012
Group 3	3.24	1.52–7.55	0.013	Group 3	4.99	2.11–11.45	0.004
Group 4	3.8	1.75–10.01	0.005	Group 4	6.56	2.39–13.83	0.001
Work of duration (≤ 11 yr)				Work of duration (> 11 yr)			
Group 1	1.00	–	–	Group 1	1.00	–	–
Group 2	2.42	1.15–5.94	0.033	Group 2	3.51	1.20–7.13	0.025
Group 3	3.31	1.48–7.49	0.015	Group 3	4.91	1.98–11.13	0.010
Group 4	4.13	1.93–11.60	0.002	Group 4	6.21	2.18–12.71	0.001
Body mass index (≤ 25 kg/m^2)				Body mass index (> 25 kg/m^2)			
Group 1	1.00	–	–	Group 1	1.00	–	–
Group 2	2.27	1.18–5.58	0.035	Group 2	3.63	1.26–7.12	0.013
Group 3	3.20	1.49–7.44	0.023	Group 3	5.01	2.15–11.62	0.008
Group 4	3.77	1.63–10.15	0.008	Group 4	7.12	2.56–13.97	0.001
Smoking (No)				Smoking (Yes)			
Group 1	1.00	–	–	Group 1	1.00	–	–
Group 2	2.14	1.07–5.31	0.045	Group 2	3.73	1.35–7.37	0.015
Group 3	3.03	1.24–6.74	0.040	Group 3	5.27	2.33–11.91	0.001
Group 4	3.42	1.36–9.80	0.005	Group 4	7.41	2.43–14.41	0.001
Dietary salt (Low and Moderate)				Dietary salt (High)			
Group 1	1.00	–	–	Group 1	1.00	–	–
Group 2	2.46	1.20–6.01	0.025	Group 2	3.34	1.14–7.02	0.028
Group 3	3.45	1.56–7.87	0.011	Group 3	4.50	1.71–10.82	0.010
Group 4	4.28	2.05–12.01	0.001	Group 4	6.01	2.07–12.25	0.001
Regular exercise (Yes)				Regular exercise (No)			
Group 1	1.00	–	–	Group 1	1.00	–	–
Group 2	2.65	1.25–6.13	0.030	Group 2	3.01	1.30–6.59	0.028
Group 3	4.00	1.43–10.20	0.018	Group 3	4.62	1.73–11.28	0.010
Group 4	4.79	2.09–12.11	0.001	Group 4	5.47	2.41–13.36	0.001
Family history of hypertension (No)				Family history of hypertension (Yes)			
Group 1	1.00	–	–	Group 1	1.00	–	–
Group 2	2.75	1.36–6.22	0.027	Group 2	2.91	1.28–6.43	0.020
Group 3	4.10	1.59–10.50	0.010	Group 3	4.47	1.69–10.90	0.005
Group 4	4.87	2.23–12.34	0.001	Group 4	5.65	2.34–13.08	0.001

severity of noise exposure of workers was not clear due to high mobility of workers in different units of the factory. However, this high mobility of workers did not exclude them from the considered classification (G1 to G4) in the study. And workers were in separated working units that facilitated our classifications and exposure assessments.

In our study, the frequency of HTN in shift workers exposed to noise higher than permissible limit was significantly more than day time workers exposed to noise lower than permissible limit. Also, shift work and unauthorized noise are considered as risk factors of HTN. Therefore, it is recommended that in industries where shift workers are exposed to unauthorized noise, cardiovascular system and BP examination should be paid special attention, besides auditory system, during their periodic physical examinations.

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