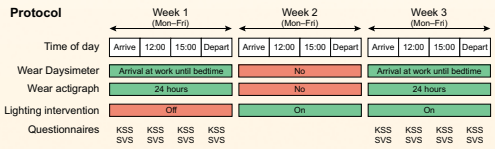
Light, Alertness, and Circadian Entrainment in Three Office Buildings

The goal of this research was to evaluate whether a lighting intervention designed to deliver high circadian stimulus (CS) in the morning to promote entrainment and low-CS red light in the afternoon to promote alertness would increase office workers' nighttime sleep quality and daytime alertness.

The LRC developed and built 20 plug-in LED luminaires for mounting on desktops near participants' computer monitors to deliver 3 lighting modes throughout the day.

Methods

Twenty office workers (13 females, mean ± SD age of 46.7 ± 13.5 years) from 3 U.S. Department of State facilities in Washington, D.C., participated in the study. The study was conducted over 3 successive 1-week periods with 2 cohorts of participants in the fall of 2017. The participants wore Daysimeters and answered questionnaires inquiring about their subjective sleepiness (Karolinska Sleepiness Scale [KSS][1]) and vitality and alertness (Subjective Vitality Scale [SVS][2]) according to the schedule shown in the protocol, below.



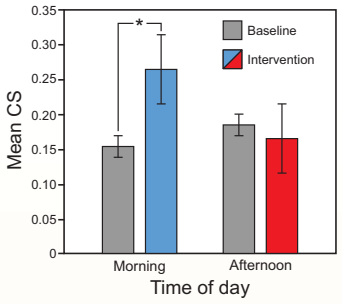
The study protocol, showing the schedule for the lighting intervention, the wearing of Daysimeters (pendant) and actigraphs (wrist), and the administration of questionnaires.

Results

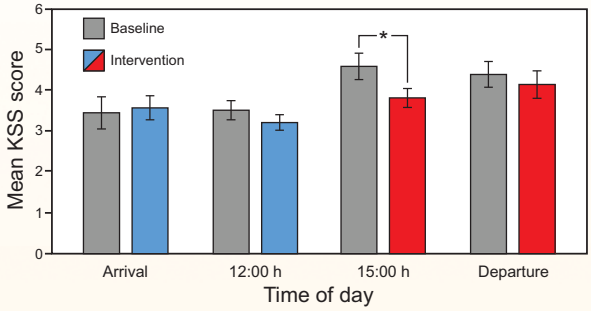
- Red light exposure significantly decreased subjective sleepiness during the post-lunch dip (15:00 h).
- High CS in the morning resulted in nonsignificantly earlier bedtimes and significantly earlier wake times.
- The lighting intervention nonsignificantly increased subjective vitality at 12:00 h, 15:00 h, and departure.

Sponsor

US General Services Administration (GSA)



Mean ± standard error of the mean (SEM) CS exposures in the morning (06:00–12:00 h) and in the afternoon (13:30–17:00 h). As expected, morning CS was significantly greater during intervention days compared to baseline, while afternoon CS was not. The asterisk denotes statistical significance ($p < 0.05$).



Mean ± SEM KSS scores at baseline and at the end of the intervention (Week 3), by time of day. Paired, 2-tailed *t*-tests showed that KSS scores were significantly reduced during the intervention week at 15:00 h. The asterisk denotes statistical significance ($p < 0.05$).

Sleep results at baseline and at the end of the intervention (Week 3).

Study week/ *p* value	Sleep start time (hh:mm)	Sleep end time (hh:mm)	Sleep onset latency (min)	Sleep efficiency (%)	Wake time (min)	Sleep time (min)
Baseline	22:27	05:41	6.9	96.2	5.9	426.6
Intervention	22:19	05:19	9.1	95.4	7.2	410.3
p value	0.60	**0.016**	0.42	0.31	0.30	0.21

Conclusions

- Red light during the early afternoon can be effective for reducing post-lunch dip sleepiness.
- Blue light received in the morning advances circadian phase, leading to earlier sleep end (i.e, wake) times.
- Social activities can counter the phase-advancing effect of morning blue light and preclude people from going to bed earlier.

References

1. Åkerstedt T, Gillberg M. Subjective and objective sleepiness in the active individual. *Int J Neurosci*. 1990;52(1–2):29–37.

2. Ryan RM, Frederick C. On energy, personality, and health: Subjective vitality as a dynamic reflection of well-being. *J Pers.* 1997;65(3):529–565.

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