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Effect of Bright Light on Shift Work Nurses in Hospitals

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Abstract: The aim of this study are to assess, in a hospital setting, the effects of Bright Light (BL) on the rhythms in body temperature, plasma melatonin, plasma cortisol and subjective alertness during shift work. In our experimental design, 34 healthy shift work nurses from a university hospital were exposed to bright light (4500 lux) during two break times (21:15 to 22; 00 and 3:15 to 4:00) for four consecutive weeks. In this survey, the subjects were studied under 24 h of realistic conditions during which their plasma cortisol and plasma melatonin was measured at 3 h intervals. In addition, their body temperatures were measured during and after night shift work. Subjective alertness and fatigue were evaluated with the Karolinska Sleepiness Scale (KSS) and Visual Analog Scale (VOI). It was found that bright light administration significantly suppressed nighttime melatonin levels during night shift, most strongly at 2:00 a.m. A one-way ANOVA, with repeated measurement design, revealed that Bright Light (BL) tended to increase cortisol levels and body temperature and improved alertness significantly during night shift. These results demonstrate that photic stimulation in a hospital setting can have a powerful influence on the adjustment of the circadian system.

Key words: Nurse, circadian rhythms, shift work, bright light, hospital

INTRODUCTION

Humans have evolved for many millions of years on Earth with a reliable daily cycle of 12 h of bright full-spectrum light and 12 h of dark (season and latitude permitting). In fact, this cycle has been a major formative factor for all life on the planet for 3 billion years (or perhaps 4 billion years) (Nemchin *et al.*, 2008). When Thomas Edison invented the light bulb around 1880, who would have thought that it would change the very nature of the workplace (Jaffe *et al.*, 1996). Over the past 100 years, we have cut our nightly sleep by more than 20% and in the last 20 years we have added about 158 h (nearly a full month) to our commuting and annual work schedules (Scott, 1994). Inherent in this discussion is talk about body clocks, a term that refers to the patterns of energy and exhaustion, functioning and resting and wakefulness and sleep that characterize everyday life. This concept of the body clock is in reference to circadian rhythms. A biological clock is any sort of mechanism internal to an organism that governs its biological rhythms. One such mechanism is the pineal gland. The pineal gland secretes two hormones (molecules that send signals to the body), melatonin and serotonin. It appears that melatonin regulates a number of diurnal, or daily, events (Khalsa *et al.*, 2003). Melatonin suppression have received scrutiny including alteration of clock gene functioning and desynchronization of the master clock in the suprachiasmatic nuclei from the peripheral clocks in tissue (Vujovic *et al.*, 2008; Stevens *et al.*, 2007).

Until recently, chronobiologists agreed that social cues were the main zeitgebers for human circadian rhythms and that the light-dark cycle, which is the most important zeitgeber for animals, was relatively unimportant for humans (Wever *et al.*, 1983). This view changed radically, however, after the discovery that exposure to bright light suppresses nighttime melatonin production; whereas ordinary room light is not sufficiently intense to be effective (Lewy *et al.*, 1980). Emergency services that involve continuous operations are particularly vulnerable to shift related fatigue. Compared with only 4% of day workers, 83% of nightshift workers report feeling tired and worker capacity typically declines between 5-10% (Bonnet, 1990).

Increasing numbers of people must do shift work in modern societies and few people will give up electric

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lighting at home. An understanding of what particular characteristics of wavelength, intensity, timing and duration most disrupt circadian rhythms would permit a minimization of any potential health risks (Hunt and Sassone-Corsi, 2007).

There are nearly half million workers in the Iran who regularly work at shift work. Many are employed in occupations in which peak functioning is critical (e.g., nurses and physicians, airline pilots, industrial workers, polices and heavy machinery and commercial drivers) (Zamanian *et al*., 2008).

In most health care systems, nurses are the largest working group and play a major role in the system's success. As health care providers, nurses are obliged to work during day and night to cater for needs of sick people. This can only be possible if nursing services are provided around the clock (Hawley, 1992). Studies have shown that shift-work has negative impact on job performance, sleep, physical and emotional health, social and family life, drug use and level of job-related stress (Brown-DeGagne and Eskes, 1998). Estryn-Behar *et al*. (1990), in a study conducted on stress at work and mental health status among female hospital workers, concluded that the evidence of association between work involving an existing accumulation of stress factors and mental well-being necessitated consideration in interventions aimed at improving working conditions of hospital workers.

Shift work, particularly that involving night work, therefore, presents a challenge to the internal de-synchronization of circadian rhythms. This study assessed, in a hospital setting, the effects of Bright Light (BL) on the rhythms in body temperature, plasma melatonin, plasma cortisol and subjective alertness among nurses during shift work.

MATERIALS AND METHODS

Shift work, particularly that involving night work, presents a challenge to the internal de-synchronization of circadian rhythms. This study assessed, in a hospital setting, the effects of Bright Light (BL) on the rhythms in body temperature, plasma melatonin, plasma cortisol and subjective alertness during shift work in October 2007 to August 2009.

Aims:

- Determination of the amount of illumination in nursing stations
- Determination of nurses' mental and physical health in different wards
- Determination of the effect of Bright light on the intrusive hormone secretion in circadian rhythm
- Determination of the relationship between Bright light and nurses' attention
- Determination of the effect of shift work on the secretion of circadian rhythm hormones

We had several steps in this study. In the first step, of 1396 registered nurses employed in all 12 hospitals in Shiraz, 1195 nurses, including 1064 female and 131 male, partook in this study. A 28 item General Health Questionnaire (GHQ-28) was used as a self-administered screening tool for detection of mental disorders. This questionnaire was developed by Goldberg and Hillier (1979) for screening somatic symptoms, anxiety and insomnia, social dysfunction and severe depression (Saiepour *et al*., 2008). In these hospitals we measured illuminance in nurse rest rooms and their stations.

Secondly, we observed shift work patterns and it became apparent that:

- Job tenure (years) under 5 (40 h work every one week): 8 night work every month
- Job tenure (years) 5-10 (36 h work every one week): 6 night work every month
- Job tenure (years) 10-15 (36 h work every one week): 4 night work every month
- Job tenure (years) 15-20 (36 h work every one week): 2 night work every month
- Job tenure (years) upper 20 (36 h work every one week): 0 night work every month
- 11 h night shift work, 7.5 h morning and afternoon shifts

Demographic characteristics of the first step of study population are presented in Table 1. The mean (SD) age of nurses was 30.81 (7.08) years; 89.04% of the participants was female and 10.96% was male. One thousand and seventy three of the nurses studied (89.79%) worked on rotating shift system and 122 nurses (10.21%) worked on fixed shift (day time). The mean (SD) job tenure of the nurses in the current hospital was found to be 7.28 (SD = 6.83) years. 50.46% of the participants were married and 62.85% worked in non-governmental hospitals (Table 1).

In the next step in our experimental design, 34 healthy shift work nurses from a university hospital were exposed to very BL (4500 lux) or normal light (300 lux) during two break times (21:15 to 22; 00 and 3:15 to 4:00) for 4 consecutive weeks.

Table 1: Some personal details of the nurses who participated in the study (n = 1195)

Characteristics	Values
Gender (%)	
Female/male	89.04/10.96
Age (years)	
M (SD) range	30.81(7.08) 19-60
Marital status (%)	
Unmarried/married	41.17/50.46
Job tenure (years)	
M (SD) range	7.28 (6.83) 1-39
Working schedule (%)	
Rotating shift/fixed daytime	89.79/10.21
Type of hospital (%)	
Governmental/nongovernmental	15.37/62.85
Education (%)	
Diploma	13.5
Associates degree	2.18
Bachelor of science	83.68
Master of science	0.84
Daily working time	
M (SD), range	8.3 (2.25), 8-18 (h)

The subjects were studied under 24 h of realistic conditions during which their plasma cortisol (RIA method) and plasma melatonin (RIA method). This assay has a sensitivity of 2.5 pg mL^{-1}, an intera-assay coefficient of variation averaged 13.8 % for values <10 pg mL^{-1}, 8.6% in the range of 10-30 pg mL^{-1} and 5.2% for values >30 mg mL^{-1}. Values reported represent the means of two determinations for each sample. It was measured at 3 h intervals. In addition, their body temperatures were measured during and after night shift work. Subjective alertness was evaluated with the Karolinska Sleepiness Scale (KSS) and fatigue was evaluated with Visual Analog Scale (VAS). This was selected because it is known to vary with the circadian rhythm of body temperature and to be sensitive to sleep loss (Dijk *et al*., 1992; Dinges *et al*., 1997; Cajochen *et al*., 1999; Wyatt *et al*., 1999).

The results were gathered in two situations: normal light (300 lux) bright light (4500 lux). Bright light administration was found to have significantly suppressed nighttime melatonin levels during night shift, most strongly at 2:00 am.

Statistical methods: A one-way ANOVA with repeated measurement design revealed that BL tended to increase cortisol levels and body temperature and improved the alertness and fatigue significantly during night shift. These results demonstrate that photic stimulation in hospital setting can have a powerful influence on the adjustment to the circadian system.

RESULTS

Based on these findings, the mean lighting intensity in nursing stations is usually 315 lux, which is suitable for semi-accurate works. But in these locations nurses often complete patient's records that can be considered as an accurate work, so because of the low light intensity, vision problems, fatigue, lack of concentration and reduction of consciousness are not unexpected to occur in nurses (Table 2).

Table 2: Mean luminosity in nurse rest rooms, stations and corridors in shift work times

Shifts	Stations	Restrooms	Corridors
Morning	315	198	260
Afternoon	287	164	254
Night	232	157	228

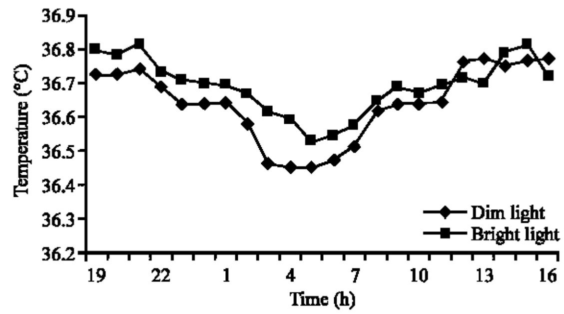

Fig. 1: Variations in nurse body temperature

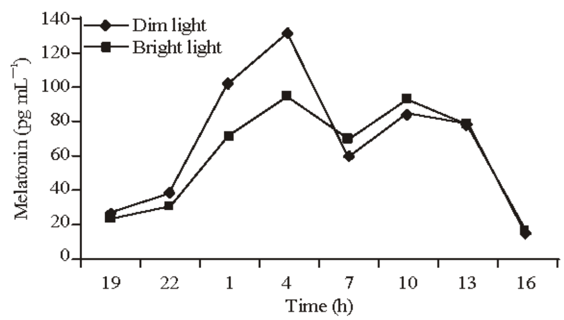

Fig. 2: Nurses plasma melatonin variations

This study shows that the temperature trend in bright light exposures and in normal lighting conditions, the maximum temperature is in 5-8 pm and when the nurses were exposed to bright light their body temperature increased 0.1°C (Fig. 1).

Figure 2 compares the model of changes of the mean melatonin concentration in the two conditions (in bright light exposures and in normal lighting conditions). It is clear that the overall model of the changes is similar. The concentration of melatonin decreases immediately after bright light contact and this decrease continues until 5 am. After 5 am, the melatonin concentration in plasma increases and from 7 to 10 am, the melatonin concentration in nurses when they are exposed to bright light is higher than when they were in normal lighting conditions (Lewy *et al*., 1998).

By comparing Fig. 1 and 2, we can deduce that the maximum amount of melatonin secretion is related to the

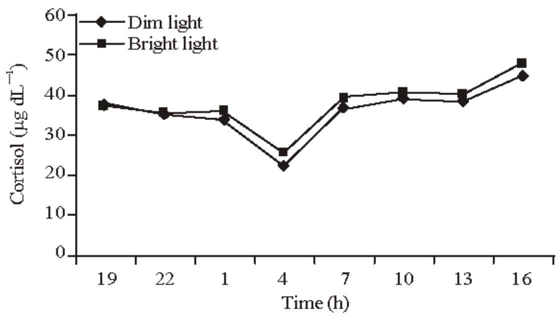

Fig. 3: Variations in nurse plasma cortisol

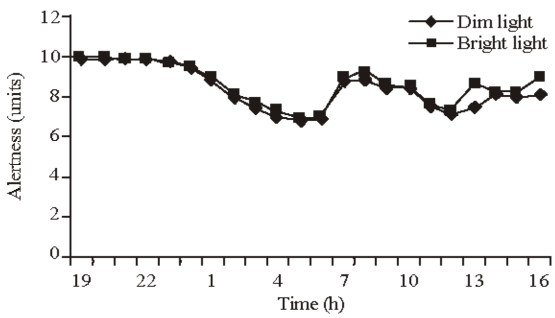

Fig. 4: Variations in the subjective alertness of nurses

time in which the body temperature is the lowest. In bright light, the amount of melatonin secretion decreases and the body temperature increases.

Locomotive activities or sleep can affect many circadian factors such as temperature and melatonin, but cortisol secretion is not controlled by acute changes in locomotion. So this research indicates that the rate of change in cortisol secretion in normal lighting and in bright lighting is exactly the same (Fig. 2).

The comparison of Fig. 2 and 3 show that the amount of melatonin secretion (in both normal lighting and bright lighting) is maximum at 4 am, while the amount of cortisol secretion in the body at this time is minimum. It is obvious that the model for concentration changes of melatonin and cortisol is opposite.

The maximum consciousness rate is in the initial work hours (7 pm in night work) and the minimum consciousness rate is identical to the 5 am rate. Rate of consciousness does not change in bright light and normal light (Fig. 4). This is maybe because of duration's time of bright light exposure and it is need more research. After a night work if nurses have sufficient rest, the rate of consciousness will increase in the afternoon. The present investigation indicates that although bright light is effective on melatonin secretion, but this change does not affect the rate of consciousness and fatigue during the day (Fig. 5).

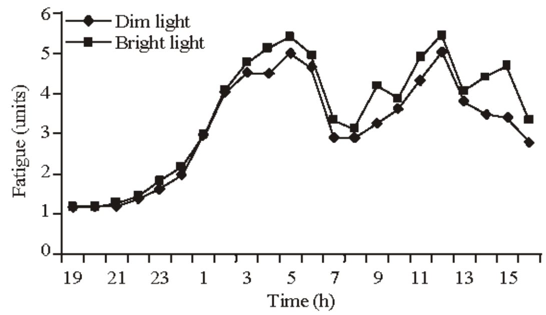

Fig. 5: Variations in nurse fatigue

The comparison between diagrams 4 and 1 shows, we would have the least consciousness rate when the temperature is the lowest as well.

DISCUSSION

Until recently, chronobiologists agreed that social cues were the main zeitgebers for human circadian rhythms and that the light-dark cycle, which is the most important zeitgeber for animals, was relatively unimportant for humans (Wever *et al*., 1983). This view changed radically, however, after the discovery that exposure to bright light suppresses nighttime melatonin production (Lewy and Newsome, 1983), whereas ordinary room light is not sufficiently intense to be effective (Lewy *et al*., 1980). One implication of these findings was that exposure to sunlight, which is generally 20 to 200 times as bright as indoor light, could synchronize human biological rhythms that remain unaffected by indoor light. Their study indicates that the bright light (4500 lux) exposure can suppress melatonin production. A second implication was that bright artificial light could be used experimentally and perhaps therapeutically, to manipulate biological rhythms in humans. In the present investigation, the idea was examined again and the same results were obtained.

Exposure to bright light increased nocturnal body temperature level and improved performance when examined under controlled constant-routine conditions (Badia *et al*., 1991; Wright *et al*., 1997a, b; Foret *et al*., 1998).

Also many studies said exposure to several hours of bright light for up to 3 consecutive days has been found to reset the endogenous circadian rhythms of core body temperature, cortisol, melatonin, alertness, performance (Allan and Czeisler, 1994; Van Cauter *et al*., 1994; Czeisler, 1995; Dawson *et al*., 1995; Eastman *et al*., 1995; Duffy *et al*., 1996; Shanahan *et al*., 1997; Youngstedt *et al*., 2002) that we obtained in this study as well (Fig. 1-5). Due to the mentioned results, when nurses who are participating in this research are in contact with bright light, their body temperature is at the lowest amount at 5 a.m., while in normal lighting conditions, the minimum body temperature is detectable in 3 to 5 a.m. As a result, this delayed temperature phase could be termed a response to the bright light exposure. These results were also obtained from other researches as well.

Studies been shown in animal studies that exposure to brief pulses of bright light can phase shift the circadian pacemaker and that the resetting action of light is most efficient during the first minutes of light exposure. Present research also proved that contacted with bright light for 45 min can shift the circadian pacemaker.

In humans, contact with bright light for consecutive days can cause the delay phase. For instance it is proved that the bright light contact for three consecutive days (40 to 60 min per day) can cause the delay phase in the circadian rhythm (Baehr *et al*., 2000).

The ability of the hormone melatonin to shift the circadian clock makes it a promising potential treatment for circadian maladaptation problems arising from jet lag and shift work. Our study demonstrated that the nurses in contact with bright light didn't have a significant increase in alertness.

The human PRC to melatonin is apparently 180° out of phase with the PRC to light (Lewy *et al*., 1996, 1998), so that melatonin administered before CBT min will advance the clock. In this research the obtained results are the same.

In the Kenneth's analysis of high-low body temperature performance, he found that a higher average body temperature of only ~0.15°C was associated with higher performance, suggesting that small changes in body temperature can influence human performance (Kenneth *et al*., 2002).

CONCLUSION

This study indicated that when the temperature is the lowest (between 3-5 a.m.), alertness rate is the least amount (Fig. 4) and fatigue increased in these hours (Fig. 5). Another outcome of this research is that intermittent bright light can facilitate circadian rhythm adaptation to the night shift. Further research should investigate the phase-shifting effects of even shorter durations for real-world applications.

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