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Investigation of Combined Effects of workplace physical agents and shift work on Physiological parameters and blood factors in nurses

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ABSTRACT

Since nurses spend most of their working time indoors, the quality of the hospital environment has a significant impact on their performance and comfort. The aim of this study was to investigate the combined effects of physical factors in the workplace and shift work on physiological parameters and blood factors among nurse staff in a specialty and sub-specialty hospital in Tehran. The present study as a cross-sectional study was conducted on 300 nurses in a specialty and sub-specialty hospital in Tehran. In order to collect the data, a demographic questionnaire was used. The physical factors of the workplace were measured using the sound level meter, lux meter and WBGT meter. A digital blood pressure monitor and heart rate monitor were used to measure physiological parameters and the blood factors were collected from the medical records (such as CBC). Finally, the data were analyzed using SPSS-20 software. The results showed that the level of sound in the workplace, as the most important physical factor, could increase the level of physiological factors, and hence the sound was identified as the most effective factor in the investigation of combined effects. Moreover, the results demonstrated that shift work has a significant impact on the physiological parameters. There was a significant difference in the blood factors and physiological parameters between the subjects with shift work and day work (P-value <0.05). Due to the importance of nurses' health as the main foundation of the health system, it is necessary to hold intervention programs and perform more detailed studies and research on the combined effects of physical factors in the workplace by controlling lifestyle and genetics.

KEYWORDS: *Shift work, Noise, Illumination, Heat Stress, Combined effects, Nurses*

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INTRODUCTION

Since nurses spend most of their working time indoors, the quality of the hospital environment has a significant impact on their performance and comfort. Numerous studies have examined the significant effects of environmental factors on employee health and performance (1-3). Until now, the effects of various factors, such as noise, lighting, and environmental conditions, have been investigated on the health and performance of employees. These environmental factors have different effects on human health and function. It is noteworthy that in workplaces different environmental parameters are interrelated and affect each other. In other words, humans perceive environmental conditions through the interaction and integration of different sensory stimuli (1, 4-6). The physical agents in the workplace have some side effects such as sleep cycle disorders, cardiovascular diseases, metabolic complications, and physiological effects. Since the physiological factors are appeared involuntarily by the body, they can be considered as the objective measurements of the effects of physical factors (7).

Various studies investigated the effects of noise on physiological parameters and reported that the blood pressure increased in exposure to sound (8). But the effect of noise on heartbeat was contradictory in different studies. A number of studies have shown that exposure to sound has no effect on increasing heartbeat (8-9); In contrast, other studies have reported rapid heartbeat as the effect of sound exposure (10-12). In another study, the results showed that exposure to aircraft noise increased the level of physiological stress, which can result in an increase in blood pressure (13). Moreover, heat as another environmental factor is considered a stressor that reduces a person's aerobic capacity. In a meta-analytic study by Pilcher et al. (14), workplace temperature was identified as an important factor in the development and spread of occupational diseases. Most of the previous studies have focused on lighting as another physical factor compared to the visual aspects, and its effect on physiological factors has received less attention. Another challenge that nurses always face is the work shift. Previous studies reported that work shift is a health risk factors among nurses is associated with increased blood pressure (15-16), cardiovascular disease (17-18), and metabolic disorders (17, 19). Few studies have investigated the combined effects of physical factors on human health. In this regard, Abbasi et al., (1) studied the combined effects of sound and temperature on neurophysiological factors in indoor environments under laboratory conditions. They also reported that the combined effects of sound and temperature were significantly greater than the independent effects of these factors. Moreover, in Golmohammadi et al., study (20) it was found that the combined effects of physical and chemical factors in the workplace can be much greater than their independent effects. In Chao et al., study (10) on the combined effects of noise, vibration and low temperature on labor employees it was found that the independent effect of each variable can be easily estimated, however, the mechanism of these two physical factors is complex and hence further investigations are required.

Clarification of interactions between sound, temperature and lighting in the workplace as well as work shifts still remain a challenge, due to the multiplicity and effecting factors, lack of sufficient sample size to achieve high reliability in results and problems in obtaining information and data (7). The reliability of the results of these studies still remains questionable. For example, Griffin et al., stated that the exposure to the cold environment is associated with hearing loss, however, there has been no sufficient evidence regarding this hypothesis (21). It is noteworthy that most of the previous studies have been conducted in a laboratory environment under fixed and predefined conditions. While, the workplace conditions are very different from laboratory conditions in terms of the combination effects of physical factors, workload, and shift work-related issues and problems.

Therefore, the present study aimed to investigate the combined effects of physical factors (noise, illumination and heat stress) on physiological parameters and blood factors on nurses working in a specialty and sub-specialty hospital in Tehran.

METHODS

The aim of this study was to investigate the combined effects of physical factors in the workplace including, noise, lighting, temperature and shift work on the physiological parameters and blood factors among nurses working in a specialty and sub-specialty public

hospital in Tehran in 2021. The research population included all nurse staff in a specialty and sub-specialty hospital in Tehran. According to the statistics provided by the deputy director of treatment of this hospital, the total number of employed nurses was estimated to be about 1000 individuals. Based on Morgan's table and Cochran equations (22) (as shown in figure 1), 278 people were selected as sample size, and finally, 310 individuals were included as the study population considering 10% of the possible fall. Inclusion criteria included having at least a bachelor's degree, employment in the shift system and having at least 1 year of work experience. The exclusion criteria were underlying cardiovascular diseases and metabolic disorders, using antidepressants and sedatives and having second job, unwillingness to participate in the study. Finally, 300 questionnaires were analyzed.

$$n=\frac{\frac{Z^2 pq}{d^2}}{1+\frac{1}{N}\left(\frac{Z^2 pq}{d^2}-1\right)}$$

Figure1: Cochran formula

Where,
z is z score
p̂ is the population proportion
n are sample size
N is the population size

After obtaining the permission of the university, the samples were collected by stratified random sampling method. For this reason, two questionnaires were prepared to collect the information, including a demographic information questionnaire and the other one in line with the objectives of the present study. The demographic characteristics questionnaire included gender, age, height, weight, level of education and work experience. First, the participants were asked to complete the informed consent form, and then the measurements were conducted. The measurements were performed in several steps. The blood pressure of all participants was measured at a certain time in the morning. Moreover, their heartbeat was measured using a Bion Heart Rate Watch-BN-A500 device, and a CE0123 Wrist Type Digital Automatic Blood Pressure monitor was used for measuring the blood pressure. Systolic and diastolic blood pressure was measured twice for each worker after five minutes of rest. They were asked to sit on a chair during the measurements, from the right hand and while the person's arm was at the level of the heart, were recorded.

Metabolic risk factors: To determine various factors, including blood sugar (FBS), Cholesterol (Chol), Triglyceride (TG), High-density lipoprotein (HDL), Glutamate (LL), Lipoprotein (Ch), glutamic-pyruvic transaminase (SGPT), and Glutamic-oxalacetic transaminase (SGOT) were evaluated, and also for more detailed study of changes in body metabolism, complete blood cell count (Blood Complete Cell) such as red blood cell count (HCT), hematopoietic (RBC), and hematopoietic Hemoglobin (HB) were tested. The results of the blood samples were extracted from their medical records between 2020 and 2021.

Equivalent Continuous Sound Level (Leq), lighting and temperature were measured using the sound level meter (Kimo DB 100 model, serial number 15041350, made in France), lux meter (Hagner ECI model, serial number 55675, made in Sweden) and WBGT meter (serial 84947, made in Taiwan), respectively. In this study, 14 active wards of the hospital were evaluated including emergency, ICU, an internal-cardiovascular ward for men and women, general surgery ward for men and women, orthopedics, pediatrics, psychiatry ward for men and women, ENT ward for men and women, Gynecology & Labor ward and urology ward.

According to the field visit, the predominant physical factors in the nurses' work environment included three following items: Leq, lighting and heat stress. As a result, these three parameters were evaluated and their effects were examined. It should be noted that the determined physical factors were investigated during about two months. According to the results, there was no obvious difference between the mean of the obtained data. As a result, it can be said that people working in the studied environments do not experience significant changes in different seasons of the year.

Physical factors such as Leq, illumination and heat stress were measured in two stages once a day and once at night. Due to the fact that nurses are more

active in the nursing station and nursing work room, these factors were measured in these stations. In the present study, to measure physiological parameters and environmental variables in the workplace, the factors in the employees were calculated after at least two hours of daily work in the morning and night shifts. These responses were measured in accordance with the international recommendations of the ISO 9886 standard (23). Preliminary analyses such as mean, standard deviation, data normality test and the relationships between variables were performed using SPSS software.

In order to conduct this research, the necessary coordination was conducted with the employed nurses and the method of conducting the study was clearly explained to them and the consent of individuals to participate in this study was obtained.

RESULTS

The study population consisted of 300 nurses working in different wards of the hospital according to Table 1.

Table 1. Sampling from different wards of the hospital

Hospital wards	Number of samples (people)
Emergency	25
ICU	15
Men internal-cardiovascular	18
Women internal-cardiovascular	17
Men general surgery	19
Women general surgery	17
Orthopedics	23
Pediatrics	26
Men psychiatry	19
Women psychiatry	22
Women ENT	28
Men ENT	24
Gynecology & Labor	23
Urology	24

The study population was divided into two groups of women (56%) and men (44%). Most of the participants (30.3%) were in the age range 25-35 years. Most of the nurses participating in this study were working in shifts. Descriptive results of the demographic variables are shown in Table 2.

Table 2. Results of descriptive statistics of demographic variables

variables	Item	Number	Frequency
Gender	male	116	38.7
	Female	184	61.3
Age	Less than 25 years	87	29
	25 to 35 years	91	30.3
	35 to 46 years	83	27.7
	More than 50	39	13
Education	Bachelor	215	71.6
	Master	85	28.3
Work Experience	Less than 10 years	125	41.7
	10 to 20 years	143	47.7
	More than 20 years	32	10.7
Shift Work	Yes	194	64.7
	No	106	35.3
Smoking	Yes	143	47.7
	No	157	52.3

The normality of the data was tested using Kolmogorov-Smirnov test. P-value less than 0.05 indicates that the test is significant and the distribution is not normal, so non-parametric tests should be used to analyze the data. The results showed that all research variables are normal. The descriptive results of the research variables are given in Table 3.

According to Table 3, the highest and lowest Equivalent Continuous Sound Level (Leq) per day were related to the pediatric ward (70.10 dB) and ICU (61.10 dB), respectively. While according to the results at night, the highest and lowest Equivalent Continuous Sound Level were related to the emergency department (63.40 dB) and women's ENT (52.60 dB), respectively. The results of the nurses' 80 ° C) wards, respectively.

office lighting showed that the highest and lowest average daylight was related to gynecological general surgery (316.20 lux) and gynecological internal medicine (180.40 lux), respectively. While according to the results, at night, the highest and lowest brightness were related to women's ENT (260.70 lux) and women's heart (102.40 lux) wards, respectively. The results of nurses' workplace temperature indicated that the highest and lowest average daily temperatures were related to ICU (28.30 ° C) and men's ENT (26.10 ° C) wards, respectively. While according to the results, the highest and lowest temperatures at night were related to the pediatric (25.70 ° C) and men's ENT (23.

Table 3. Results of measuring physical factors of the workplace by section

Hospital wards	Physical Factors					
	Mean Temperature (°C)		Mean lighting (Lux)		Mean Leq (db)	
	Night	Day	Night	Day	Night	Day
Emergency	24.15	26.40	198.20	258.60	63.40	68.20
ICU	25.40	28.30	210.30	298.20	53.70	61.10
-Men internal cardiovascular	25.60	27.40	115.20	175.60	56.30	64.60
-Women internal cardiovascular	24.40	26.20	102.40	180.40	57.40	66.10
Men general surgery	24.50	26.80	134.80	214.70	53.10	62.50
Women general surgery	25.10	26.30	217.30	316.20	53.70	63.80
Orthopedics	24.30	26.60	198.15	256.50	58.60	69.14
Pediatrics	25.70	27.20	186.30	135.20	61.80	70.10
Men psychiatry	25.30	27.10	102.60	190.70	56.30	63.20
Women psychiatry	24.60	27.30	140.10	225.80	54.70	64.80
Women ENT	24.50	26.40	260.70	310.40	52.60	62.90
Men ENT	23.80	26.10	168.40	298.60	54.70	66.10
Gynecology & Labor	25.10	26.70	106.15	186.50	56.80	68.70
Urology	25.20	27.50	140.60	230.40	54.50	65.30

According to the results (Table 4,) the results of statistical tests showed a significant difference between cholesterol and triglyceride in the studied nurses on working day and shift ($p < 0.05$). The mean and standard deviation of cholesterol in the studied nurses were 183.92 ± 10.29 and 200 ± 10.85 in nurses with day-work and shift-work, respectively. Also, the mean levels of triglyceride in the studied nurses with day-work and shift work were 134.14 ±17.68 and 100.64 ± 20.93, respectively. No significant relationship was found in other blood factors such as WBC, RBC, HB, HCT, MCV, MCH, FBS, LDL, HDL and liver enzymes including SGOT and SGPT between the groups with shift and fixed work ($p > 0.05$).

Table 4. Frequency of blood factors based on shift work

Variable	Rotational shift	Fixed shift	P-value
	Mean ± SD	Mean ± SD	
WBC	6.55 ± 1.56	6.87 ± 1.70	0.1
RBC	5.32 ± 0.66	5.33 ± 0.56	0.81
HB	15.47 ± 1.83	15.59 ± 1.53	0.58
HCT	44.65 ± 5.34	44.98 ± 3.89	0.59
M.C.V	84.21 ±5.70	85.16 ± 5.92	0.18
M.C.H	29.07 ± 2.54	29.34 ± 2.18	0.37
FBS	94.66 ± 3.78	95.11 ± 3.56	0.33
CHOL	200 ± 10.85	183.92 ± 10.29	0.001
TG	100.64 ± 20.93	134.14 ± 17.68	0.001
LDL	88.14 ± 27.33	86.54 ± 30.22	0.66
HDL	52.71 ± 24.90	54.49 ± 10.83	0.56
SGOT	22.45 ± 10.78	22.46 ± 10.84	0.99
SGPT	28.05 ± 16.90	26.70 ± 16.32	0.51

The results of shiftwork showed that people who work in shifts, systolic and diastolic blood pressure and BMI have a significant difference compared with the nurses with day work. The mean heart rate in shift workers was 65.94 ± 4.35, which was slightly higher than day-workers, while the statistical analysis did not show a significant relationship between the mean heart rate of the day-workers and shift-workers ($p > 0.05$). The correlation results of the studied variables indicated that BMI was significantly associated with systolic blood pressure ($p < 0.05$, $r = 607$), diastolic ($p < 0.05$, $r = 212$) and heart rate ($p < 0.05$, $r = 164$). The results of the frequency of physiological parameters are shown in Table 5.

Table 5. Frequency of physiological parameters based on shift work

Variable	Rotational shift	Fixed shift	P-value
	Mean ± SD	Mean ± SD	
Systolic blood pressure	126.14 ± 5.12	124.75 ± 3.97	0.001
Diastolic blood pressure	84.27 ± 3.71	83.22 ± 3.11	0.001
heartbeat	65.94 ± 4.35	65.58 ± 3.65	0.48
BMI	27.25 ± 3.71	26.09 ± 3.06	0.001

Due to the fact that the study of the combined effects of physical factors in the workplace on physiological factors and blood factors is very difficult and challenging. In this study, the physiological parameters and blood factors among the physical factors of the workplace were compared in pairs by significant level of 0.05. The results are shown in Table 6.

Table 6. Results of combined effects of physical factors on physiological parameters and blood factors

Variable	Combined effects of physical factors	P-value	R	R^2
Systolic blood pressure	Noise Temperature	0.001	0.553	0.305
	Noise Lightning	0.001	0.563	0.317
	Temperature Lightning	0.001	0.387	0.150
Diastolic blood pressure	Noise Temperature	0.001	0.570	0.325
	Noise Lightning	0.001	0.556	0.309
	Temperature Lightning	0.001	0.296	0.087
Heartbeat	Noise Temperature	0.001	0.531	0.286
	Noise Lightning	0.001	0.517	0.267
	Temperature Lightning	0.001	0.258	0.067
HB	Noise Temperature	0.001	0.250	0.062
	Noise Lightning	0.260	0.133	0.018
	Temperature Lightning	0.339	0.123	0.015
SGOT	Noise Temperature	0.180	0.145	0.021
	Noise Lightning	0.518	0.104	0.011
	Temperature Lightning	0.003	0.228	0.052
SGPT	Noise Temperature	0.024	0.193	0.037
	Noise Lightning	0.773	0.078	0.006
	Temperature Lightning	0.426	0.114	0.013
LDL	Noise Temperature	0.948	0.049	0.002
	Noise Lightning	0.452	0.111	0.012
	Temperature Lightning	0.001	0.309	0.095
CHOL	Noise Temperature	0.821	0.152	0.020
	Noise Lightning	0.350	0.152	0.020
	Temperature Lightning	0.197	0.072	0.005
TG	Noise Temperature	0.015	0.202	0.041
	Noise Lightning	0.281	0.130	0.017
	Temperature Lightning	0.037	0.184	0.034

The results of studying the combined effects using regression test showed that the physical factors of the work environment in the both (noise and temperature), (noise and light) and (temperature and light) with systolic blood pressure, diastolic blood pressure and heartbeat were significantly correlated ($p < 0.05$). These physical factors were significantly associated with blood factors such as HB in (noise and

temperature) and (noise and light), but there was no significant relationship in (temperature and light) (P> 0.05). The combined effects of physical factors at work on liver enzymes including SGPT and SGOT were not significantly related to SGPT except for (noise and temperature). There was no significant relationship between LDL and cholesterol in the combined effects in all three cases (P> 0.05). While there was a significant relationship in HDL between (noise and temperature) and (noise and light). Also, TG, as another blood component, showed a significant relationship only in mode (noise and temperature).

DISCUSSION

The aim of this study was to investigate the combined effects of physical factors in the workplace (sound, lighting and environmental conditions) and shift-work on physiological and blood factors in nurse staff in a specialty and sub-specialty hospital. The results demonstrated that the level of sound, lighting and environmental conditions were not significantly different from the standard limits in nursing stations. The investigation of the effect of different physical factors on physiological factors faces many challenges, and still now, few studies have investigated the combined effects of these physical factors on the physiological factors of shift-work and day-work nurses. The physiological factors are generally influenced by many factors such as genetics, lifestyle and work environment.

Many studies have conducted on the effects of hospital noise pollution on patient's health status. While few studies have focused on the negative effects of noise pollution on nurses and physicians (24-25). Evidence suggested that nurses and physicians are unaware of the physiological effects of noise pollution on their health status (26).

Morriosn et al., for the first time tried to measure the effects of hospital noise pollution on nurses by examining its association with a nursing stress questionnaire, salivary amylase and heart rate. In the mentioned study, a positive correlation was observed between increased levels of noise pollution and increased levels of stress, heart rate, and the rate of harassment and injury (27). In this regard, the results of the present study showed that noise pollution has the greatest impact on physiological factors in the workplace. This result is consistent with the findings of previous studies. In the present study, the noise of nurses' workplaces had a significant relationship with systolic and diastolic blood pressure and heartbeat. Various studies have shown that the parameters of blood pressure, heartbeat and respiration rate are affected when exposed to harsh environmental conditions (28-29). The results of studies have shown that continuous exposure to noise of at least 85 dB led to increased blood pressure in noise exposed individuals (7). Numerous studies have confirmed the relationship between blood pressure and noise exposure (11). However, most of these studies have focused on sound higher than 85dB. Veitch et al., (30) have introduced the equivalent level of exposure noise in network A as a suitable parameter for determining the amount of sound comfort and sound above 45 dB is considered as noise annoyance. Given that the equivalent sound level obtained in the present study was about 65 dB, it seems necessary to investigate the effects of sound less than 85 dB on physiological factors. Sorensen et al., (31) in their study on road traffic noise less than 60 dB reported that men's blood pressure increased by 0.25 mm Hg/year per 10 dB increase in average road traffic noise.

In this study, using regression analysis and eliminating the effect of shift work and age, systolic and diastolic blood pressure increased with increasing the duration of noise exposure and showed that this result is consistent with the findings of Lang and Motamedzadeh study (32-33).

Also, in the field of hypertension due to exposure to sound, the vast opinion of researchers confirms the findings of this study (34-35). In addition, the observation of increased blood pressure obtained by removing the effect of noise due to shift work in this study is consistent with the findings of Motamedzadeh study (33).

In a study conducted by Rahimpour et al., on hospital nurses, they concluded that increasing noise increased blood pressure. In the study, after exposure to noise at the end of the work-shift, systolic and diastolic blood pressure increased by 5 and 4 mm Hg, respectively, which is consistent with the results of the present study (36). The results of the shift-work showed that people who work in a shift work method have higher systolic

and diastolic blood pressure, cholesterol, triglyceride and fasting blood sugar than day-workers. Previous studies have shown that people night shift workers have a higher risk of developing diabetes, cardiovascular disease, and high blood pressure compared to day-workers (37-38).

In Zara et al., study, the results indicated that the systolic and diastolic blood pressure of employees increased with increasing the level of sound pressure and the number of night shifts, which is consistent with the findings of the present study (39).

Previous studies have shown that night shifts increased blood pressure and heart rate over time. It has also been shown that shift working can increase the caffeine consumption and smoking in employees, which subsequently leads to weight gain, decreased glucose tolerance, and increased rates of gastrointestinal and cardiovascular disorders in employees (40).

Another important issue in hospital environments is providing patient comfort that physical factors of the work environment such as noise, poor lighting and heat stress can reduce the comfort of staff and patients and ultimately disrupt the treatment of hospitalized patients. Major sources of noise in hospital wards include human activities, pager system, air conditioning system, monitors, injection pumps and other equipment. Previous studies have shown that hospitalized patients with exposure to noise above 60 dB A had significantly higher concentrations of their sympathetic enzymes than other patients, and therefore their sense of environmental comfort was lower than that of inpatients. The sound pressure level was less than 60 dB (41-42).

The results showed that the combined effects of sound and lighting increased the mean factors of triglycerides, heartbeat, fasting blood sugar and cholesterol. Moreover, according to the results, sound and lighting together increase systolic and diastolic blood pressure. The combined effects of sound and temperature showed that the mean heartbeat increased by increasing temperature and sound levels. Finally, the results showed that the mean of the factors such as triglyceride, systolic and diastolic blood pressure increased by increasing sound level and shift work.

The results showed that the combined effects of temperature and lighting, temperature and shift work did not increase the mean of any of the variables. The study of the combined effects of lighting and shift work showed that these factors increased systolic and diastolic blood pressure. In line with the results of the present study, the results of Piasecki et al., study (43) showed that people's perception of thermal conditions did not change through short-term exposure to different levels of sound. Pellerin et al., (44) reported that sound may alter human thermal comfort in warm environments; they also observed that a 1 ° C increase in temperature was similar to a 2.6 dB increase in sound, which is contrary to the results of the present study. It is noteworthy that the different temperatures measured in the present study were not significantly different and due to the type of work environment, it was not possible to measure the effects of low and high temperatures. Also, the measured sound level was much lower than the level recommended to prevent auditory effects. For this reason, it can be stated that this increase in blood pressure and heartbeat is due to exposure to this level of sound or the factors such as genetics and lifestyle. Therefore, more studies are needed in this regard to confirm the results and hypotheses of the present study.

CONCLUSION

In general, the results of the present study showed that physical factors in the workplace can have different effects on physiological factors and blood factors. However, this important issue. It has received less attention due to the complexity of the investigation of the combined effects of physical factors in the workplace and the elimination of confounding factors. A better understanding of health disorders and physiological mechanisms underlies the development of prevention strategies and coping with health-related issues. Therefore, it is recommended to conduct further studies on these factors and their combined effects in different occupations.

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CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

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