Relationship between oral temperature and sleepiness among night workers in a hot industry

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ABSTRACT

Night work can have a significant impact on health, well-being, performance and occupational safety of workers. Night workers often complain about the sleep disorder characterized by excessive sleepiness. The aim of the study was to determine the level of sleepiness among night workers and investigate its relationship with oral temperature in a hot industry. This cross-sectional study involved 80 night workers. Stanford Sleepiness Scale (SSS) has been used to measure the level of sleepiness. Oral temperature and SSS were recorded at different hours of night shift (23 pm to 4 am) for two consecutive nights. The analysis of results showed that there was a positive linear trend in the sleepiness scale (Pvalue<0.001) and an increasing trend in the oral temperature between 23pm and 1am. Then a decreasing trend has been observed after 1am for both of them (Pvalue <0.001). Comparison of the results for two nights indicated that the mean sleepiness index in the second night is higher than the first (Pvalue <0.001), but the mean oral temperature in the second night was equal to that in the first night. Findings suggest a weak negative association between sleepiness and oral temperature. (r=-0.24, Pvalue =0.03). A substantial proportion of subjects were working while sleepy, especially at late night and early morning hours. The combination of heat stress and sleepiness can lead to impaired performance. The growing amount of sleepiness index indicates the high risk of sleep disorders and the other possible problems related health among night shift workers.

Keywords: Night work; Sleepiness; Oral temperature.

INTRODUCTION

Night work refers to working during the night and into the early morning hours (approximately 18 pm to 7am), medical professionals, law enforcement officers, industrial workers and delivery drivers are just some of people who work the night shift [1-2]. In Europe and North American, it is estimated that nearly 25 percent of the working population are engaged in shift work [3-5], that 13–20% of them spent working at night [6]. It is commonly found that cardiovascular disease, gastrointestinal malfunction, increased accident risk, sleep disturbances and increased fatigue, internal desynchronization and disturbed circadian performance rhythm, are more prevalent among shift workers compared to day workers [2, 7-8]. Besides the health problems caused by shift work, it can disrupt the personal, family and social life of shift workers [9-10].

However, the most damage produced by shift work disorder is due to the increased fatigue and sleepiness. Since shift work is associated with significant neurocognitive impairment and the reduced productivity, the economic costs of shift work disorders are too high, and the most of the costs are related to efficiency loss and accidents [5, 11-13].

The reason for the night shift sleepiness is the nadir (low point) of the circadian pattern, and characteristic of most physiological and psychological variables like alertness [7].

The role of disturbed circadian rhythm in health problems such as sleep disorders of shift workers is well known [8]. Beside of the influence of circadian rhythms on sleep-wake cycles, it can effect on hormone production, body temperature, brain wave activity and other important bodily functions [14-15]. The first research on the changes in oral temperature during shift work has been conducted by Colquhoun et al. They found out that body temperature generally displays fluctuations, with the minimum occurring around 5 AM and the maximum occurring around 21 PM [16]. It indicated that the maximum and minimum body temperature is correlated to the level of consciousness of the shift workers [17].The positive correlations between daily rhythms of body temperature and neurobehavioral performance and alertness in humans by some researches [18-24]. During the night, the release of melatonin from the pineal gland causes a decrease in body temperature, so the increased sleepiness, and decreased performance [18, 25-26]. In studies of night-shift work, low performance and sleepiness associated with low body temperature has been reported [24]. Heat stress is common problem in glass manufacturing industries [27-28] that can lead to the increase in body temperature as the most common physiological responses to heat stress [29]. Yet, it has been unclear that in hot industries and under heat stress how body temperature and sleepiness can be associated, so the aim of the study was to determine the level of sleepiness among night workers and investigate its relationship with oral temperature in a hot industry.

MATERIALS AND METHODS

A cross-sectional descriptive study was performed to assess the variations in oral temperature and sleepiness of night shift workers during night at a hot industry, Securit® glass manufacturing industry in Arak. All 80 night workers volunteered for the investigation that most of them were working near operational furnaces. Their work schedule included two days on morning shift (6 am - 14 pm), two days on swing shift (14-22 pm), two days night on shift (22 pm to 6 am followed by two days off. Measurements were carried out over two consecutive nights. For assessing sleepiness, Stanford Sleepiness Scale questionnaire (SSS) was used [30]. Beginning at 22:00, the level of sleepiness was evaluated every 2 hours using the Stanford Sleepiness Scale. SSS is a self-rating scale and a subjective measure of sleepiness that can quantify progressive steps in sleepiness at specific moments in time [31-32].SSS provide a reliable assessment of acute sleepiness and there are significant relationship between the SSS and a decrease in performance [33-34] . SSS is a 7-point scale, ranging from 1 (high consciousness) to 7 (high sleepiness). Rating between 3 and 7 indicates that you are carrying too much sleep debt [35]. The validity of this questionnaire using Wilkinson Addition test and Wilkinson Vigilance test is calculated 0.68. The reliability has been reported at 0.88 [33]. We provide the acceptable and easy to understand Persian version of SSS by the forward and back-translation method (Cronbach's alpha=0.88).

The oral temperature was measured using a simple (non-digital) oral medical thermometer six times (23pm, 24pm, 1am, 2am, 3, and 4 am) at each night. The demographic data of subjects including age, height, weight, gender, education level, marital status, the shift work experience, and smoking were collected. For assessing the heat stress, Wet Bulb Globe Temperature (WBGT) as the most widely used index of heat stress was measured. For this purpose, the environmental parameters such as dry temperature, natural wet-bulb temperature, globe temperature and relative humidity were recorded by a calibrated WBGT meter (CASELLA) based on ISO7243.Then, WBGTTWA (Time-Weighted Average) was calculated by the relevant formula [29]. Data analysis was performed in SPSS (v. 18) statistical software using independent samples t test, one-way analysis of variance (ANOVA), and Pearson correlation coefficient. The 0.05 level of significance was taken for all analyses.

RESULTS

Participants were 21 to 45 years old, with a mean age of 30.2 years and BMI of 24.3 kg/m^2. 21.3 percent of individuals were singles and 27.5

percent were cigarette smokers as well as 6.2 percent of the shift workers had high school diploma. Mean subjective measures for the Stanford Sleepiness Scale (SSS) over two consecutive nights are presented in Table 1.

An assessment of subjective measures, using repeated measures analysis of variance and independent 2-group t-test, showed that sleepiness index measured for the first night in 22 pm , 24 pm, 2 am and 4 am was 1.9±0.3, 3.09±0.53, 3.79±0.58, and 4.24±0.83, respectively. The findings indicated that there is a statistically significant relationship between sleepiness time and sleepiness index, so the more late night hours, there was a higher risk of sleepiness (Pvalue <0.001). The effect size, which is a measure of the strength of the relationship between two variables, for time indicates that the effect size of time on the sleepiness index is very high (effect size = 0.9). The values of sleepiness index for second night were similar to those of the first night. Comparison of mean sleepiness index shows that in 22 pm, 24 pm and 4 am there is a statistically significant relationship in two nights. Table 2 shows mean of oral temperature in different hour measurement over two consecutive nights.

The mean oral temperatures for first night in 23 pm and 24 pm, 1 am, 2 am, 3 am, and 4 am were recorded as 36.42±0.14 ^{oC}, 36.48± 0.19 ^{oC}, 36.87±0.19 ^{oC}, 36.580.±0.19 ^{oC}, 36.54±0.20 ^{oC}, and 36.49±0.16 ^{oC}, respectively. As our results, a statistical correlation was found between time and oral temperature in which the mean oral temperature displayed an increasing trend from 23 pm to 2 am and a decreasing trend afterwards (Pvalue <0.001).

The difference between mean oral temperatures over two nights would not have been significant. Examination of the relationship between index of sleepiness and oral temperature indicated that with an increase in oral temperature, sleepiness displayed a significant decrease (r=0.24, Pvalue <0.03).

Table 1. Mean (±SD) subjective measures for the Stanford Sleepiness Scale (SSS) over two consecutive nights.

Variable	**Night**	**Number**	**Mean (±SD)**				**Effect size of time**	**Pvalue (Repeated measures analysis of variance)**
			Measurement hours					
			10 pm	12 pm	2am	4 am		
Sleepiness index	**First night**	80	1.9±0.3	3.09±0.53	3.79±0.58	4.24±0.83	0.9	<0.001
	Second night	80	1.56±0.52	2.7±0.7	3.64±0.79	4.49±0.76	0.92	<0.001
	Pvalue (Independent 2-group t-test)		<0.001	<0.001	0.15	0.03		

Table 2. Mean (±SD) of oral temperature over two consecutive nights

Variable	**Night**	**Mean (±SD)**						**Effect size of time**	**Pvalue (Repeated measures analysis of variance)**
		Measurement hours							
		23 pm	12 pm	1 am	2 am	3 am	4 am		
Oral temperature (Celsius)	**First Night**	36.42±0.14	36.48±0.19	36.78±0.19	36.58±0.19	36.54±0.2	36.49±0.16	0.68	<0.001
	Second Night	36.43±0.16	36.48±0.18	36.91±0.23	36.57±0.18	36.5±0.16	36.54±0.13	0.66	<0.001
	Pvalue (Independent 2-group t-test)	0.66	1	0.3	0.76	0.2	0.05		

The further examining indicated that the mean sleepiness index in single workers (3.23±0.25) is more than that for married subjects (3.15±0.35). The mean sleepiness index for participants in higher education of high school diploma (3.37±0.44) was more than others. The mean sleepiness index was higher in non-smokers (3.18±0.3) than smoker people (3.14±0.41). There was no significant correlation between sleepiness and marital status (Pvalue <0.4), education (Pvalue <0.34), and smoking (Pvalue =0.59). There was no significant relationship between sleepiness index and age (r=-0.01, Pvalue <0.89), body mass index (r=-0.12, Pvalue <0.27), and shift work experience (r=0.08, Pvalue <0.44).

The heat stress assessment by WBGT index showed these values are higher than the ACGIH (American Conference of Governmental Industrial Hygienists) threshold limit values (mean $WBGT_{TWA}$= 35.6 ^{oC}, dry temperature=43.5 ^{oC} and RH=65%).

DISCUSSION

Based on our findings of subjective measurement of sleepiness, it was observed that in both consecutive night shift works, there was a significant relationship between time and sleepiness index among night shift workers, so more late night hours, the higher mean sleepiness index they had (Pvalue <0.001). This link between sleepiness and the night time work might be due to fatigue caused by two consecutive night shift works. Consistent with another study [36], results of the present study indicate that the maximum mean value for sleepiness has been recorded for 4 am. According to Table 1, in which the subjective sleepiness index has been compared in two consecutive nights, there is a statistically significant difference between mean of sleepiness index in 22 pm, 24 pm and 4 am at two nights, so that it achieves the better mental adjustment to night shift in the second night; other studies have also found this [36-37]. Drake and colleagues reported that 32.1% and 26.1% of night-shift and rotating-shift workers, respectively, experienced insomnia, compared with 18.0% of day workers [38-39].Our results pointed out that at both 2 am and 4 am for two nights the sleepiness index is greater than 3; this indicates that all subjects have too much sleep debt.

As measuring oral temperature showed, the mean value of oral temperature has significant relationship with time (Pvalue <0.001). The mean oral temperature from 23 pm to 2 am displayed an increasing trend and a decreasing trend afterwards. This is consistent with the findings of Fuerberg study, carried out on night workers. In Feuerberg’s study, oral temperature was increased up to 1 am, and then it was reduced [40]. Studies on day workers and night workers revealed that the oral temperature has the maximum value in 21 pm, then it exhibits a decreasing trend, that this finding is not in agreement with the present study [16].

Unlike sleepiness index, there was no significant difference between oral temperatures in different hours for both nights, which it can result from the more stability in oral temperature than the subjective sleepiness. The correlation was found between sleepiness and oral temperature, so that with an increase in oral temperature, the mean sleepiness index was decreased significantly (r=-0.24, Pvalue =0.03) [16, 40]. Therefore, our results are consistent with the findings of other research [24,41].

CONCLUSION

It can be concluded that in a hot industry, like every other workplace, decreasing oral temperature is linked to an increase in sleepiness. In the present study, the sleepiness index was recorded based on individual subjective expressions.

So, factors such as the state of dissatisfaction in the work environment and the avoidance of answering could be effective on their responses. It is suggested that in the future research, objective data collection is considered, and clinical experiments such as hormonal tests and in-depth body temperature (if possible) are used.

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