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Original Article

Driving home from the night shift: a bright light intervention study

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ABSTRACT

Sleep deprivation (SD) impairs vigilance and increases the risk of driving accidents during the commute home after night work. Bright light (BL) can enhance alertness and cognitive performance. We examined the effects of BL (5600 lux) versus dim light (DL, 35 lux) at the end of a night awake on driving performance.

Methods: Subjects (N = 19, 22.8 ± 4 ya) completed three conditions, counterbalanced for order at >1 week intervals. The two overnight SD conditions began in the lab at usual bedtime. After six hours in DL, subjects were exposed to 45 min BL or continued DL, and then completed a 44 min driving test (two lap circuit) in a high fidelity simulator. In the rested condition, subjects slept at home until habitual wakeup time, were transported to the lab and ~45 min after wakeup, received BL and then the driving test.

Results: Oral temperature decreased while reaction time and sleepiness increased across both SD nights. BL suppressed salivary melatonin but had little or no effect on sleepiness or reaction time. SD markedly increased incidents and accidents. Five subjects (26%) sustained a terminal accident (eg, car flip) in the SD-DL condition, but none did so in the SD-BL or rested-BL conditions. Compared to SD-DL, SD-BL was associated with fewer incidents and accidents overall, and with better performance on the second lap of the circuit on several performance measures.

Conclusion: BL at the end of a night shift may have potential as a countermeasure to improve driving following night work.

1. Introduction

Sleepiness is a significant risk factor for automobile accidents, due to its negative impact on vigilance, reaction time and higher cognitive processes [1–8]. Specific deficits in driving performance with increased sleepiness are well-documented [9–23]. Sleepiness reflects an interaction between the duration of time awake, time of day and environmental conditions [24–26]. This places shift workers commuting home from the night shift at special risk, as they commonly experience acute and chronic sleep restriction, are driving near the nadir in the circadian rhythm of alertness, and may be driving before sunrise during some times of year, numerous studies confirm these increased risks [27–36].

Sleepiness at the end of the night shift can be reduced by napping or consuming stimulants such as caffeine. However, these strategies can be counterproductive, due to sleep inertia following naps or by interfering with sleep onset at home [37–40]. Another procedure that can promote alertness is bright light exposure. Bright light (particularly at night), can reduce subjective sleepiness and improve cognitive performance [41–48]. At some times of year in many geographical locations, commutes home from night work occur prior to sunrise. In the absence of daylight, scheduled bright light exposure in the workplace near the end of the night shift may enhance alertness and improve driving performance, at least temporarily.

Assessments of light as a potential countermeasure for driver sleepiness at night are to date quite limited. One study used a dashboard mounted blue light and showed benefits of light exposure during an overnight 250 km road test [49]. Another study showed a benefit of bright light in combination with caffeine, administered at multiple times across the night, on driving at 06:00 h compared to driving earlier in the night [50]. The aim of the present study was to assess the possible benefits of bright light exposure at the end of a night awake on driving performance during a simulated 44 min commute home. We hypothesized that following a night awake, driving performance in a high fidelity

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simulator would be impaired, and that deficits in one or more performance measures would be attenuated by 45 min of bright light exposure immediately prior to the drive.

2. Methods

2.1. Subjects

The study was approved by the Simon Fraser University Research Ethics Board. Subjects were recruited from the university undergraduate population. Twenty-one subjects (six females) completed the study. Data from two subjects (one male and one female) were excluded due to loss of driving data in one of the three conditions. All subjects had a Canadian driver's license with at least one year of driving experience and completed a general health questionnaire as well as a motion sickness questionnaire. Subjects were enrolled if they were healthy, did not have a sleep disorder, did not use sleep medications (melatonin or hypnotics) or non-steroidal anti-inflammatories, and did not have an extreme chronotype (Morningness-Eveningness Questionnaire [51]. Munich Chronotype Questionnaire [52]) did not allow subjects to work evening or night shifts, travel across time zones in the past three months, did not drive as a profession and did not suffer from motion sickness during a 15 min test in the driving simulator. No other psychological or medical tests were administered to diagnose potential unreported psychological or medical conditions, and no toxicology screens were conducted. Average age was 22.8 ± 4 years. Subjects were paid $50 for their participation.

2.2. Procedure

The study employed a repeated measures design that included two sleep deprivation conditions with bright light or dim light and one rested condition with bright light. The three conditions were scheduled using a cross-over balanced design, with at least one week between conditions. Subjects were recruited from among students taking classes in the winter (N = 5), summer (N = 9) and fall (N = 5) semesters. Sessions within subjects fell within one semester, therefore the three conditions were balanced across season. All subjects were asked to maintain a regular sleep-wake schedule and to maintain a sleep diary for at least one week prior to each condition. Subjects wore an Actiwatch (Philips Respironics, Inc.) for two to three days before the start of each of the three conditions. An email was sent to the subjects 48 h prior to the start of each condition to remind them to avoid alcohol, caffeine and naps and to forward their sleep diaries. Average bed time and wake time during the week prior to each of the three conditions were calculated from the diary and used to determine when each condition would begin. Sleep deprivation sessions were scheduled only for nights when the subjects had no work or school obligations the following day.

The experimental protocol is illustrated in Fig. 1. For the two sleep deprivation conditions, subjects arrived at the sleep lab at least one hour prior to their average bedtime. Starting at their average bedtime, the subjects remained awake for the next ~8 h under the supervision of one or two research assistants. Ambient light during this time was maintained at <50 lux (averaging ~35 lux, incandescent lighting), an intensity representative of indoor work environments at night [53]. At the beginning of the sleep deprivation, the subjects completed the Karolinska Sleepiness Scale (KSS) [54]. Body temperature was measured orally (T_o) and reaction time (RT) was measured using the psychomotor vigilance test (PVT) on a PALM Pilot personal digital assistant. T_o and RT were then measured every 30 min for the next six hours. Between measurements, the subjects were allowed to engage in quiet activities such as reading, homework, watching a pre-screened movie, and chatting with the research assistants. Water and caffeine-free snacks were provided (fresh vegetables, fruit and a small chicken or vegetarian wrap). Subjects did not consume liquid or food within 15 min of T_o assessments.

At 6 h after the start of the sleep deprivation, a saliva sample was collected in polystyrene tubes and immediately stored at −20 °C until assay for melatonin (ALPCO Kit, Biomarkers Core Laboratory, Atlanta, USA). The normal assay range was 0.5–50 pg/ml for a 400 μl sample. The inter-assay coefficient of variation was 12.94% at 1.6 pg/ml and 7.16% at 13.8 pg/ml. The intra-assay coefficient of variation was 10%. The subjects then put on tight fitting UVEX

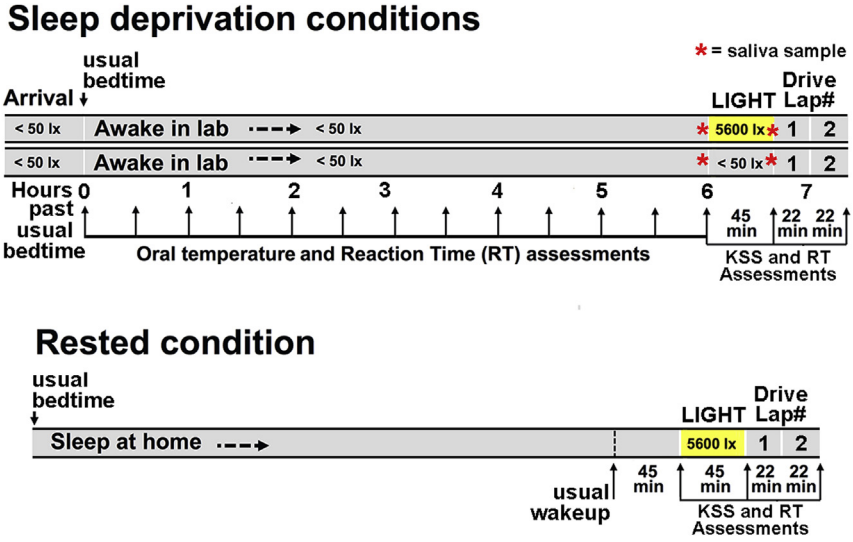

Fig. 1. Graphical representation of the study protocol for the two sleep deprivation conditions and the rested condition. In the two sleep deprivation conditions, subjects arrived in the lab prior to their usual bedtime (the average from the previous week of sleep diary entries). The sleep deprivations began at the usual bedtime, and all events were scheduled relative to that time point (designated hour 0; for average clock times, see Table 1). In the rested condition, subjects slept at home, and were driven to the lab just after their usual wake time. All subjects lived on campus or close by, and therefore the bright light treatment began ~45 min after wakeup. Abbreviations: KSS, Karolinska Sleepiness Scale; RT, reaction time.