



## Investigating the effect of night shifts rotation speed on the pattern of melatonin secretion and sleepiness among petrochemical control room operators

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### Abstract

**Introduction:** This paper aims to explore the main effect of night shift rotation speed on the pattern of melatonin secretion and the sleepiness, among control room operators (CORs) in a petrochemical industry

**Material and method:** In this study, 60 CORs operators within two different patterns, including 7 nights and 3 nights shift works were selected from a petrochemical industry to investigate the influence of rotation speed on their melatonin secretion and the sleepiness pattern. Thus, melatonin was sampled from saliva, and the sleepiness and sleep quality were assessed using Karolinska Sleepiness Scale (KSS) index. Data analysis was carried out using spss18, Chi square, t-test, and GLM model.

**Results:** Melatonin values and their general changes during shift were noticeably different in two proposed patterns ( $P < 0.05$ ). The sleepiness index was significantly different only at 3:00 in both patterns, whereas the interaction of light and caffeine on both melatonin changes and sleepiness was not significant ( $P < 0.05$ ). Moreover, a significant difference was observed between the process of melatonin changes and sleepiness in the two studied patterns ( $P < 0.05$ ).

**Conclusion:** Adopting slower shift schedules rotations would be more appropriate, from the viewpoints of the importance of alertness and performance for human error prevention, among people working in serious worksites such as control rooms.

**Keywords:** Night Shift Working, Melatonin, Sleepiness, Control Room.

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## 1. Introduction

Today's, shift working in many industries such as petrochemicals and steel companies, power plants, and service sectors like police offices and hospitals, has increasingly become critical and unavoidable [1]. Particularly, reducing the alertness and performance, due to the mismatch between the body's internal circadian rhythm and the artificial sleep-wake pattern created by working conditions at night and daily sleep disturbances, is a major challenge among shift workers [2]. One of the important consequences of the shift working, which may result from non-compliance of circadian rhythms and the reduced alertness, is the occurrence of accidents and human errors [3]. Adapting to night work (changing the phase of the circadian clock) in people on shift is a proper way to increase alertness and to improve sleep quality during the day.

In this matter, the number of consecutive night shifts and the rotation speed are the critical factors in adapting people to the night shift working. For instance, it has been described that increasing the number of consecutive nights may vary the circadian phase of the day and night, and therefore helps to improve people's performance at night and their alertness [4]. Therefore, this paper aims to compare salivary melatonin and night sleepiness index in CORs with different night shift patterns in terms of rotation speed. Noticeably, the work shift pattern, which leads to a decrease in melatonin secretion at night would be more appropriate for this job (CORs), as the peak of its secretion is transferred to the end of the shift, based on which people are less sleepiness.

## 2. Material and Methods

### 2.1. Instructions and participants

In a petrochemical industry in the coastlines of southern part of Iran, the shift work systems are employed similar to the common patterns at sea. In such schedules, each cycle contains a 14-day successive period, including night (N) and day (D) shifts, and a 7- or 14-day off (O) period. As, the 12-hour systems of 7N (slow) and 3N (fast)

are two most common shift patterns used in these industries, and it is only adopted in a number of consecutive night shifts (rotation speed). It should be mentioned that they are only together in terms of working hours in each shift, the number of turns, the number of shift at the day, and the number of rest times.

In this paper, the CORs are the target group because they play a key role to control and handle the inherently dangerous processes. Therefore, a suitable design of the shift work systems would help to maintain process safety, in addition to their health keeping effects [5]. Furthermore, the shift workers are usually encountered almost the same light during shifts hours and other physical stresses such as sound and heat due to the constant existence in the control rooms. For this purpose, 60 CORs with a good mental and physical health were chosen from a petrochemical industry.

Considering the aim of the study and emphasizing on the effect of consecutive night shifts on melatonin pattern and sleepiness while performing the duty, the last night shift before changing the daily shift was studied and compared in these two systems. In this way, to measure melatonin, each participant was taken four saliva samples at 4-hour intervals, and then the participants were asked to record their mental assessment of sleepiness at 4-hour intervals.

### 2.2. Melatonin measurement

Melatonin is a very reliable indicator of circadian rhythms that has been investigated extensively in previous studies. In this study, salivary melatonin (which is a reliable index) was measured at about 30% of plasma melatonin levels. Today's, due to its non-invasive nature, its utilization is increasingly more common (2008). In this regard, the saliva collector (Sartsert, Germany) took four saliva samples from each person at 19-21-23-3-5 during the night shift. Then, to control the effect of food on melatonin, participants were asked to avoid eating for an hour before sampling. After applying centrifugation, the samples taken were immediately frozen and stored at  $-20^{\circ}\text{C}$  and then transferred to the laboratory. Then, the melatonin levels were

measured directly by the biotech kits made by biotech China. The sensitivity of the experiment was  $1.6 \pm 1.3$  pg / ml.

### 2.3. Karolinska Sleepiness Scale (KSS) index and sleep quality

Here, Karolinska Sleepiness Scale (KSS) index was utilized to measure sleepiness as self-expression. This test contains a relatively good validity and reliability [6]. The KSS includes nine points' indicators, including: 1= very alert; 3= alert; 5= neither alert nor sleepy; 7= sleepy; and 9= too sleepy, and trying to stay awake. In this study, participants had to identify their sleepiness rate every 2 hours. In addition, a well-known and widely used Pittsburgh Sleep Quality Index (PSQI) was employed to assess sleep quality.

### 2.4 Light intensity

Lighting, known as an important and influential factor in circadian rhythm, was focused in this study as an interventional factor. Therefore, the light intensity value was measured individually using LMT pocket lux 2 luxury meter.

### 2.5 Statistical analysis

Data analysis was implemented using SPSS18 software. The Chi square and *t*-test were used for a single-variable analysis. Besides, Duplicate data analysis (GLM) was utilized to compare the trend of melatonin rhythm changes as well as the sleepiness between two work shift patterns. Light and caffeinated beverages (tea, Nescafe, etc.) were used as the intervening variables, whereas the melatonin and sleepiness were included in this model as dependent variables and the significance

level was at 0.05.

## 3. Results and Discussion

Table 1 reports the obtained values and differences between demographic and baseline features. According to this table, there was no significant difference between those variables. Moreover, the results of independent t-test between the first and second values of melatonin in two shift patterns were not significantly different, but the values of the third and fourth general measurements and changes were significantly different in the two patterns ( $P < 0.05$ ). In addition, there was no significant difference between the sleepiness values, except sleepiness values at 3 pm, between two patterns.

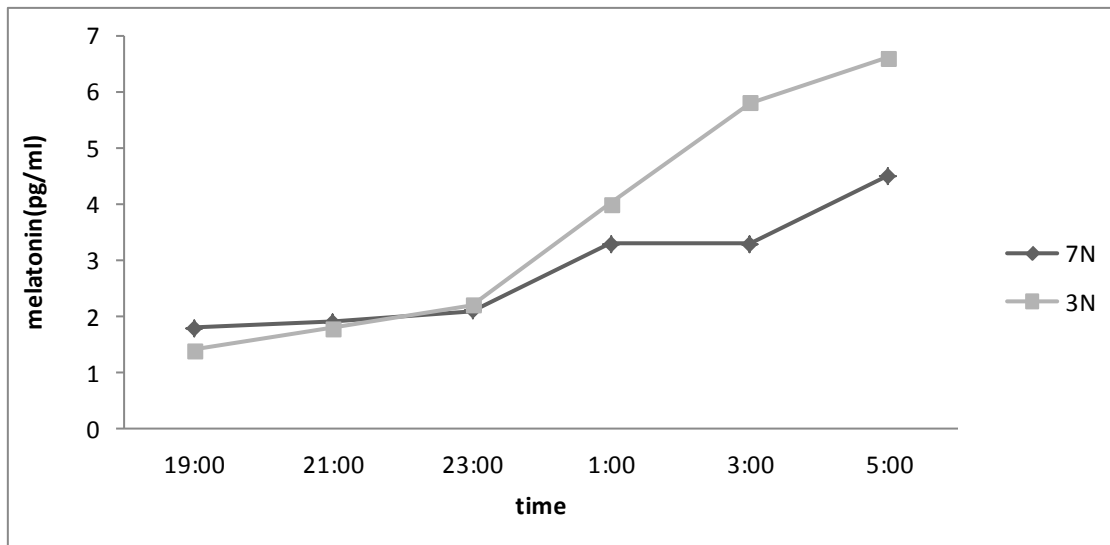
The repeated data Analysis method revealed a significant difference between four melatonin concentrations during work shift. In addition, the trend of melatonin changes after controlling caffeine and light factors was significantly different between two patterns ( $P < 0.001$ ). Figure 1 illustrates the increasing trend of melatonin in two shift patterns. Likewise, as can be seen in Figure 2, there was a significant difference in the values of sleepiness in each and between two patterns ( $P < 0.001$ ). However, both light and caffeine did not have a significant effect on sleepiness and melatonin ( $P > 0.05$ ), although the effect of light on sleepiness was relatively significant ( $P < 0.056$ ).

## 4. Conclusions

This field study is the first paper to be designed to compare the ratios of melatonin and the sleepiness index among CORs in petrochemical industry between two different night shift working systems. The general analysis confirmed that in individuals,

**Table 1.** Demographic and basic characteristics in the two shift patterns studied

variables	Slow rotation	Fast rotation	P value
age	31.1(2.6)	32.2(2.3)	0.3
experience	9.3 (1.7)	8.5(1.9)	0.06
Sleep quantity	8.0(2.12)	7.7 (1.0)	0.3
Sleep quality	7.6 (2.5)	7.4(1.8)	0.2
light	350(34.2)	382(40)	0.13
Caffeinated drink	2.3 (1.5)	3.0(1.2)	0.7

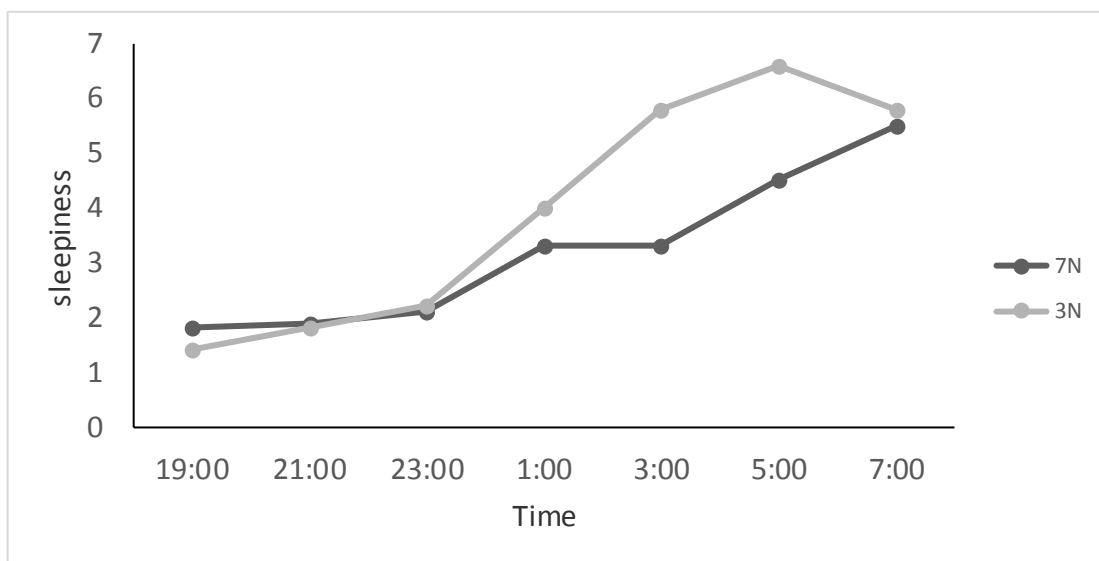


**Fig. 1.** Compare the rate of melatonin changes during night shifts in both fast and slow work rotations

the pattern of 7N adaptation was strongly better than one of 3N. Furthermore, there are significant differences between the rhythms of nocturnal melatonin in the two patterns studied so that the most important is the melatonin secretion peak. A change in melatonin acrophase (i.e. melatonin secretion peak) is a reliable measure of the compliance with night shift work that has been conducted in several studies [7].

Overall, it can be said that the 7- successive night shift working system would be better adapted

to the change in melatonin acrophase at the end of the shift. In addition, in this group, the sleepiness index during the shift was revealed less than the 3N pattern, which can enhance their performance that can lead to creating a reduction in human errors due to sleepiness and fatigue. Finally, it is recommended to avoid fast rotation shift working systems due to the incompatibility of shift workers due to the need for proper alertness for CORs in the petrochemical industry.



**Fig. 2.** Compare the rate of sleepiness changes during night shifts in both fast and slow work rotations

**Table 2. Results** of salivary melatonin levels in two groups of shift workers with different shift rotations

Shift time	shift rotation				P value
	Slow rotation		Fast rotation		
	Mean	SD	Mean	SD	
19:00	4.6	2.6	5.3	3.0	5.0
23:00	10	4.4	7.7	2.4	0.07
3:00	15.2	5.6	25.3	9.2	0.001
7:00	19.8	6.7	13.8	5.7	0.03

### 5. Acknowledgment

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