SYNOPSIS

KEY POINT SUMMARY

OBJECTIVES

This study investigated whether exposure to red light at night would not only increase measures of alertness but also improve performance. It was hypothesized that exposure to both red (630 nm) and white (2,568 K) lights would improve performance, but that only white light would significantly affect melatonin levels.

Light at night and measures of alertness and performance: Implications for shift workers

Figueiro, M. G., Sahin, L., Wood, B., & Plitnick, B. 2015 | *Biological Research for Nursing* Volume 18, Issue 1, Pages 90-100

Key Concepts/Context

Rotating-shift workers, particularly those working at night, are likely to experience sleepiness, decreased productivity, and impaired safety while on the job. Light at night has been shown to have acute alerting effects, reduce sleepiness, and improve performance. However, light at night can also suppress melatonin and induce circadian disruption, both of which have been linked to increased health risks. Previous studies have shown that long-wavelength (red) light exposure increases objective and subjective measures of alertness at night, without suppressing nocturnal melatonin.

Methods

Seventeen individuals participated in a three-week, within-subjects, nighttime laboratory study. Participants remained in dim white light (<5 lux at the cornea from a 3,500 K fluorescent lamp placed in an uplight luminaire) until the end of the experimental session. At three appointed session times (19:00, 23:00, and 03:00), participants were presented with one of three experimental conditions that lasted 120 min. each: (1) dim white light, (2) red light goggles, or (3) white light goggles. The presentation order of the three conditions was randomized so that at least four participants experienced each of the conditions

Under the dim light condition, participants stayed in the laboratory's dim light (<5 lux at the cornea) and did not wear light goggles. Under the red light and white light conditions, the light goggles were energized for 120 min. preceded by a 10-min. dim (<5 lux at the cornea) period when the light goggles were not energized.

Concurrent with each lighting condition, a 130-min. data collection protocol consisting of saliva samples, Karolinska Sleepiness Scale (KSS), Electroencephalogram (EEG), and performance tests was conducted, with the same protocol followed for each session. EEG data collection occurred during the first hour of each session, while the performance tests occurred during the second hour.

Findings

Study results suggest that red light can increase measures of alertness in the early evening, while white light was only effective during the latter part of the night.

Participants' mean performance tests were significantly increased during the dim light condition than during the red and white light conditions, suggesting that participants were reacting faster after light exposure.

Results suggest that there may have been a trade-off between speed and accuracy under the red light condition, with participants responding more quickly but not necessarily more accurately.

Lighting condition had no effect on one of the performance tests (ART).

Statistical analysis (ANOVA) did not reveal any main effect of lighting conditions, sessions, or trials for salivary alpha-amylase levels. However, the t-tests showed that melatonin levels were higher during the red light condition than during the white light condition.

These results are consistent with the expectation that participants would get sleepier toward the end of the study and that, within each session, participants reported feeling sleepier as time passed. These results may reflect boredom that participants experienced during each experimental session.

The present results are the first to show that exposure to red light, which does not suppress melatonin or change circadian phase at the levels employed in this study, not only increases objective alertness, as previously demonstrated by other research studies, but also significantly decreases reaction times (i.e., improves performance) on one of the performance tests (GO/NOGO task) at night.

The present results support the hypothesis that melatonin suppression does not necessarily mediate the alerting effects of light in humans.

Consistent with the findings of another 2014 published study, these results suggest that lighting characteristics needed to affect measures of alertness may differ from those needed to affect measures of performance. The present results are not consistent with those of a 2010 published study that showed that red light increased cortisol levels at night.

Design Implications

The practical implications of our results for nurses working rotating nightshifts may be significant, particularly in light of the fact that the suppression of melatonin by light at night has been linked to increased risk for disease in shift workers. Nurses could use red light exposure to maintain alertness and improve certain types of performance without suppressing melatonin and changing circadian phase, thereby reducing the chance for increased risk of disease incurred by exposure to white light. While red light may not improve performance as much as high levels of white light or blue light, which are both known to suppress melatonin, it could be an adequate compromise.

The use of red light as a supplemental light to increase alertness at night may have to be coordinated with current lighting practice and may only make sense in some areas of the healthcare facility. The NICU would be an ideal location for the use of red light, while the effects of red light on nurses working in the emergency room may be muted because they are already being exposed to high levels of white light.

Alternative ways for nurses to receive red light include the use of light boxes or perhaps an array of red LEDs around a computer screen, if nurses are sitting at computer stations.

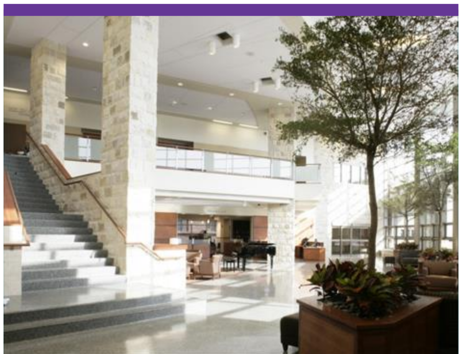
Limitations

The fact that participants were faster to respond in the GO/NOGO task in white light and red light compared to dim light but throughput was only significantly greater after exposure to white light suggests a weaker overall effect of red light on performance compared to white light. This is a finding that needs to be considered when using red light to improve performance at night. It should also be noted that there were no significant differences between the lighting conditions for one of the performance tests (ART). This lack of effect for lighting condition may have occurred because the tone presented to the subjects was easily detectable. Perhaps the effect can only be seen when the signal to noise ratio is low (i.e., close to threshold). The MAT data results showing that subjects performed better on the tracking task in dim light than when exposed to either red or white light were unexpected.

We hypothesize that task visibility was reduced through the light goggles as a result of luminous veil in the field of view. The visual stimulus in the GO/NOGO task was larger, thus disability glare from the light goggles may not have affected task visibility.

Moreover, it is important to note that the overall observed impact of light was modest compared to the increase in fatigue over the course of the night. In other words, not unlike other stimulants, light can only do so much to improve performance at night.

Other limitations include the small sample size and the fact that subjects may have become bored with the experiment.



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