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Outline of Changes in Cortisol and Melatonin Circadian Rhythms in the Security Guards of Shiraz University of Medical Sciences

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ABSTRACT

Background: According to the literature, a large number of people working in industries and service providing personnel, such as firefighters, physicians, and nurses are shift workers. The spread of shift working in industrial societies and the incidence of the problems resulting from shift working have caused the researchers to conduct studies on this issue. The present study also aimed to investigate melatonin and cortisol circadian rhythms in the security guards of Shiraz University of Medical Sciences, Shiraz, Iran.

Methods: The present study was conducted on 20 security guards of Shiraz University of Medical Sciences. In order to collect the study data, blood samples were taken from the study subjects in different times of the day (1, 4, 7, 10, 13, 16, 19, and 22) and cortisol and melatonin levels were determined using the radioimmunoassay and enzyme immunoassay techniques, respectively.

Results: The results showed that as the intensity of light increased at night, the plasma cortisol level increased, as well. Besides, no statistically significant difference was found between the plasma cortisol levels in natural light and 4500-lux light. On the other hand, a significant difference was observed between the plasma cortisol levels in natural light and 9000-lux light as well as 4500- and 9000-lux lights. The study findings also showed that as the intensity of light increased at night, the plasma melatonin level decreased. In addition, a statistically significant difference was found between the plasma melatonin levels in natural light and 4500-lux light. Nevertheless, no significant difference was observed between the plasma melatonin levels in the natural light and 9000-lux light as well as 4500- and 9000-lux lights.

Conclusions: The present study aimed to investigate the subsequences of shift working in the security guards of Shiraz University of Medical Sciences and showed that occupational exposure to bright light could affect some biological markers, such as melatonin and cortisol secretion.

Keywords: Adrenal gland, light, occupational exposure, plasma, shift working

Original Article

INTRODUCTION

Shift working is a social phenomenon, which has its roots in human history. In the past, shift working was limited to a small group of people who mainly worked in service providing departments, and they had accepted shift working as a part of their jobs. However, after the industrial revolution and development of science and technology, fundamental changes took place in the human communities resulting in new laws and regulations. During the 1970s, the prevalence of shift working in the US[1] and Western Europe[2] was reported as 20% of the whole workforce. Of course, some researchers believed 20% to be an underestimation of the actual measure.[3]

The findings of chronobiology show that a lot of physiological changes occur in the human body during the day and the body has a specific status in different times of the day. In fact, the day-night cycle causes changes in production of different hormones by various glands, including, hypothalamus, pituitary, pineal, adrenal, and thyroid glands. Overall, some hormones are produced in darkness and some in light.[3]

Cortisol is one of the hormones produced by the adrenal cortex and is considered as one of the most important body hormones because of the variety of activities it performs. Naturally, the highest level of cortisol is secreted into the blood in the morning while it's the lowest level is released at night. Although stress is not the only reason for secretion of cortisol into the blood since high levels of cortisol are released in response to stress and cortisol is responsible for the stress-related changes in the body, it is called "the stress hormone," as well.

Melatonin is another hormone, which is affected by darkness and light. This important hormone is produced by the pineal gland in the brain, retina, lens, and the gastrointestinal system. Since, the identification of this hormone in 1958, several studies have shown that melatonin regulates other hormones in the body. Melatonin secretion also helps regulate the sleep/wake cycle.

These two hormones regulate the 24-h pattern of the body function and response. Thus, in case the hormone-production cycle is disturbed by staying awake at night or sleeping during the day (as in shift working), it may lead to mood changes, dizziness, irritability, depression, and metabolic disorders, such as type II diabetes. The body's immune system may also be damaged, and consequently, the body will be more susceptible to the communicable, infectious diseases.[4]

Elimination of the problems resulting from shift working requires multifaceted strategies among, which training both the shift workers and the employers is of utmost importance. In fact, it is necessary that the shift workers scientifically pay attention to their problems, gain knowledge about the nature of the problems as well as their status, and attempt to find solutions, and this is only possible through training.

In health and treatment centers, shift working is an inevitable fact and at the same time, a factor for presenting continuous services. In addition, the security guards play key roles in safety of all organizations. Therefore, the present study aims to investigate the effect of occupational exposure to bright light on the circadian rhythm of some biological markers; i.e., cortisol and melatonin, by assessing the effects of shift working on the security guards of Shiraz University of Medical Sciences, Shiraz, Iran and provide appropriate patterns and approaches for the shift workers' adaptability.

METHODS

Data collection

In this study, the plasma cortisol level was measured using the radioimmunoassay technique which is quick, inexpensive, and reliable.[5] Moreover, the melatonin level was measured using the enzyme immunoassay technique; i.e., quantitative determination of antigens through the serological methods, which is used for qualitative laboratory diagnosis of melatonin in human serum and plasma.[6]

After the necessary arrangements, general meetings were held in order for the security guards of the university to get familiar with the objectives, methods, and advantages of the research. Then, 20 security guards were selected through simple random sampling and after signing the written informed consents were an entered in to the study, which consisted of three phases. All subjects were carefully screened to ensure they were healthy and free of medicines and drugs, and had no history of psychiatric disorders. Their mean age was 40 years (range 35-45 years), and they had been working at the Shiraz University of Medical Sciences on shift schedules that included night shifts for 10.5 years (range 5-15 years). First, during a night shift starting at 7 P.M., blood samples were taken from the study subjects every 3 h for 24 h. Blood taking was not stopped after the end of the shift at 8 A.M. and the guards rested in quiet, dark rooms until the end of the 24 h. Then, the serums were obtained from the blood samples and kept at −70°C; so that their cortisol and melatonin levels could be determined after the collection of all study samples.

In the second phase of the study, the light intensity of the guards' rooms was increased to 4500-lux, and they were required to be exposed to the bright right 2 times each lasting for 45 min (22-22.45 and 3-3.45) during the night shift. This exposure continued for 4 weeks and after that, the circadian rhythms of the study physiological indexes; that is, cortisol and melatonin, were measured similar to the first phase.

Finally, the intensity of the artificial light was increased to 9000-lux and similar to the second phase, the guards were exposed to bright light for 4 weeks. At the end of this phase, cortisol and melatonin levels of the serums were measured using the above-mentioned techniques.

RESULTS

The mean plasma cortisol level in different time periods with different light intensities is presented in Table 1. As the table depicts, the lowest plasma cortisol level was related to 4 A.M. in natural and 4500-lux lights and 7 A.M. in 9000-lux light. This shows that by severe increase in light intensity, the plasma cortisol level increased, as well. In addition, the results of ANOVA revealed no statistically significant difference between the plasma cortisol levels in natural and 4500-lux lights ($P = 0.527$). Nevertheless, a statistically significant difference was observed between mean plasma cortisol levels in natural and 9000-lux lights as well as 4500- and 9000-lux lights ($P < 0.001$).

For better understanding, the trend of changes in cortisol level in natural and bright lights (4500- and 9000-lux) among shift working guards is shown in Figure 1. As the graph depicts, the amount of cortisol was similar in natural and 4500-lux lights; however, a considerable increase was observed in plasma cortisol level at night after exposure to 9000-lux light.

The mean plasma melatonin level in different time periods and different light intensities is presented in Table 2. As the table shows, as the intensity of light increased at night, the amount of plasma melatonin decreased (from 10 P.M. to 4 A.M.). Moreover, the results of one-way ANOVA revealed a statistically significant difference between the mean plasma melatonin levels in natural light and 4500-lux light ($P = 0.03$). On the other hand, no significant difference was found between the mean plasma melatonin level in natural and 9000-lux lights as well as 4500- and 9000-lux lights ($P > 0.05$).

Figure 2 depicts the trend of daily melatonin changes in natural and bright lights (4500- and 9000-lux) among the shift working

Table 1: The changes in the subjects' plasma cortisol level (μg/dL) by increasing the light intensity

Measuring time	Measuring hours	Natural light	4500-lux light	9000-lux light
1	19	50.186	50.5	54
2	22	36.63	37.7	58
3	1	37	38.333	68.6
4	4	25.3	26.5	62.3
5	7	50.186	51.667	51.40
6	10	41.186	45.26	60.39
7	13	39.71	44.05	57.41
8	16	37	42.07	65
Mean	-	39.61*	42.01*	59.64*
SD	-	8.125	8.04	5.66

*One-way analysis of variance for comparison of means in the three groups. SD=Standard deviation

Table 2: Changes in the subjects' plasma melatonin level (pg/mL) by increasing the light intensity

Measuring time	Measuring hours	Natural light	4500-lux light	9000-lux light
1	19	32.69	32.69	38.84
2	22	42.00	38	31.70
3	1	81.35	71.35	63.65
4	4	80.05	60.225	55.70
5	7	91.2	46.333	48.40
6	10	134	54	68.60
7	13	110	40	64.10
8	16	30	25	27.60
Mean	-	75.16*	45.95*	49.67*
SD	-	37.68	15.25	15.78

*One-way analysis of variance for comparison of means in the three groups. SD=Standard deviation

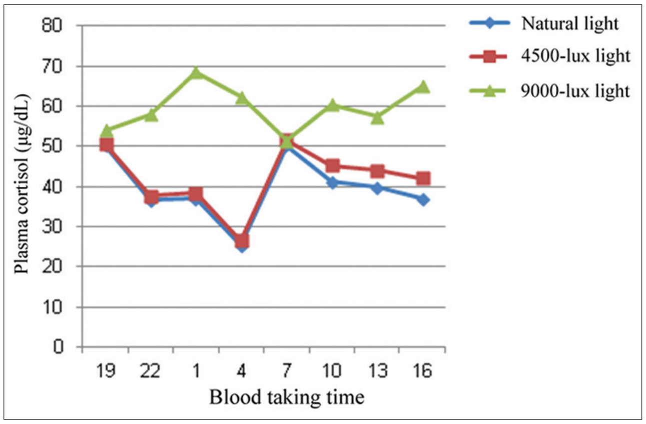

Figure 1: The trend of changes in the subjects' daily cortisol in natural, 4500-lux, and 9000-lux lights

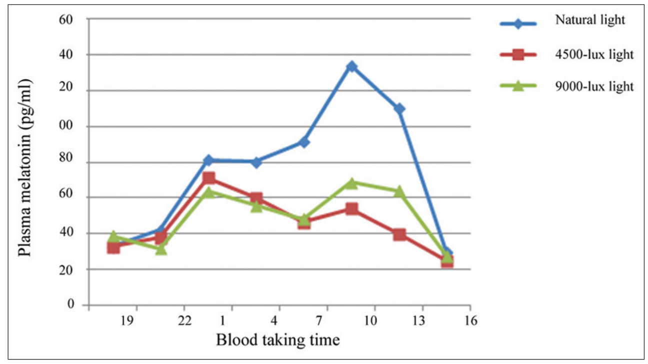

Figure 2: The trend of daily melatonin changes in natural and bright lights (4500- and 9000-lux) among the study subjects

guards. According to this graph, a similar trend of change in the plasma melatonin level can be observed in various light intensities; that is natural, 4500-lux, and 9000-lux, which shows the maladaptation of the guards to night working. However, a sudden decrease of the melatonin level can be seen at 4 A.M. and this difference had continued until 1 P.M.

DISCUSSION

Shift working is a stressful condition, which affects the balance of the shift workers' body performance.[7,8] Furthermore, one of the factors affecting the night workers' health is staying awake during unusual hours in which one must naturally be asleep. In general, the sleep/wake cycle is influenced by changes in light during the day, which affects the amount of melatonin and cortisol secretion. According to a study, conducted on the effects of light on the psycho-somatic processes, we are far away from predicting the best light quality, which can affect the psycho-somatic processes; nevertheless, we can certainly say that there is a direct relationship between light and health and artificial bright light affects the night workers' mental status.[3] Furthermore, several studies conducted on the issue have shown that exposure to bright light for several consecutive days affects endogenous circadian rhythms, including, deep body temperature, cortisol level, melatonin level, consciousness, function, and TSH (Thyroid-stimulating hormone).[8-10]

The findings of the present study showed that as the intensity of light increased at night, the plasma cortisol level increased, as well. Therefore, changes in the light intensity can improve the adaptation to night working, which is consistent with the results of other studies conducted on this issue.[11-13]

On the other hand, the study results showed that as the intensity of light increased at night, the plasma melatonin level decreased. The results also revealed the minimum and maximum melatonin secretion to have occurred at 4 P.M. and 4 A.M., respectively, which is in line with the findings of other studies.[14,15] In fact, exposure to bright light leads to lack of melatonin secretion and since the circadian cycle is under the influence of melatonin, these two factors can be used in order to investigate the effect of light on sleeping as well as changes in the level of consciousness during the night shifts.[14] Furthermore, the field studies performed on night working and melatonin rhythm have shown the rate of phase lag and adaptation to night working to be related to the intensity of light.[16]

The studies conducted during the recent two decades have mentioned exposure to light as one of the strategies, which improve the adaptation of the staffs' biological rhythms. Several filed studies performed by NASA have also shown that prolonged exposure to high-intensity light can improve the adaptation to night working. Of course, short exposures have shown to have similar effects, as well.[17]

Based on the studies performed in this field and since various studies have proved the advantages of increasing the intensity of light, the light intensity of the workplace is recommended to be increased during the night shift. Moreover, a large number of studies have shown that the increase of bright lights can result in the increase in consciousness and consequently, bright lights are recommended to be utilized during the night shifts.[18-20] The researchers have also shown that in a work shift with a quick rotation, such as two consecutive night shifts if the individuals are exposed to 2350-lux light 4 times for 20 min, their fatigue will be reduced and their memory function will be increased.[21] On the other hand, some studies have revealed that lack of sleep has a negative effect on the individuals' consciousness as well as cognitive function.[22]

CONCLUSIONS

The present study aimed to investigate, the effects of shift working on the security guards of Shiraz University of Medical Sciences, Shiraz, Iran and showed that occupational exposure to bright light could affect some biological markers, such as melatonin and cortisol secretion.

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