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Research & Practice on Aging Journal©
Volume 1, Number 2, 2012

THERAPEUTIC LIGHT AND SLEEPINESS AT MEALS IN WOMEN WITH ALZHEIMER'S DISEASE

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Abstract: *Objective:* The objective of this study was to determine the effect of therapeutic light on excessive daytime sleepiness (EDS) during meal times in females with Alzheimer's disease (AD) associated dementia. *Design:* The study employed a two-group experimental design with repeated measures on one of the factors. Participants were randomly assigned to either the experimental group receiving blue-green light (BGL) or the control group receiving dim red light (DRL). *Setting:* The study was conducted in a long-term care facilities where the study participants were residents. *Participants:* The sample consisted of 20 females mean age 85.9 (+ 6.24) with AD who were residents in a nursing home for at least six months. *Intervention:* Timed BGL at 12,000 lux was the experimental condition and timed DRL at 5 lux was the control condition. Light in both conditions was delivered for 30 minutes per day between 6 am - 7 am for 14 consecutive days. *Measurements:* EDS was measured using the Stanford Sleepiness Scale at mealtimes. *Results:* Reductions in EDS were' demonstrated in the experimental group post-intervention. *Conclusion:* Replication studies are needed to support pilot findings. Reducing EDS in AD has the potential to reduce weight loss and maintain nutrition.

Key words: Daytime sleepiness, dementia, cognition, light, diet.

Introduction

Alzheimer's disease is on the rise, and coupled with rising health care costs and shortages in the health care work force, makes the general investigation of modalities to maintain health and functional independence in the elderly vitally important (1). Interventions that could delay onset of AD or prevent disease progression have the potential to significantly impact overall economic, social, and public health costs (2).

Sleep disruption is a common circadian symptom in AD, and research has linked sleep loss with physiologic dysfunction, as well as declines in cognitive and global function. Chronic sleep loss (> 2 weeks) in healthy adults has been shown to diminish immune response and result in cognitive changes and an increase in mood disorders (3, 4).

Evidence exists that eating habits are circadian based (5). Nutrition in individuals with dementia is of paramount importance as dementia, and specifically AD, has been shown to alter metabolism and body mass composition (6). Individuals with dementia are at increased risk for malnutrition, which has been shown to increase with increased levels of cognitive impairment, and those with AD tend to weigh less and require more calories to maintain their weight (7, 8). Unintended weight loss in nursing home residents has been linked to increased muscle wasting, weakness, impaired immunity, depression, fatigue, disease complications (e.g., bed sores), reduced functional ability, and increased mortality (9-12).

Since women tend to live to ages at which AD is expressed at higher rates, and AD pathology has been shown to be clinically expressed at higher rates in women, they are at even higher risk for these adverse consequences than the general cohort of individuals with AD, including low muscle mass which has been associated with cognitive impairment in older women (13, 14). Maintaining cognitive function in women with AD has the potential to improve quality of life, delay institutionalization, and compress morbidity at the end of life.

The major objectives of the study were: (1) to examine the effects of timed blue-green light on the 24 hour sleep-wake pattern in females with AD, and (2) to explore the effects of timed blue-green light on EDS at meal times. The central hypothesis of this study is that timed blue-green light exposure, given at the appropriate time of day in females with AD will synchronize disorganized circadian sleep-wake rhythms, thereby resulting in phase advancement of the daily rest-activity pattern, increased sleep efficiency, decreased levels of sleep fragmentation, decreased levels of EDS, and improvements in global function. This paper presents results with respect to the

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Received November 2, 2010
Accepted for publication September 5, 2011

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portion of the study which focused on addressing the effect of therapeutic light on EDS at meals.

Light Effects on Excessive Daytime Sleepiness

Light therapy has been investigated for the management of sleep, behavioral, and mood disturbances in dementia. Several studies have examined light effect on daytime sleepiness as a result of correction in circadian dysfunction, with improvements in daytime sleepiness and number of naps (15-17).

In the current study, blue-green light was chosen for the experimental condition, because the physiologically effective wavelength for stimulation of melanopsin cells to shift circadian rhythm is thought to be the short wavelength light (~470-500nm) that comes from blue-green to blue light (18-20). Dim red light was used as control, since red light has been shown to have no significant effect on the circadian sleep system (21, 22). Dim red light was also employed in this study to control for placebo effects as well as for effects of research staff-patient interactions during the treatment sessions (21, 22).

Methods

Design, Sample, and Setting

The study utilized a two-group experimental design with repeated measures on one of the factors. Twenty female participants with AD were recruited from a population of nursing home residents, and randomly assigned to either the experimental group receiving blue-green light (BGL) or the control group receiving dim red light (DRL). Staff and families were blinded to the experimental and control condition.

Outcome Measure

Excessive daytime sleepiness (EDS) in this study is defined as a score on the Stanford Sleepiness Scale (SSS) greater than or equal to 6. A level of 6 (fighting sleep; woozy; prefers to be lying down) on the SSS is likely indicative of a state in which a participant is unable to take adequate oral input. The SSS is a Likert-type scale consisting of seven responses ranging from alert, wide awake, functioning with no problems (score of 1) to being in reverie having lost the fight to remain awake (score of 7). It is brief, straightforward, and has shown adequate reliability as a subjective measure of daytime sleepiness (23-25). While it is true that this measure has historically been utilized as a self-report tool for subjective levels of EDS, no measure exists to date that has been shown to accurately report subjective levels of EDS in patients with dementia who cannot self-report.

Procedure

The study consisted of five phases: screening and consent, collection of baseline data, the experimental-control condition, collection of post-test data, and collection of follow-up data at three additional time-points. The study commenced after receipt of Human Investigation Committee approval.

Phase 1. Upon referral by facility staff, the study was fully explained to potential participants and/or to their legal guardian. Consent was obtained, participants were screened, and if they met study inclusion criteria were randomized to experimental condition or control group.

Phase 2. Baseline data on sleep and were collected for 7 consecutive days on the facility-based participants via wrist actigraphy. Measures of EDS utilizing the SSS were collected at each meal during the 7 day baseline period.

Phase 3. Phase three was the intervention phase. Based on group assignment, participants received either timed blue-green light at 12,000 lux via cap visor (Physician Engineered Products, Fryeburg, ME) (experimental) or dim red light at 5 lux via cap visor (Physician Engineered Products, Fryeburg, ME) (control). Participants received light delivery as a collective group, and were monitored for side effects and visor position. Visors were equipped with 30 minute timers with an automatic light shut-off. Light was delivered for 30 minutes per day between 6-7 a.m. for 14 consecutive days.

Phase 4. Phase four involved collecting post-test data immediately following the intervention phase. Actigraphic measurements of sleep characteristics were collected for 5 consecutive days. Measures of EDS were collected for 5 consecutive days in the same fashion as during the baseline period.

Phase 5. Following the initial post-test data collection, three follow-up measurement periods occurred at 2-week intervals over the remaining 6 weeks of the study protocol. Actigraphic measurements of sleep characteristics were collected for 5 consecutive days at the end of each 2-week interval. Measures of daytime sleepiness at meals were collected for 5 consecutive days in the same fashion as during the baseline period at the end of each 2-week interval.

Data Analysis

Descriptive statistics including frequency distributions, percentage distributions, and means and standard deviations were used to describe the sample of female participants with dementia. Analysis of the raw 24 hour actigraphic data was performed by the program provided by the manufacturer (Ambulatory Monitoring, Inc., Ardsley, NY). Variables that were significantly correlated with the outcome measures for a given analysis were treated as covariates. To address the working hypotheses, multivariate repeated-measures analysis of variance and

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covariance was used to determine the changes in response variables within subjects, between subjects, and within-subjects-by-between-subjects interactions. To compare the difference in outcome variables from the baseline and subsequent treatments, the contrast and profile transformations in repeated-measures ANOVA were employed. For simultaneous testing of hypotheses, the Bonferroni method for controlling the overall error rate was used. Serial measures were designed into the study as a way to determine how long the effect of such a light intervention, if any, might last.

Results

Sample Characteristics

Data was obtained and analyzed for a total of 20 female participants with dementia. The mean age of the sample with dementia was 85.9 (SD+ 6.24) years. In terms of race, 18 (90%) were Caucasian, 1 (5%) was African American, and 1 (5%) was Hispanic. The level of dementia ranged from moderate to severe, and participants, on average, had severe dementia. The results on group comparisons with respect to possible confounders found that the Fisher's exact tests examining the drug classes, diagnostic categories, and demographic variables were all statistically nonsignificant except for the HMG CoA reductase inhibitors, commonly known as 'statins'. In the experimental group, 7 participants (35%) were prescribed statins versus only 1 (5%) of the control group.

Effect of Therapeutic Light on Excessive Daytime Sleepiness

The SSS was utilized as a measurement tool to quantify levels of daytime sleepiness in this cohort of individuals who could not self report. It should be noted that daytime sleepiness at breakfast (EDS-B) in the experimental group was higher at baseline than in the control. After light, EDS-B was significantly improved (p=.002) in the experimental group.

Daytime sleepiness at lunch (EDS-L) in the experimental and control groups were at similar levels at baseline, and the change in the experimental group was significantly improved post-intervention at lunch as well (p=.01).

Daytime sleepiness at dinner (EDS-D) in the experimental group was slightly, but not significantly higher from the control group at baseline. The reduction in EDS-D in the experimental group was significant post-intervention (p=.02).

Throughout the remainder of the study, changes in levels of EDS continued above baseline. EDS-B remained significantly reduced from baseline at 6 weeks (from baseline to follow-up Time 3), and EDS-D remained significantly reduced from baseline at 4 weeks (from baseline to follow-up Time 2). This may indicate that the effect of light on EDS at breakfast and dinner lasted to a significant degree for 4-6 weeks post light application.

Study limitations

This study had several limitations. The sample size of the study was small but given the minimal funding available, the decision was made to utilize a sample large enough to result in a power of .80 and an effect size of .35, but small enough to tightly control the methodology of the study (26). The wrist actigraph did not have the ability to monitor ambient light levels directly received by participants, therefore ambient light monitors were mounted in participants' rooms, and also used in the common areas. Baseline sleep efficiencies in the participants were higher than anticipated. While formal inter-rater reliability for the subjective measure of daytime sleepiness (the SSS) was not tested, scores were determined either through direct observation by the PI or through dialogue with facility staff in order to arrive at a score that staff agreed accurately reflected participants' level of sleepiness at each meal.

Discussion

The study findings are comparable to two studies published in the literature that examined the effect of bright light on EDS. Mishima and colleagues (15) delivered morning light at 3000-5000 lux for 28 consecutive days to 14 participants with dementia, and found a significant decrease in daytime sleepiness. Their study utilized hourly recordings by nursing staff in sleep diaries post-intervention to quantify EDS.

Kobayashi and colleagues (16) delivered one hour of light at 8,000 lux during lunch for 3 weeks to 10 participants with dementia, with nursing staff rating sleepiness according to the modified Matsubara Yamaguchi scale.

Our study utilized the SSS to quantify EDS. While this might be seen as a limitation, as the SSS was originally designed as self-report tool, it should be noted that it is a 7-point scale, thus more sensitive than the 3-point Matsubara Yamaguchi scale. Additionally, the measures of EDS in our study were made at specific consistent points during the day, making the comparison across time more meaningful than generalities of 'drowsiness in the morning' or 'drowsiness in the evening'.

Overall, a reduction in EDS was demonstrated in the experimental group post-intervention across all three mealtimes. This is possibly the result of more consolidated and less fragmented sleep that was observed which resulted in reduced levels of EDS. A reduction in EDS at mealtimes is significant in the

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Alzheimer's population for several reasons; in particular, mealtimes are a time of social interaction important for cognition as well as the time at which primary sources of nutrition are consumed.

The above findings, in addition to the finding that EDS was reduced at mealtimes in the experimental group that received blue-green light in this study, indicate this light intervention warrants further investigation as to its potential to reduce or prevent unintended weight loss, as well as maintain and or improve nutrition in this frail cohort requiring higher levels of energy consumption to maintain their weight.

Conflict of interest: None of the authors had a conflict of interest in relation to this manuscript.

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