Effects of Bright Artificial Light on Subjective Mood of Shift Work Nurses

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Abstract: The effects of bright artificial light on the subjective mental state of 10 female nurses working shifts at a university hospital were assessed. We investigated two series of five consecutive workshifts rotations comprising one normal, two night and two evening shifts, using two self-administered rating scales. The subjects were exposed to artificial light, brighter than 3,000 lux, for a total of 30 min during each workshift of the second series, whereas they worked under normal lighting conditions (approximately 250 lux) during the first series. A three-way layout ANOVA, with repeated measures, revealed that bright light tended to improve eagerness and reduce tension, and improved vigor, eagerness, appetite and impairment (the latter only on the second night) significantly or nearly significantly during night, but not evening, shifts. These results suggest that bright artificial light affects the mental state of nurses during night, but not evening, shift work.

Key words: Fatigue, Lighting, Nurse, Shift work, Subjective mood

Introduction

Currently, the number of shift workers in the industrial society is increasing and, at present, at least one-fourth of the working population of most industrialized countries are shift workers1. Shift work has been reported to induce sleep disorders, fatigue and health disturbances, one of the causes of which has been suggested to be that it has some physiological and psychological effects on the circadian rhythms of shift workers2–4. As the sleep-wake schedule is phase-shifted by shift work, the circadian system is under the influence of conflicting synchronizers, such as body temperature and hormonal secretion, and cannot adjust completely to the hours of work and sleep. Shift work is a stressful condition which interferes with the normal synchronization of body functions5.

Bright light, in excess of 2,500 lux, has been reported to have certain physiological and/or behavioral effects on humans, e.g., alterations of the melatonin-rhythm generating system6 and suppression of melatonin secretion7, and effectively entrains the internal desynchronizations among circadian rhythms8–9. Desynchronizations, typically observed in patients with seasonal affective disorders10,11, jet-lag syndrome12 and delayed sleep phase insomnia13, could be adjusted and improved by bright light exposure, leading to the called phase-shift hypothesis10,14. Therefore, it is possible that exposure to bright light will cause mood changes in shift workers by adjusting desynchronizations.

In their study on exposure of shift workers to bright light, Eastman and his colleagues15–17 observed that bright light could entrain the circadian body temperature rhythm to a 26-h sleep-wake schedule (gradual 2-h delayed schedule) and they suggested that bright light could be used to help shift workers rotate between the day and night shifts. Previous

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field studies\textsuperscript{15-19} utilized simulated day-night shifts, e.g., several (base-line) days with nighttime sleep followed by several night shifts with daytime sleep. In Japan, however, a day-night-evening rapidly rotating shift system, in which the same workshift does not last more than four or five days, is the most common. Although some recent studies have addressed the effects of bright artificial light on the subjective mood and psychophysical state of nurses carrying out rapidly rotating shift work\textsuperscript{20-22}, as far as we know, no researchers have investigated both night and evening shifts simultaneously, and this was the purpose of our study.

When bright artificial light is used in this kind of study, the timing, duration and intensity of exposure should be taken into consideration. As discussed in the review by Rosenthal \textit{et al.}\textsuperscript{23}, bright light of 2,500 lux has a greater anti-depressant effect than dim light of less than 400 lux. The duration of exposure to bright light in a clinical setting is usually about two to three hours\textsuperscript{24,25}, but such a long exposure is not feasible in the workplace. For example, the nurses we studied only have a 45-min rest period during each workshift. Therefore, in this study, we exposed our subjects to artificial light, in excess of 3,000 lux placed horizontally at eye level, for a total of 30 min.

\textbf{Materials and Methods}

\textbf{Subjects}

The subjects were 10 psychiatric nurses working at a university hospital. Their mean age was 29.5 years (range: 24–40 years), and their mean working experience as a nurse was 7.9 years (range: 3–16 years). Prior to the study, they had been working three shifts of eight hours each with a 45-min rest period (day (D) shift: 08:15–17:00, evening (E) shift: 16:15–01:00, and night (N) shift: 00:15–09:00). The rotating pattern of shifts was irregular, but a typical shift pattern was three or four normal days, preceded by one day off, followed by two night and two evening shifts, in this order, i.e., a counterclockwise shift system. The subjects were asked to avoid drinking alcohol, medication and sitting up late at night, as far possible, during the investigation. All the subjects gave oral and written informed consent and participated in this study voluntarily.

\textbf{Procedure}

We investigated two series of five consecutive days (D-N-N-E-E) with the typical shift pattern described above. During the first series, the subjects were not exposed to bright light, and the lighting intensities in the nurse unit and rest rooms were approximately 250 lux horizontally at eye level (normal light). During the second series, we set up bright light exposure equipment (Nihon Koden Medical Co.), a panel of seven fluorescent lights, on a working table in the center of the nurse unit room and on a table in the rest room, which exposed the nurses to bright artificial light, in excess of 3,000 lux, horizontally at eye level.

We instructed the subjects to look at the light at least once a minute for a few seconds, for total of 30 min when they were working. They sat in front of the bright light panel while they were writing records in the nurse unit room or resting including eating, in the rest room. They were exposed to bright light mainly around 02:00–03:00 during the night shifts and around 20:00–21:00 during the evening shifts. If we had planned a procedure based on an ideal experimental design, the lighting conditions should have been assigned randomly to the subjects. However, this would have meant that some subjects would have been exposed to bright light, and others would not during the same workshift, leading to behavioral restriction, as some subjects would not have been able to use the rest room during the rest period. We considered that keeping the activities of the subjects normal was far more important than obtaining data under well-designed but relatively restricted conditions. Accordingly, bright light exposure was not assigned randomly in this field investigation.

The mean interval between the last evening shift of the first series (without bright light exposure) and the first night shift of the second series (with bright light exposure) was 16.3 days (range: 11–30 days). None of the subjects menstruated during either series, and no unusual events with respect to the inpatients the nurses were caring for during our investigation occurred. Thus, nurses' workloads appeared to be the same in both series of shifts. Subjective physical and psychological conditions were measured using two self-administered rating scales twice (before and after) each shift.

\textbf{Measurements}

A visual-analogue scale (VAS) with eight items of psychological and physical strain, which was derived mainly from depressive symptomatology, was utilized to assess subjective mood or symptoms. The validity level of this kind of VAS scale for assessing psychological symptoms has been reported to be at satisfactory\textsuperscript{26}. Each subject was asked to make a mark across a 100-mm line, which defined the extremes of a bipolar scale (from $-50$ to $+50$), at a position she considered indicated how she felt at the time. The raw score on each scale was derived from the distance (mm) between the subject's mark and the center of the scale.
The “subjective symptoms test for fatigue” (Fatigue) designed by the Industrial Fatigue Research Committee of the Japanese Association of Industrial Health was also used to measure subjective symptoms of fatigue. This instrument consists of three scales with 10 items each, A: ‘dull and sleepy,’ B: ‘decline of working motivation/difficult concentrating and attending,’ and C: ‘projection of fatigue to parts of the body/projection of physical impairment,’ and each subject was asked to check whether she did (scored 1) or did not (0) agree with each symptom item. In this study, we used three scale scores, instead of the score for each item, to represent the fatigue symptomatology of the subjects. The score range of each scale was 0 to 10.

**Statistical analysis**

The VAS and fatigue score scale changes from before to after work were used as variables in this study, because we did not intend to take the differences between the scores before work into account in this study, and our purpose was to examine the score changes after exposure to bright light. We revised the scoring direction of some items so that a positive score change represented ‘improvement’ or indicated a change in a desirable direction of each subjective symptom. A three-way layout analysis of variance (ANOVA), with repeated measures, was used to determine the main and interaction effects of “bright light (on/off),” “shift (night/evening),” and “day (1st/2nd)” on the score change. The Statistical Analysis System was used to perform these analyses.

**Results**

Table 1 shows the mean score change of each VAS item and fatigue scale from before to after work during the four consecutive workshifts (N-N-E-E) with/without bright artificial light.

<table>
<thead>
<tr>
<th></th>
<th>Normal light</th>
<th>Bright light</th>
<th>F values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Night</td>
<td>Evening</td>
<td>Bright light</td>
</tr>
<tr>
<td>Visual analogue scale (VAS)</td>
<td></td>
<td></td>
<td>Bright light</td>
</tr>
<tr>
<td>Appetite</td>
<td>18.2 (28.0)</td>
<td>1.6 (27.1)</td>
<td>7.2 (25.0)</td>
</tr>
<tr>
<td>Easeness</td>
<td>4.6 (11.4)</td>
<td>1.3 (10.7)</td>
<td>10.9 (13.3)</td>
</tr>
<tr>
<td>Depressed mood</td>
<td>5.0 (8.6)</td>
<td>14.4 (19.6)</td>
<td>2.1 (22.8)</td>
</tr>
<tr>
<td>Vigor</td>
<td>9.4 (11.7)</td>
<td>11.8 (14.5)</td>
<td>7.1 (11.3)</td>
</tr>
<tr>
<td>Tension</td>
<td>5.5 (13.5)</td>
<td>0 (7.6)</td>
<td>2.2 (16.7)</td>
</tr>
<tr>
<td>Impairment</td>
<td>2.8 (9.1)</td>
<td>2.0 (15.2)</td>
<td>2.2 (11.8)</td>
</tr>
<tr>
<td>Tiredness</td>
<td>17.3 (34.2)</td>
<td>17.3 (24.2)</td>
<td>9.9 (15.1)</td>
</tr>
<tr>
<td>Sleepiness</td>
<td>1.4 (21.6)</td>
<td>0.3 (30.2)</td>
<td>7.3 (17.9)</td>
</tr>
</tbody>
</table>

Subjective symptoms of fatigue

A: Dull and sleep

|                | 1.3 (1.5)   | 0.9 (2.5)   | 1.0 (1.9)   | 1.4 (2.8)                | -1.3 (2.4) | -1.8 (3.1) | -1.8 (2.3) | -2.4 (2.2)               | 0.14 | 2.20   | 0.12 | 1.76 | 0.11 | 1.02 | 0.66 |

B: Difficult concentrating

|                | 2.1 (2.0)   | 1.0 (1.8)   | 0.9 (1.4)   | 1.0 (1.6)                | -0.6 (1.6) | 0.8 (2.2)  | -1.5 (2.6) | -0.9 (1.0)               | 0.88 | 0.01   | 0.89 | 3.26 | 0.10 | 0.16 | 1.12 |

C: Projection of physical impairment

|                | 0.7 (1.2)   | 0.4 (1.1)   | 0.5 (1.4)   | 0.3 (0.9)                | -0.3 (0.9) | -0.3 (0.9) | 0.3 (0.8)  | 0.3 (0.7)               | 0.51 | 0.19   | 0.22 | 0.19 | 0.62 | 0.01 | 0.01 |

( ): Standard deviation; +, * and **: significance level of p<0.10, p<0.05 and p<0.01, respectively, according to the repeated ANOVA (all the degrees of freedom=1, 9); positive score change indicates improvement or desirable direction of symptom change.
exposure. The order in which these data are presented is the actual order in which our survey was carried out. The results of the repeated ANOVA are also presented (the degree of freedom for each F value was 1, 9).

Main, although not significant, effects of "bright light" were only found for the eagerness ($p<0.07$) and tension ($p<0.09$) scores. "Shift" had a significant or nearly significant ($p<0.10$) main effect on the scores of five of eight VAS items: sleepiness ($p<0.002$), eagerness ($p<0.003$), depressed mood ($p<0.02$), vigor ($p<0.03$) and appetite ($p<0.06$). No significant main "day" effects were observed. The interaction between "bright light" and "shift" had a significant effect on the vigor ($p<0.04$) and eagerness ($p<0.05$) scores, and its effect on appetite almost reached significance ($p<0.07$). The interaction between "shift" and "day" showed a weak effect only on the impairment score ($p<0.10$), as did the interaction between "bright light", "shift" and "day" ($p<0.07$).

As a whole, subjective symptoms were improved more with "bright light" during the second night shift compared with those during the first night and both the first and second evening shifts, whereas this visual impression was not necessarily supported by significant improvements in some symptoms. No significant main or interaction effects were found for the fatigue scales, which may have been due, at

**Fig. 1.** Relationships between bright artificial light and score changes of selected subjective symptoms of 10 hospital nurses, according to night/evening workshifts

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least in part, to the small variances of the score changes of these scales.

Figure 1 shows the significant and nearly significant effects of interactions between "bright light" and "shift" on the score changes found in this study. The patterns of the relationships between these two factors for all the symptoms were quite similar: although the score change was the same for the night and evening shifts with the bright light off, it increased more with the bright light on during the night shifts, but this never occurred during the evening shifts. Furthermore, although not significant, this tendency was also observed for other symptoms, e.g., tiredness (Fig. 1-d) and 'B: decline of working motivation/difficult concentrating and attending.' The aforementioned relationship applied to the impairment score change on the second (Fig. 1-f), but not the first (Fig. 1-e) night.

Table 2 shows the number of VAS item scores that changed by more/less than 10 mm, an arbitrary criterion, during the four consecutive workshifts with/without bright light exposure for each subject. We found large individual variations in the responses to bright light exposure. For example, subject number 1 showed greater improvement of her mood due to the bright light, but subject numbers 9 and 10 showed an opposite tendency. Large variations in the number of VAS items across workshifts and days were also observed and presented in this table.

Discussion

This study indicated that bright artificial light tends to improve eagerness and reduce tension in shift work nurses. Moreover, several psychological symptoms, such as vigor, eagerness, appetite and impairment (the latter only on the second night), improved significantly or nearly significantly due to bright artificial light during the night, but not the evening, shifts. It should be noted, however, that this picture was not necessarily consistent for all the symptoms we studied.

Honma and Honma reported that the circadian sleep rhythm was phase-advanced by exposure to light pulses early in the morning (around 03:00), whereas at night (around 21:00), light pulses appeared ineffective. Our subjects were

<table>
<thead>
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<th>No.</th>
<th>Age (yrs)</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Night 1st 2nd</td>
<td>Night 1st 2nd</td>
</tr>
<tr>
<td>1</td>
<td>40</td>
<td>(+)</td>
<td>2 1 1 0</td>
<td>8 4 0 0</td>
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<td></td>
<td></td>
<td>(-)</td>
<td>1 2 3 2</td>
<td>0 0 0 0</td>
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<td>2</td>
<td>30</td>
<td>(+)</td>
<td>2 5 4 6</td>
<td>6 6 3 2</td>
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<td></td>
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<td>(-)</td>
<td>2 0 0 0</td>
<td>0 1 4 3</td>
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<td>3</td>
<td>24</td>
<td>(+)</td>
<td>0 1 2 0</td>
<td>5 3 2 0</td>
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<td>4 4 0 5</td>
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<tr>
<td>4</td>
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<td>(+)</td>
<td>1 3 4 1</td>
<td>4 7 1 0</td>
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<td>0 0 0 4</td>
<td>4 0 1 4</td>
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<tr>
<td>5</td>
<td>28</td>
<td>(+)</td>
<td>1 0 0 1</td>
<td>3 3 2 0</td>
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<td>4 6 6 3</td>
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<td>6</td>
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<td>3 1 1 0</td>
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<td>7</td>
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<td>(+)</td>
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<td>10</td>
<td>26</td>
<td>(+)</td>
<td>3 2 3 1</td>
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<td></td>
<td></td>
<td>(-)</td>
<td>1 3 5 5</td>
<td>3 3 4 2</td>
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</tbody>
</table>

(+): VAS score changed by more than 10 mm, indicating improvement of symptoms.

(-): VAS score changed by less than 10 mm, indicating worsening of symptoms.
exposed to bright light mainly at around 02:00–03:00 during the night shifts and 20:00–21:00 during the evening shifts, and therefore, our results seem to agree with their findings.

Costa et al.20 exposed 14 hospital nurses working on a rapid rotating shift schedule comprising two consecutive night shifts to bright light (2,350 lux) for short periods (4 x 20 min), and found neither hormonal excretion nor body temperature altered, although some positive effects on psychophysical conditions and performance efficiency were observed. Therefore, the dose of light (i.e., duration and number of days) we used may not have been high enough to produce phase-shifts in our subjects. Nevertheless, in this study, bright light tended to ameliorate subjective symptoms more on the second than the first night, suggesting that a small phase-shift could have been emerging.

Other explanations, however, could account for our results. Bright light itself did not appear to have a mood-enhancing effect, as it had no such effects during the evening shifts. We speculate, therefore, that bright light at this time could have enhanced the effect of sleep deprivation30,31. We investigated no physiological variables relevant to internal circadian rhythms, so the exact cause remains uncertain. In our future study, not only psychological conditions but also physiological phenomena, such as the functioning of circadian pacemakers, will be investigated simultaneously.

This study demonstrated that subjective symptoms, such as sleepiness, eagerness, depressed mood and vigor, deteriorated more during evening than night shifts, under both normal and bright light conditions, a problem which was not addressed in the earlier studies. However, we only investigated N-N-E-E shift work, and the actual effect of bright light on the subjective mental state during the evening shifts could not be addressed fully. As discussed above, if exposure to bright light on the preceding two nights does cause a small phase-shift in the subjects, the explanation that their internal rhythms were contradictory to the subsequent evening work is plausible. Our findings indicate clearly how difficult it is to devise effective strategies with a rapid rotating shift system, which is particularly common in Japanese workplaces. In future studies, attention should be paid to finding effective strategies, including shift systems and individual behavior, such as napping and others, that will ensure the psychophysical conditions of workers during evening shifts are good.

Detailed inspection of the data for each item revealed that bright light did not necessarily have positive effects on all the subjects (Table 2). This might be attributable to the different times they were exposed to light and/or to individual differences in sensitivity to bright light. We could not set an exact time schedule for light exposure because we wished to avoid restricting the subjects' actual work, and the dose of bright light we used may not have exceeded the threshold for needed by some individuals for "change" to occur.

Although our findings suggest that bright artificial light may be practically useful to shift workers, some limitations should be borne in mind. First, the number of subjects was small and individual behavior (e.g., napping and pre-work activities) were not taken into account. Second, we did not use the dim light setting as a control and the measurements we used were based only on subjective complaints, not objective ones. Third, the chronic effect of bright light was not examined. Further studies of this kind performed under more precisely conditioned field settings are needed to clarify the acute and chronic effects of bright light on both psychological and physiological phenomena. An optimal dose level which is more effective than the one used in our study and applicable to an actual workplace should be established by such careful investigations.

Note

The authors (N.I. and K.E.) wish to dedicate this paper to the family of the late Dr. Sadaaki Ichii.

Acknowledgments

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