Influence of Bright Light during Daytime on Sleep Parameters in Hospitalized Elderly Patients

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Abstract. Nurses frequently care for sleepless elderly patients on bed rest in a hospital environment. Our previous study with young adults showed that bright light exposure during the daytime affected the induction of nocturnal deep sleep. The purpose of this study is aimed at finding whether similar research could be observed with hospitalized elderly patients. Seven patients (mean age 67; range 57–77 yrs, males 3: females 4) served as participants and their informed written consent was obtained. A fluorescent lamp fixed in the bed frame near the head of the patient was turned on at 10:00 h and off at 15:00 h each day for 1 week (BL). Moreover, each patient was required to stay near this light during this period. The patients lived in a room facing north, where the ambient light intensities ranged from 50 to 300 lx during the daytime. Their activities were continuously measured using an Actiwatch (model-AWL, Mini-Mitter, USA). Salivary samples were collected at midnight for the measurement of melatonin. The findings were compared between 2 days before BL exposure (baseline) and the last 2 days during BL exposure, respectively. The bright light exposure during the daytime prolonged “Time in Bed” (p<0.05), increased “Immobile Minutes” (p<0.05), and delayed “Get up Time”(p<0.01). The average melatonin secretion at midnight in four patients increased from 7.5 ± 2.6 pg/ml to 13.3 ± 9.2 pg/ml. These findings suggest that diurnal bright light exposure for hospitalized elderly patients lying in bed under dark condition during the daytime may favor clinically the induction of nocturnal deep sleep. Attention should be given to the illumination conditions for elderly patients in hospitals to improve their impaired sleep. J Physiol Anthropol 20(6): 345-351, 2001 http://www.jstage.jst.go.jp/en/

Keywords: bright light, sleep promotion, circadian rhythm, elderly sleep

Introduction

The number of people who do not retire until midnight has increased over the last three decades in Japan (NHK Survey, 1996). Until recently, although we lived in synchrony with the cycles of the environment, such as work during day and rest at night, new life styles have reduced sleeping hours. According to a report of “the warning in USA” (Leger, 1994), sleep deprivation is probably a major cause of a catastrophe, and the modern society is chronically sleep-deprived under the influence of night without darkness. Moreover, these situations may seriously influence health. Therefore, the natural light-dark cycle means a reasonable distribution of activity and rest.

The sleep and wakefulness cycle is an important behavior in our daily life, being linked with the natural light-dark cycle. This disturbance of the sleep pattern was defined as “Disruption of sleep time causes discomfort or interferes with desired lifestyle” (NANDA, 1996). Altered sleep-wake patterns due to the rest-activity schedule of the hospital could phase-shift the times of falling asleep and wake in inpatients (Floyd, 1984). Webster and Thompson (1986) reported that sleeping patterns for inpatients would be influenced by several factors such as age, noise, ambient room temperature, comfort, pain and so on. And then, the choices of view through a window, either trees or walls may influence the feeling and analgesic dose in post-operating patients (Ulrich, 1984). However, the environment of a patient’s room is not fully taken into account for their therapeutic effects.

With regard to their window views, the strongest Zeitgeber in humans have been noted to be light-dark cycle (Czeisler et al., 1989). Although bright light exposure is effective in phase shifting of the circadian rhythm, the timing of exposure to light must be taken into account (Wever, 1989). Morning light is more effective than evening light in helping patients with winter
depression (Lewy et al., 1987). On the other hand, the greater part of the daytime is characterized by a “dead zone” where the pacemaker is unresponsive to light stimulation (Dann and Pittendrigh, 1976), and so this period during the daytime for light therapy has not been considered. However, bright light exposure during the daytime could influence the circadian rhythms of core body temperature (Park and Tokura, 1998), melatonin secretion (Hashimoto et al., 1997; Park and Tokura, 1999), thermal perception (Teramoto et al., 1996), and sleep quality in the young adults (Wakamura and Tokura, 2000).

Sleep is important for health and the quality of life at all ages. Especially, elderly people have an impaired capacity to maintain sleep (Miles and Dement, 1980). Ageing is characterized by changes in circadian rhythms and sleep quality. The most remarkable change is an attenuation of amplitude (Weitzman et al., 1982; Monk and Buysse, 1989). This change means a reduction in nighttime sleep quality that may be associated with a reduction in daytime alertness and cognitive performance (Hayter, 1983; Middelkoop et al., 1996). Elderly people have increased sleep latency, more awakenings during sleep, reduced total sleep time, and less REM and slow-wave-sleep (Miles and Dement, 1980), and typically go to bed earlier than younger adults (Tune, 1969). Concerned with the age-related differences in the circadian phase, the rate of re-entrainment to changes in photoperiod and the magnitude of phase shifts induced by light may be affected by ageing (Rosenberg et al., 1980). Furthermore, phase advance in the rhythms of old people has been reported (Vitiello et al., 1986), but not consistently (Zeppelin and McDonald, 1987). Although napping increases with ageing, it was not correlated with total sleep time and sleep latency during nocturnal sleep (Carskadon et al., 1982; Hayter, 1983; Floyd, 1995). These findings suggest that more attention about sleep problem should be paid to the hospitalized elderly patients.

Although bright light may be connected with sleep, even in community-living elderly subjects, the period exposed to light exceeding 2,000 lx was about 1 hour per 24 hours (Campbell et al., 1988). The environmental structure surrounding the elderly patient’s room in the hospital may have a restorative influence. Beck-Little and Weinrich (1998) emphasized that, for gerontology nurses, a knowledge of sleep disorder will help alleviate the problems arising from sleep disrupted elderly people, but the restorative environments such as lighting conditions were not included in the related assessment and intervention. Few studies are available with respect to the circadian rhythm and sleep patterns of elderly people in nursing research (see Humm, 1997). Nurses should obtain more information about changes in rhythmicity. Besides, several proposals have been offered to solve the sleep disorders associated with ageing. As treatments of insomnia, there are pharmacological, sleep hygiene and behavioral treatments (Hauri, 1998; Asplund, 1999). One behavioral treatment, light therapy, has been used for insomnia in depression (Lam et al., 1997), delayed sleep phase syndrome (Terman et al., 1995) and in elderly suffering from sleep-maintenance insomnia. Since the minimum of core body temperature could be delayed using light treatment, insomnia could be alleviated in the second half of the night (Campbell et al., 1993). There is a possibility that exposure of bright light during daytime is effective for elderly hospitalized elderly patients.

Our previous study with young adults showed that bright light exposure during the daytime (ca. 12 h photoperiod) influenced nocturnal sleep (Wakamura and Tokura, 2000). Exposure to bright light during the daytime may simulate natural sunlight and lead to an improved distribution of activity and rest. We must establish an adequate, timely nursing intervention for elderly people by setting environmental factors. The present study was performed to investigate whether bright light during the daytime could improve nocturnal sleep with hospitalized elderly patients.

Methods

Seven patients (mean age 67; range 57–77 yrs, males 3: females 4) in a National Hospital of Japan were studied. The purpose and risks of the study were explained before the patients gave their written consent. They were permitted to refrain from attending the experiment at any time. The Ethic and Research committee of Nara Women’s University approved this experiment. The experiments were carried out between July and September 1998.

The patients stayed in the chest disease ward where the windows faced north, and ambient light intensity ranged from 50 to 300 lx at their eye levels during the daytime even under fair weather. Ambient light intensities on the bed near the windows facing north were compared with those near windows facing south as shown in Fig. 1. Although all patients were ambulatory, they mostly lie in bed. Female subjects were menopausal. They spent time obeying the ordinary schedules of the hospital routine. Meals were supplied at 7:30, 12:00, and 18:00. Patients went to bath from 15:00 to 18:00.

Their diseases are presented in Table 1. They did not have extreme sleep disturbance or other apparent disorders. All their medications were the same through these experimental days. Hospital routine has a lights-out time (22:00–6:00 h), but the patient’s exact period of sleep was confirmed by continuous monitoring of ambulatory activity (Actiwatch, model-AWL, Mini-Mitter, USA). The data obtained by Actiwatch were stored every...
1-minute. Values were expressed in arbitrary units. The sensitivity setting was selected high. A commercially available algorithm scored activity/inactivity from which the derived times of sleep/wake were estimated. The following sleep parameters were calculated.

**Bed Time**: the time at which the subject went to bed or turned off the lights.

**Get up Time**: The time at which the subjects left the bed or turn on the light.

**Time in Bed**: Using researcher-defined parameters, it represents the difference in hours and minutes between the Bed Time and Get up Time.

**Sleep Start**: The time defined as the first period of 20 consecutive epochs in which a maximum of one contained a non-zero value.

**Sleep End**: At the ten-minute period before the Get up Time, the last epoch with no movement will be scored as the Sleep End time.

**Actual Awake Time**: It represents the time during which the activity counts exceed the threshold sensitivity value.

**Assumed Sleep**: The difference in time between the Sleep End and the Sleep Start times.

**Actual Sleep Time**: This was calculated by subtracting the Actual Awake Time from the Assumed Sleep time.

**Immobile mins**: The total period of time where no movement occurred.

A saliva sample was collected at about midnight (0:00–2:00 h), when the subject woke up to go to bathroom, for the measurement of melatonin. Mean collection times for two days before and the last two days during bright light exposure were 1:06 ± 0.37 and 0:55 ± 0:47, respectively. Saliva was collected in a collection tube (SALIVETTE®, Bühlmann, Allschwill, Switzerland) using only a foot light; it was then separated by centrifugation (300 g for 5 min) and stored at −30°C until analysis. Salivary melatonin was measured in duplicate by RIA using commercially available kits (Bühlmann, Switzerland) in the SRL laboratory (Tokyo). The inter-assay variations were 4.26–7.64% (n=10) and intra-assay variations were 7.49–12.5% (n=10).

Baseline measurements were collected for 2 days before bright light exposure. For this bright light exposure, the light box (SunLight Jr, SB-682, SUNBOX, USA) fixed in the bed frame near the head of the patient was turned on at 10:00 h and off at 15:00 h each day for 1 week. Patients were exposed to at least 3,000 lx at their eye levels during these periods. The used fluorescent lamp (Matsushita Electric Industrial, FML55E50, JAPAN) emitted red, green and blue light with peak spectral radiance of 610, 540 and 450 nm, respectively, and the color temperature of this temperature was 5,000 K. Patients were required to stay near this light box during this period except during his/her examinations. Every patient used a room light from sunset (ca. 18:00) to sleep in both conditions. The highest light intensity in this period was 200 lx at their eye level.

Measurements collected for the last 2 days during bright light exposure were compared with those from the baseline period. Since the illumination after the light box had been turned off was natural brightness until sunset and nobody had a psychiatric diagnosis (see Table 1), the patients did not suffer from the “sundown syndrome” (Burney-Puckett, 1996).

The values are presented as the mean ± SEM, and were analyzed statistically using Students’ paired t test.

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**Table 1** Characteristics of subjects

<table>
<thead>
<tr>
<th>ID</th>
<th>Sex</th>
<th>Age</th>
<th>Disease</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>M</td>
<td>77</td>
<td>Abscess of the chest wall</td>
<td>160</td>
<td>53.5</td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>57</td>
<td>Pulmonary mycobacterium avium complex infection</td>
<td>158</td>
<td>58.0</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>68</td>
<td>Dyspnea (oxygen ventilation)</td>
<td>143</td>
<td>37.8</td>
</tr>
<tr>
<td>4</td>
<td>M</td>
<td>67</td>
<td>Lung cancer</td>
<td>170</td>
<td>57.0</td>
</tr>
<tr>
<td>5</td>
<td>F</td>
<td>59</td>
<td>Pulmonary mycobacterium avium complex infection</td>
<td>160</td>
<td>36.8</td>
</tr>
<tr>
<td>6</td>
<td>M</td>
<td>62</td>
<td>Lung cancer</td>
<td>172</td>
<td>68.0</td>
</tr>
<tr>
<td>7</td>
<td>F</td>
<td>77</td>
<td>Abscess of the chest</td>
<td>158</td>
<td>50.0</td>
</tr>
</tbody>
</table>
Influence of Bright Light on Elderly Patients

Results

Sleep parameters

A typical example of the sleep analysis of a subject (ID: 5, female) for the two days before bright light exposure and the last day of exposure is shown in Fig. 2. As shown in Fig. 2, the nocturnal sleep movements appeared smaller during bright light exposure than before. Although the “Get up Time” and the “Sleep end” were almost the same period in both conditions, the rate of “immobile mins” was high during bright light exposure than before.

As shown in Table 2, the average “Bed Time” was 21:08 ± 00:20 h and 20:37 ± 00:21 h for the two days before bright light exposure and the last two days during exposure, which were not significantly different. The average “Get up Time” was 06:26 ± 00:11 h and 06:41 ± 00:10 h for the two days before bright light exposure and the last two days during exposure were significantly different (t=5.86, p=0.001). In other words, “Sleep Start”,

ID 5
Subject age 58  Subject sex F

Before Bright Light Exposure

<table>
<thead>
<tr>
<th>Time (h)</th>
<th>Activity</th>
</tr>
</thead>
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<tr>
<td>00:00</td>
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<tr>
<td>12:00</td>
<td></td>
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<tr>
<td>00:00</td>
<td></td>
</tr>
<tr>
<td>12:00</td>
<td></td>
</tr>
</tbody>
</table>

21:00 — 22:00  23:00  00:00  01:00  02:00  03:00  04:00  05:00  06:00 — 07:00 — 08:00

20:10  | Analysis start
6:00   | Analysis end

- Bed time 21:47
- Get up time 07:16
- Sleep start 23:31
- Sleep end 07:05
- Immobile mins 328.0
- Time in Bed 09:29
- Assumed sleep 07:34

During Bright Light Exposure

<table>
<thead>
<tr>
<th>Time (h)</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>00:00</td>
<td></td>
</tr>
<tr>
<td>12:00</td>
<td></td>
</tr>
<tr>
<td>00:00</td>
<td></td>
</tr>
<tr>
<td>12:00</td>
<td></td>
</tr>
</tbody>
</table>

21:00 — 22:00  23:00  00:00  01:00  02:00  03:00  04:00  05:00  06:00 — 07:00 — 08:00

20:10  | Analysis start
6:00   | Analysis end

- Bed time 20:28
- Get up time 07:11
- Sleep start 23:22
- Sleep end 06:56
- Immobile mins 379.0
- Time in Bed 10:43
- Assumed sleep 07:34

Fig. 2  Typical example of the sleep analysis of a subject. The values were compared between the day before bright light exposure and the last day during bright light exposure. Top: Before bright light exposure. Bottom: During bright light exposure. Grey area: time zone subjected to sleep analysis.
i.e. the time of sleep onset, was not significantly different ($t=1.37$, $p=0.22$), “Sleep End”, i.e. the time of sleep termination during the bright light exposure tended to be delayed ($t=2.32$, $p=0.059$). Naturally, “Assumed Sleep”, i.e. the difference between “Sleep End” and “Sleep Start” times tended to be extended during the bright light exposure ($t=1.98$, $p=0.095$). Consequently, “Actual Sleep Time”, which was calculated by subtracting the “Awake Time” from the “Assumed Sleep Time” was extended during the bright light exposure ($t=2.44$, $p=0.050$). The “Immobile mins” were 375.1 $\pm$ 15.4 mins and 407.0 $\pm$ 20.8 mins for the last two days before and during the bright light exposure, respectively. The “Immobile mins” during nocturnal sleep increased significantly for the last two days during the light exposure ($t=2.96$, $p=0.025$).

Melatonin

Three of the seven patients showed values lower than the threshold value (2.8 pg/ml) of the melatonin at midnights, which were not used for analysis. The average melatonin secretion at midnight in four patients was 7.5 $\pm$ 2.6 pg/ml and 13.3 $\pm$ 9.2 pg/ml for the last two days before and during bright light exposure, respectively. Melatonin secretion increased in three (ID: 2, 4, 5) of the four patients during bright light exposure (Fig. 3).

Discussion

The present experiment disclosed that the bright light exposure during the daytime prolonged “Time in Bed”, increased “Immobile mins”, and delayed “Get up Time”. However, it did not alter “Naptime”. Mishima et al. (1994) reported that the morning bright light from 9:00 h to 11:00 h prolonged nocturnal sleep time and diminished naptime in elderly patients with elderly dementia. Since the present subjects could spend time in hospital with less restraint than the elderly people with dementia, social contacts were more frequent, which might have obscured the differences in naptime between controls and the bright light group. However, the present findings on prolongation of the sleep time by the bright light during the daytime are consistent with those of Mishima et al. (1994). Furthermore, the immobile time during night time became longer after diurnal bright light exposure, suggesting that they slept more deeply (Shirakawa, 1989).

The melatonin secretion is a good indicator of the endogenous biological clock (Lewy et al., 1996). The nocturnal increase in melatonin was accelerated more significantly under the influence of diurnal higher bright light exposure compared with dim light exposure with young adults (Hashimoto et al., 1997; Park and Tokura, 1999). In the present experiment, three (ID: 1, 6, 7) of seven melatonin secretions did not respond to diurnal bright light exposure, because two (ID: 1, 7) of the three patients were 77 yrs old, reflecting a probable age-dependent functional change (Iguchi et al., 1982; Korf et al., 1998). The reason why melatonin in the remaining patient (ID: 6) did not respond to bright light is not clear. The present observation was field study, therefore, it was difficult to control their daily lives precisely. These uncontrolled factors might have been responsible for the non-response and opposite reactions. However, as shown in Fig. 2, this patient improved sleep quality and melatonin secretion responded to diurnal bright light exposure. It is suggested that the nocturnal increase in melatonin might have been responsible for the improved sleep-like increase in “time in bed” and in “immobile minutes”, because nocturnal melatonin could decrease the level of the core temperature (Cagnacci, 1992), resulting in deeper sleep (Teramoto et al., 1998; Park and Tokura, 1999) and, furthermore, improve the quality of sleep (Kendler, 1997).

Moreover, the dim light during the daytime in hospitals
has an adverse effect upon recovery from illness due to shallow sleep. Possibly related to this, it could precipitate senile nocturnal delirium to place an elderly demented patient in a darkened room during the daytime (Cameron, 1941). As shown in Fig. 1, the daytime illumination of a room depends upon where it is sited. A daytime intensity of 50–300 lx appears to be too dark to induce good nocturnal sleep. Therefore, it becomes important to consider whether the illumination in a patient’s room is adequate during the daytime. In addition to whether the view through the window is trees or walls (Ulrich, 1984), the nurse must take into account the illumination surrounding the patient during the daytime.

In conclusion, the present findings suggest that diurnal bright light exposure could improve nocturnal sleep with hospitalized elderly patients. Therefore, this intervention may affect the elderly patients to be attenuated to the amplitude of sleep wake cycle. More systematic and clinical studies are required to clarify their sleep disorders by the usage of diurnal bright light. Thus, as it has a therapeutic significance, nurses must provide adequate illumination during the daytime for patients, which may accelerate their recovery. Therefore, nurses assert these therapeutic effects of diurnal bright light exposure in order to improve patients environment and should engage themselves more in hospital administration and the design or redesign of patient’s lighting environment in the architecture.

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