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ORIGINAL ARTICLE

Multiple environmental and psychosocial work risk factors and sleep disturbances

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Abstract

Background This study aimed to investigate the relationship between multiple psychosocial and environmental work risk factors and sleep disturbances.

Methods This cross-sectional study was conducted among 90 workers in a brick factory in Iran. The health and safety executive (HSE) tool, Epworth Sleepiness Scale (ESS), and Stop-Bang questionnaire were used to determine psychosocial factors, subjective sleepiness, and obstructive sleep apnea (OSA), respectively. Standard objective methods were used to assess the environmental risk factors, including noise, light, heat stress, and respirable particles.

Results Most psychosocial and all environmental work factors were moderately to highly correlated to the ESS score. There were also moderate correlations between the demands (including work load, work patterns, and work environment), role (including a clear understanding of the employees about their role in the organization), and lighting variables and the Stop-Bang score. The results of multivariate logistic regression analysis showed that job control, wet bulb globe temperature (WBGT), and respirable dust were predictive of an ESS score indicating abnormal sleep status and noise was predictive of a Stop-Bang score predictive of OSA.

Conclusions The results suggest that stressors, especially noise, heat stress, and respirable dust, are related to the employees' indices of sleep disturbance independent of other potential workplace confounding factors. These results can highlight the importance of considering multiple psychosocial and environment work risk factors for implementing occupational health and ergonomics interventional programs to prevent sleep disturbances in the workforce.

Keywords Job stress · Heat stress · Noise · Respirable dust · Light · Sleep disorders · Ergonomics

Introduction

Sleeping is one of the basic human needs and each person devotes one-third of each day to sleeping (Chandola et al. 2010). Quality and quantity of sleep are considered as factors affecting humans' health, social relationships, efficiency, and safety (Lockley et al. 2007; Magnavita and Garbarino 2017). Sleep disturbances include difficulty in falling sleep or going back to sleep, alterations in sleep duration, recurrent awakening, reduction in sleep stages, etc. (Kawada 2011; Sharafkhaneh et al. 2009). These problems are considered to be the one of major problems for individual and social well-being (Schneider et al. 2004). They are associated with a wide range of health problems, especially heart disease and diabetes, suppress the immune system, decrease functioning of the hypothalamus, pituitary, and adrenal glands, and reduce cognitive performance and work ability (Cappuccio et al. 2010; Gharibi et al. 2016; Halperin 2014; Kazemi et al. 2018; Mokarami et al. 2017; Ohayon 2002; Sofi et al. 2014). The prevalence of sleep disturbances, such as insomnia, has increased significantly in many societies in the recent years. According to global estimates, about 32% of people suffered from insomnia in 10 different countries in the world and 24% of them were sick of having insufficient sleep (Soldatos et al. 2005).

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Industrial workers are among individuals who suffer from insomnia and sleep problems. It has been estimated that approximately 18% of European workers (Dregan and Armstrong 2011) and 23% of United States workers (Kessler et al. 2011) suffered from sleep problems. Sleep disturbances have a negative effect on organizational performance and productivity. Workers who suffer these disorders are significantly more likely to be absent from work (Godet-Cayre et al. 2006). This problem also causes significant costs for employers and the community. People with sleep disturbances in work environments have less self-confidence and lower job satisfaction (Park et al. 2013). Indeed, the rate of accidents and occupational errors is higher among these people and their productivity is lower (Garbarino et al. 2017; Uehli et al. 2014).

Multiple risk factors in occupational environments can have a negative effect on employees' sleep, subsequently causing health problems. Psychosocial factors are among the most important work-related risk factors that have been emphasized in various studies for their role in these disturbances (Akerstedt 2006; Park et al. 2013). These risk factors can reduce sleep stages, especially stages 3 and 4, and shorten and interrupt sleep (Akerstedt 2006). Imbalance between effort-reward (Johannessen and Sterud 2017; Kim et al. 2011; Ota et al. 2009), overcommitment (Jackowska et al. 2011; Ota et al. 2009), low job control (Kim et al. 2011; Knudsen et al. 2007; Loudoun et al. 2014; Van Laethem et al. 2013), conflict and ambiguity in the role (Eriksen et al. 2008; Iwasaki et al. 2018; Knudsen et al. 2007), high job demands (Eriksen et al. 2008; Kim et al. 2011; Knudsen et al. 2007; Van Laethem et al. 2013), poor interpersonal relationships (Kim et al. 2011; Nakata et al. 2004), job insecurity (Kim et al. 2011), poor social support (Jackowska et al. 2011; Johannessen and Sterud 2017; Kim et al. 2011; Ota et al. 2009), and exposure to threats and violence at work (Eriksen et al. 2008) are important risk factors affecting work-related sleep disturbances (Akerstedt et al. 2010; Park et al. 2013). Linton et al. conducted a review study focusing on studies with prospective or randomized designs and suggested that high job demands, control over work, social support at work, workplace violence, job strain, organizational injustice, and the effort-reward imbalance were related to sleep disturbances (Linton et al. 2015).

Environmental work risk factors, including chemical agents, noise and vibration, biological materials, and atmospheric and lighting conditions, are other risk factors that can affect sleep disorders among employees. However, few studies have been conducted on these risk factors and their association with sleep disturbances (Linton et al. 2015). Only one comprehensive study has been done to examine the effects of multiple environmental work risk factors on sleep disturbances (Heo et al. 2013). The results of this study showed that exposure to noise, inappropriate temperature conditions, vibration, chemical agents, and biological agents could increase the risk of sleep disturbance. In that study, as in most studies surveying the effect of workplace risk factors on sleep disorders, self-report questionnaires were used to examine the exposure to environmental risk factors (Heo et al. 2013).

Based on what was mentioned above, comprehensive research is needed to explore the simultaneous effects of multiple psychosocial and environmental work risk factors (using standard methods) on sleep disturbances. The simultaneous effects are needed to be considered because of mutual confounding; that is, stressful workplaces are often also dirty and loud workplaces. To the best of our knowledge, no study has addressed the simultaneous effects of psychosocial and environmental factors on sleep disturbances. Previous studies have only investigated the effect of one environmental work risk factor or psychological risk factor on sleep disturbances. Therefore, the present study aims to investigate the relationship between predictors of abnormal sleep and work-related environmental and psychosocial factors. In this project, standard objective methods were used to measure environmental risk factors. Also, for measuring sleep disturbances, two validated questionnaires were used.

Methods

Study design and subjects

This cross-sectional and descriptive-analytical study was conducted in a brick factory in Iran. In this factory, workers were exposed to many environmental risk factors, such as heavy work demand, air pollution, extreme temperatures, and noise. At the time of the study, 105 employees were employed in different parts of the factory (all workers were male). The research project was approved by the Ethics Committee of Shiraz University of Medical Sciences. The study objectives were discussed with the factory management and then, a permit was issued to enter the factory. The inclusion criteria of the study were having at least 1 year of job tenure and working full time. The exclusion criterion was suffering from diseases that could disturb sleeping, such as thyroid disorders, diabetes, cardiovascular problems, and renal failure, according to medical records. A total of 95 workers were enrolled into the study 90 of whom were willing to participate in the research. All these employees worked on a day shift schedule during the past year.

The study data were collected through face-to-face interviews. The employees who agreed to take part in the study were required to sign written informed consent forms for participation. All measurements were made on the same day of the week for each individual. Before distributing the questionnaires and measuring the risk factors, the research objectives and procedures were explained to the participants and they were assured that no personal information provided by them would be analyzed individually. It should be noted that anonymous questionnaires were used and the data were collected in person.

Measures

Stop-Bang questionnaire

This questionnaire is a validated tool to identify the people who are at risk of OSA. This instrument consists of four items designed in yes/no format evaluating snoring, tiredness during daytime, observed apnea, and high blood pressure and four demographic and anthropometric items (yes/no) including Body Mass Index (BMI > 35 kg/m^2), age (> 50 years), neck size (≥ 40 cm), and gender (male) (Chung et al. 2008). Having three or more positive answers to eight items on the questionnaire (scores ≥ 3) is considered to be a sign of moderate and severe risk for OSA (Chung et al. 2008). The reliability and validity of the Persian version of this questionnaire have been reported by Sadeghniiat-Haghighi et al. (2015).

Epworth sleepiness scale (ESS)

ESS is a validated scale, which contains eight questions that subjectively measure daytime sleepiness in eight different activities, including reading, watching TV, talking, sitting quietly, sitting in a public place, traveling, relaxing, and driving behind the traffic (Johns 1991). The items are responded through a 4-point scale ranging from 0 to 3. Scores > 10 are considered to be a sign of moderate and severe sleepiness, which is clinically significant (Walsleben et al. 2004). The psychometric properties of the Persian version of this questionnaire have been reported by Sadeghniiat-Haghighi et al. (Sadeghniiat Haghighi et al. 2013).

Health and safety executive (HSE)—management standards (MS) indicator tool

This validated questionnaire is one of the comprehensive questionnaires used for assessment of psychosocial stressors in the workplace. It was developed by the UK's Health and Safety Executive. The HSE–MS tool includes seven dimensions measured by 35 questions. These seven dimensions include demands (including work load, work patterns, and work environment), control, supervisor support (including support and resources provided by the employer), peer support (including support and resources provided by colleagues), relationships (including effective measures to prevent conflict and dealing with inappropriate behaviors), role (including a clear understanding of the employees about their role in the organization), and changes (including how to manage changes in the organization and transfer them to employees) (Cousins et al. 2004). In current study, a higher score in each dimension (5) indicated a lower level (1) of stress. The validity of the Persian version of this questionnaire was approved by Gharibi et al. (Gharibi et al. 2016).

Socio-demographic and work-related variables questionnaire

This questionnaire was designed to determine socio-demographic characteristics and work-related variables. This questionnaire included age, marital status, education level, exercising, smoking, job tenure, work hours, job title, second job, and overtime working.

Wet bulb globe temperature (WBGT) index

The WBGT index is one of the most important and reliable indicators for assessing environmental heat stress in the workplace and is expressed in °C or °F. This index is determined based on the measurement of the wet-bulb temperature, dry-bulb temperature, and globe thermometer temperature (Budd 2008). A calibrated Microtherm Heat Stress WBGT Meter (Casella CEL Ltd, Bedford, England) was used based on the standard method ISO 7243 (2017b). The measurements were carried out at three stages, namely before the beginning (7 A.M.), four hours after the beginning (11 A.M.), and after the end (3 P.M.) of the work. It should be noted that three measurements were made at each stage. The WBGT index was measured at three heights (head, abdomen, and ankles) at the workstations. Then, the WBGT value was calculated using the following equation:

$$\mathrm{WBGT} = 0.7\ \mathrm{Tnwb} + 0.3\ \mathrm{Tg}$$

where Tnwb represented natural wet-bulb temperature (sometimes called NWB) and Tg indicated globe temperature (sometimes called GT).

The overall WBGT index was calculated using the following formula:

$$\mathrm{WBGT}_{\mathrm{total}} = \frac{\left(\mathrm{WBGT}_{\mathrm{head}}\right) + \left(2 \times \mathrm{WBGT}_{\mathrm{abdomen}}\right) + \left(\mathrm{WBGT}_{\mathrm{ankles}}\right)}{4}.$$

Considering the participants' work hours (8 h), pattern of allocation of work in a cycle of work and recovery (50%–75%), and work demands (moderate), the threshold limit value (TLV) of the WBGT index was considered as 29 °C according to the American Conference of Governmental Industrial Hygienist (ACGIH 2019).

Noise

To determine exposure to full-shift noise levels, a calibrated PCE-353-ICA sound level meter (PCE Inst., Meschede, Germany) was used based on the standard method of ISO 1996-2: 2017 (ISO 2017a) (46). Measurement of noise was carried out at a height of 1.6 meters above the ground level at the center of each workstation. Three measurements were made for each workstation. According to the TLV recommended by the ACGIH (2019) and the Iranian Center for Environmental and Occupational Health (2015), noise level of 85 decibels (dBA) or higher over an eight-hour work shift has been considered unacceptable and can be harmful to human health.

Lighting

The light intensity was measured using a lux meter (Hagner EC1 Digital luxmeter). In doing so, the lux meter was placed on the work surface where the participants carried out their tasks. The measurements were carried out at three stages; i.e., before the beginning (7 A.M.), four hours after the beginning (11 A.M.), and after the end (3 P.M.) of the work, and the average of the three steps was reported. According to the Iranian Center for Environmental and Occupational Health (2015), ≥ 250 lx light levels have been recommended for all jobs and workstations in brick industries.

Respirable dust

The standard NIOSH 0600 method was used for sampling respirable dust from the workers' breathing zone. In so doing, air sampling filter holders were attached to the workers' collars (NIOSH 1998). For this purpose, 10 mm nylon cyclone, polyvinyl chloride filters with 5.0-µm pore size, and a calibrated sampler pump (Universal PCXR8, SKC Inc.) with a flow rate of 1.7 L/min were used. All filters were placed in the desiccator for 24 h before and after the sampling due to the possibility of moisture absorption. Before sampling, the sampling pump was calibrated using a rotameter with a flow rate of 1.7 L/min. The initial weights of the filters were measured at the beginning of sampling. After sampling from all workstations, the collected samples were transferred to the laboratory according to the sampling instructions. Then, the secondary weights of the filters were determined by gravimetric method using a digital scale with the accuracy of four decimals (CP225D model) manufactured by Sartorius Company. Based on the standard method, control samples were used to remove the effects of confounders. A control filter (field blank) was used at each workstation. These filters were handled, stored, and shipped in the same manner as other sampling media used in the sampling of respirable dust, with the exception that no air was drawn through them. Totally, proportional to the number of workstations, 30 samples were collected from the workers' breathing zones at each workstation. None of the collected samples was overloaded. The average sampling time was 120 min.

The concentration of the pollutant (mg/m^3) was calculated using the following equation:

$$C = \frac{\left(W_2 - W_1\right) - \left(B_2 - B_1\right)}{V} \times \left(10^3\right),$$

where W2 represented the post-sampling weight of the sample-containing filter (mg), W1 was the tare weight of the filter before sampling (mg), B2 was the mean post-sampling weight of the blank filter (mg), B1 was the mean tare weight of the blank filter (mg), and V was the volume as sampled at the nominal flow rate (1.7 L/min). According to the ACGIH standard, the TLV for respirable dust was 3 mg/m^3 (ACGIH 2019).

Statistical analysis

Descriptive analyses were used to describe the characteristics of the participants. A series of univariate and multiple regression analyses were used to investigate the relationship between the independent variables and sleep disturbances. Mann–Whitney *U* and Kruskal–Wallis tests were used to examine the relationship between socio-demographic and work-related variables and STOP-Bang and ESS scores. Spearman's correlation coefficient was also used to investigate the association between psychosocial and environmental work risk factors and the STOP-Bang and ESS scores. The Mann–Whitney *U* test was used to determine whether individuals whose STOP-Bang and ESS scores indicated abnormal sleep status experienced increased psychosocial and environmental work risk factors compared to those whose scores did not indicate abnormal sleep status. $P < 0.05$ was considered to be statistically significant. Finally, a hierarchical multiple logistic regression was used to examine the simultaneous relationship between the psychosocial and environmental work risk factors and STOP-Bang and ESS scores. Initially, a Variance Inflation Factor (VIF) was used to study the multicollinearity between the studied independent variables. Then, for regression modeling, all studied socio-demographic and work-related variables (control variables) were introduced into the model. In the second stage, psychosocial and environment work risk factors were introduced. It should be noted that the workers who received an OSA score of ≥ 3 and ESS score of Scores > 10 were classified as abnormal sleep status (Chung et al. 2008; Walsleben et al. 2004). The variables with $p < 0.05$ were maintained in the final model. All statistical analyses were done using the SPSS software, version 23 (USA, SPSS Inc.).

Results

The mean (SD) age of the participants was 35.6 (4.3) years, ranging from 22 to 68 years. Besides, the means (SD) of their BMI and job tenure were 25.5 (4.4) kg/m^2 and 7.4 (3.1) years, respectively. Nearly 18% of the participants had university degrees and nearly 90% of them were line workers. The participants' socio-demographic and work-related factors as well as their relationships with ESS and Stop-Bang scores have been presented in Table 1. The results showed that older age groups and lower education groups had higher Stop-Bang scores compared to younger age groups and higher education groups. Office

Table 1 The participants' socio-demographic and work-related factors and their associations with the ESS and Stop-Bang scores ($n = 90$)

Characteristics	*N* (%)	ESS		Stop-Bang	
		Mean (SD)	*P*-value	Mean (SD)	*P*-value
Age groups (years)					
≤29	15 (16.7)	14.1 (3.6)	0.437[a]	1.7 (0.9)	**0.002**[a]
30–39	62 (68.9)	13.0 (4.3)		1.9 (0.9)	
≥40	13 (14.4)	13.6 (4.9)		3.0 (1.0)	
Marital status					
Single	15 (16.7)	14.7 (4.8)	0.258[b]	1.9 (0.7)	0.780[b]
Married	75 (83.3)	13.0 (4.1)		2.1 (1.0)	
Body mass index (kg/m^2)					
≤24.9	46 (51.1)	13.1 (3.6)	0.926[a]	2.2 (1.1)	0.549[a]
25–29.9	29 (32.2)	13.7 (4.8)		1.9 (0.9)	
≥30	15 (16.7)	13.0 (5.1)		2.1 (1.0)	
Education level					
Elementary	22 (24.4)	12.1 (3.5)	0.314[a]	1.1 (0.2)	**0.030**[a]
Diploma	52 (57.8)	13.7 (4.3)		0.9 (0.1)	
University degree	16 (17.7)	13.2 (5.1)		0.8 (0.2)	
Exercise activity					
Yes	39 (43.3)	13.3 (4.9)	0.613[b]	1.9 (1.0)	0.311[b]
No	51 (56.7)	13.2 (3.8)		2.1 (0.9)	
Smoking					
No	44 (48.9)	12.5 (4.5)	**0.041**[b]	1.7 (0.9)	**0.003**[b]
Yes	46 (51.1)	14.0 (3.9)		2.3 (1.0)	
Job tenure (year)					
<5	17 (18.9)	11 .9 (4.7)	0.174[a]	1.9 (0.8)	0.116[a]
5–10	35 (38.9)	13.2 (4.2)		1.8 (0.9)	
≥10	38 (42.2)	13.9 (4.1)		2.3 (1.1)	
Workday hours					
8	38 (42.2)	13.9 (4.9)	0.546[a]	2.3 (1.1)	0.113[a]
9–11	20 (22.2)	12.9 (2.7)		1.8 (0.9)	
12	32 (35.6)	12.7 (4.2)		1.8 (0.9)	
Job title					
Office workers	10 (11.1)	7.3 (1.3)	**0.000**[b]	1.5 (0.7)	0.061[b]
Line workers	80 (88.9)	14.0 (3.9)		2.1 (1.0)	
Second job					
Yes	16 (17.8)	12.9 (5.2)	0.456[b]	1.7 (0.9)	0.112[b]
No	74 (82.2)	13.3 (4.1)		2.1 (1.0)	
Overtime					
Yes	54 (60)	12.9 (4.2)	0.337[b]	2.1 (1.0)	0.627[b]
No	36 (40)	13.8 (4.4)		2.0 (1.0)	

ESS epworth sleepiness scale; higher scores in ESS (> 10) and Stop-Bang (≥ 3) questionnaires indicated worse sleep

[a]Kruskal–Wallis test; [b]Mann–Whitney *U* test

workers had lower ESS scores compared to line workers. Non-smokers had lower ESS scores and Stop-Bang scores compared to smokers.

The mean scores of ESS and Stop-Bang as well as their relationships with environmental and psychosocial work risk factors have been presented in Table 2. The results of Spearman's correlation coefficient showed that all psychosocial variables (except for changes) and all environmental work risk factors, including heat stress, noise, lighting, and respirable dust, were weak to moderate correlated to the ESS score. There was also a moderate correlation between the Stop-Bang score and demands, role, and lighting variables. Moreover, the participants with a risk of OSA (Stop-Bang ≥ 3) and higher sleepiness (ESS > 10) were more exposed to environmental and psychosocial stressors (Table 3). The results of Mann–Whitney U-test indicated that the participants with abnormal ESS mean scores were more exposed to environmental and psychosocial risk factors compared to those with abnormal scores.

The VIF values of all environmental and psychosocial stressors were between one and six, which indicated no multicollinearity between the variables. The lowest and highest VIF values were related to respirable dust (1.6) and managerial support (5.3), respectively.

The results of univariate logistic regression analysis showed that control, peer support, role, WBGT, lighting, and respirable dust were highly correlated with the dichotomous ESS outcome (Table 4). The results of multivariate logistic regression analysis also showed that control, WBGT, and respirable dust were highly correlated to the ESS score. On the other hand, the results of univariate analysis indicated that demands and lighting were significant predictors of the Stop-Bang score. The results of multivariate analysis also showed that only noise had a very strong OR 0.05 (95%CI 0.01–0.63) with the Stop-Bang score.

Discussion

In this study, for the first time, the simultaneous relationships between sleep disturbances and multiple environmental stressors including noise, lighting, heat stress, and respirable dust and psychosocial work-related stressors including demands, control, managerial support, peer support, relationships, and role were evaluated. The results indicated that the stressors, especially the environmental factors of noise, heat stress (WBGT), and respirable dust that were measured using objective standard methods, were moderately correlated to sleep disturbances. Moreover, sleep disturbances, especially the prevalence of sleepiness, were worse among the workers exposed to higher levels of noise compared to those exposed to lower noise levels. These workers had higher odds ratios of sleep disturbance. Similarly, Heo et al. reported that the

Table 2 Mean, SD, and correlations between the ESS and Stop-Bang scores and independent variables among the study participants ($n=90$)

Variable	Mean	SD	α	1	2	3	4	5	6	7	8	9	10	11	12	13
1. ESS	13.3	4.3	0.72	1												
2. Stop-Bang	2.0	1.0	NA	0.378**	1											
3. Demands	3.3	0.7	0.79	− 0.262*	− 0.241*	1										
4. Control	2.5	0.8	0.78	− 0.257*	− 0.174	0.492**	1									
5. Managerial support	3.2	1.0	0.80	− 0.290**	− 0.142	0.586**	0.433**	1								
6. Peer support	3.2	1.1	0.84	− 0.307**	− 0.116	0.475**	0.322**	0.825**	1							
7. Relationships	3.6	0.9	0.72	− 0.320**	− 0.113	0.662**	0.370**	0.715**	0.686**	1						
8. Role	3.3	1.2	0.91	− 0.403**	− 0.218*	0.545**	0.413**	0.695**	0.653**	0.660**	1					
9. Changes	2.9	0.8	0.70	− 0.113	0.016	0.268*	0.376**	0.621**	0.611**	0.436**	0.448**	1				
10. WBGT (°C)	27.7	4.9	NA	0.393**	0.204	− 0.529**	− 0.521**	− 0.625**	− 0.555**	− 0.639**	− 0.518**	− 0.395**	1			
11. Noise (db)	71.2	17.5	NA	0.333**	− 0.020	− 0.130	− 0.278**	− 0.429**	− 0.498**	− 0.342**	− 0.552**	0.280**	0.325**	1		
12. Lighting (Lux)	255.1	97.9	NA	− 0.504**	−.295**	0.465**	0.304**	0.546**	0.493**	0.589**	− 0.560**	− 0.276**	− 0.536**	− 0.152	1	
13. Respirable dust (mg/m^3)	2.8	2.8	NA	0.481 **	0.065	0.013	− 0.226*	− 0.297**	− 0.299**	− 0.235*	− 0.411**	0.252*	0.234*	0.565	− 0.407	1

α Cronbach's alpha, *ESS* Epworth sleepiness scale, *WBGT* wet bulb globe temperature, *NA* not applicable

Spearman's correlation coefficient, $^{*}P<0.05$, $^{**}P<0.01$

Table 3 The scores of environmental and psychosocial work risk factors according to the sleep disturbances status among the study participants ($n=90$)

Variable	ESS			Stop-Bang		
	Normal	Abnormal > 10	*P*-value[a]	Normal	Abnormal ≥ 3	*P*-value[a]
Demands (mean ± SD)	3.7 ± 6.8	3.2 ± 6.6	**0.008**	3.5 ± 6.2	3.1 ± 0.8	**0.023**
Control (mean ± SD.)	3.2 ± 1.0	2.3 ± 0.6	**0.001**	2.6 ± 0.8	2.5 ± 0.8	0.347
Managerial support (mean ± SD)	3.8 ± 1.0	2.9 ± 0.9	**0.002**	3.3 ± 1.0	3.0 ± 1.0	0.237
Peer support (mean ± SD)	4.0 ± 1.0	3.0 ± 1.0	**0.001**	3.3 ± 1.1	3.0 ± 1.0	0.210
Relationships (mean ± SD)	4.2 ± 0.8	3.4 ± 0.9	**0.001**	3.7 ± 0.9	3.4 ± 0.9	0.216
Role (mean ± SD)	4.1 ± 1.0	3.1 ± 1.1	**0.001**	3.5 ± 1.2	3.0 ± 1.2	0.070
Changes (mean ± SD)	3.4 ± 1.0	2.8 ± 0.7	**0.040**	2.9 ± 0.8	3.0 ± 0.8	0.667
WBGT (°C) (mean ± SD)	23.6 ± 4.6	28.9 ± 4.3	**0.000**	27.0 ± 5.1	29.1 ± 4.2	0.105
Noise (db) (mean ± SD)	52.7 ± 24.8	76.5 ± 10.0	**0.001**	70.3 ± 19.9	72.8 ± 12.2	0.752
Lighting (Lux) (mean ± SD)	328.1 ± 88.2	234.3 ± 90.7	**0.000**	271.5 ± 83.7	225.4 ± 115.0	**0.013**
Respirable dust (mg/m^3) (mean ± SD)	1.1 ± 2.2	3.3 ± 2.8	**0.000**	2.8 ± 3.0	2.9 ± 2.5	0.385

Bold values are significant ($p<0.05$)

[a]Mann–Whitney *U* test

SD standard deviation, *ESS* Epworth sleepiness scale, *WBGT* wet bulb globe temperature

employees exposed to high noise levels had higher odds ratios of sleep disturbance in comparison to non-exposed ones (Heo et al. 2013). The effect of noise on sleep can be attributed to physiological and physical changes in the body, including increased secretion of adrenaline, noradrenaline, and cortisol, changes in heart rate and blood flow volume, and changes in respiration, immune, and neurocirculatory systems (Halperin 2014; Kawada 2011). In a recent study, Lin et al. investigated the effect of daily exposure to noise on night-time sleep (Lin et al. 2018). Their results demonstrated that noise had an adverse effect on the participants' sleep quality, specifically slow wave sleep and sleep efficiency. They explained that these disorders resulted from increased cortisol secretion and autonomic nervous system (ANS) activity.

Respirable dust was one of the most important environmental risk factors in the present study. The results of multivariate analysis indicated that this risk factor was predictive of an ESS score indicating abnormal sleep status. To the authors' knowledge, no studies have been conducted in this area. Nevertheless, the potential impact of workplace inhalational exposures, especially solvents, on OSA has been reported in the previous studies. Prolonged exposure to these pollutants could cause sleep disturbances, especially sleep apnea syndromes (SAS) (Viaene et al. 2009). The results of a recent meta-analysis by Schwartz et al. also revealed that exposure to solvents increased the risk of OSA (Schwartz et al. 2017). However, the exact mechanism of the influence of workplace inhalational exposures on sleep disturbances is not clear (Heo et al. 2013). Smoking is a risk factor for the development of OSA (Schwartz et al. 2017). In this regard, the results of univariate analysis in the current study showed a high relationship between smoking as a non-occupational respiratory exposure and sleep disorders. Accordingly, smokers had higher ESS and Stop-Bang scores compared to non-smokers. Nicotine in cigarettes can affect sleeping through its impact on the release of neurotransmitters, which control the sleeping-awakening cycle (Morioka et al. 2018; Saint-Mleux et al. 2004). Smoking can also cause sleep disturbances by affecting airway obstruction (Kutty 2004; Lewis 2001).

The results of univariate and multivariate analyses indicated that heat stress based on the WBGT index was predictive of an ESS score of abnormal sleep status. High exposure to this risk factor is a stressful occupational factor and, similar to other risk factors in the workplace, can affect sleep by disrupting the hypothalamic–pituitary–adrenal axis and the hormonal system (Heo et al. 2013). However, review of the literature showed that no studies have been conducted on the effect of daily exposure to heat stress in working environments on sleep quality. This risk factor is also present in urban environments; consequently, it may be necessary to examine the effect of daily exposure to this risk factor on sleep amongst the general population.

In line with the previous studies, psychosocial stressors were associated higher ESS scores. However, multivariate analysis with other potential work place risk factors and social factors suggests potential confounding. As it stands, it is unclear to what extent these factors may independently be associated with abnormal sleep status. The results of multivariate analysis indicated that control factor was a positive predictor of the higher ESS score category. The findings of a study conducted among Korean workers showed that insufficient work control was among the most important factors affecting sleep disorders (Heo et al. 2013). The results obtained by

Table 4 Univariate and multivariate logistic regression analyses predicting sleep disturbances in the studied population ($n=90$)

Variable	ESS						Stop-Bang					
	Univariate[a]			Multivariate[a]			Univariate[a]			Multivariate[a]		
	OR	95% CI	*P* value	OR	95% CI	*P* value	OR	95% CI	*P* value	OR	95% CI	*P* value
Demands (ref: unexposed)	0.00	–	0.999	0.00	–	0.999	7.84	1.5–40.4	**0.014**	6.2	0.66–57.9	0.110
Control (ref: unexposed)	6.74	2.3–20.2	**0.001**	4.21	1.2–14.8	**0.025**	1.08	0.44–2.68	0.862	.88	0.16–4.93	0.884
Managerial support (ref: unexposed)	3.56	0.95–13.3	0.059	1.42	0.15–13.7	0.760	2.04	0.83–5.05	0.122	1.35	0.25–7.27	0.724
Peer support (ref: unexposed)	3.37	1.1–11.1	**0.046**	2.12	0.18–25.5	0.556	1.56	0.65–3.74	0.324	1.84	0.34–10.1	0.482
Relationships (ref: unexposed)	4.75	0.58–38.6	0.145	1.03	0.05–20.9	0.983	2.43	0.79–7.48	0.122	0.45	0.07–2.81	0.392
Role (ref: unexposed)	5.65	1.2–26.3	**0.027**	0.93	0.11–8.16	0.949	1.80	0.72–4.47	0.208	1.49	0.25–9.02	0.663
Changes (ref: unexposed)	1.29	0.41–4.0	0.664	0.12	0.01–1.23	0.074	0.74	0.28–1.96	0.546	0.70	0.14–3.29	0.628
WBGT (°C) (ref: unexposed)	7.58	1.6–35.2	**0.010**	5.54	1.1–30.1	**0.048**	2.22	0.91–5.40	0.078	1.02	0.16–6.61	0.983
Noise (db) (ref: unexposed)	2.27	0.60–8.59	0.229	1.56	0.19–13.1	0.680	0.56	0.19–1.60	0.275	0.05	0.01–0.63	**0.020**
lighting (Lux) (ref: unexposed)	4.75	1.4–15.6	**0.010**	0.92	0.15–5.52	0.923	3.36	1.36–8.31	**0.009**	1.45	0.32–6.57	0.628
Respirable dust (mg/m^3) (ref: unexposed)	5.35	1.4–19.9	**0.012**	7.27	1.8–30.1	**0.006**	1.44	0.60–3.46	0.410	1.95	0.41–9.39	0.405

Bold values are significant ($p<0.05$)

The subjects who received an OSA score of ≥ 3 and ESS score of Scores > 10 were classified as abnormal sleep status

OR odds ratio, *ESS* Epworth sleepiness scale, *WBGT* wet bulb globe temperature.

[a]Adjusted for age, marital status, education level, exercise activity, smoking, job tenure, work hours, job title, second job, and overtime

Murata et al. also showed that high job demands, low job control, and poor human work relations were effective in different dimensions of insomnia, such as poor quality of sleep, difficulty initiating sleep, and difficulty maintaining sleep (Murata et al. 2007). Overall, psychosocial work-related stressors might disrupt the ability to fall asleep, thereby decreasing the quality of sleep and increasing sleep disorders (Park et al. 2013). This association could be attributed to the effect of these risk factors on the hypothalamic–pituitary–adrenal axis and increased secretion of stress hormones, including epinephrine, norepinephrine, and corticosteroids (Heo et al. 2013).

The aim of present study was to investigate the simultaneous effects of multiple environmental and psychosocial work risk factors on sleep disturbances. In this regard, the results indicated that in addition to psychosocial risk factors, environmental risk factors can simultaneously effects sleep disturbance. To the best our knowledge, no study has addressed this simultaneous effects. However, the results of a study on Iranian workers indicated that the work ability could be affected by multiple work-related risk factors (Mokarami et al. 2017).

Limitation

Despite the strengths of this study, especially the high response rate, use of standard objective methods for assessing environmental workplace risk factors, and use of valid questionnaires for assessing sleep disturbances, it had several limitations. First, the cross-sectional design of the study could not prove causal relationships. Hence, prospective studies are suggested to confirm the findings. Second, the study was conducted only among males who worked based on a daytime schedule in one organization. Thus, generalization of the results to other settings and organizations should be done with caution. Third, self-reported questionnaires were used to assess sleep disturbances and psychosocial factors, which introduced the possibility of recall bias. It is also noteworthy that although the questionnaires were validated, they did not represent the gold standard for gathering such data on sleep. Fourth, despite all efforts made to exclude people with sleep-related illnesses, it is possible that people with sleep-related illnesses were not excluded. Finally, HSE questionnaire with seven dimensions was used to assess psychosocial stressors, while other psychosocial factors could have affected the participants' sleep disturbances.

Conclusion

The results indicated that stressors, especially environmental risk factors such as noise, heat stress, and respirable dust, may affect abnormal sleep status and independent of potential mutually confounding other workplace risk factors. These results highlighted the importance of considering multiple psychosocial and environmental work risk factors for implementing interventional programs to prevent employees' sleep disturbances. Despite the importance of sleep on employees' health and productivity, this variable is less noticeable in healthcare intervention programs in Iran. Therefore, further research, specifically prospective studies, is required to be conducted on the effects of multiple workplace risk factors on sleep disturbances, so that the results will be used for implementing interventional programs.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interests.

Ethical approval This study was conducted according to the principles of the Declaration of Helsinki and the Ethical Guidelines for Medical and Health Research Involving Human Subjects of the Ministry of Health, Iran. The protocol was also approved by the Ethics Committee of Shiraz University of Medicine Science (IR.SUMS.REC.1397.568).

Informed consent The participants were informed about the study purposes, their autonomy, and confidentiality of the responses and data handling.

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