

The Effects of Occupational Noise Exposure on Serum Cortisol Level and Some Blood Parameters in Steel Industry Workers

Zahra Zamanian¹, Reza Rostami¹, Kiana Nikeghbal²

¹Department of Occupational Health, School of Health, Shiraz University of Medical Sciences, Shiraz, Iran;

²Department of Radiology, School of Dentistry, Shiraz University of Medical Sciences, Shiraz, Iran

Correspondence:

Reza Rostami,
Department of Occupational Health,
School of Health,
Shiraz University of Medical Sciences,
Shiraz, Iran

Tel: +98 71 37251001

Fax: +98 71 7260225

Email: Reza_bh838@yahoo.com

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Abstract

Background: Noise is one of the most important hazardous physical factors in industrial environments. This study aimed to determine the effects of noise exposure on serum cortisol level and some blood parameters among male workers of a steel production company.

Methods: This cross-sectional study was conducted on 50 male workers in a steel production company. In order to assess the changes in blood parameters, such as serum cortisol level, lipid profile, and blood sugar, blood samples were taken from the participants before and after the work shift. Besides, CEL 440 sound level meter was used to measure the equivalent sound pressure level (L_{Aeq}) and analyze the noise in octave band frequencies. Analyses of data were performed by SPSS software (version 16) using the Paired sample t-test.

Results: The laboratory findings indicated an increase in serum cortisol at all exposure levels. However, the changes were not statistically significant. An increase was observed in blood sugar levels at all the three noise levels and the increment was statistically significant at 95 dB noise level.

Conclusion: The present study showed that exposure to high sound levels leads to changes in biological parameters, although under the scenario explained in this study these changes did not reach statistical significant.

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Introduction

Noise is considered a physical stressor in the work environment. After air pollution and smoking, noise is the second most important cause of heart attack among residents of some cities.¹ Currently, studies have been performed on several aspects of noise impacts on human health, including damage to the hearing system, interference with conversations, impact on visual and balance systems, social disorders, neuropsychiatric effects, impacts on electrolytes, and physiological effects. World Health Organization (WHO) introduced noise pollution as the third most dangerous contamination in Metropolitans.² Anger and colleagues³ stated that noise had a lot of adverse effects on health, productivity,

and performance in any workplace, such as office, laboratory, or industry. Occupational noise exposure is one of the major problems in various industries and work environments and presence of undesirable noise in workplace can have serious impacts on health.⁴ WHO estimated that the rate of noise damage was about 4 million dollars per day.⁵

Human's reaction while exposed to loud noise is similar to their reaction to imminent threat. These reactions include secretion of adrenaline hormone and changes in heart rate and blood pressure.^{6,7} Acute changes in the urinary cortisol level have also been reported following occupational noise exposure in some experimental studies.⁸ Moreover, stress hormones levels in body fluids are useful indicators for assessment of

acute and chronic stress. These parameters change in the short run and, as a result, their measurement is popular in assessment of stressful work areas.^{9,10} Considering the importance of health, the relationship between cortisol level and noise exposure is under investigation.⁸ Chronic effects of occupational noise exposure in industries have been evaluated in the previous studies. For instance, Wayne and colleagues¹¹ and Melamed and Bruhis¹² found an increase in urinary cortisol levels after exposure to 85 to 95 dB sound levels.

From the biological point of view, noise can lead to the release of stress hormones. Exposure to stressors for a long time results in increase of cortisol levels. It has been suggested that the ability to regulate cortisol levels may be exhausted in the individuals exposed to severe stressors for a long period of time.¹³ Cortisol, the major glucocorticoid in humans, is the final product of the Hypothalamus–Pituitary–Adrenal (HPA) axis. Waking up in the morning is associated with a 50–100% increase in cortisol level, peaking about 30 minutes after awakening.¹⁴

In the recent years, noise has been mentioned to cause changes in the levels of stress hormones, such as adrenaline, noradrenaline, and cortisol, which are in turn considered as the risk factors of cardiovascular disorders.^{11,15,16}

Brandenberger and colleagues¹⁷ studied the acute effects of noise on cortisol. In their study, plasma cortisol levels were measured every ten minutes from 08:00 to 15:00 among the subjects exposed to 85-105 dB(A) noise levels. They found that noise did not change the normal decline of cortisol compared to that seen during a control day. Yet, further studies are required to be conducted on the noise-induced chronic irregularity of cortisol and its long term health effects.¹⁸

The steel industry, due to the nature of the work, involves high noise pressure levels. A study carried out by Atmaca and colleagues⁴ on different industries, such as iron, steel, textile, etc., demonstrated that noise levels exceeded 80 dB (A) in these industries. In addition, Golmohammadi and colleagues¹⁹ conducted a study at Isfahan steel rolling workshop and found that the noise pressure levels at this workplace ranged from 75 to 105 dB(A). Considering the inconsistencies about the effects of noise exposure on the cortisol levels, the present study aimed to investigate, more thoroughly, the effects of workplace noise exposure on the cortisol level and some blood parameters among the steel industry workers.

Methods

Study Design

The present cross-sectional study consisted of three stages, including collecting the demographic

data, field study, and laboratory study under controlled conditions (Figure 1).

Study Population

This study was conducted on 50 Aboughaddareh steel industry male workers randomly enrolled into the study in 2014. At first, written informed consents for taking part in the study were obtained from all the participants. Then, the participants' demographic information was collected using a questionnaire. The inclusion criteria of the study were not having history of diseases, not taking medications that could interfere with the functioning of the HPA axis responsible for cortisol secretion, and not having a recent history of psychiatric or neurological diseases. On the other hand, the exclusion criteria of the study were alcohol abuse, hypnotic drug use, smoking, and shift working.

Exposure Assessment

In field conditions, while controlling some factors, such as nutrition (all the participants were required to follow a particular food diet), 5 ml blood samples were taken from the participants before and after the work shift (7:00 AM to 4:00 PM). After extracting the samples' sera, cortisol levels were measured using Radio Immunoassay (RIA). Besides, Equivalent Sound Pressure level (LA_{eq}) was measured during the 8-hour work shift by the CEL-440 sound level meter (England, CEL Company) that was calibrated before using in field. The equipment's noise was recorded using a microphone attached to the workers' collars and was broadcasted for the individuals in controlled laboratory conditions. The background noise was 40 dB (A). The selected individuals were exposed to 85, 95, and 105 dB (A) noise levels for 5 minutes for three consecutive days. Before and after the noise exposure, 5 ml fasting blood samples were taken from the workers and were sent to the Namazi hospital laboratory to be analyzed; serum cortisol, Triglycerides (TG), High Density Lipoprotein (HDL), and Low Density Lipoprotein (LDL) were compared before and after noise exposure.

Statistical Analysis

Analyses of data were performed by SPSS software (version 16). The results of One-Sample Kolmogorov-Smirnov test confirmed the normal distribution of the participants' blood parameters. Paired sample t-test was used to compare the participants' biochemical parameters and cortisol levels in the three sound pressure levels.

Results

Demographic characteristics of the study subjects are presented in Table 1.

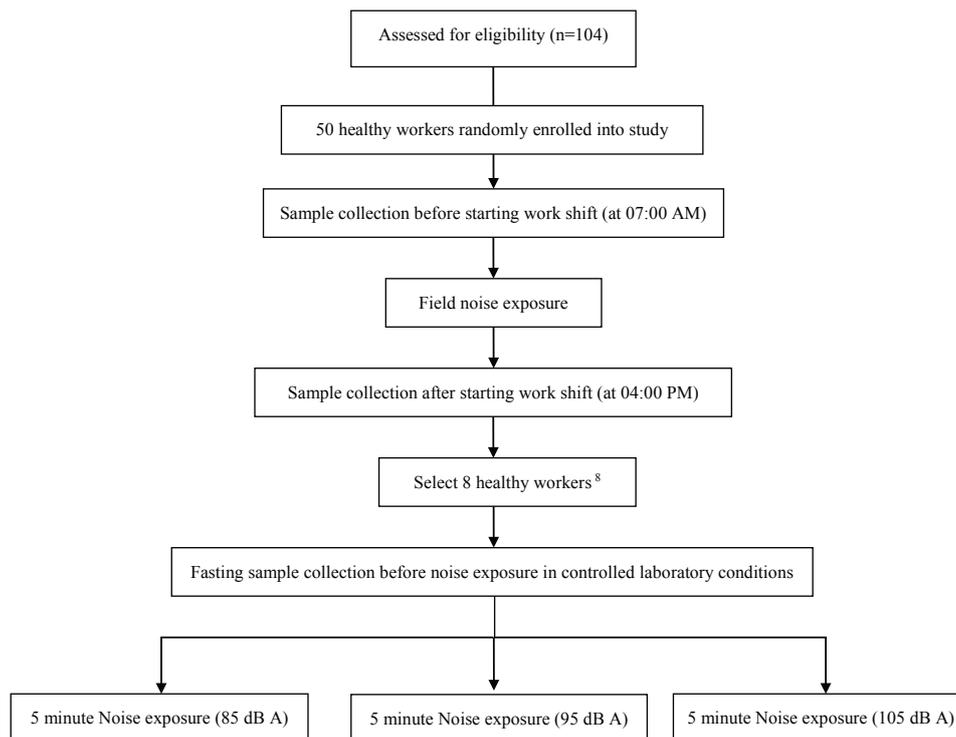


Figure 1: This figure indicates the study design flowchart.

Table 1: Demographic characteristics of the study subjects (Mean±SD) (n=50)

Variable	Mean±SD	Max.	Min.
Height (cm)	174±6.14	189	160
Weight (kg)	71.78±12.16	110	49
BMI	23.42±3.28	32.14	16.95
Age (years)	28.92±5.40	42	19
Working experience (months)	10±3.63	12	2

Measurement of the workplace's sound level indicated that the subjects were exposed to 92.1 dB(A) sound level in an 8-hr shift work. Octav-band noise analysis also showed that the dominant frequency was 2000 Hz with the noise level of 82 dB. In general, hormones levels gradually decrease during the day. The study results showed that after acute exposure to noise at 85, 95, and 105 dB(A) in laboratory conditions, the cortisol levels increased by 0.8, 1.35, and 0.85 µg/dL, respectively; however, the differences were not statistically significant ($P=0.05$) (Table 2). The results also revealed a decrease in TG, HDL, and LDL levels after exposure to noise, but the changes were not statistically significant ($P=0.05$).

Discussion

This study was conducted in field and laboratory conditions. The results of field experiments have been reported and used for screening the subjects to be selected to take part in the laboratory phase. Haratian et al. studied the effects of gender and age on cortisol secretion and found a significant reverse association

between age and cortisol secretion. Also, no significant relationships were observed between gender and serum cortisol levels.²⁰ Therefore, the present study was only conducted on men.

Generally, some factors may contribute to obtaining inconsistent results, including individual differences, various research methods, dissimilation of HPA activity in dealing with stressors, and moderating factors (e.g. coping with recent stress exposure history).²¹ Individual differences in cortisol secretion is also one of the most important variables mentioned in the previous studies.²² Other stress hormones, such as catecholamines, may also be secreted during the exposure to stress.²³ Some studies have shown a relationship between noise-induced stress and serum cortisol in such a way that acute and chronic exposure to noise could affect serum cortisol levels.²⁴ The laboratory results in our study demonstrated no significant increase in cortisol secretion after noise exposure. This might be attributed to the short exposure period and the small sample size of the study. This finding was in agreement with that of the study

Table 2: The results of biochemical tests before and after noise exposure in field and laboratory conditions

	Noise pressure level	Variable	Mean (SD) before exposure	Mean (SD) after exposure	P value*
In laboratory (n=8)	85 dBA	Cortisol (µg/dL)	9.80(2.20)	10.60(4.39)	0.554
		TG (mg/dL)	176.00 (93.46)	164.00(82.57)	0.850
		HDL (mg/dL)	38.16 (6.68)	37.70(5.54)	0.537
		LDL (mg/dL)	77.33(24.76)	72.07(16.68)	0.234
	95 dBA	Cortisol	11.46(3.18)	12.81(3.63)	0.505
		TG	185.50 (111.52)	172.75(102.62)	0.300
		HDL	35.95(7.73)	41.43(20.12)	0.341
		LDL	78.80 (24.15)	77.51(25.25)	0.173
	105 dBA	Cortisol	8.87(2.74)	9.46(2.52)	0.431
		TG	140.12(89.96)	128.75(73.17)	0.220
		HDL	26.46(6.34)	24.88(5.17)	0.512
		LDL	61.51(26.17)	69.07(26.44)	0.301
In field(n=50)	Before exposure	Cortisol	9.20(3.92)	5.21(1.99)	0.037
		TG	153.38(83.46)	228.38(149.44)	0.039
		HDL	30.47(5.53)	28.35(5.93)	0.109
		LDL	76.47(31.41)	77.97(33.95)	0.282

*Paired samples t-test

by Prasher who came to the conclusion that serum cortisol levels were higher among the workers exposed to noise compared to the control group. However, no significant association was found between the noise level and serum cortisol level.²⁵

In the majority of studies, measurements of adrenaline, noradrenaline, and cortisol have been used for investigating the noise stress effects.²⁶ Some of these hormones, such as cortisol, have circadian rhythm.²⁷ Therefore, in order to control the physiological changes of cortisol in this study, a 24-hour time interval was considered between the tests. In addition, the study was performed when cortisol was at its peak value to assess the effect of noise on changes of this hormone with the lowest possible error.

Ising et al.²⁸ have shown that acute exposure to maximal noise pressure levels above 90 dB(A) had the potential to stimulate the sympathetic nervous system and increase the release of adrenaline and noradrenaline. Noise levels above 120 dB(A) increase cortisol in humans and animals. Moreover, long-term exposure to low frequency noise with $L_{max} < 55$ dB(A) during the night resulted in chronic increase of excretion of free cortisol in the first half of the night.²⁹

Limitations

One of the limitations of this study was the short period of noise exposure without control group under laboratory conditions. Considering cortisol's short biological half-life in the blood and its limited peak duration (approximately one hour), the length of exposure to noise is effective in changes of this hormone. Therefore, further studies are needed to achieve more accurate results.

Conclusion

Acute exposure to high levels of noise increases serum cortisol levels. However, since the non-auditory effects of noise exposure are multi-factorial, and there was no significant difference in the observed results before and after the exposure to noise, these effects cannot be certainly attributed to noise. Therefore, in order to obtain more accurate results, future studies with different designs are required to be conducted on the issue.

Conflict of Interest: None declared.

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