Functional Consequences of Light Treatment in Healthy Older Adults Living in a Residential Facility: A Naturalistic Study

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Background

- Light has a critical role in a range of physiological and circadian functions, including sleep, mood, cognition, and performance.

- Young adults in industrialized countries typically receive 20–120 min of daily light (>1000 lux) and older adults only 30-60% as much (Esperito et al., 1994; Savides et al, 1986; Hebert et al., 1998).

- Typical residential illuminance is too low for circadian and sleep needs, even in young adults (Turner et al., 2009).

- Even with normal visual acuity, aging leads to progressive loss of light transmission particularly for shorter (bluer) wavelengths, most valuable for circadian photoreception (Barker et al, FDA, 1991; Berson et al., 2002).

- Aging is associated with sleep and circadian difficulties, including insomnia, lighter, more fragmented sleep and advanced sleep phase.
Published outcome studies

- Individualized light therapy is effective in the treatment of sleep problems in the elderly, (van Maanen et al., 2016), however it is time-consuming, effortful, costly, and lacks sufficient dissemination.

- Brightly illuminated classrooms significantly improve student test performance (Nicklas et al., 1996), while lit workplaces increase office productivity and reduce absenteeism (Edwards et al., 2002).

- Institutionalized Alzheimer’s patients showed mild improvements in sleep and cognition with slightly higher residential illumination (1000 lux) for extended day (Riemersma-van der Lek et al., 2008).

- Methodological variability shows increasing light strength and exposure to short wavelength light may increase effectiveness of treatment in multiple functional areas (Turner et al, 2008).
Study Objective

• Few studies have examined the functional impact of ambient residential lighting in healthy elderly living in the community or in senior-living residences.

• We examined whether non-invasive, high intensity, light exposure (LED), administered in a residential group format is a feasible and beneficial treatment paradigm for sleep, cognition, mood, and daytime function in healthy older adults.

Hypotheses:

(1) Sleep initiation and continuity will show mild improvement in the light compared to control group.

(2) Irrespective of sleep improvement, high intensity illumination in the morning will independently and significantly improve cognitive performance, mood, and QoL measures.
Participants

Recruitment:
• Beit Tovei Hair Senior Living Facility, Jerusalem

Exclusion criteria:
• SDB, PLMS, and RLS
• BMI > 25
• Medium to high caffeine, nicotine, or alcohol use
• Ocular condition interfering with light reception (e.g. untreated glaucoma, cataracts, or macular degeneration)
• Medium to high depressive or anxiety symptoms or use of antidepressants/anxiolytics
• Moderate to high cognitive impairment
• Major medical conditions

<table>
<thead>
<tr>
<th>Gender</th>
<th>12 women/5 men</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Mean 81.5 (± 9.3) years (range 62-92)</td>
</tr>
<tr>
<td>BMI</td>
<td>Mean 26.2 (± 3.2)</td>
</tr>
<tr>
<td>Country of Birth</td>
<td>Europe (4), North America (10), Israel (1), Africa (1), Missing (1)</td>
</tr>
<tr>
<td>Mother-tongue</td>
<td>English (13), Hebrew (1), European Language (3)</td>
</tr>
<tr>
<td>Education</td>
<td>Elementary School (1), High School (1), Trade School (2), University (12), Missing (1)</td>
</tr>
<tr>
<td>Marital Status</td>
<td>Single (1), Married (8), Divorced/Separated (8)</td>
</tr>
<tr>
<td>Health Status (SR)</td>
<td>Excellent (2), Very Good (4), Good (11)</td>
</tr>
<tr>
<td>MMSE</td>
<td>27.6 (1.7) [range 24-29]</td>
</tr>
<tr>
<td>GDS</td>
<td>1.4 (1.6) [range 0-5]</td>
</tr>
<tr>
<td>PSQI</td>
<td>6.9 (4.0) [range 1-15]</td>
</tr>
</tbody>
</table>
Protocol

Baseline
N=17

Light Group
[3000-4000 lux]
n=12

No-light Group
[500-800 lux]
n=5

• 5 days of sleep monitoring
• 2h in common room (9-11am)
• Under regular light conditions
• Neuropsychological testing
• Mood and QOL measures

Measures:
• Sleep and alertness: Actigraphy and sleep diaries
• Fatigue: Functional Assessment of Chronic Illness Therapy-Fatigue (FACIT)
• Mood: Profile of Mood States (POMS)
• QoL: World Health Organization Quality of Life (WHQOL)
• Cognition: Neurotrax computerized test battery.
Results: Objective Sleep

- SOL
- TST
- WASO
- Num of awakenings
- SE
Results: Subjective Sleep & Fatigue

- **SLEEP QUALITY**
  - EXP: LIGHT: 3.8, NO LIGHT: 3.8
  - BL: LIGHT: 4.1, NO LIGHT: 3.8

- **FACIT TOT SCORE - Fatigue**
  - EXP: LIGHT decreases, NO LIGHT increases
  - BL: LIGHT decreases, NO LIGHT increases

- **MORNING ALERTNESS**
  - EXP: LIGHT increases, NO LIGHT decreases
  - BL: LIGHT increases, NO LIGHT decreases
Results: Mood & QOL

- No differences were found on any of the mood subscales: depression, tension, vigor, anger, confusion, or fatigue.

- The light group endorsed greater improvement in environmental QOL after light treatment ($p<.05$). No differences in social, psychological, or health QOL.
## Results: Cognitive Functioning

<table>
<thead>
<tr>
<th></th>
<th>Attention</th>
<th>Memory</th>
<th>Executive Functions</th>
<th>Visuo-spatial Skills</th>
<th>Motor Skills</th>
<th>Global Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BL</td>
<td>EXP</td>
<td>BL</td>
<td>EXP</td>
<td>BL</td>
<td>EXP</td>
</tr>
<tr>
<td><strong>Light</strong>*</td>
<td>92.0 (2.5)</td>
<td>102.0 (2.8)</td>
<td>86.0 (3.6)</td>
<td>93.7 (3.0)</td>
<td>92.8 (3.1)</td>
<td>99.7 (2.6)</td>
</tr>
<tr>
<td><strong>No-Light</strong>*</td>
<td>105.0 (3.8)</td>
<td>109.0 (4.3)</td>
<td>102.0 (5.6)</td>
<td>98.1 (4.6)</td>
<td>105.5 (5.4)</td>
<td>105.0 (4.5)</td>
</tr>
<tr>
<td><em>p</em></td>
<td>.36</td>
<td>.03</td>
<td>.22</td>
<td>.70</td>
<td>.83</td>
<td>.03</td>
</tr>
</tbody>
</table>

*Means ± SE of normed values (with a mean of 100 and SD of 15).*
## Results: Memory Abilities

<table>
<thead>
<tr>
<th></th>
<th>Light*</th>
<th></th>
<th>No-Light*</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BL</td>
<td>EXP</td>
<td>BL</td>
<td>EXP</td>
<td>p</td>
</tr>
<tr>
<td><strong>Repetition 1</strong></td>
<td>93.0 (4.2)</td>
<td>98.8 (4.5)</td>
<td>105.9 (6.3)</td>
<td>100.3 (6.6)</td>
<td>.16</td>
</tr>
<tr>
<td><strong>Repetition 2</strong></td>
<td>90.5 (4.4)</td>
<td>98.9 (4.0)</td>
<td>105.5 (6.7)</td>
<td>94.5 (5.9)</td>
<td>.03</td>
</tr>
<tr>
<td><strong>Repetition 3</strong></td>
<td>89.1 (4.4)</td>
<td>97.8 (4.3)</td>
<td>104.6 (6.6)</td>
<td>97.4 (6.4)</td>
<td>.02</td>
</tr>
<tr>
<td><strong>Repetition 4</strong></td>
<td>90.6 (4.9)</td>
<td>96.6 (4.6)</td>
<td>103.7 (7.2)</td>
<td>94.6 (6.8)</td>
<td>.03</td>
</tr>
<tr>
<td><strong>Total Accuracy</strong></td>
<td>89.8 (4.5)</td>
<td>98.2 (4.4)</td>
<td>105.2 (6.6)</td>
<td>96.3 (6.5)</td>
<td>.01</td>
</tr>
<tr>
<td><strong>Delayed Recall</strong></td>
<td>86.6 (4.3)</td>
<td>99.4 (3.6)</td>
<td>102.0 (6.4)</td>
<td>99.1 (5.3)</td>
<td>.11</td>
</tr>
<tr>
<td><strong>Repetition 1</strong></td>
<td>89.9 (6.3)</td>
<td>91.0 (5.1)</td>
<td>103.8 (10.4)</td>
<td>96.7 (8.5)</td>
<td>.49</td>
</tr>
<tr>
<td><strong>Repetition 2</strong></td>
<td>83.3 (6.1)</td>
<td>97.1 (4.5)</td>
<td>104.3 (10.1)</td>
<td>111.7 (7.5)</td>
<td>.64</td>
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<tr>
<td><strong>Repetition 3</strong></td>
<td>82.6 (5.3)</td>
<td>93.6 (4.2)</td>
<td>104.0 (8.8)</td>
<td>106.2 (6.9)</td>
<td>.40</td>
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<tr>
<td><strong>Repetition 4</strong></td>
<td>84.3 (5.0)</td>
<td>92.4 (3.8)</td>
<td>101.9 (8.3)</td>
<td>103.7 (6.2)</td>
<td>.46</td>
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<tr>
<td><strong>Total Accuracy</strong></td>
<td>83.0 (5.9)</td>
<td>93.1 (4.1)</td>
<td>104.4 (9.8)</td>
<td>105.5 (6.8)</td>
<td>.38</td>
</tr>
<tr>
<td><strong>Delayed Recall</strong></td>
<td>81.4 (6.1)</td>
<td>85.6 (4.5)</td>
<td>103.9 (11.2)</td>
<td>107.6 (8.1)</td>
<td>.97</td>
</tr>
</tbody>
</table>

*Means ± SE of normed values (with a mean of 100 and SD of 15).
Summary

• Environmental illumination plays an important role in human health.

• Morning light exposure above 3000lux improved sleep initiation and cognitive performance, particularly verbal memory ability.

• Although no mood effects were found, participants reported increased satisfaction with their environmental well-being, including their home environment and recreation.

• Residential illumination is a feasible, non-invasive, convenient, and cost-effective method that may have wide-ranging applicability and benefit on health and functioning of healthy older adults living in residential facilities.

• Future studies should examine effects of specific light wavelengths and differences between natural and artificial light.
Acknowledgments

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- The residents of Beit Tovei Hair