Short communication

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by Sadeghniiat-Haghighi K, Yazdi Z, Jahanihashemi H, Aminian O

Affiliation: Number 6, Taleghani Street, Qazvin, Iran 432- 284256- 9. yazdizohreh@yahoo.com

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The effect of bright light on sleepiness among rapid-rotating 12-hour shift workers

by Khosro Sadeghniiat-Haghighi MD,[1] Zohreh Yazdi, MD,[2] Hassan Jahanihashemi, PhD,[3] Omid Aminian, MD [4]

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Objective About 20% of workers in industrialized countries are shift workers and more than half of them work on night or rotating shifts. Most night workers complain of sleepiness due to lack of adjustment of the circadian rhythm. In simulated night-work experiments, scheduled exposure to bright light has been shown to reduce these complaints. Our study assessed the effects of bright light exposure on sleepiness during night work in an industrial setting.

Methods In a cross-over design, 94 workers at a ceramic factory were exposed to either bright (2500 lux) or normal light (300 lux) during breaks on night shifts. We initiated 20-minute breaks between 24.00 and 02.00 hours. Sleepiness ratings were determined using the Stanford Sleepiness Scale at 22.00, 24.00, 02.00 and 04.00 hours.

Results Under normal light conditions, sleepiness peaked at 02:00 hours. A significant reduction (22% compared to normal light conditions) in sleepiness was observed after workers were exposed to bright light.

Conclusion Exposure to bright light may be effective in reducing sleepiness among night workers.

Key terms circadian rhythm; shift work; night work.

Many critical aspects of modern life, including medical care, power generation, the military, law enforcement, and public transportation, depend on shift workers (1, 2). Shift work is associated with numerous negative effects, the most prominent of which is disturbed sleep. Working at night typically results in sleepiness and reduced performance and an increase in accidents and health problems (3, 4). Circadian rhythms are generated by a central pacemaker, the suprachiasmatic nucleus (SCN) in the anterior hypothalamus, and are synchronized to the external environment (5, 6). Light regulates this pacemaker, independent of the timing of the sleep/wake cycle (7, 8).

Bright light has been proposed as a countermeasure to physiologic maladaptation to shifted sleep/wake schedules based on a number of previous laboratory investigations (9). Field studies on night workers support the efficacy of bright light treatment during the night shift, although some negative results have been reported (10). A recent study of operators in a truck production plant in Sweden revealed a beneficial effect of bright light exposure on reducing sleepiness and melatonin levels during night shifts, with no disturbance of sleep on days off (11). Similar observations have been reported for oil-rig workers on rotating shifts (12); however, not all field studies support the use of bright light for shift workers. In one study of night workers on an oil platform (13) who were isolated from outdoor light, short exposure (120 minutes) to bright light was not found to significantly enhance adaptation to night work compared to exposure to normal indoor light. The optimal light intensity and minimal duration of exposure necessary to produce phase shifts in circadian rhythm has not yet been elucidated (13).

Our study tested if a short exposure (20 minutes) to bright light during regular breaks at night would decrease sleepiness during the night shift.

1 Baharloo Hospital, Occupational Medicine Department, Tehran University of Medical Science, Tehran, Iran.
2 Department of Community Medicine, Qazvin University of Medical Science, Qazvin, Iran.
3 Department of Biostatistics, Qazvin University of Medical Sciences, Qazvin, Iran.
4 Tehran University of Medical Science, Tehran, Iran.

Correspondence to: Zohreh Yazdi, Number 6, Taleghani Street, Qazvin, Iran 432- 284256- 9 [E-mail: yazdizohreh@yahoo.com].

Methods

The study participants worked as operators in a ceramic production plant in Iran. Ninety-seven shift workers volunteered for the study. Of these, 94 participants completed the study. Three workers had to be excluded from the final analysis due to personal reasons. Subjects were asked to sign a consent form confirming that they understood the goals, risks, and potential benefits of the study as well as their right to withdraw from the study at any time. The University of Tehran Ethics Committee approved the study.

All subjects worked two 12-hour day shifts (06.00–18.00 hours) followed by two days off work, and two 12-hour night shifts (18.00–06.00 hours); then the schedule was repeated. The average working time per month was 220 hours.

The design of this study was 2×2 cross-over; the first group received bright light in the first period and normal light in the second. The second group received normal light in the first period and bright light in the second. Between the first and second period, there was a four-day washout period.

Subjective sleepiness was assessed using the Stanford Sleepiness Scale (SSS) every two hours during the night shift at 22.00 (time 1), 24.00 (time 2), 02.00 (time 3) and 04.00 hours (time 4). SSS is a 7-point verbally anchored scale, with high scores indicating higher sleepiness (14).

The light exposure occurred during two short breaks during the night shift. Each break was approximately 20 minutes long. The interval between the two breaks was two hours, with the first break starting at 00:30 hours. Two break rooms were set up that were highly similar (eg, with respect to temperature, décor, and general ambience) apart from lighting conditions. One of the break rooms was modified for bright light. Fluorescent tubes in the ceiling of the break room were installed using an up-light armature that gave an indirect white light with a mean luminance level of 350 candela m^{-2}, generated by full-spectrum light tubes with temperatures of 5000 K. To increase luminance, an off-white floor was installed and the walls of the room were covered with a white textile. This generated a mean exposure of 2500 lux at eye level (with an 80 ° gaze angle) for a person sitting down. Workers were instructed to go to the light room for all breaks during night work. Under the normal light condition, workers went to the room with normal illumination (300 lux).

For the statistical analysis, we used SPSS version 13 for Windows (SPSS Inc, Chicago, IL, USA). A two-factor repeated measurement ANOVA was used (factors: treatment and time) and the P-values were corrected for sphericity (using the Huynh-Feldt coefficient). Significance was defined at $P<0.05$.

Results

All participants were male, and the mean age was 33 years (range 21–45 years). Under both conditions, the workers took two breaks at work. The first break had a mean length of 22.0 ± 0.2 minutes and the second break lasted 21.2 ± 0.4 minutes. The timing of breaks or their frequency did not significantly differ between the two conditions. During normal light conditions, sleepiness peaked at 02.00 hours. Also the ratings at 24.00 and 04.00 hours were clearly elevated. Bright light exposure decreased sleepiness ratings and the late-night peak disappeared (see table 1 for two periods, and figure 1 for period 1).

A two-factor repeated measurement ANOVA (treatment and time) for period 1 showed a significant effect of time and time×treatment ($F=40.98$, $F=8.76$, respectively, $P<0.001$). The analysis for period 2 also showed a significant effect of time and time×treatment ($F=9.872$, $P<0.001$ and $F=5.124$, $P<0.01$, respectively).

Discussion

This study demonstrates the effectiveness of exposure to bright light on decreasing the level of sleepiness among shift workers during their breaks. Despite the short duration of exposure to bright light (two 20-minute breaks), significant effects was observed. The results are consistent with results from a similar study in Sweden where exposure to two 20-minute periods of bright light exposure during the night significantly reduced sleepiness (measured using the Karolinska Sleepiness Scale) (12).

Further research is necessary to determine the persistence of this effect and assess the effects in terms of worker safety and productivity. The optimal dose, intensity and timing of bright light exposure are still undetermined and need to be established.

Considering the cost and practicality of the use of bright light exposure in the workplace, it is recommended

Table 1. The overall mean and standard error (SE) of sleepiness in two groups and two periods. Range: 1=low sleepiness – 7=high sleepiness.

	Period I		Period II	
	Mean	SE	Mean	SE
Group 1	2.43	0.12 [a]	3.07	0.09 [b]
Group 2	2.77	0.11 [b]	2.07	0.09 [a]

[a] Bright light

[b] Normal light

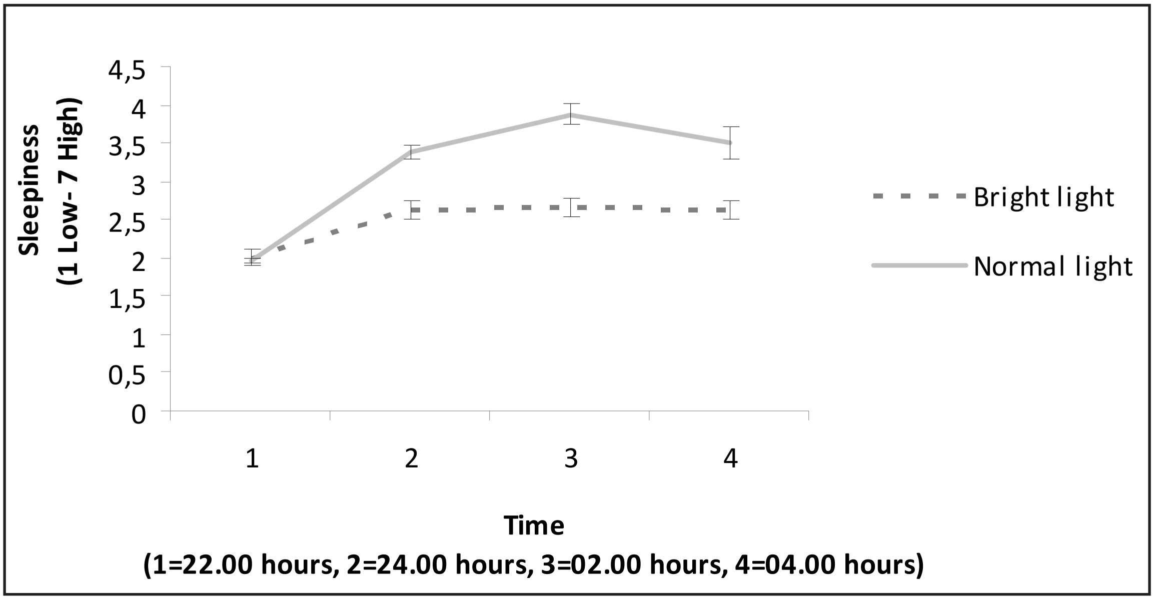

Figure 1. Mean (and standard error of mean) of scores in four times in two groups. The differences between Times 2, 3, and 4 are significant (P<0.001)

that selected rooms be equipped with bright light rather than supplying the whole workplace with bright light.

One limitation of this study was that the participants were aware of the two conditions and thus the study lacked a true placebo condition. It is possible that this may have had an effect on the results. Other limitations in our study were that: (i) no objective measures of sleepiness were used and (ii) that the long-term effects are unknown. It might be that the increase in alertness becomes weaker when the "novelty effect" wears off.

In conclusion, exposure to bright light during short breaks may be an effective countermeasure of sleepiness on the night shift. Bright light may improve circadian adaption or induce an acute effect due to melatonin suppression.

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