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Tailored lighting intervention for persons with dementia and caregivers living at home

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ABSTRACT

Objectives: Light therapy has shown promise as a nonpharmacological treatment to help regulate abnormal sleep-wake patterns and associated behavioral issues prevalent among individuals diagnosed with Alzheimer disease and related dementia (ADRD). The present study investigated the effectiveness of a lighting intervention designed to increase circadian stimulation during the day using light sources that have high short-wavelength content and high light output.
Methods: Thirty-five persons with ADRD and 34 caregivers completed the 11-week study. During week 1, subjective questionnaires were administered to the study participants. During week 2, baseline data were collected using Daysimeters and actigraphs. Researchers installed the lighting during week 3, followed by 4 weeks of the tailored lighting intervention. During the last week of the lighting intervention, Daysimeter, actigraph, and questionnaire data were again collected. Three weeks after the lighting intervention was removed, a third data collection (post-intervention assessment) was performed.
Results: The lighting intervention significantly increased circadian entrainment, as measured by phasor magnitude, and sleep efficiency, as measured by actigraphy data, and significantly reduced symptoms of depression in the participants with ADRD. The caregivers also exhibited an increase in circadian entrainment during the lighting intervention; a seasonal effect of greater sleep efficiency and longer sleep duration was also found for caregivers.
Conclusions: Ambient lighting interventions designed to increase daytime circadian stimulation can be used to increase sleep efficiency in persons with ADRD and their caregivers and may also be effective for other populations such as healthy older adults with sleep problems, adolescents, and veterans with traumatic brain injury.

Background

As Alzheimer disease and related dementia (ADRD) progresses, families are sometimes forced to move their loved ones from home to assisted living facilities or nursing homes. Often, the precipitating factor is disturbed sleep-wake cycles in which the person with ADRD is awake at night, causing tremendous stress and fatigue to family caregivers. These unpredictable wake episodes at night and associated wandering and disruptive behaviors tend to increase as ADRD progresses and are among the most prevalent reasons for institutional placement of persons with ADRD.[1]

Compared to normal older adults, persons with ADRD demonstrate lower sleep efficiency and more frequent arousals, with the severity of sleep disturbances paralleling progression of the disease.[2,3] Physiological studies have demonstrated fragmented circadian rhythms, phase delays, and diminished regularity of circadian temperature and hormonal cycles in persons with ADRD.[4,5] Several mechanisms have been postulated for these effects, such as degeneration of the retinal ganglion cells[6,7] and loss of functionality of the "biological clock" located in the suprachiasmatic nuclei.[8,9] Moreover, optical changes to the aging eye, particularly smaller pupils and denser lenses, reduce retinal illuminance by more than two-thirds relative to young adults. Exacerbating these neurologic and optical factors, persons with ADRD are often exposed to low light levels during the day.[10]

Light therapy has shown great promise as a nonpharmacological treatment to help regulate sleep and improve cognition in individuals with ADRD. Studies have demonstrated that daytime light exposure can consolidate sleep at night and increase nighttime sleep efficiency, while increasing daytime wakefulness and reducing evening agitation.[11-14] One landmark study showed that light can improve sleep

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as well as cognition.[15] Longer and better sleep during the night can reduce disruptive behaviors associated with ADRD and, by extension, have a positive impact on caregivers, both in institutions and at home.

Sleep-wake cycles respond differentially to the spectral power distributions of light. Human melatonin suppression (a marker of circadian phase) has a peak sensitivity to light close to 460 nm[16,17]; thus, light with relatively more energy at short wavelengths will be relatively more effective at affecting the circadian clock. Light sources typically used in eldercare facilities do not necessarily provide efficacious stimulation of the circadian system. Recently, it was shown that high correlated color temperature polychromatic light sources (bluish-white light) during daytime hours decreased depression and agitation scores in those with ADRD living in long-term care facilities.[18] The same lighting improved subjective and objective measures of sleep.

Not all of the studies to date showed positive results of light therapy for persons with ADRD. Colenda et al[19] did not see an effect of a light visor on sleep patterns, and Fontana Gasio et al[20] did not see an effect of a dawn simulator on circadian rhythm disturbances in persons with ADRD. Sloane et al[21] recently used a similar protocol to those employed by Figueiro et al[18] and did not show an effect of a tailored lighting system on measures of sleep and behavior of persons with ADRD, but there was a significant improvement in sleep quality in caregivers. The authors hypothesized that personal light exposures collected 1 day during the intervention period and 1 day during the control period showed that exposures during the intervention period, although higher than those experienced during the control period, did not seem to be high enough to elicit a biological response in this population.

A recent Cochrane review included 8 studies that met their criteria for inclusion in their review. The authors concluded that there is not enough evidence to justify the use of light therapy to improve sleep and behavior in persons with ADRD.[22] However, the authors analyzed studies that used a variety of light therapy approaches, and critically, it is uncertain how the actual light doses received by the study participants were measured or monitored. This is an important point to consider because, in studies where carefully controlled light stimulus was delivered, researchers, in fact, did find a positive impact of light on the sleep quality of persons with ADRD.[18,23]

The goal of the present study was to extend those by Figueiro et al[18] and Sloane et al[21] by investigating the effectiveness of a lighting intervention designed to increase circadian stimulation during the day using light sources that have high short-wavelength content and high light output. Based upon calculation,[24] the use of "bluish-white" light sources allowed us to reduce light levels to about one-third of those used in previous studies where "warm" light sources were used.

Participants and methods

Participant selection

Thirty-five participants with ADRD (9 females; mean age, 80.8 ± 7.9 years) and 34 caregivers (27 females; mean age, 71.8 ± 12.3 years) completed the study and had usable data. The participants with ADRD lived at home with their caregivers, except one who did not have a caregiver, and were diagnosed with mild to moderate ADRD based on National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer's Disease and Related Disorders Association criteria, categorized with a Clinical Dementia Rating of 1 to 2 (mild or moderate), and had a score from the Mini-Mental State Examination (MMSE) between 12 and 24. The control group consisted of the cohabitating, non-ADRD caregiver spouses or relatives of the participants with ADRD, who were also preassessed with the same clinical tools. Caregivers with an MMSE <24 were excluded. Once prequalified, dyads were accepted or excluded from the study using the following criteria: (1) Inclusion criteria: To be eligible for the study, physicians of potential participants must have confirmed a diagnosis of mild-moderate dementia based on the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* criteria and agreed that their patient was suitable for participation in the study. Participants with ADRD taking antidepressants were included, and the types of medicine and dosage intake were monitored. In each dyad, the caregiver lived in the same household and provided primary care for the participant with ADRD, and the household was located within a 20-mile radius of Case Western Reserve University main campus. There were no exclusions based on age, gender, race, or ethnicity. (2) Exclusion criteria for all participants with ADRD included major organ failure, major illness including psychiatric disorders, history of head injury, or uncontrolled generalized disorders such as hypertension or diabetes. Exclusion criteria also included sleep apnea, use of psychotropic (sleep aid) medicine, obstructing cataracts, macular degeneration, blindness, and caregiver cognitive impairment. If the caregiver did not provide informed consent, was not willing to participate in key aspects of the study protocol, was in unstable health (based on physician's report), was unable to communicate adequately with study staff, or had a MMSE score of <24, the dyad was excluded. Both members of the dyad received compensation for study participation. There were 2 seasonal data collection periods, "summer" and "winter." Participant dyads were eligible to participate in both periods. Many dyads declined this option citing family schedules, a household move, or illness.

All study materials and procedures were reviewed and approved by the Institutional Review Board at Rensselaer Polytechnic Institute, Louis Stokes Cleveland Veterans Affairs Medical Center, and University Hospitals Case Medical Center. Informed written consent was obtained from both members of the dyad after full explanation of the procedures, in accordance with the Helsinki Declaration of 1975.[25]

Methods

Field monitoring procedures

a. Daysimeter

The Daysimeter is a small device that continuously records personal light exposures (using red-green-blue solid-state photosensor package) and activity levels.[26] Each study participant wore a Daysimeter device as a pendant (at chest length) during waking hours and placed the device next to their bed during sleep. Participants were instructed not to cover the device with blankets, coats, or sweaters. Upon downloading, the red-green-blue values were converted into illuminance, circadian light (CL_A), and circadian stimulus (CS) levels. Briefly, illuminance is irradiance weighted by the photopic luminous efficiency function ($V(\lambda)$), an orthodox measure of the spectral sensitivity of the human fovea, peaking at 555 nm. CL_A is irradiance weighted by the spectral sensitivity of the retinal phototransduction mechanisms stimulating the response of the circadian clock, based on nocturnal melatonin suppression. CS is a transformation of CL_A into relative units from 0, the threshold for circadian system activation, to 0.7, response saturation, and is directly proportional to nocturnal melatonin suppression after 1 hour of exposure (0%-70%). A value of 0.7 is equivalent to exposure to approximately 2000 lux at the cornea, which is comparable to morning daylight exposure.

Rest-activity patterns are recorded from a 3-axis, monolithic solid-state accelerometer calibrated in g-force (1 g-force = 9.8