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Functional Consequences of Light Treatment in Healthy Older Adults Living in Residential Facility

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Abstract

Aging is associated with sleep difficulties, including insomnia, lighter more fragmented sleep and advanced sleep phase. These sleep problems have been linked with fatigue, cognitive deficits, reduced Quality of Life (QoL), and increased health risks in the elderly. This study examined non-invasive light treatment administered in a residential group format to examine whether such a treatment paradigm is feasible and beneficial for sleep and daytime function. We conducted a randomized, placebo-controlled, 2x2 mixed study design. Seventeen healthy older adults [12F and 5M, 81.5(± 9.3) years, BMI 26.2(± 3.2)]. All participants underwent 5 consecutive days of 2 hours/day of "typical" light exposure (500-1000lux, 09.00-11.00) in a designated common room. They were then randomized to treatment (T; n=12; 3000-5000lux) or control (C; n=5; "treatment as usual": 500-1000lux) groups, and repeated the above protocol, with the respective light intensity. Participants wore actigraphs throughout the study and at the end of each exposure period, conducted a computerized neuropsychological battery and filled out questionnaires. We observed reduction in objective Sleep Onset Latency (SOL) in the T vs C. The improve in global cognitive and memory scores was greater in T vs C. In the environmental health-related QoL we found greater improvement in T vs C. Continuous morning light exposure seems to primarily affect cognitive functioning, specifically memory ability. Interestingly, participants also reported increased satisfaction with their environmental well-being, including their home environment and recreation. This innovative, non-invasive approach to light administration is feasible and may have wide-ranging applicability for older adults living in residential facilities.

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Introduction

Aging is associated with specific changes in sleep patterns, such as lengthening of sleep onset, sleep fragmentation, increases in time spent awake at night, and advances in sleep phase, often leading to shortened sleep duration, reduced sleep quality, and poorer sleep efficiency [1,2]. While multiple factors negatively affect sleep in older adults, one of the suggested main causes is lower daylight exposure, due to decreased in time spent outdoors, as well as decreases in blue light perception due to ophthalmic changes, such as cataract formation and retinal degeneration [3]. Moreover, light levels in nursing homes have been shown to be low and adding brighter light has been shown to decrease night time awakenings [4]. Insufficient or poor-quality sleep has been shown to have a detrimental effect on cognitive functions, and specifically memory consolidation in older adults [5]. Unfortunately, many older adults and their caregivers are led to believe that their sleep and cognitive problems is a natural part of aging and should be tolerated, rather than treated.

Lack of treatment for sleep or sleep-related cognitive difficulties, may be in part due to the scarcity of studies examining feasible, non-invasive pharmacological treatment options. We have found very few studies looking at non-pharmacological therapy for sleep disturbances in older adults. Wang et al examined the effect of music on sleep quality and found it to be effective, but there was no assessment of cognitive parameters [6]. Others assessed the effect of exercise such as thi-chi [7]. Again, no cognitive parameters were assessed. Cognitive behavioral therapy has been found to be effective for insomnia in the elderly [8,9]. But unfortunately, this type on intervention is often unavailable due to cost, time needed, need for patient cooperation with the treatment requirements and availability of coalified therapists.

Table 1: Demographic information for the study sample.

Age (years)	81.5 ± 9.3
Gender	12 women/5 men
BMI	Mean 26.2 (± 3.2).
Country of Birth	Europe (4) North America (10) Israel (1) Africa (1) Missing (1)
Mother-tongue	English (13) Hebrew (1) European Language (3)
Education	High School (3) Trade School (2) University (12)
Marital Status	Single (1) Married (8) Divorced/Separated (8)
Health Status (self-reported)	Excellent (2) Very Good (4) Good (11)

Hopikns et al. [10] described a light therapy intervention using blue light enriched room illumination in elderly living in care-homes. Their results showed that exposure to blue light was associated with a reduction in subjective (PSQI) and objective (sleep efficiency, total sleep time) sleep quality parameters [10].

The aim of this study was to examine the effects of a non-invasive group format behavioral treatment, i.e. light exposure, on sleep and cognitive performance on healthy, independent, older adults living on a residential facility. We hypothesize that the clinical light treatment group will show significant improvement in reported sleep quality, mood, and cognitive function.

Methods

Participants

Seventeen healthy older adults participated in the study (age range 62-92 years). All participants were recruited from the residential population, living at the Beit Tovei Hair residential facility, Jerusalem, Israel. Volunteers needed be in good health, aged sixty or above, and with at least 12 years of education to be eligible to participant in the study. Exclusion criteria included: high risk for sleep-related breathing disorders, periodic limb movements in sleep and/or restless leg syndrome; diagnosis of major depression or severe anxiety disorder, nicotine or alcohol use; body mass index > 25; any ocular condition which may interfere with bright light exposure (e.g. untreated glaucoma or macular degeneration; dementia; and any medical or psychiatric condition which, in the opinion of the study physician would pose a medical or psychological risk for the volunteer if she or he participated in the study. Given the visual modality of the stimulus and its presentation, anyone with non-correctable vision impairment was also be excluded.

The study was approved by Helsinki Committee of the Assuta Medical Center, Tel Aviv, and Israel. All participants provided written informed consent in their preferred language (English or Hebrew) prior to participation. Participants were provided a monetary compensation for the time and effort.

Protocol

Participants were recruited from the population living in the residential facility. Interested volunteers first met with a staff coordinator, during which information was collected on their general health and medication intake, psychological well-being, and sleep/wake habits (sleep routines, symptoms of sleep or circadian disorders, excessive daytime sleepiness, circadian phase, light exposure, and hypnotic use). Following the intake interview, eligible participants were randomized into the experimental/light treatment group or the placebo control group. They were also given a wrist –worn actigraph (Respironics, Model II, Philips Inc., Andover, MA, USA) and complementary daily sleep diaries and instructed on how to use them. An actigraph is small non-invasive wrist-worn device (looks like a small wrist watch) which allows for the objective evaluation of sleep/wake patterns, light exposure, and sleep/wake circadian rhythms in the natural environment. Actigraphs have been well-validated against the gold-standard polysomnographic approach and have the added benefit of allowing long-term non-invasive monitoring within the natural environment of the participant [11,12]. Actigraphs were worn for the duration of the study.

Participants underwent the protocol in groups of five to six persons. Once a group was formed, all participants underwent a five-day baseline period with sleep monitoring. In addition, each morning, from 09.00-11.00, the group engaged in specified group activities in a designated common room. Type of activities included art, reading, or social activities such as board or card games, but no exercise or physical activity. Light snacks and non-caffeinated drinks were also provided. During this baseline period, light exposure was maintained at the levels typical for the residential facility (between 500-1000lux).

Following the baseline visit, the placebo group (n=5) received a placebo treatment, i.e. a brief lesson (15min) and handout on how to maintain good sleep hygiene practices. In addition, they continued to meet from 09.00-11.00 each day for an additional five-day period while engaging in specified group activities (see above) in same designated common room. Light exposure was set at the same baseline levels, 500-800 lux. The active light treatment group (n=12; two groups of six persons) engaged in the same specified group activities, and received the same brief lesson/handout on good sleep hygiene practices and light snacks/drinks were provided again During the treatment period, the identified common room was lit using bright LED lamps with light exposure set at 3000-4000 lux.

At the end of the baseline period and the placebo/experimental period, participants administered either the English or Hebrew-version of a digitized neuropsychological test battery (Neurotrax™, Houston, TX, USA). This computerized assessment battery has a user-friendly interactive platform of tasks used for both clinical and research purposes. Tasks included encompass multiple cognitive domains, including attention, visual-spatial skills, verbal function, memory (verbal and non-verbal), executive function, information processing, and motor skills. Task instructions are very simple and do not require more than six years of schooling to comprehend. All tasks are administered in a fixed order by a trained research assistant and all responses are provided using the mouse or keyboard only. The Neurotrax™ battery has been extensively used and in geriatric populations [13].

Outcome parameters for each individual test include both raw and normed accuracy and Reaction Time (RT) data (per trial). The age, gender, and education normed data (relative to a large Neurotrax™

Table 2: Means (±SEM) for the Actigraphic sleep parameters: Sleep Onset Latency (SOL), Number of Nocturnal Awakenings (NOA), Wake after Sleep Onset (WASO), Total Sleep Time (TST), and Sleep Efficiency (SE). *p<0.05.

	Baseline Week	Manipulation Week
SOL- light	31.7 (28.0)	16.8* (15.3)
SOL- no light	24.5 (24.6)	68.2* (99.0)
NOA- light	2.5 (1.4)	2.2 (1.4)
NOA- no light	2.8 (0.7)	3.1 (1.1)
WASO- light	57.3 (45.3)	55.4 (52.8)
WASO- no light	76.3 (65.0)	84.5 (137.6)
TIB- light	7.5 (1.0)	7.4 (0.8)
TIB- no light	8.1 (0.8)	7.8 (1.2)
TST- light	6.4 (0.9)	6.6 (0.7)
TST- no light	5.9 (1.3)	5.9 (1.7)
SE- light	84.8 (12.4)	87.8 (9.4)
SE- no light	73.8 (18.1)	77.9 (24.6)

normative database) have a distribution with a mean of 100 and a standard deviation of 15. In order to examine overall performance, task-specific performance indices (accuracy/RT*100) provided by the software program, will used. The Neurotrax™ battery has been shown to have good validity and reliability and high test-retest reliability. The complete battery takes approximately 45 minutes to complete. Participants were administered the battery in their preferred language (English or Hebrew).

And the end of each baseline or placebo/treatment visit, participants filled out questionnaires on their mood (Profile of Mood States; POMS), sleep (Pittsburg Sleep Quality Index; PSQI), fatigue levels (Functional Assessment of Chronic Illness Therapy-Fatigue; FACIT-F), and health-related quality of life (World Health Organization Quality of Life questionnaire; WHOQOL-BREF) [14-17]. In addition, participants filled out a sleep diary each morning which included an alertness and sleepiness measure on a Likert scale.

Statistical analysis

A randomized, 2x2 factorial mixed study design with 2 condition of treatment (light/ no-light) and repeated measure of time (baseline/ manipulation). Two-tailed *P* values below 0.05 were considered significant. Statistical analyses were performed using SPSS version 22 (SPSS Inc., Chicago, IL, USA).

Results

Participants

Seventeen older adults participated in the study, of which 12 comprised the experimental group (with light exposure) and 5 the control group. Descriptive information on the study sample is listed in (Table 1).

Sleep

Sleep Onset Latency (SOL) was significant ($F_{(1,15)}$= 5.95 p<0.05), with the light exposure resulting in shorter SOL (from 31.7 min to 16.8 min) which was not observed in the control group (from 24.5 min to 68.2 min). No other main or interaction effects were found for the number of nocturnal awakenings, wake after sleep onset, total sleep time, or sleep efficiency (Table 2).

Self-reported mood, fatigue and alertness

We did not find any significant main or interaction effects on any the Profile of Mood States (POMS) scales, Functional Assessment of Chronic Illness Therapy-Fatigue (FACIT-F) scales or alertness level in the morning.

Table 3: Means (±SEM) for Health-Related Quality of Life (QOL) for the parameter's environment, physical health, psychological and social. *p<.05.

	Baseline Week	Manipulation Week
Environment- light	7.1 (0.6)	7.9* (0.4)
Environment- no light	8.6 (1.0)	7.8* (0.7)
Physical health- light	7.9 (0.5)	8.3 (0.3)
Physical health- no light	7.4 (0.7)	7.4 (0.5)
Psychological- light	25.8 (1.8)	27.6 (0.6)
Psychological- no light	27.6 (0.9)	28.2 (2.8)
Social- light	7.1 (0.6)	7.9 (0.4)
Social- no light	8.6 (1.0)	7.8 (0.7)

Table 4: Mean (±SEM) scores for cognitive performances parameters: Global, Memory, Attention, Visuospatial skills, Motor skills and Executive Functions. *p<.05.

	Baseline Week	Manipulation Week
Global - light	91.1 (2.3)	95.5* (2.3)
Global- no light	102.6 (3.6)	101.9* (3.5)
Memory- light	86.0 (3.6)	94.0* (2.9)
Memory- no light	102.9 (5.6)	98.1* (4.6)
Attention-light	92.0 (2.5)	102.0 (2.8)
Attention- no light	105.0 (3.8)	109.0 (4.3)
Visuospatial skills- light	95.8 (4.3)	92.4 (5.4)
Visuospatial skills- no light	99.8 (6.5)	93.4 (8.0)
Motor skills- light	89.9 (5.2)	93.2 (3.5)
Motor skills- no light	102.4 (8.3)	107.4 (5.6)
Executive Functions- light	92.8 (3.1)	99.7 (2.6)
Executive Functions- no light	105.5 (5.4)	105.0 (4.5)

Health-Related Quality of Life (WHO-QoL)

A main effect of time on environmental QoL was found, i.e. all participants reported lower environmental QOL from pre to post-treatment ($F_{(1,15)}$= 19.6; p<0.05). However, a significant treatment t*time interaction effect was also found, suggesting this reduction in QoL was milder in the light group that in the control group ($F_{(1,15)}$= 4.6; p<.05). No effects were found for physical, psychological, or social QoL (Table 3).

Cognitive Performance

Light improved global cognitive score and memory index score in the light compared to the control group (Table 4). Significant interaction effects were found for the global test score ($F_{(1,15)}$= 5.5), p<0.05) and the memory index score ($F_{(1,15)}$= 6.00 p<0.05), suggesting the light exposure improved overall cognitive ability and particular memory ability in the experimental group, when compared to the control group. A time effect on the global score ($F_{(1,15)}$= 2.9; p<0.05) and the memory index score ($F_{(1,15)}$= 4.72; p<0.05), was also found, reflecting that all groups performed better on these cognitive tasks on the second testing session, when compared to the first. No differences were found in any other cognitive domain index scores, including attention, executive function, visuospatial skills, and motor skills.

Discussion

Morning bright light exposure improved sleep initiation and overall cognitive ability scores, and specifically improved memory capacity in our sample of older healthy adults living independently in a residential facility.

The importance of light in the regulation of sleep-wake cycle is well-known. Elderly people living in the community and in nursing homes tend to spend most of the day indoors and thus are not sufficiently exposed to bright light, which is extremely important for maintaining their sleep, health, and overall well-being [4]. Moreover, increased awareness of bright light conditions in residential facilities and nursing homes can lead to changes in light exposure levels in the public areas in which habitants spend many of their waking hours. Such changes may greatly improve overall cognitive functioning and the well-being of this population. Non-pharmacological strategies to improve sleep problems in older populations have the added advantage of being non-invasive and tolerable, particularly given many elderly individuals already face problems associated with polypharmacy [18]. Moreover, light therapy, provided by changing ambient indoor light levels, requires no effort or action on the part of the older adult, increasing feasibility and treatment adherence.

This study results are promising however they are based on a limited number of subjects due to the stringent exclusion criteria we used. These preliminary results invite future studies based on a larger older adult population.

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