Field Study

Effect of Reduced Illumination on Insomnia in Office Workers

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Abstract: Effect of Reduced Illumination on Insomnia in Office Workers: Tomoaki Kozaki, et al. Faculty of Design, Kyushu University—Objective: We evaluated the possible effects of reduced illumination in the workplace on insomnia among office workers. Methods: Seventy-two office workers answered the Athens Insomnia Scale (AIS) in July 2009 (under ordinary illumination, OI conditions) and July 2010 (under reduced illumination, RI conditions). The workers were divided into three groups, indoor workers (IW), semi-outdoor workers (SWs) and outdoor workers (OWs), according to the frequency of working outside of the office because a worker with a high frequency of working outside of the office might rarely be exposed to the lighting condition within an office. The first five items of the AIS (AIS-5) were used to assess sleep difficulties, and the last three items (AIS-3) assessed next-day consequences of sleep or daytime symptoms, which often result from insomnia and/or sleep disorders. Results: Illuminance levels at a height of 1,100 mm from the floor under the RI conditions (550–490 lux) were significantly lower than under the OI conditions (750–700 lux). The AIS-5 score of the IWs was significantly increased under the RI conditions compared with the OI conditions. There was no difference in AIS-3 scores between conditions for any group. Conclusion: Indoor workers hardly went outside of the office and were exposed only to office light during the daytime. Thus, the underexposure to light could have had an impact on insomnia in those individuals. A novel lighting environment is required to optimize work-related levels of light exposure. (J Occup Health 2012; 54: 331–335)

Key words: Athens Insomnia Scale, Insomnia, Light, Office worker

Many workers have problems with sleep owing to their working conditions. Along with medical and psychological conditions, physical conditions may contribute to insomnia. Light is well known to be the most powerful synchronizer of the biological rhythms in humans1–3). According to the phase-response curve to light, bright morning light synchronizes the circadian rhythm with the natural bright-dark cycle. Insufficient bright light during the day thus might cause desynchronization of the sleep-awake cycle, inducing sleep problems. In fact, blind subjects showed significantly higher occurrences of insomnia than controls4, 5). A recent study6) reported a high frequency of insomnia and daytime somnolence in subjects who worked underground (metro and trains) compared with those working overground (buses and trams). These findings suggest that underexposure to light during the day may induce insomnia.

In recent years, governments of many countries, particularly Japan, have promoted policies to save energy. In line with the policies, many companies are decreasing the lighting in workplaces such as offices; however, the reduced light in daytime work sites may increase insomnia. In this study, we estimated insomnia symptoms in office workers exposed to reduced light compared with those exposed to normal light.

Methods

This survey was conducted in a real-estate development company in Tokyo, Japan, in July 2009 (under ordinary illumination, OI conditions) and July 2010 (under reduced illumination, RI conditions). Environmental factors (illuminance, room temperature and relative humidity) were measured for four days in each surveillance period. This survey was approved by the ethics committee of the Faculty of Design, Kyushu University.

Participants

Workers in an interior division of the company were informed about the goal of this study but were not given details on the effects of light on sleep problems; they gave informed consent to participate in this study. Ninety-six workers participated in the first survey held in July 2009, and 72 of the workers answered the questionnaire again in July 2010. In this study, the data of the 72 workers were utilized in
A repeated-measure design. The workers were divided into three groups according to the frequency of working outside of the office because a worker with a high frequency of working outside of the office might rarely be exposed to lighting conditions within an office. A worker working outside of the office up to twice a month was considered an indoor worker (IW), one working outside more than once a week and less than twice a week was considered a semi-outdoor worker (SW), and one working outside more than three times a week was considered an outdoor worker (OW).

Assessment of insomnia

Insomnia was assessed by a Japanese version of the Athens Insomnia Scale (AIS)\(^7\). The scale is a self-administered inventory consisting of eight items. The first five items assess difficulty with sleep induction, awakening during the night, final awakening earlier than desired, total sleep duration and overall quality of sleep. The remaining three items involved sense of well-being during the day, functioning during the day and sleepiness during the day. The first five items (AIS-5) were used to assess sleep difficulties with regard to sleep quantity and quality, and the last three items (AIS-3) assessed next-day consequences of sleep or daytime symptoms, which may result from insomnia and/or sleep disorder\(^7\). Each item of the AIS is rated on a scale from 0 (no problem at all) to 3 (very serious problem). Respondents were required to rate themselves on the basis of the items and calculate their score depending on whether they had experienced sleep difficulties at least three times a week during the last month. The questionnaire was distributed to the workers on the first day of each survey period, and they were instructed to return the questionnaire before the last day of each survey period.

Environmental factors

The horizontal illuminance level at a height of 1,100 mm from the floor was obtained by an illuminance meter (Konica Minolta, CL-100, Tokyo, Japan) in the early morning (9:00–10:00), late morning (11:00–12:00), afternoon (13:00–14:00) and early evening (16:00–17:00) for four days in each survey period. The office space was divided into three parts with respect to sunlight through the windows; the near area of the windows (NAW) was within 4 m of the windows, the middle area (MAW) was more than 4 m and less than 8 m from the windows, and the far area (FAW) was more than 8 m from the windows. The room temperature and relative humidity were minutely measured by a thermo recorder (Espelecnic, RS-13, Aichi, Japan). The weather was fine on all days of each survey period.

Potential analysis

Potential occupational differences among groups were tested using the Kruskal–Wallis test with Bonferroni-Dunn's post hoc correction. Statistical analyses were performed using SPSS version 16.0 (SPSS, Chicago, IL, USA). Differences for which \( p \) was <0.05 were considered statistically significant.

Results

There were no differences in room temperature between the OI and RI conditions (OI, 26.90 ± 0.25°C; RI, 26.88 ± 0.34°C). The difference in relative humidity between the OI (52.68 ± 1.47%) and RI conditions (51.95 ± 1.60%) was less than 1%. The illuminance levels of MAW and FAW under the RI conditions were significantly lower than those under the OI conditions at all times (Fig. 1, top and middle). The illuminance level of NAW was significantly lower in the RI condition in the morning, but not in the afternoon (Figure 1, bottom). The increment in the illuminance level of NAW in the afternoon was caused by sunlight from the west-side window. However, the workers were assumed to be hardly exposed to sunlight in the office because NAW was a small meeting area and contained no worker's desks (Table 1).

The sociodemographic and work characteristics of each group are shown in Table 2. The mean age of the SWs was significantly higher than those of the IWs and OWs. There was no significant difference in BMI among the groups during each survey period. OWs included a high proportion of works that required communication with external people (sales and marketing and construction management).

Under the OI conditions (Table 3), there was no significant difference among the groups in AIS-5 scores, although the mean scores of the IWs were slightly lower than those of the other groups. The AIS-5 scores of the IWs were significantly increased under the RI conditions compared with the OI conditions. There was no difference in AIS-3 scores between conditions for any group.

Discussion

A significant increase in AIS-5 scores of indoor workers (IW) was obtained under the reduced illumination (RI) conditions. Indoor workers (IW) hardly went outside of the office and were exposed only to office light during the daytime. Thus, underexposed to light could have had an impact on insomnia in office workers as well as underground workers\(^6\). The AIS-5 score has been found to have a positive correlation with the Hamilton Depression Rating Scale (HDRS)
The far area of the windows (FAW)
Means±(SD)
- OI: 706±(28) lux
- RI: 496±(33) lux

The middle area of the windows (MAW)
Means±(SD)
- OI: 751±(25) lux
- RI: 547±(71) lux

The near area of the windows (NAW)
Means±(SD)
- OI: 919±(152) lux
- RI: 812±(564) lux

Table 1. The number of worker’s desks in the far area (FAW), middle area (MAW) and the near area of the windows (NAW) during the survey period

<table>
<thead>
<tr>
<th></th>
<th>FAW</th>
<th>MAW</th>
<th>NAW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indoor workers</td>
<td>24</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Semi-outdoor workers</td>
<td>18</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Outdoor workers</td>
<td>7</td>
<td>17</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 2. Sociodemographic and work characteristics of workers with low frequency (indoor workers, IWs), middle frequency (semi-outdoor workers, SWs) and high frequency (outdoor workers, OWs) of working outside of the office

<table>
<thead>
<tr>
<th></th>
<th>IW</th>
<th>SW</th>
<th>OW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of subjects</td>
<td>26</td>
<td>22</td>
<td>24</td>
</tr>
<tr>
<td>Number of females</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Mean age at RI</td>
<td>36.9±9.7</td>
<td>46.2±8.9</td>
<td>38.9±6.4 **a, b</td>
</tr>
<tr>
<td>BMI at OI</td>
<td>21.7±2.5</td>
<td>21.9±1.5</td>
<td>22.9±2.7</td>
</tr>
<tr>
<td>BMI at RI</td>
<td>21.9±2.6</td>
<td>21.7±1.6</td>
<td>22.9±2.7</td>
</tr>
<tr>
<td>Kind of occupation (%)</td>
<td>a, c</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sales and marketing</td>
<td>0%</td>
<td>9.1%</td>
<td>33.3%</td>
</tr>
<tr>
<td>Construction management</td>
<td>0%</td>
<td>9.1%</td>
<td>12.5%</td>
</tr>
<tr>
<td>Drawing</td>
<td>15.4%</td>
<td>36.4%</td>
<td>16.7%</td>
</tr>
<tr>
<td>Planning</td>
<td>11.5%</td>
<td>13.6%</td>
<td>16.7%</td>
</tr>
<tr>
<td>Other (e.g. purchase)</td>
<td>73.1%</td>
<td>31.8%</td>
<td>20.8%</td>
</tr>
</tbody>
</table>

\( p<0.05 \) for IW vs. SW, \( p<0.05 \) for SW vs. OW, \( p<0.05 \) for IW vs. OW.

Table 3. Mean scores of 5 items (AIS-5) and 3 items (AIS-3) of the Athens Insomnia Scale (AIS) for each group under the ordinary illumination (OI) and reduced illumination (RI) conditions

<table>
<thead>
<tr>
<th></th>
<th>OI</th>
<th>RI</th>
</tr>
</thead>
<tbody>
<tr>
<td>All workers</td>
<td>AIS-5</td>
<td>3.1±1.9</td>
</tr>
<tr>
<td></td>
<td>AIS-3</td>
<td>1.6±1.2</td>
</tr>
<tr>
<td>Indoor workers</td>
<td>AIS-5</td>
<td>2.4±1.4</td>
</tr>
<tr>
<td></td>
<td>AIS-3</td>
<td>1.4±1.0</td>
</tr>
<tr>
<td>Semi-outdoor workers</td>
<td>AIS-5</td>
<td>3.6±1.8</td>
</tr>
<tr>
<td></td>
<td>AIS-3</td>
<td>1.6±0.9</td>
</tr>
<tr>
<td>Outdoor workers</td>
<td>AIS-5</td>
<td>3.5±2.3</td>
</tr>
<tr>
<td></td>
<td>AIS-3</td>
<td>1.8±1.6</td>
</tr>
</tbody>
</table>

\( **p<0.01 \) for OI vs. RI. Means±SD.

Fig. 1. Illuminance levels of the far area (FAW: top), middle area (MAW: middle) and near area of the windows (NAW: bottom) under the ordinary (OI) and reduced illumination (RI) conditions.
scores⁸). Insomnia is considered to be related to hypertension and coronary artery disease⁹, ¹⁰. Workers with AIS-5 score of 3 or more showed significantly higher psychological and physical stress responses compared with workers with scores lower than 3⁹. In the present study, underexposure to light resulted in the indoor workers' scores increasing from 2.4 to 3.1. Insufficient light in the workplace might cause psychological and physical health risks in the workers. On the other hand, for AIS-3, which includes questions about sense of well-being during the day, functioning during the day and sleepiness during the day, the scores did not indicate significant differences between the conditions for any group. Although no clear explanation is possible, the illuminance level of the reduced illumination (RI) conditions, approximately 500 lux, may have produced some alerting effects. Since light exposure of 100 lux during nighttime induces alertness¹², light exposure of 500 lux could reduce next-day consequences of sleep and/or daytime symptoms. However, a lower illuminance level than 500 lux in the workplace may have an impact on work efficiency.

There were significant differences in age and type of work among the groups. While the total AIS-5 score has been reported to relate to job stress¹¹, it had no relationship with age⁹. Outdoor workers (OWs) had jobs that require communicating with external people, such as sales and marketing and construction management. In fact, the initial mean AIS-5 score of indoor workers was nonsignificantly lower than those of the other groups. Since being underexposed to light could have an impact on sleep in a low-stress subject group, any workers who spend most of their working time under office light might be impacted.

In this study, the decrement of the office light was about 200 lux (750–700 lux under the ordinary illumination (OI) conditions vs. 550–490 lux under the reduced illumination (RI) conditions), and the difference in illuminance level was assumed to be smaller than in the study of underground workers⁹. Socio-environmental factors surrounding the workers in the present study may contribute to the impact of the mildly decreased illuminance level. There are many 24-hour convenience stores and restaurants in Japan that have nocturnal bright lights that are known to delay circadian rhythms², ¹³ and induce alertness¹², ¹⁴. In Japanese homes as well as stores and restaurants, fluorescent lamps are used as the most common light source. This light source emits white light that includes a large blue portion compared with the light source of other lamps such as incandescent lamps. Blue light has an acute impact on the circadian system compared with green-red light¹⁵, ¹⁶. White and high intensity light during the nocturnal period might contribute to the impact of the mildly decreased light intensity in the office.

This study suggests that a decreased illuminance level in the office might induce insomnia. Although the present findings indicated that reduced illumination of 500 lux had no impact on next-day consequences of sleep or daytime symptoms, a lower illuminance level may reduce work efficiency. Since depression and working efficiency were not assessed in this study, their impact cannot be adequately discussed. Furthermore, the history of light exposure in each subject was not measured. Light outside of the office could affect circadian systems and/or sleep; for example, a worker who is exposed to an adequate light level before coming into the office may not show the impact of office light. From the point of view of workers' health, bright light might be necessary in workplaces during the daytime. However, saving energy in the office is necessary particularly in Japan. A novel lighting environment is required to optimize work-related levels of light exposure.

Competing interests: The authors declare that they have no competing interests.

References

9) Suka M, Yoshida K, Sugimori H. Persistent insom-


