Effect of Smoking and Noise Exposure on Hearing Threshold Levels in Industrial Workers in West of Iran

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ABSTRACT
Cigarette smoking had many adverse effects on health, also exposure to industrial noise is known as a health risk factor in the workplaces. The aim of this study was to investigate the relationship between industrial noise exposure and smoking on the hearing threshold levels in workers.
In the study, 200 male workers in the two groups (100 smokers and 100 nonsmokers with noise exposure) were involved. To assess noise exposure used calibrated noise dosimeter. Demographic, smoking habits and health status information was obtained via questionnaire.
The results showed a significant difference between noise-induced hearing loss (NIHL) in two ears and total NIHL in smokers and non-smokers with less than 10 years and more 10 years of noise exposure duration.
From the outcome of this investigation it is possible to conclude a positive effect between cigarette smoking and noise exposure on hearing loss and it can be suggested that hearing protection programs should train workers about the increased risk of developing NIHL from smoking and exposure to high occupational noise levels.
Key words: Noise, Smoking, Hearing Loss, Occupational Health

Abbreviations:
NIHL: noise-induced hearing loss
PTA: pure tone audiometry

INTRODUCTION
In the last few years, there has been a growing interest in the effects of cigarette smoking on health. Nowadays smoking is very common in the world, including Iran. More than one billion and three hundred million people worldwide are diagnosed with smoking and over 80 percent of them (800 million) are in developing countries [1]. According to the World Health Office, Iran has 13 million smokers [2]. The fundamental pathogenic mechanisms are the established vascular changes which include capillary vasoconstriction, cochlear hypoxia and increased blood viscosity related to smoking [3, 4]. Smoking is a risk factor that causes hearing loss. Many researchers reported harmful effects of tobacco smoking on the cochlea resulting in hearing loss [1, 5]. Some studies have established a positive relationship between smoking and noise-induced hearing loss [6, 7]. Also, a study showed smokers in normal and high frequencies had more loss of hearing compared to non-smokers with the same conditions [8]. By contrast, very few studies have shown that smoking has no effect on hearing loss [9]. Noise is one of the most common work-related risk factors [10, 11]. Occupational noise exposure is a major factor in the workplaces and it is estimated that around 600 million workers are exposed to it [12]. Effects of noise include two aspects: direct such as hearing loss and indirect effects on health such as increased blood pressure, annoyance and stress, sleeping problems, performance etc. [13-15]. The aim of this study was to investigate the relationship between industrial noise exposure and cigarette smoking on the hearing threshold in industrial workers in Iran.

MATERIALS AND METHODS
A cross-sectional study was conducted on cigarette smoke relation with NIHL. Participants included male workers (N = 200) employed in a steel factory in Iran. Of the 200 workers, 100 were smokers and had noise exposure and 100 were nonsmoker without noise

exposure. All participants were required to complete a physical examination and health-related information questionnaire, which was filled by interview. The inclusion criteria in the study for selected workers were included as (1) The noise exposure level ($L_{Aeq, 8h}$) ≥80 dB (A), (2) noise exposure duration ≥ 10 years, and (3) a stable occupational history of noise exposure. Exclusion criteria included the following: 1- history of ototoxic drug use. 2- History of head injury or otologic surgery. 3- History of diabetes mellitus, hyper and hypo thyroid. 4- Workers who had pure tone audiometry (PTA) unilateral hearing loss or conductive hearing loss. 5- Workers with a history of any exposure to loud and unconventional in their previous job or a second job. Participants were introduced to the purpose of and procedures to be followed in the study by an occupational physician. The research protocol was approved by the Ethics Committee, and all participants enrolled voluntarily in this study.

Noise exposure measurement

Due to the movement of employees in the work places, noise exposure levels were measured using personal dosimeters (Casella CEl 360, Uk). Amount of received noise dose was measured during 8 hours to determine the equivalent of continuous sound level. This was calculated using the following equation [13]:

$L_{Aeq-8h} = 10 \log10 ((Dose/100) (8/T)) + 85$ dB-A

Where, Dose: a noise exposure dose, in percentage acquired in T hours, L_{Aeq}: A-weighted, sound pressure level over T hours, T: the running time, in hours, of the measurement. For this purpose, before and after each run of experiments calibration was carried out with calibrator (CEL-4726). Dosimeters were installed to the waist of the worker and the microphone in the back of the collar.

Audiometry test

PTA was carried out according to ISO 8253 standards in an isolated acoustic room with a calibrated PTA (Model CA 86, Pajvak Ava Company, Iran) by an audiologist. Hearing thresholds were measured at frequencies of 500, 1000, 2000, 4000, 6000 and 8000 Hz in each ear and at least 14 h after the worker's last occupational noise exposure. At the beginning of the work day.

Smoking status survey

Health and lifestyle questionnaire were obtained and filled by interview. Data acquisition of smoking habit included smoking status (non‑smokers and smokers) and a daily number of cigarettes smoked.

Statistical analysis

For data analysis, descriptive statistical parameters were used including min, max, mean and standard deviation and the relationship between variables was tested by independent t‑tests and one-way ANOVA. All reported P-values were two-tailed, and P-value ≤ 0.05 was established as the level of significance.

RESULTS

In Table 1 descriptive statistics of participants in two groups (smokers and non-smokers) is presented. Job experience as a scale to determine noise exposure duration in two groups showed no significant difference. In Tables 2 and 3 hearing threshold levels in right and left ears in two groups (smokers and nonsmokers) are presented. According to the two way ANOVA test, in comparison of smoker and non-smoker workers with noise exposure, the result showed hearing thresholds in right and left ears in smoker workers has significantly increased (P<0.05). In the right ear, all frequencies except 500 Hz showed a significant difference between smokers with noise exposure group and non-smokers with noise exposure group. Also in the left ear, only two frequencies, 0.5 and 1 kHz, showed no significant difference between groups. As a known role, increase in hearing threshold levels of high frequencies especially in 4000 Hz, is a sign of hearing loss because of noise exposure in work places, which this condition in smokers without noise exposure in comparison with smokers with noise exposure is not the same and is affected by smoking. And this difference can be seen even in lower frequencies but with less extent.

Table 1: descriptive statistics of participants in two groups

Item	Smokers (n=100) ,mean ± SD (min, max)	Non-smokers (n=100) mean ± SD (min, max)	P_{value}
Age (year)	36.5 ± 5.2	35.5 ± 4.2	0.261
Job experience (year)	15.2 ± 5.9	14.6 ± 4.7	0.154
L_{Aeq-8h} (dB-A)	91.12 ± 7.3 (80.2, 99.6)	90.62 ± 6.6 (81.6, 100.3)	0.701

*Significant differences (P≤0.05)

Table 2: The results of hearing threshold levels in the right ear of two groups

Groups \ Frequency(Hz)			500	1000	2000	4000	6000	8000
Smokers and noise exposure	**N=100**	**Mean (dB)**	13.2	15.5	18.25	34.95	34	32.5
		SD	6.29	8.27	8.94	16.19	16.34	18.5
Non-smoker and noise exposure	**N=100**	**Mean (dB)**	12	12.3	13.4	23.7	24	23.8
		SD	7.3	5.7	5.8	11.7	13.3	17.5
P-value			0.06	0.05*	0.05*	0.03*	0.05*	0.001*

*Significant differences (P≤0.05)

Table 3: The results of hearing threshold levels in the left ear of two groups

Groups \ Frequency(Hz)			500	1000	2000	4000	6000	8000
Smokers and noise exposure	N=100	Mean (dB)	13.9	15.6	19.2	35.1	37.5	35.4
		SD	5.9	6.6	8.6	13.7	16.4	20.4
Non-smoker and noise exposure	N=100	Mean (dB)	12.4	12.7	14.1	23.9	24.2	25.8
		SD	7.2	4.9	6.4	11.4	16.2	19.5
P-value			0.07	0.07	0.05*	0.003*	0.05*	0.001*

*Significant differences ($P \leq 0.05$)

In Table 4, the average value of age, job experience, equivalent noise exposure, noise-induced hearing loss (right ear, left ear and total) in two groups (smokers and nonsmokers) in two categories of noise exposure duration are showed. The results of independent T-test showed a significant difference between noise-induced hearing loss in two ears and total NIHL in smokers and non-smokers with less than 10 years of noise exposure duration. Also, similar results were obtained for other workers with more than 10 years of noise exposure. Fig. 1 shows comparison of the binaural hearing loss median between groups in right and left ears.

Table 4: Results of the descriptive statistic of smokers and nonsmokers in two groups of noise exposure duration

Variable	Noise exposure duration of ≤ 10 years			Noise exposure duration > 10 years		
	Smokers (n=50) mean ± SD	Non-smokers (n=50) Mean ± SD	P_{value}	Smokers (n=50) mean ± SD	Non-smokers (n=50) mean ± SD	P_{value}
Age (year)	33.5 ± 4.2	31.5 ± 3.4	0.198	37.5 ± 6.2	36.5 ± 5.3	0.201
Job experience (year)	8.2 ± 2.9	8.6 ± 1.6	0.430	19 ± 4.5	17.2 ± 3.3	0.082
L_{Aeq-8h} (dB-A)	88.3 ± 3.6	89.2 ± 4.4	0.990	92.1 ± 2.2	91.7 ± 2.4	0.732
NIHL $_{right\ ear}$ (dB)	16±4.5	14.7±5.8	0.044*	19.7±3.7	15.4±3.3	0.010*
NIHL $_{left\ ear}$ (dB)	15±4.4	12.4±2.3	0.021*	20.2±4.6	16.3±2.8	0.011*
NIHL $_{Total}$ (dB)	15.2±4.2	12.5±1.8	0.028*	19±3.5	15.5±3.3	0.038*

*Significant differences ($P \leq 0.05$)

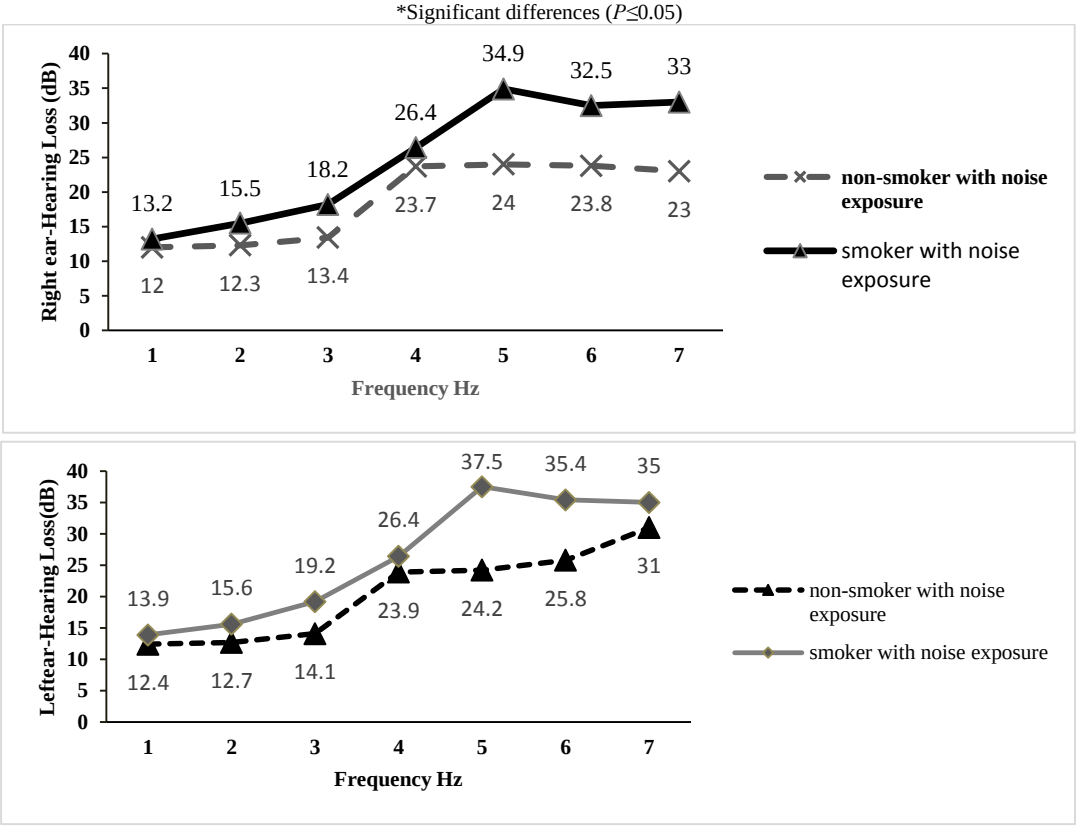

Fig. 1: Comparison of the binaural hearing loss median between two groups (a) right ear (b) left ear

DISCUSSION

It was the main purpose of this study to draw attention to the combined effects of cigarette smoking and noise exposure's adverse effects on the auditory system. Results showed that cigarette smoking could have a harmful effect on the hearing threshold of workers exposed to high levels of industrial noise. Thus, cigarette smoking should be considered as one of the important parameters in determining the hazards to hearing status by high-level industrial noise for hearing protection programs. The results showed that in high frequencies (4, 6 and 8 kHz), the differences between smokers and non-smokers with noise exposure are more than other frequencies (500, 1000 and 2000 Hz). This finding is similar to other studies by Wild *et al.*, Nomura *et al.*, Tao *et al.*, Mehrparvar *et al.* and Kumar *et al.* [7, 8, 16-18]. Also, some studies showed that cigarette smoking can cause hearing loss at low frequencies [19, 20]. According to the results of comparison of NIHL in two ears and total NIHL in two groups (smoker and nonsmoker) with noise exposure duration less than 10 years, results showed that increase in NIHL amounts in smoker groups are more than another group. In addition, similar results were observed between two groups with noise exposure duration above 10 years. Thus, this finding of this study determined a positive effect of cigarette smoking and exposure to industrial noise on NIHL. Many studies reportedthe additive effect of smoking without occupational noise exposure [16, 21-23]. Furthermore, some studies reviled synergistic effect between smoking and occupational noise exposure [6, 24]. As a reason for positive effect from noise and cigarette smoking on hearing loss, this condition can be explained with a potentiation of NIHL caused by simultaneous exposure to carbon monoxide from cigarette smoking and hazardous noise exposure for long time [3, 16, 25]. The other possible mechanism responsible for this adverse impact can be vascular changes such as cochlear hypoxia, capillary vasoconstriction, and increased blood viscosity related to smoking and to long‐term noise exposure [3, 4, 25, 26]. From the outcome of this investigation, it is possible to conclude a positive effect between cigarette smoking and noise exposure on hearing loss and it can be suggested that hearing protection programs should train workers about the increased risk of developing NIHL from smoking and exposure to high occupational noise levels.

CONCLUSION

The study results reveal that workers with smoking habit who work in high levels of industrial noise are in higher danger of developing NIHL. More researches into smoking and noise exposure are still necessary before obtaining a definitive answer to the adverse effect of smoking.

ETHICAL ISSUES

Ethical issues such as plagiarism have been observed by the authors.

CONFLICT OF INTEREST

Authors have no conflict of interests.

AUTHORS' CONTRIBUTION

All authors equally help to write this manuscript.

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