

# Tailored light treatment improves measures of sleep, depression and agitation in persons with dementia living in long-term care facilities

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## Introduction

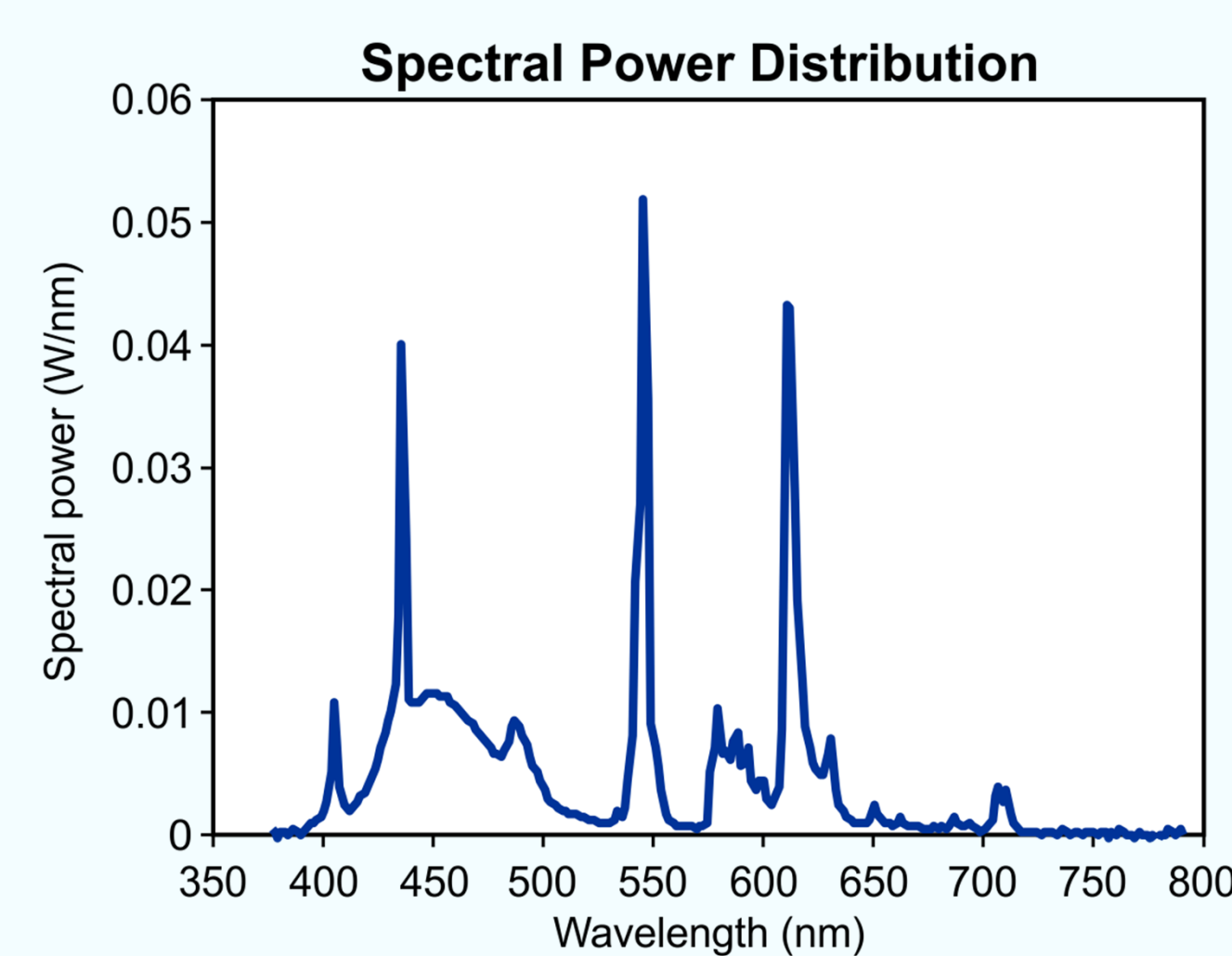
Persons with Alzheimer's disease and related dementias (ADRD) are often difficult for family caregivers to manage because of sleep problems, nocturnal wandering, and associated daytime irritability. Preliminary studies using light therapy have shown that appropriately-timed light exposure can consolidate and improve nighttime sleep efficiency, increase daytime wakefulness, and reduce evening agitation (Van Someren et al. 1997; Mishima et al. 1998; Ancoli-Israel et al. 2003). Since the human circadian system is maximally sensitive to short-wavelength (blue) light, lower, more targeted lighting interventions for therapeutic purposes can be used. The present study was designed to test the effectiveness of a tailored light treatment on measures of sleep quality, agitation and depression in those with ADRD living in nursing homes.



**Figure 1.** The Daysimeter (left), worn on the wrist, was used to record calibrated light and activity levels. The tailored lighting intervention used that was installed in a patient's room (right) used two GE 45851 F55BX/AR/FS fluorescent lamps inserted in a luminaire head (Elco Lighting, ETC 454, Line Voltage T5 Fluorescent Wall Washer).

## Methods

Modest levels (300-400 lux at the cornea) of a bluish-white light source (correlated color temperature (CCT) > 9000 K, Figure 2) was installed in 14 nursing home resident's rooms for a period of four weeks. The model of human circadian phototransduction by Rea and colleagues (2005) was used to estimate the circadian stimulus (CS) of the lighting intervention. While melatonin levels were not collected, model calculations showed that 1-h exposure to 300-400 lux at the eye of the bluish-white light would result in at least 50% melatonin suppression, indicating that the lighting intervention delivered a strong circadian stimulation.

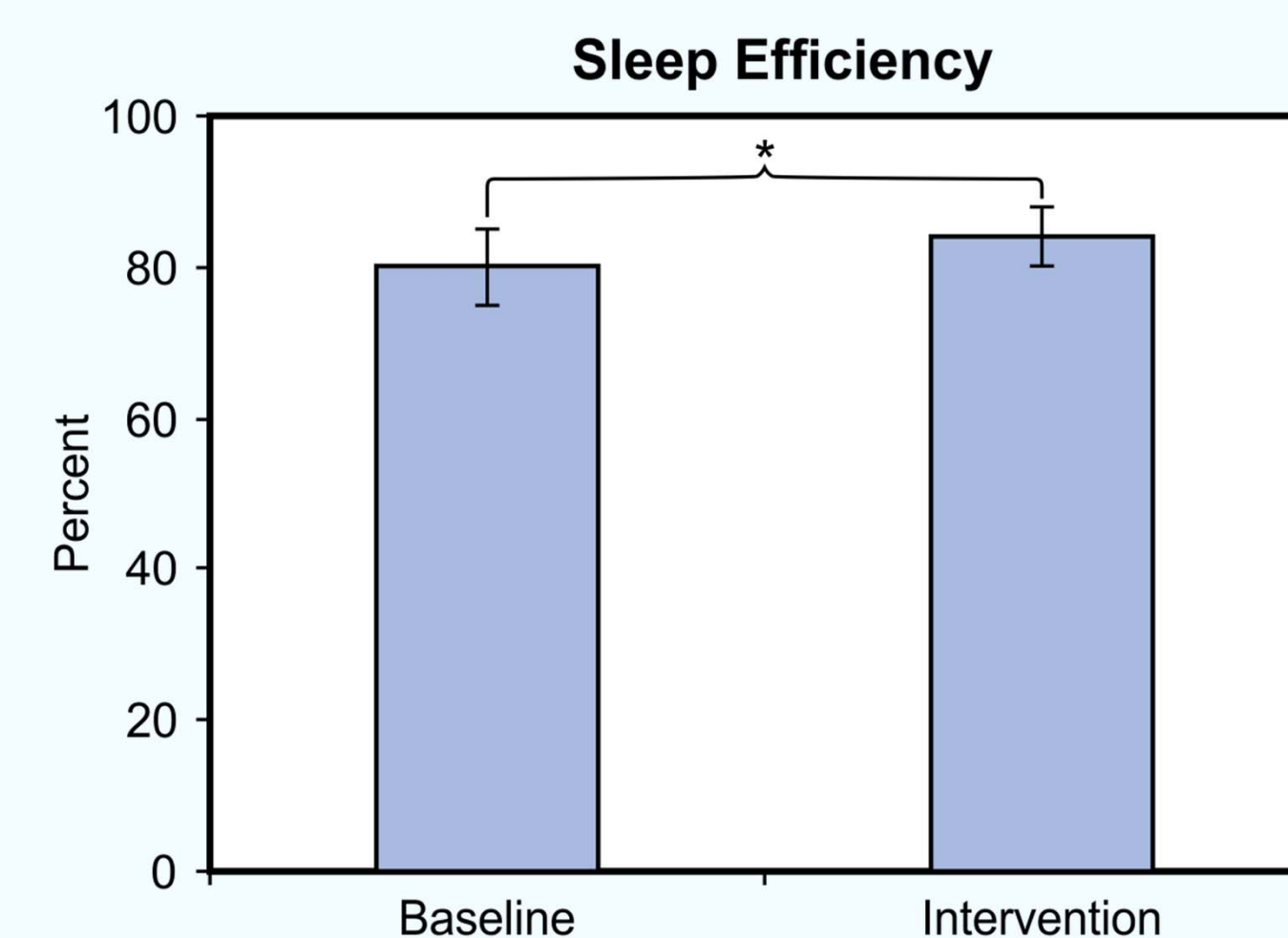


**Figure 2.** Spectral power distribution of the light source used in the study. The measured CCT of the light source was 9325 K.

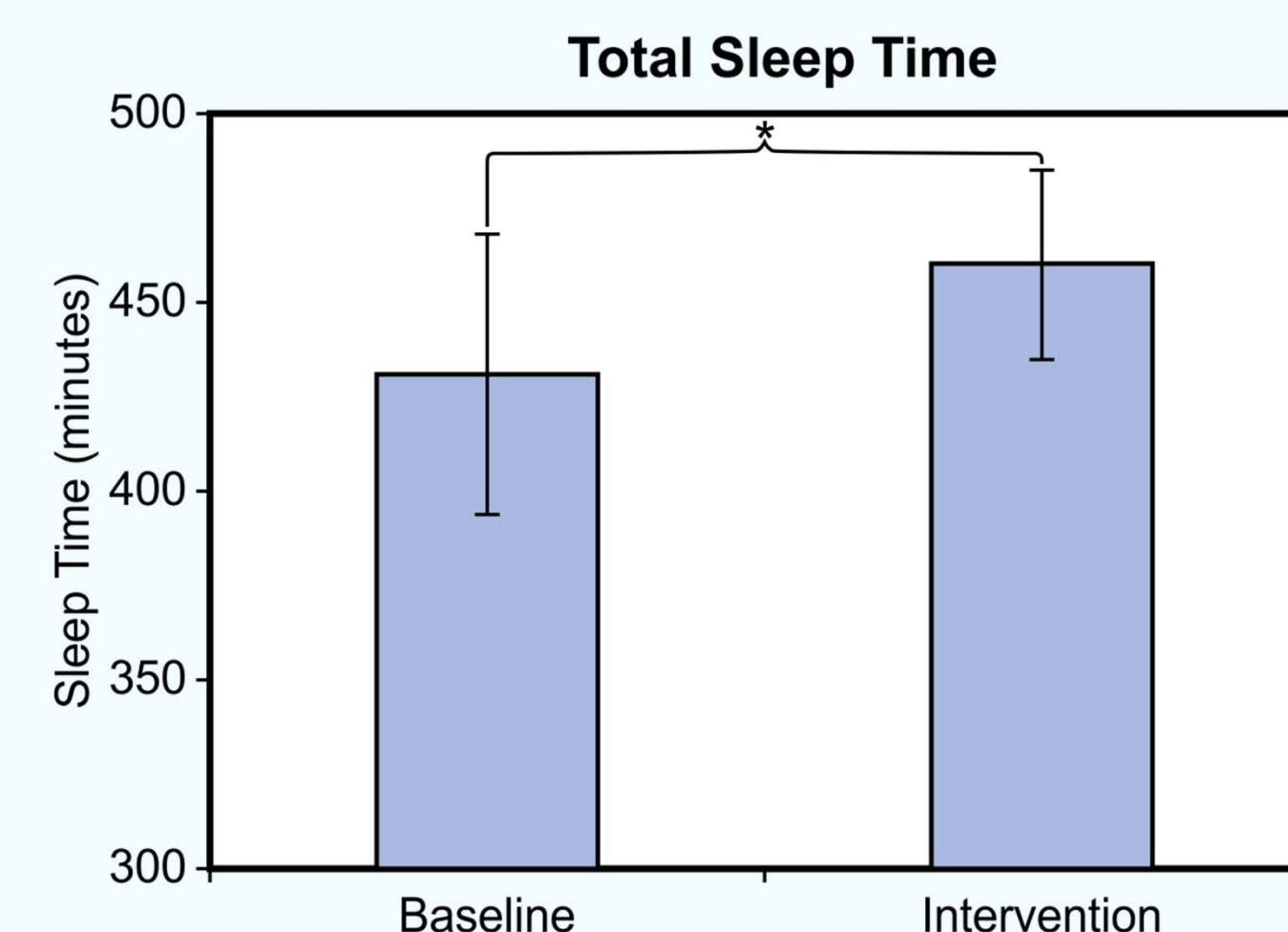
The outcome measures included objective measures of sleep, rest/activity patterns, and circadian disruption, using data from the Daysimeter (Figueiro et al. 2013) and subjective measures of sleep quality, depression, agitation and activities of daily living, using standardized questionnaires. Data were collected 1) prior to the lighting intervention installation (baseline), 2) at the end of the four-week lighting intervention (intervention period) and 3) four weeks after the lighting intervention was removed (post-intervention period). Two-tailed Student's t tests were used to compare data collected at baseline to those collected after intervention and post-intervention periods.

## Results

Exposure to the tailored light treatment significantly ( $p < 0.05$ ) increased global sleep scores from the Pittsburgh Sleep Quality Index (PSQI), decreased depression scores from the Cornell Scale for Depression in Dementia (CSDD) and decreased agitation scores from the Cohen-Mansfield Agitation Inventory (CMAI). Light exposure also significantly ( $p < 0.05$ ) increased phasor magnitude, a measure of the 24-h resonance between light-dark and activity-rest patterns, consistent with an increase in circadian entrainment. Total sleep time and sleep efficiency (ratio of total time asleep and total time in bed) were also significantly greater ( $p < 0.05$ ) after the light intervention than after baseline.



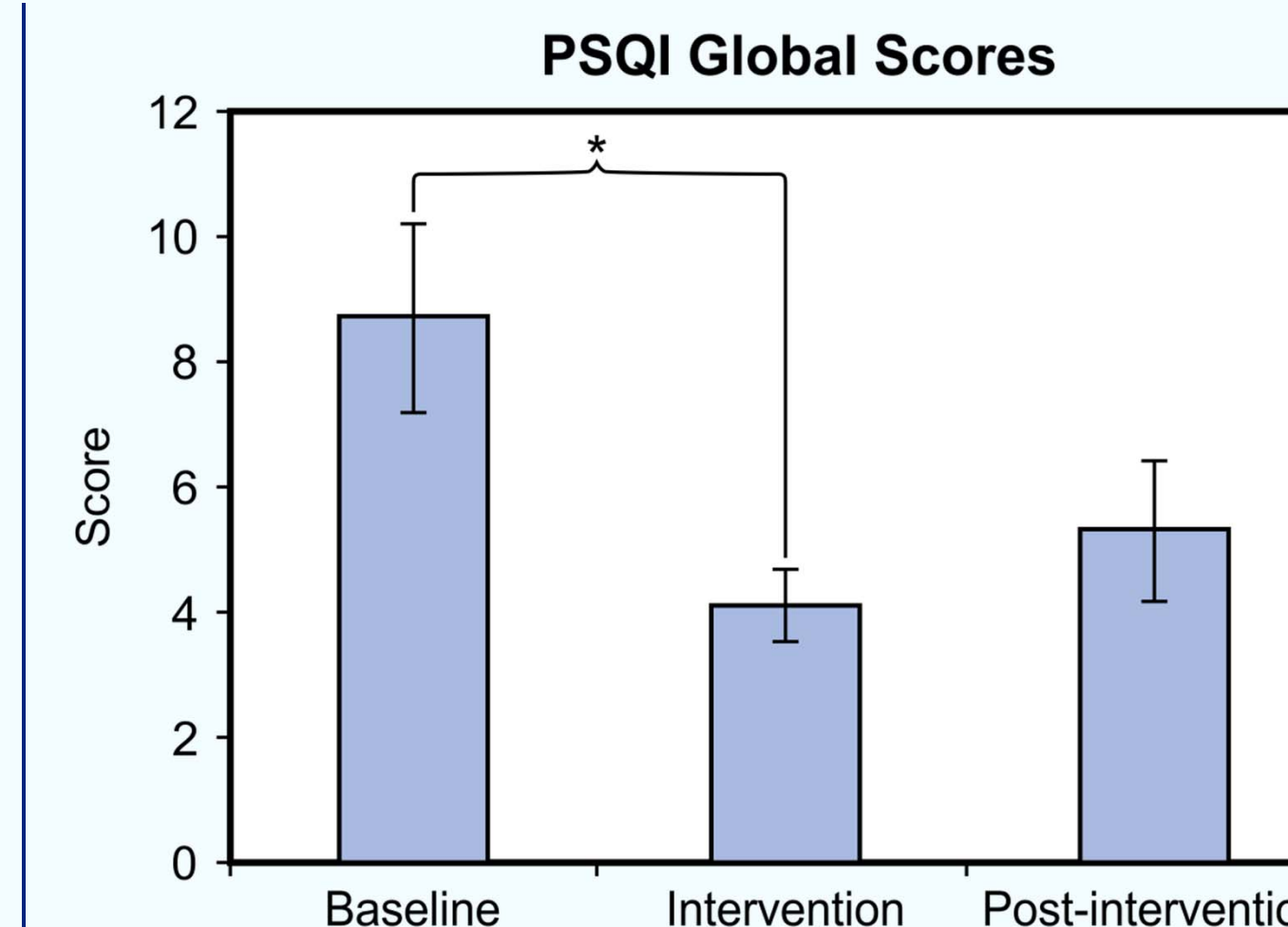
**Figure 3.** Mean  $\pm$  standard error of the mean (S.E.M) sleep efficiency was  $80\% \pm 5\%$  at baseline and  $84\% \pm 4\%$  after intervention. Sleep efficiency after the lighting intervention was significantly greater than after baseline ( $p = 0.03$ ). Daysimeter data were not available for post-intervention period due to poor compliance.



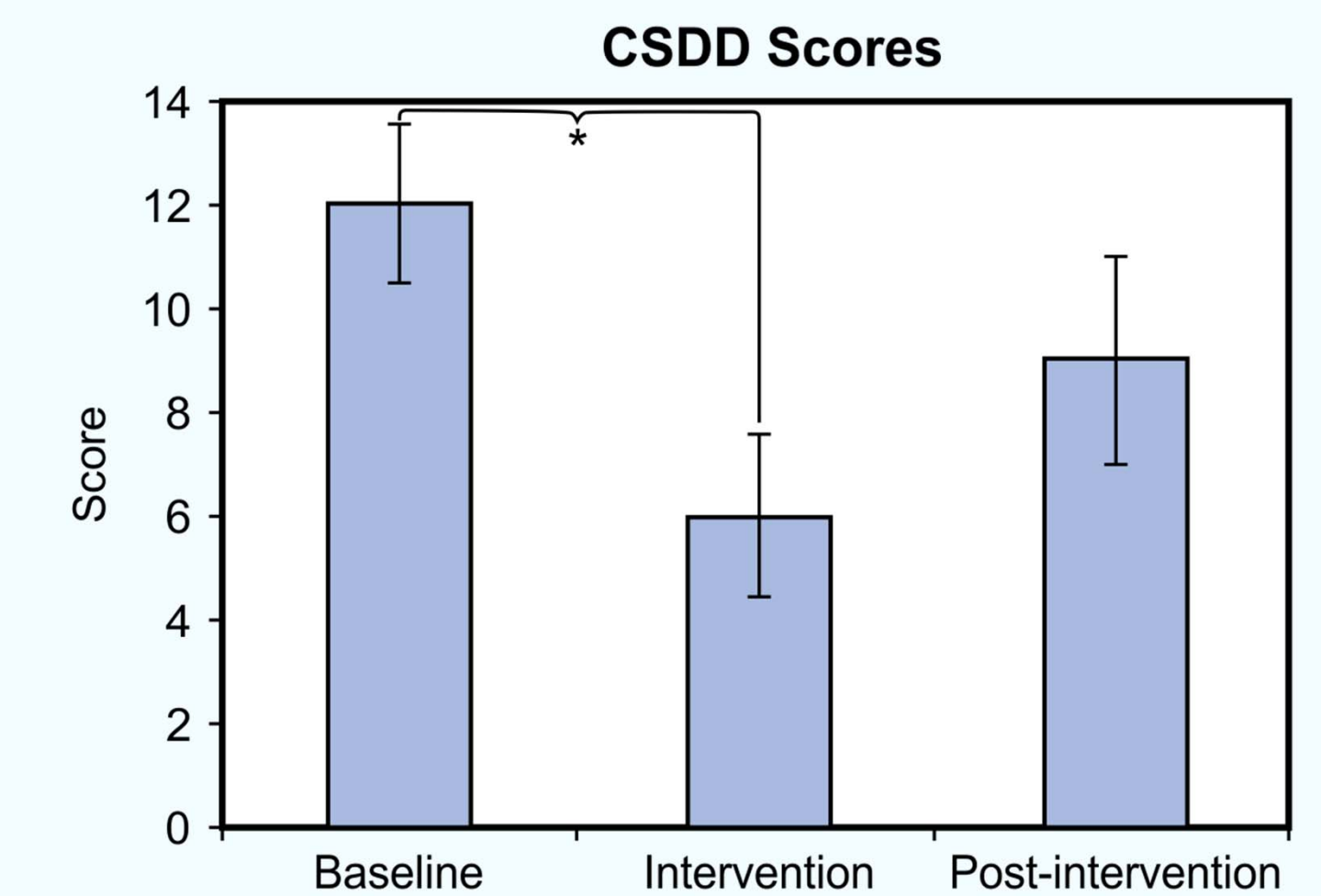
**Figure 4.** Mean  $\pm$  S.E.M. total sleep time (in minutes) was  $431 \pm 37$  at baseline and  $460 \pm 25$  after intervention. Sleep time after lighting intervention was significantly greater than after baseline ( $p = 0.03$ ). Daysimeter data were not available for post-intervention period due to poor compliance.

## Sponsors

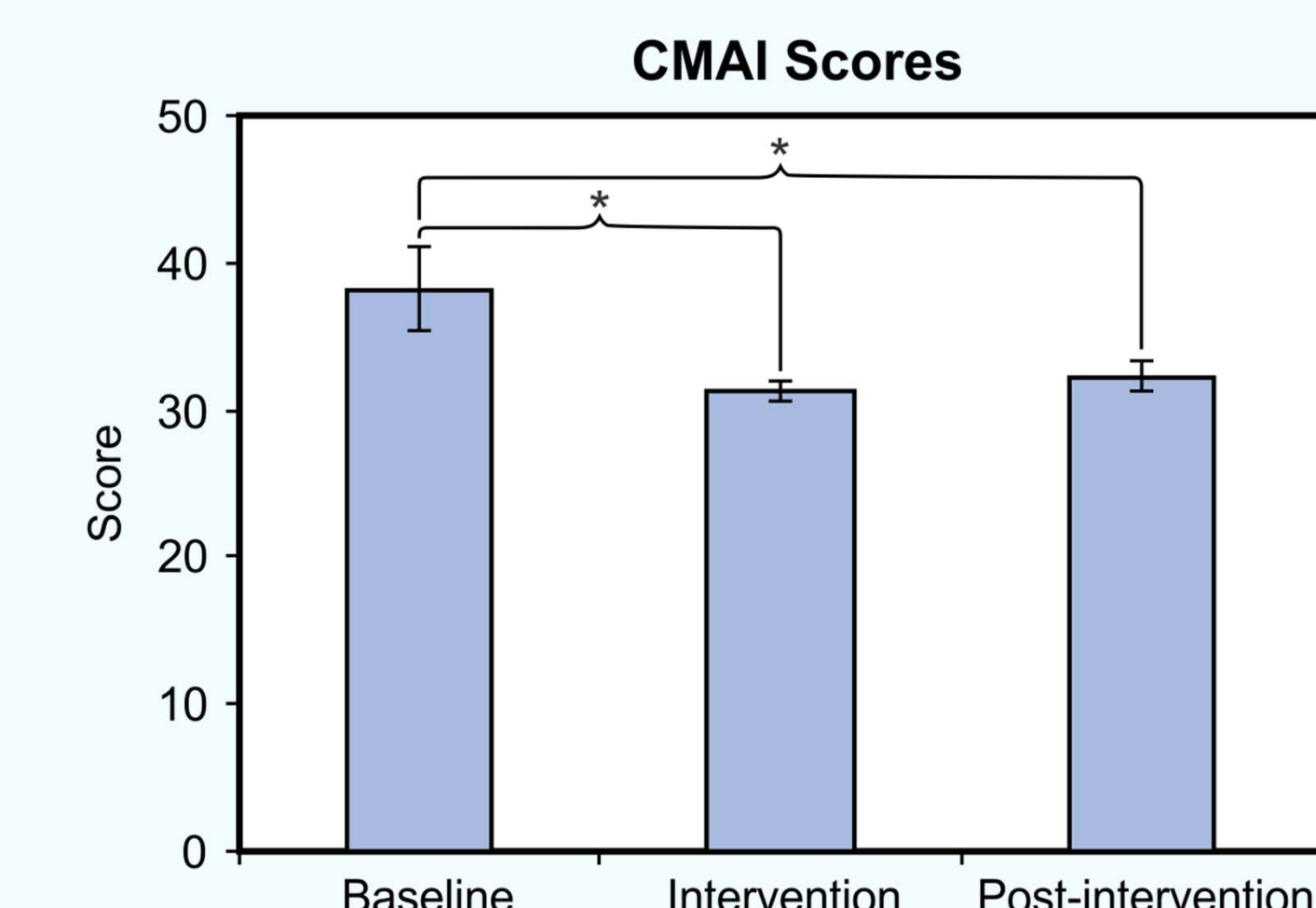
This project was funded by the National Institute on Aging (R01AG034157). Products were donated by GE Lighting.



**Figure 5.** Mean  $\pm$  S.E.M. PSQI scores were  $8.7 \pm 1.5$  at baseline,  $4.1 \pm 0.6$  after intervention, and  $5.3 \pm 1.1$  post-intervention. A significant higher PSQI score was observed after baseline than after the lighting intervention period ( $p = 0.01$ ). Scores > 6 indicate sleep disturbances.



**Figure 6.** Mean  $\pm$  S.E.M. CSDD scores were  $12.0 \pm 1.5$  at baseline,  $6.0 \pm 1.6$  after intervention, and  $9.0 \pm 2.0$  post-intervention. A significant higher depression score was observed after baseline than after the lighting intervention period ( $p = 0.03$ ). Higher scores are associated with greater self-report of depression.



**Figure 7.** Mean  $\pm$  S.E.M. CMAI scores were  $38.2 \pm 2.8$  at baseline,  $31.2 \pm 0.7$  after intervention, and  $32.3 \pm 1.1$  post-intervention. A significant higher CMAI score was observed after baseline than after the lighting intervention ( $p = 0.037$ ) and the post-intervention ( $p = 0.03$ ) periods. A higher CMAI is associated with greater agitation.

## Conclusion

A light treatment tailored to increase circadian stimulation during the day can be used to increase quality of life in those with ADRD. The benefits of using a more targeted light source is that lower light levels can be used to achieve the same circadian stimulation. A larger study should be conducted to confirm the present results. Given that practical and effective systems such as the ones used in the present study can be designed and installed, light treatments could be beneficial to those with ADRD and their caregivers.

## References

- Ancoli-Israel S, Martin JL, Gehrman P, et al. Effect of light on agitation in institutionalized patients with severe Alzheimer's disease. *Am J Geriatr Psychiatry* 2003;11(2):194-203.
- Figueiro MG, Hamner R, Bierman A, Rea MS. Comparisons of three practical field devices used to measure personal light exposures and activity levels. *Lighting Research & Technology* 2013;45(4):421-434.
- Mishima K, Hishikawa Y, Okawa M. Randomized, dim light controlled, crossover test of morning bright light therapy for rest-activity rhythm disorders in patients with vascular dementia and dementia of Alzheimer's type. *Chronobiol. Int.* 1998;15:647-654.
- Rea MS, Figueiro MG, Bullough JD, Bierman A. A model of phototransduction by the human circadian system. *Brain Research Reviews* 2005;50(2):213-228.
- Van Someren EJW, Kessler A, Mirmiran M, Swaab DF. Indirect bright light improves circadian rest-activity rhythm disturbances in demented patients. *Biol. Psychiatry* 1997;41:955-963.