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A Systematic Review: Light Therapy for Individuals with Dementia and Implications for Practice

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INTRODUCTION

Sundowning describes an array of neuropsychiatric symptoms and is a common occurrence among individuals with dementia. The highest prevalence occurs in community-dwelling and institutionalized older adults (Canevelli et al., 2016; Gnanasekaran, 2015). During sundowning, symptoms such as confusion, agitation, and aggression typically emerge in the late afternoon when light exposure is diminished (Canevelli et al., 2016). A higher incidence of sundowning has been reported in individuals with advanced stages of dementia, as well as during the winter months when there is less sunlight (Canevelli et al., 2016). It is believed that sundowning hastens the progression of cognitive impairment and increases the rates of hospitalization, institutionalization, and caregiver burnout (Canevelli et al., 2016).

Sundowning has been recognized by medical professionals for over 70 years; yet, it is not included in the Diagnostic and Statistical Manual of Mental Disorders (DSM–5) (Gnanasekaran, 2015). Presently, there are no established guidelines for the management of symptoms associated with sundowning syndrome. Although pharmacological interventions have been used for treatment of sundowning, their effectiveness is limited and the risk of interacting with other medications is high (Gnanasekaran, 2015).

Non-pharmacological interventions, such as environmental modifications, have emerged as safer alternatives to medication; however, their efficacy is still unknown (Gnanasekaran, 2015). One of these emerging alternatives to traditional treatment is light therapy (Gnanasekaran, 2015). The effects of light therapy on sundowning have not been widely studied. Nevertheless, the limited research available has suggested its potential to improve symptoms (Gnanasekaran, 2015). This systematic review seeks to answer the question: is light therapy an effective intervention for sundowning symptoms experienced by individuals who have dementia?

TEXT BOX 1

Dementia: Overarching term that describes a group of symptoms related to cognitive impairment, a decline in memory, and decreased functioning.

Sundowning: Overarching term for neuropsychiatric symptoms (e.g. agitation, aggression, and confusion) that emerges in individuals with dementia due to lack of exposure to light (Canevelli et al., 2016).

Pharmacological: Medications and drugs used to treat illness.

Non-pharmacological: Alternative therapies to medications and drugs.

Light therapy: The treatment of medical or psychiatric conditions by the controlled application of light.

METHODS

A protocol was developed prior to conducting a comprehensive systematic review (Appendix A). The protocol is a step-by-step procedure to identify and appraise all relevant studies.

Identification of Relevant Studies:

A comprehensive and systematic search for relevant studies was conducted in February and March of 2019, using the following databases: PsychINFO, OT Search, OT Seeker, CINAHL,

Health & Medical Complete, Cochrane, and PubMed. The inclusion and exclusion criteria included: (1) quantitative study (2) published in English and (3) peer-reviewed. The search terms used, keyword combinations, and subject headings relative to each database can be found in the protocol (Table 3).

To be included in the systematic review, studies retrieved during the search met the following criteria: (1) population with a diagnosis of dementia, (2) light therapy used as the primary means of intervention, (3) the outcome measured at least one of three predetermined characteristics of sundowning (agitation, confusion, and aggression). Studies whose population had comorbid conditions causing memory loss (e.g. traumatic brain injuries or seizures) were excluded. Also excluded were articles that discussed other forms of light therapy not as defined in Text Box 1 (e.g. color therapy, heliotherapy, wave therapy, etc.). A complete list of inclusion and exclusion criteria was established in the protocol (Table 5).

A group of six reviewers and six research assistants independently assessed articles retrieved from the selected databases using the predetermined inclusion and exclusion criteria. The title and abstract of each study were screened by two reviewers to determine article eligibility. When a determination from these sections alone could not be reached, the full article was assessed. Following independent assessment, the two assigned reviewers compared their findings of each article and discussed and resolved any discrepancies until a consensus was reached. When necessary, a third reviewer was utilized to assist with resolving discrepancies between the two assigned reviewers. All the articles included or excluded were summarized in a flowchart (Figure 1).

Appraisal of Included Studies:
After all inclusion and exclusion criteria were applied and the authors came to a consensus there were 16 articles (Figure 1). In compliance with the protocol, two independent reviewers appraised each article to determine the quality of evidence (Text Box 2) by using predetermined, study design-specific criteria. Each pair of reviewers compared individual ratings of the quality of evidence for each study (Table 6). Discrepancies between reviewers were resolved through discussion until a consensus was reached. A third party reviewer was consulted when an agreement could not be agreed upon.

Collaboratively, the two reviewers compiled recorded findings into a descriptive table detailing nine categories: design type, quality of evidence, study population, intervention and sample size, outcomes, measurement tools, point estimate, clinical significance, and statistical significance (Table 7). Relevant statistical terminology is defined in Text Box 2. In cases with no reported clinical significance, a manual calculation of the minimally detectable difference (MDD) was performed when possible. Practice recommendations and clinical implications were generated from findings.

TEXT BOX 2:

Statistical Significance: A term indicating that the results of a study are unlikely to be the result of chance. (Portney & Watkins, 2009)

Level of Evidence: A ranking system used to show the strength of a study based on predetermined criteria.

Quality of Evidence: the degree to which the study being analyzed is deemed reliable.

Point Estimate: numerical data presented as mean scores with standard deviations.

Minimally Detectable Differences (MDD): the smallest amount of change that can be detected to reflect the true difference. (Portney & Watkins, 2009)

Minimally Clinically Important Difference (MCID): the smallest difference detected that the patient perceives to be beneficial. (Portney & Watkins, 2009)

RESULTS

The database searches retrieved a total of 701 articles. There were 16 articles that met pre-established inclusion criteria and were subsequently reviewed. The flowchart provides a detailed breakdown of the study identification process (Figure 1).

Of the analyzed studies, seven of the studies followed a quasi-experimental study design, involving the application of the intervention without random assignment of participants to conditions or orders of conditions. Two studies were single case research designs, where participants serve as their own control while also receiving the intervention. In this case, repeated measures are recorded at multiple phases: baseline, intervention, and follow-up or withdrawal. Seven studies were randomized control trials (RCTs), in which group allocation (control or intervention) was determined through a process of randomization. RCTs are considered level I evidence, one of the highest levels of evidence in intervention studies.

The level of evidence of the studies analyzed in this systematic review ranged from level I to IV with levels I and III being the most frequently represented. The quality of individual studies ranged from low to high and can be found on the quality of evidence table (Table 6). A total of 11 studies ranged from moderate to high-quality evidence, while five were found to be of low quality (Table 6). Four studies presented with high quality, meeting 70% or more of design specific criteria and seven studies presented with moderate quality ranging from 40% to 70% of criteria being met. Five articles were low quality, meeting less than 40% of design specific criteria (Table 6). The included studies measured at least one of three identified outcomes related to sundowning: (1) agitation, (2) aggression or (3) confusion.

Agitation

Of the 16 included studies, 15 evaluated the efficacy of light therapy when utilized as an intervention to treat agitation. In regards to level of evidence, five of these studies provided level I evidence, four provided level III, and four provided level IV (Table 6). The quality of evidence ranged from low to high. Four studies presented with low quality, six with moderate quality, and three with high quality (Table 6).

There were 10 outcome measures utilized to evaluate agitation across the 15 identified studies; with some studies utilizing more than one outcome measure to estimate agitation (Table 8). There were 10 studies that utilized six of the identified outcome measures and found light therapy to be effective in treating agitation ($p<0.05$; Table 8). Three studies, through three outcome measures, found no statistical significance and two studies which utilized the outcome measures of observation and the Confusion Rating Scale (CRS) did not provide information regarding statistical significance (Table 8).

In regards to clinical significance, 11 studies using eight outcome measures found no clinical significance when utilizing light therapy as an intervention to decrease agitation (Table 8). Two studies, which both utilized the *Cohen-Mansfield Agitation Inventory (CMAI)* as an outcome measure, found light therapy to be a clinically significant intervention and two studies did not provide information regarding clinical significance nor provide sufficient data for significance to be calculated by reviewers (Table 8).

Aggression

Five of the studies included in the systematic review evaluated the efficacy of light therapy for treating aggression. Two of these studies provided level I evidence, with one being high-quality evidence and one being low-quality evidence (Table 8). The remaining three studies provided low-quality, level III evidence (Table 8). There were six outcome measures utilized across the five identified studies which measured agitation (Table 8). Three studies, using four of the identified outcome measures among them, found light therapy to be effective in decreasing aggression ($p<0.05$; Table 8). One study, which utilized both the *Gedragsobservatieschaal voor Intramurale Psychogeriatrie (GIP)* and the *Social Dysfunction and Aggression Scale (SDAS-9)* as outcome measures for aggression, found mixed results in regard to statistical significance and one study did not provide information regarding statistical significance (Table 8).

In determining the clinical significance of utilizing light therapy as an intervention to decrease aggression, one study that utilized the *Behavioral Pathology in Alzheimer Disease Scale (BEHAVE-*

AD) as an outcome measure found clinical significance. Two studies found no clinical significance and one study did not provide information regarding clinical significance nor sufficient data for significance to be calculated by reviewers (Table 8). The remaining study which utilized both the *GIP* and *SDAS-9* to estimate aggression found no clinical significance among the results of the *GIP,* and did not provide information regarding clinical significance from the results of the *SDAS-9* (Table 8).

Confusion

Five out of the 16 included studies evaluated the efficacy of light therapy as an intervention to treat the sundowning symptoms of confusion. Three of these studies provided level I evidence, and two studies provided level IV evidence (Table 8). The quality of evidence among the five identified studies ranged from low to high. Two studies had high quality evidence, two studies had moderate quality evidence, and one study had low-quality evidence (Table 8).

Within the five relevant studies, there were five outcome measures utilized to evaluate confusion (Table 8). One study which utilized the *GIP* as an outcome measure, found light therapy to be effective in decreasing confusion ($p<0.05$; Table 8). Three studies found no statistical significance, and one study, which utilized the *CRS* to estimate confusion did not provide information regarding statistical significance (Table 8). In regards to clinical significance, two studies found light therapy to have clinically significant results in treating symptoms of confusion, while three studies did not (Table 8).

PRACTICE RECOMMENDATIONS

Agitation

There were 15 studies that met this systematic review inclusion criteria addressed the effectiveness of light therapy in the treatment of agitation. The level of evidence ranged from Level I to level III, with a preponderance of level I studies. Using a modified Grading of Recommendations Assessment, Development and Evaluation (GRADE) system, this outcome demonstrated low quality due to many of the studies yielding mixed results regarding clinical and statistical significance. As well as the individual studies having low quality of evidence regardless of level of evidence. Further research will most likely impact the reviewers' confidence in the estimate of effect and more organized and structured study designs with larger study populations are suggested for more evidence. (Guyatt et al, 2011).

Aggression

Five studies analyzed in this systematic review addressed the use of light therapy in reducing sundowning symptoms, specifically aggression. The level of evidence ranged from level I to level III with a preponderance of level III studies. Using a modified GRADES classification system, this outcome demonstrated low quality because only one of the six studies resulted in high quality of evidence (Guyatt et al, 2011). This indicates that further research will most likely impact confidence in the estimate of effect. Higher level studies with better quality levels are suggested in order to increase the validity and reliability of research evidence (Guyatt et al, 2011).

Confusion

Five of the 16 studies analyzed in this systematic review addressed the use of light therapy in reducing the sundowning symptoms related to confusion. A preponderance of these studies were RCTs, which are considered level I evidence. However, due to discrepancies in both the levels of quality of evidence and the clinical and statistical significance results, this outcome is considered of moderate quality based on the GRADES classification system (Guyatt et al, 2011). Further research is likely to have an impact on confidence in the estimate of effect. Rigorous study methods and designs are suggested for future studies with the expectation that improved research validity is produced.

CLINICAL IMPLICATIONS

The 16 included studies in this systematic review evaluated the efficacy of light therapy on sundowning symptoms in individuals with dementia. The three outcomes addressed—agitation, aggression, and confusion—were considered to have low and moderate quality based on the GRADES classification system (Guyatt et al, 2011).

Confusion was considered to have a moderate quality designation from the modified GRADES system which suggests that further research is necessary and may impact clinical understanding of light therapy and its effect on sundowning symptoms in the future. However, agitation and aggression were both found to have low-quality based on the GRADES classification system, which suggests that further research is necessary and will impact clinical understanding of light therapy and its effect on sundowning symptoms in the future.

This systematic review shows that currently, the preponderance of evidence provided in these studies had moderate to low clinical significance and p-values that demonstrated low statistical significance. The benefits of utilizing light therapy as an intervention to reduce sundowning symptoms are unclear. Clinicians must analyze each case, taking into consideration the cost and burden of specialized lighting equipment, as well as the lengthy administration time and supervision needed for the intervention. Although study limitations exist, utilizing bright light therapy to treat sundowning symptoms is an option that would be weakly recommended when addressing aggression, agitation, and confusion in individuals with dementia. This is due to the low to moderate clinical significance of the three outcomes analyzed. The significance of the outcomes were further limited by multiple lower level studies and limited sample sizes. Therefore, it is suggested that clinicians discuss the potential risks and benefits, as well as the unknown effectiveness, with clients and their families before implementing this intervention.

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Table 1

PICO question			
P - Individuals with dementia	**I -** Light therapy	**C -** * no comparison needed	**O –** Decreased sundowning behaviors

Table 2. List of the Databases to be Searched:

Databases Included in SR Search	Planned the Search		Will conduct the Search	
	Person 1	**Person 2**	**Person 1**	**Person 2**
PubMed	group	group	Amanda	Christine
Cinahl	Alyssa	Amanda	Christine	Vivian
PsychINFO	Christine	Erica	Elise	Amanda
OT Seeker	Vivian	Erica	Alyssa	Amanda
OT Search	Alyssa	Amanda	Christine	Elise
Health and Medical Complete	Vivian	Elise	Erica	Alyssa
Cochrane	Elise	Christine	Vivian	Erica

Table 3. List of Search Terms:

	Construct 1		Construct 2		Limits (if any)
Database	**Subject Headings**	**Keywords**	**Subject Headings**	**Keywords**	
Health and Medical Complete (ProQuest Thesaurus, NOT MeSH)	Dementia	Dementia (all subjects & indexing-SU), "neurocognitive dis*" (all subjects & indexing-SU), Alzheimer* (all subjects & indexing-SU) A cross search was run using keywords in all fields vs keywords in SU and the remaining results were irrelevant	Light therapy	Phototherapy, light therap*, light treatment *light treatment has to be utilized as a keyword for this database as it retrieves relevant results that are not included when searched without it	
PsycINFO	Dementia	Dementia, Alzheimer*, "Neurocognitive Dis*"	Phototherapy	Phototherapy, "Light therap*", "light treatment"- not included as it did not effect relevant	**Subject headings found in apa thesaurus**

				search results	
CINAHL	Dementia [MeSH] OR “neurocognitive disease [MeSH]”	Dementia OR “Neurocognitive dis”	Phototherapy [MeSH]	“Light Therap*” OR “Phototherap*”	
OT Seeker	**no subject headings recognized	“Neurodegenerative dis*” Alzheimer’s Dementia **-degenerative vs. -cognitive. -cognitive yields 0 results.	**no subject headings recognized	“Light therap*” ***Tried phototherapy, came up with 3 results, 2 of which were same as light therapy, one was irrelevant.	
OT Search	*This site does not utilize subject headings*	Dementia, Alzheimer, neurocognitive disease	*This site does not utilize subject headings*	Phototherapy OR light therapy *This site does not recognize truncation*	
Cochrane	**Not necessary to include subject heading as keyword search returns only 4 results (1 relevant)**	Dementia OR “neurocognitive disorder”	**Not necessary to include subject heading as keyword search returns only 4 results (1 relevant)**	“Light therapy” OR phototherapy	
PubMed	Dementia	Dementia, Neurocognitiv	Phototherapy	Phototherapy, light therap*	

		e disorder, Alzheimer*			

Note:

- **Cochrane Library:** Use search category "title, abstract, keywords"

Table 4. Boolean Sentence for each database:

Database Name	Boolean Sentence
PsycINFO	(IndexTermsFilt: "Phototherapy" OR Any Field: ***phototherapy*** OR Any Field: (***"light therap*")***)AND (IndexTermsFilt: "Dementia" OR ***Any Field: dementia*** OR Any Field: ***alzheimer**** OR Any Field: (***"neurocognitive dis*"***))
Health and Medical Complete	MAINSUBJECT.EXACT("Dementia") OR su(***"neurocognitive dis*"***) OR su(**dementia**) OR su(***"alzheimer*"***) AND (MAINSUBJECT.EXACT("Light therap*") OR ***Phototherapy*** OR ***"Light therapy"*** OR ***"Light treatment")***
CINAHL	**(**"Dementia [MeSH]**"** OR ***"Dementia*" OR*** ~~"Neurocognitive disease [MeSH]~~**"** OR **"Neurocognitive dis*") AND (**"Phototherapy [MeSH]**"** OR ***"Phototherapy*"*** OR ***"Light therap**")***
OT Seeker	**(Alzheimer's OR dementia) AND ("Light therapy") ***Tried phototherapy, came up with 3 results, 2 of which were same as light therapy, one was irrelevant.*****
OT Search (POWER SEARCH)	**("Dementia" OR "Alzheimer" OR "neurocognitive disease") AND ("light therapy" OR "phototherapy")**
Cochrane	***(Dementia*** OR "***neurocognitive disorder***") AND (***"Light therapy"*** OR ***Phototherapy)***
PubMed	("Dementia" [Mesh] OR ***Dementia*** OR ***"Neurocognitive disorder"*** OR ***Alzheimer****) AND ("Phototherapy" [Mesh] OR "light therap*" OR ***phototherapy***)

Table 5. Article inclusion and Exclusion Criteria

Inclusion Criteria			
Population	**Intervention and Comparison**	**Outcome**	**Other**
Dementia	Light therapy (The treatment of medical or psychiatric conditions by the controlled application of light.)	Sundowning behavior	Peer Reviewed English Quantitative studies
Any type of dementia		Must have at least 1 of 3 characteristics of sundowning (agitation, confusion, and aggression)	
All races, ethnicities, genders, socioeconomic statuses			
Any stage of dementia			
Exclusion Criteria			
Population	**Intervention and Comparison**	**Outcome**	**Other**
Not memory loss due to other conditions ex. TBI or seizures	Not color therapy		
	Not heliotherapy		
	Not wave therapy		
	Not low-level light therapy		

	(Defined as Low-level laser therapy is a form of alternative medicine that applies low-level lasers or light-emitting diodes to the surface of or in orifices of the body)		

Table 6. Quality of Evidence Worksheet

		Quality Criteria											
Citation	Type of design	1	2	3	4	5	6	7	8	9	10	Quality Level	Evidence Level
Ancoli et al., 2003	3	1	0	1	1	0	0	0	0	1	0	Moderate	1
Barrick, A. L., et al., 2010	6	0	1	1	0	0	1	0	1	n/a	n/a	Moderate	3
Burns et al. 2009	3	1	0	1	1	1	1	1	1	1	0	High	1
Dowling, Graf, Hubbard, & Luxenberg, 2007	3	1	0	1	1	0	1	0	1	1	1	High	1
Figueiro et al., 2014	6	0	1	0	0	1	0	0	0	n/a	n/a	Low	3
Haffmans et al., 2001	3	0	0	0	1	1	0	1	0	1	0	Moderate	1
Lovell et al., 1995	7	1	1	1	1	0	1	1	1	n/a	n/a	High	4
Lyketsos et al., 1999	3	0	0	1	1	1	0	0	0	1	0	Moderate	1
Munch et al., 2017	5	0	1	1	0	0	0	1	1	0	1	Moderate	2
Onega, Pierce & Epperly, 2016	3	0	0	0	1	1	0	1	1	1	0	Moderate	1
Riemersma et al., 2008	3	1	1	0	1	1	1	1	1	0	0	High	1
Satlin, et al, 1992	6	0	1	0	0	0	0	1	0	n/a	n/a	Low	3

Schindler, et al, 2002	7	0	1	0	0	0	0	0	1	n/a	n/a	Low	4
Skjerve et al., 2004	6	0	1	0	0	1	1	0	0	n/a	n/a	Low	3
Thorpe et al., 2000	6	0	0	0	0	1	1	0	0	n/a	n/a	Low	3
Wahnschaffe et al., 2017	7	0	1	1	1	0	0	0	1	n/a	n/a	Moderate	4

Table 7. Study Description Table

Study	Design Type	# of Criteria met/ Quality Level	Population (including age)	Intervention/ Comparisons/ N in each group	Outcome(s)	Measurement (include units & direction of differences)	Point estimate (Means & SD)	Clinical Significance	Statistical significance
Ancoli et al., 2003	RCT	4/10 Moderate	Dx: Dementia Age:61-99	10 days of Tx; Apollo Brite Light Boxes for 2 hours a day Morning Bright Light (n=10) vs Dim Red Light (n=31) vs Evening Bright Light (n=31)	1.Agitation (observed) 2. Perceived level of agitation	1. ABRS (observation); reported in mean scores as well as average amount of time; ↓=better 2. CMAI (Nursing Staff report) ↓=better	**1. ABRS verbal agitation morning shift** Baseline= 0.24 (0.61) days 1-5= 0.19 (0.55) days 6-10= 0.18 (0.55) follow-up= 0.15 (0.47) **ABRS verbal agitation evening shift:** Baseline= 0.26 (0.61) days 1-5= 0.26 (0.64) days 6-10= 0.27 (0.63) follow-up= 0.25 (0.61) **ABRS Physical agitation (hours):** Morning Bright Light: baseline= 12:51(4:03) days 1-5= 14:52 (2:47) days 6-10= 14:47 (3:36) follow-up = 13:36 (4:12) **2. *No tables provided with CMAI means or S.D**	1. MDD for ABRS verbal agitation morning shift: 0.305 > -0.09; N.S MDD for ABRS verbal agitation evening shift: 0.305 > 0.01; N.S MDD for ABRS physical agitation (mins): 121.5 > 116; N.S 2. CMAI: Unable to be calculated	**1. ABRS:** -Verbal Agitation decrease during the morning shift (overall) (p= 0.023); -Verbal agitation during evening shift (evening bright light group) (p =0.011) **2. CMAI:** -Subscales in agitation ratings baseline to Tax dys 6–10 (p= 0.008) (all groups) -Physical Agitation (p= 0.007) -Verbal Agitation (p= 0.001) -Total Agitation (p= 0.0004) -Overall effect of nursing staff shift (p= 0.0001) -N.S among treatment groups between (p= 0.993) or within (p= 0.46) nursing shifts.
Barrick et al., 2010	Quasi-Experimental	4/8 Moderate	Dx: Dementia Age: 65+	4 BLT conditions: - AM BLT (7-11AM) - PM BLT (4-8PM) - All Day BLT (7AM-8PM) - Standard Light (baseline) Total n=66 (North Carolina n= 46; Oregon n= 20).	1. Agitation 2. Agitation	1. CMAI, 29-item, scale of 1–7, ↓=better 2. Staff observed agitation; 8 agitated behaviors	**Odds Ratio [CI]** **1.** AM vs Standard 0.89 [-0.64,2.41] PM vs Standard 0.56 [-1.06,2.18] All Day vs Standard -1.53 [-3.14,0.08] AM vs PM light 0.32 [-1.24, 1.88] AM vs All Day 2.41 [0.93,3.89] PM vs All Day 2.09 [0.44,3.73] **2.** **Mild to Moderate Dementia** AM vs Standard 1.57 [1.18,2.08] PM vs standard 1.90 [1.42,2.55] All Day vs Standard 1.63 [1.22,2.18] AM vs PM 0.82 [0.64, 1.07] AM vs All Day 0.96 [0.74, 1.24] PM vs All Day 1.17 [0.90, 1.52] **Severe/Very Severe Dementia**	**1.** CI confirms **AM and PM light** ↓ agitation **compared to standard light.** **All day vs standard:** CI confirms **all day light** ↑ agitation.. **AM vs PM:** CI confirms **AM light** ↓ agitation. CI confirms **AM and PM light** ↑ agitation **compared to All day light**. **2. Mild to Mod Dementia:** CI confirms **AM light, PM light, and All day light** ↑ agitation **compared to standard light**. **AM vs PM:** CI confirms AM light ↓ agitation. **AM vs All Day:** CI confirms AM	1. Staff reported CMAI NC -AM compared with All Day p < .002) -PM compared with All Day light p = 0.013 - All Day compared with Standard light p = 0.064) - staff on the day shift p = 0.021 - night shifts p = 0.036) Staff reported CMAI OR - All Day compared with AM light (1.63 points, p = 0.030) 2. Observed agitation - AM light (p = 0.003) - PM light (p = <0.001) - All Day light (p = 0.001) - Severely demented participants AM light 0.055 - Agitation ↑ for all participants under all four conditions p =
							Am vs Standard 1.22 [1.00,1.49] PM vs Standard 1.11 [0.90,1.36] All Day vs Standard 1.05 [0.86, 1.29] AM vs PM 1.10 [0.90,1.34] AM vs All day 1.16 [0.95,1.42] PM vs All Day 1.06 [0.86,1.29]	light ↓ agitation. **PM vs All Day:** CI confirms PM light ↑ agitation. **Severe/Very Severe Dementia:** **AM vs Standard:** CI confirms AM light ↑ agitation; CI confirms **PM light and All day light** ↓ agitation **compared to standard light.** **AM vs PM:** CI confirms AM light ↓ agitation. CI confirms that **AM light and PM light** ↓ agitation **compared to All day light**.	<0.001
Burns et al., 2009	RCT	8/10 High	Dx: Dementia Mean Age: 83.5	BLT (Light box, 10000 lux); n=22 Vs. Standard light tube box (100 lux); n=26	1. Agitation 2. Psychopathology in Dementia 3. Agitated Behaviors	1. CMAI, 29-item scale of 1–7, ↓=better 2. MOUSEPAD, 59 items, 4 point scale, ↓=better 3. CRBRS 5 point scale, ↓=better.	1. CMAI: Week 0 t= -1.0 Week 4: F=.5 Week 8: F=0.3 2. MOUSEPAD Week 0: t= -0.03 Week 4: F=0.01 Week 8: F=0.4 3. CRBRS total Week 0: t=0.7 Week 4: F=5.1 Week 8: F=0.2	**1. CMAI:** 49.5 - 62.0 = -12.5 -12.5 < ½ SD; N.S **2. MOUSEPAD:** 8.0 - 13.5 = -5.5 -5.5 < ½ SD; N.S **3. CRBRS:** 4.8 - 10.1 = -5.3 -5.3 < ½ SD; N.S	1. CMAI: Week 0 :p=.34 Week 4 p=.51 Week 8 p=0.56 2. MOUSEPAD Week 0 p=0.98 Week 4 P=0.97 Week 8 P=0.51 3. CRBRS total Week 0: p=0.52 Week 4: p=0.029 Week 8: p=0.51
Dowling, Graf, Hubbard, & Luxenberg, 2007	RCT	7/10 High	Dx: Alzheimer's Disease Mean Age: 84 (SD=10, range=58-98).	BLT vs Typical light in long-term care facilities Morning light group (n=29) Afternoon light group (n=24) Control group (n=17)	1. Agitation/ aggression, depression/ dysphoria, aberrant motor behavior, appetite/eating disorders	1. NPI-NH, 12 items, ↓=better	**1. Baseline measurements of all 12 behaviors measured by the NPI-NH:** Mean(SD): • Morning group: 29.4(20.7) • Afternoon group: 27.0(15.7) • Control group: 24.1(15.8) **End of intervention of all 12 behaviors measured by the NPI-NH:** Mean (SD): • Morning group: 26.3(13.9) • Afternoon group: 27.5 (16.5) • Control group: 19.6 (10.8)	**1. NPI-NH:** **Domain Total:** • Morning: 26.3 - 29.4 = -3.1 -3.1 < ½ SD; N.S • Afternoon: 27.5 - 27.0 = 0.5 0.5 < ½ SD; N.S **Disruptiveness:** • Morning: 7.2 - 8.7 = -1.5 -1.5 < ½ SD; N.S • Afternoon: 7.2 - 6.5 = 0.7 0.7 < ½ SD; N.S	1. Behavior/ Symptoms: **Baseline:** • Hallucinations (r=0.59, p<.05) • Agitation/ aggression (r=0.47,p<.05) • Anxiety (r=0.50, p<.05) • Disinhibition (r=0.53, p<.05) • Irritability/ Lability (r=0.40, p<.05) **End of intervention:** • Delusions (r=0.46,p<0.5) • Agitation/ Aggression (r=0.45, p<.05)

									• Anxiety (r=0.45, p<.05) • Aberrant motor behavior (r=0.48, p<.05)
Figueiro et al., 2014	Quasi-Experimental	2/8 Low	Dx: Dementia Mean Age: 86.9 (±4.4 yrs)	Light therapy; 300-400 lux; 8-10 hours per day for 4 wks n=14	1. Depression 2. Agitation	1.CSDD , 19-item tool. ↓=better 2. CMAI, 29-item, scale of 1–7, ↓=better	1. CSDD: Mean(SD) 0: 12.0(±1.5) 4: 6.0(±1.6) 8: 9.0(±2.0) 2. CMAI: Mean(SD) 0: 38.2(±2.8) 4: 31.2(±0.7) 8: 32.3(±1.1)	1. CSDD 9-12=-3>½ SD; CS 2. CMAI 32.3-38.2=-5.9<½ SD; N.S	1. CSDD: p=0.03 2. CMAI: B/w base and inter p=0.037 B/w base and post p=0.03
Haffmans et al., 2001	RCT	4/10 Moderate	Dx: Dementia Mean Age: 72.1	BLT & Melatonin Vs. BLT & Placebo n=10 (5 per group)	1. Motor restless behavior 2. Social, psychomotor and emotional behavior (This is confusion too) 3. Extrovert aggression	1. CGI; 7pt observation scale; ↓=better 2.GIP; 14 subscales; ↓=better 3. SDAS-9; 9 item observation scale; ↓=better	**BLT + Placebo** Before therapy: 1. CGI motor= 5.0 (1.3) 2. GIP 10 item 3= 2.9 (0.8) GIP 10 item 5= 2.6 (0.7) After therapy: 1. CGI motor= 3.7 (1.3) 2. GIP 10 item 3= 1.9 (0.5) GIP 10 item 5= 1.5 (0.8) 3. SDAS= not provided **BLT +melatonin** Before therapy: 1. CGI motor= 4.4 (0.9) 2. GIP 10 item 3= 2.1 (0.4) GIP 10 item 5= 1.8 (0.9) After therapy: 1. CGI motor= 4.1 (0.7) 2. GIP 10 item 3= 2.0 (0.0) GIP 10 item 5= 1.3 (0.5) 3. SDAS= not provided	1. MDD for CGI: BLT/Placebo: 0.65 > -1.3; N.S 2. MDD for GIP • subscale 10 item 3: 0.4 > -1.0; N.S • subscale 10 item 5: 0.35 > -1.1; N.S 3. SDAS unable to be calculated	**1. CGI:** BLT/Placebo- p= 0.049 BLT/Melatonin- N.S **2. GIP (subscale 10 item 3):** BLT/Placebo- p= 0.007 **GIP (subscale 10 item 5):** BLT/Placebo- p= 0.01 BLT/Melatonin- N.S **3. SDAS-9:** N.S (in either group)
Lovell et al., 1995	Single Case Design	7/8 High	Dx: Dementia Mean Age : 89.2	Light (2500 lx) administered for 2 hrs. in morning for two l0-day periods. n= 6	1.Agitation	1. ABRS 0=none 1= mild 2= moderate 3=severe	1. A=Baseline Mean: 20.03(13.90) B=Treatment Mean: 10.53(5.91 C =Post-treatment Mean: 16.98(8.85) D= Baseline Mean: 19.83(6.11) E= Treatment Mean: 8.90(6.05) F =Posttreatment Mean: 21.40(16.73)	1. ABRS: C-A: 16.98 - 20.03 = -3.05 (MDD) 3.05 = 1/2SD N.S F-D: 21.40 - 19.83 = 1.57 (MDD) 1.57 < 1/2SD N.S	1. ABRS: A vs B: P <0.05 B vs C: NS D vs E: P <0.025 E vs F: P < 0.001 B and E vs C and F: P < 0.001
Lyketsos et al., 1999	RCT	4/10 Moderate	Dx: Dementia Mean age: 80.8 (SD 8.7)	Morning BLT vs Dim Light (control group) Total: n=15 (not listed per group)	1. Nocturnal Sleep 2. Agitated behavior 3. Mood	1. Sleep Log; mean hours of sleep; é= better 2. Behave-AD; 30 item questionnaire; ↓=better 3. CSDD; 19 item scale; ↓=better	**2. Behave AD:** BLT: Baseline: 14.9 (SD 3.83) Week 2: 13.1 (SD 6.09) Week 4: 12.6 (SD 4.79) Dim light (Control): Baseline: 13.7 (SD 3.49) Week 2: 13.5 (SD 6.28) Week 4: 10.7 (SD 4.85) **3. CSDD:** No mean scores or SD provided	2. MDD for Behave-AD: 1.49 > -2.3; N.S 3. CSDD: Unable to be calculated	2. Behave-AD: (p> 0.05); N.S 3. CSDD: (p> 0.05); N.S
Munch et al., 2017	Quasi-Experimental	5/10 Moderate	Dx: Dementia Mean Age :78.4 (SD= ± 9 ; Range =55-95)	Dynamic BLT High light group (n=44; 17 men and 27 women) Low light group (n=45; 14 men and 31 women)	1. Emotions 2. Agitation 3. Quality of life 4. Melatonin secretions 5. Circardian rest-activity cycles	1. S-MMSE (0-30 points; ↑=+) 2. CADS (Maximum score of 48 points; ↑=+) 3. CMAI (Maximum score of 203 points; ↓=+) 4. QUALID (Maximum score of 55 points; ↓=+) 5. OERS (↓=+) 6. Activity watch worn on wrist 7. Saliva samples to measure circadian phase	**1. S-MMSE:** • Low light group= 7.8 ± 9.9; • High light group = 9.7 ± 10.6; 2. **CADS (baseline)** • Men = 26.1 ± 8.8; • Women = 20.9 ± 7.5) 3. **CMAI (baseline)** • Men = 55.5 ± 16.0; • Women = 46.3 ± 10.9; 4. **QUALID** • ↑ scores in high light group (low light group = 53.8% ± 10.9%; high light group = 58.1% ± 11.0) 5. **OERS** • low light group = 4.5 ± 0.6 min; • high light group = 4.7 ± 0.5 min 6. **Activity Monitor** • Men in high light group had > activity than women in high light group during 5 hour period (men = 20:36 ± 04:32; and women = 23:09 ± 03:59;) **7. Saliva Samples** • No conclusive result	**1. S-MMSE:** • **MDD:** Low light group: 8.8-7.8=1; 1 < ½ SD High light group: 8.8-9.7=-0.9; -0.9 < ½ SD Men: 1.6-7.8=3.8 3.8 < ½ SD Women: 7.3-7.8=-0.5 -0.5 < ½ SD *Results are CS **2. CADS:** Unable to be calculated (no post-measurements provided) 3. **CMAI** Unable to be calculated (no post-measurements provided) 4. **QUALID** Unable to be calculated (no post-measurements provided) 5. **OERS** Unable to be calculated (no post-measurements provided)	**1. S-MMSE:** • Comparable scores b/w high light and low light groups (p=0.3) 2. **CADS** • ↑ scores for men vs. women (p=0.02) • Men in high light group more independent than women in high light group (p=0.005) 3. **CMAI** • ↑ agitation scores for men vs. women (p=0.006); no significant difference b/w lighting groups 4. **QUALID** • ↑ in high light group vs. low light group (p<0.05) 5. **OERS** • ↑ scores for pleasure (p=0.037) and general alertness (p=0.004) in high light group 6. **Activity Monitor** • Men in high light group had ↑ activity than women in high light group (p<0.05)

Onega, Pierce & Epperly, 2016	RCT	5/10 Moderate	Dx: Dementia Mean Age: 82.6 (SD=9.60)	BLT n=30, low light (placebo) n=30	Agitation	**1.** CMAI-F; 29 items rated on scale 1-7; ↓=better 2. CMAI-D; 29 items rated on scale 1-5; ↓=better 3. PAS; 4 items with 5 response choices; ↓=better 4. BARS; 10 items with 4 response choices; ↓=better	**Pre-Intervention** BLT: 1. CMAI-F: 54.00 (19.78) 2. CMAI-D: 43.93 (14.89) 3. PAS: 4.57 (3.93) 4. BARS: 7.17 (4.83) Placebo: 1. CMAI-F: 42.27 (14.28) 2. CMAI-D: 34.20 (10.40) 3. PAS: 2.27 (3.26) 4. BARS: 4.00 (3.86) **Post-Intervention** BLT: 1. CMAI-F: 41.17 (13.78) 2. CMAI-D: 34.17 (7.88) 3. PAS: 1.30 (1.91) 4. BARS: 3.53 (3.83) Placebo: 1. CMAI-F: 49.83 (21.65) 2. CMAI-D: 41.23 (14.26) 3. PAS: 3.03 (4.77) 4. BARS: 6.83 (6.17)	**1. CMAI-F:** η2 = 0.056; medium effect **2. CMAI-D:** η2 =0.067; medium effect **3. PAS:** η2 = 0.128; medium effect **4. BARS:** η2 = 0.096; medium effect	1. CMAI-F: p = 0.069 2. CMAI-D: p = 0.046 3. PAS: p = 0.005 4. BARS: p = 0.016
Riemersma et al., 2008	RCT	7/10 High	Dx: Dementia Mean Age: 85.8 (SD= +/--5.8)	Long term daily treatment of whole day bright (1000 lux) or dim (300 lux) light and participant to placebo or evening melatonin (2.5mg) Active 6 facilities n=98 Placebo 6 facilities n=91	Bright light only (n=49) Bright light plus melatonin (n=49) Melatonin Only (n=46) Placebo (n=45)	1. CSDD (range 38-0, cutoff 8 minor and 12 major) 2. NPI-Q severity (range 36-0) 3. NPI-Q distress (range, 60-0) 4.CMAI (range, 203-0)	**Mean (SD)** 1.CSDD a. Light 7.4 (6.9) b. Melatonin 7.0 (5.5) c. LxM 7.8 (5.4) d. None 7.6 (5.1) 2. NPI-Q severity e. Light 4.3 (4.4) f. Melatonin 5.7 (5.2) g. L x M 3.9 (5.0) h. None 5.2 (5.5) i. 3. NPI-Q distress a. Light 4.8 (5.5) b. Melatonin 5.6 (6.8) c. LxM4.4 (6.0) d. None 4.8 (6.3) 4. CMAI a. Light 45 (13) b. Melatonin 48 (17) c. LxM 44 (15) d. None 45 (18)	**Confidence Interval** 1. 3.5 year follow up Light -1.47 **Not CS** Melatonin -0.82 **CS** L x M -0.94 **CS** 1.5 year follow up Light-1.76 **Not CS** Melatonin -0.73 **CS** L x M -1.01 **Not CS** 2. 3.5 year follow up Light 0.23 **CS** Melatonin -0.41 **CS** L x M -0.36 **CS** 1.5 year follow up Light 0.06 **CS** Melatonin -0.54 **CS** L x M -0.42 **CS**	1. CSDD a. 3.5 year follow up i. light : p-value.02 ii. Melatonin p-value .12 iii. LxM .24 b. 1.5 year follow up i. Light: p-value .01 ii. Melatonin p-value .18 iii. LxM p-value .20 2. NPI-Q Severity a. 3.5 year follow up i. light : p-value .41 ii. Melatonin p-value .52 iii. LxM .77 b. 1.5 year follow up i. Light: p-value .90 ii. Melatonin p-value .20 iii. LxM p-value .45 3. NPI -Q Distress a. 3.5 year follow up i. light : p-value .18 ii. Melatonin p-value .32 iii. LxM .80 b. 1.5 year follow up i. Light: p-value .85 ii. Melatonin p-value .15 iii. LxM p-value .41 4. CMAI a. 3.5 year follow up
								3. 3.5 year follow up Light 0.25 **CS** Melatonin -0.41 **CS** LxM -0.56 **CS** 1.5 year follow up Light 0.11 **CS** Melatonin -0.72 **CS** LxM -0.54 **CS** 4. 3.5 year follow up light -1.61 **Not CS** Melatonin 1.28 **Not CS** LxM -3.90 **Not CS** 1.5 year follow up Light -1.85 **Not CS** Melatonin 1.40 **Not CS** LxM -3.83 **Not CS**	i. light : p-value .33 ii. Melatonin p-value .44 iii. LxM .01 b. 1.5 year follow up i. Light: p-value .26 ii. Melatonin p-value .41 iii. LxM p-value .01
Satlin, Volicer, Ross, Herz & Campbell, 1992	Quasi-Experimental	2/8 Low	Dx: Dementia Mean Age: 70.1, (SD=5.1)	BLT 2 hour a day (7:00pm to 9:00pm) 1500-2000 lux for one week n=10 (9 males, 1 female) no control group	↑ in sleep-wakefulness; ↓ in severity of sundowning;	• Daily ratings (3x/day) by nurses(0-3 scale for agitation and sleep-wakefulness; ↑ = more severe) • Use of restraints (0-2 scale; ↑ = more restraints) • Medication administration (0-2 scale; ↑ = more medication) • Locomotor activity (measured by activity monitor)	**Group Activity Data** 1.Nocturnal Activity -Week 1: mean=18.4; SD=7.9 -Week 2: mean=11.6; SD=6.6 -Week 3: mean=17.1; SD=11.2 2. Interdaily Stability -Week 1: mean=0.68; SD=0.17 -Week 2: mean: 0.71; SD=0.12 -Week 3: mean=0.63; SD=0.09 3. Intradaily Variability -Week 1: mean=1.04; SD=0.34 -Week 2: mean=0.71; SD=0.22 -Week 3: mean=1.06; SD=0.38 4. Mesor (Mean Daily Activity Count) -Week 1: mean=393; SD=192 -Week 2: mean=401; SD=222 -Week 3: mean=400; SD=231 5.Relative Amplitude -Week 1: mean=0.65; SD=0.36 -Week 2: mean=0.90; SD=0.23 -Week 3: mean=0.69; SD=0.41 6. Acrophase (peak locomotor time) -Week 1: mean=16:15; SD=120 -Week 2: mean=15:23; SD=108 -Week 3: mean=15:21; SD=129	1. 17.1-18.4 = 1.4 <1/2 SD; CS 2. 0.63-0.68 =0.05 > SD; N.S 3. 1.06-1.04= 0.02 <1/2 SD; CS 4. 400-393 =7 <1/2 SD; CS 5. 0.69-0.65 =0.04 <1/2 SD; CS 6. 15:21-16:15 = 1:24 > ½ SD; N.S	t ↓ in 9 out of 10 patients (p=0.02) 2. Interdaily Stability No significant change 3. Intradaily variability of activity monitor ↓ during week 2 (p=0.03) 4. Mesor (Mean Daily Activity Count) No significant change 5. Relative amplitude ↑ in 7 out of 10 patients (p=0.02) 6. Acrophase (peak locomotor time) No significant change Overall results: Positive correlation between severity of sundowning and improvement during treatment (p=0.02) and posttreatment (p=0.04)

Schindler et al., 2002	Single Case Design	2/8 Low	Dx: Dementia (ALzheimer's type) Mean age: 81.8	BLT (2.500 lux) administered for 2 hrs daily b/w 10 am and 12 am for 14 days Baseline CRS delusion subscore n=5	1.Agitation 2. Delusion	1. CRS 2. CRS ↓ = better	Mean delusions change in CRS subscore: -.4 SD: .9	Prior to BLT: 1.5 < 1.6 (MDD); Sig. Druing BLT: 2 >1.6 (MDD); N.S. Change in CRS subscores: 0.45 < 1.6 (MDD); N.S. Baseline IDSR: 3.6 < 6.3 (MDD); N.S.	p-values were not given for this study and statistical significance was not stated either.
Skjerve et al., 2004	Quasi-Experimental	3/8 Low	Dx: Alzheimer's /Vascular dementia Mean Age: 79.4	BLT, 45min/day for 4 week n= 10	Behavioral disturbances	1. CMAI, 29-item scale of 1–7, ↓=better 2. Behave-AD, ↓=better	1. CMAI T1: 68.40(14.94) T2: 61.20(12.46) T3: 53.2(12.35) 2. Behave-AD T1: 15.00(5.48) T2: 12.80(5.47) T3: 9.70(4.27)	1. CMAI: 15.2>1.295, CS 2. Behave-AD 5.3>.605, CS	1. CMAI P=0.001 2. Behave-AD P=0.006
Thorpe et al., 2000	Quasi-Experimental	2/8 Low	Dx: Dementia Mean Age: 60-89	Light administered through Day Light Box 30 mins/ morning n=16	1. Agitation 2. Disruptive behavior/ Positive Behavior 3. Sleep	1. CMAI 2. EBIC 3. Nightly 12-hour sleep charts	1.Total score= 0.9 + change. 2. Seasonal changes from fall/spring to summer= 16 - change. (Shows less agitation) Positive behavior= 0 change Disruptive behavior= 6.5 - change. (Shows less agitation/disruptive behavior) 3.Monday-Friday sleep= +0.30 (more sleep)	MDD calculated, N.S	1. Total Scores p=0.04 2. Seasonal pattern results p=0.002 3. Disruptive behavior p=0.05 positive behavior p=0.08
Wahnschaffeet al., 2017	Quasi-Experimental	4/8 Moderate	Dx: Dementia Mean Age : 79.1	Dynamic lighting system n=15 3 withdrew 12 analyzed	1. Agitation 2. Rest-activity cycles	1. CMAI sum score 2. Rest-activity cycle – measured by activity watches RA: 0-1 IS: 0-1 IV: 1 to >2	1. CMAI scores: before mean = 30.17, during mean = 27.92	1. MDD calculated, CS	1. CMAI: Significant 2. Rest-Activity: not significant

Table 8. Results Summary

# of Articles	Level of Evidence	Quality of Evidence	Outcome Measures	Statistical Significance	Clinical Significance
Agitation					
15	I - IV	Low: 5 Moderate: 6 High: 4	1.CMAI (9) 2.ABRS (2) 3. CRBRS (1) 4. NPI-NH (1) 5. BEHAVE-AD (1) 6. CADS (1) 7. CRS (1) 8. BARS (1) 9. PAS (1) 10.Observation (1)	1 S. (6) N.S (3) 2. S. (2) 3. N.S (1) 4. S. (1) 5. N.S.(1) 6. S. (1) 7. Not Provided 8. S. (1) 9. S. (1) 10. Not Provided	1. S. (3) N.S.(6) 2. N.S (2) 3. N.S. (1) 4. N.S.(1) 5. N.S. (1) 6. Not Calculable 7. N.S (1) 8. N.S. (1) 9. N.S. (1) 10. Not Calculable
Aggression					
5	I-III	Low: 3 Moderate: 1 High: 1	1. NPI-NH (1) 2. GIP (1) 3. SDAS-9 (1) 4. BEHAVE-AD (1) 5. EBIC (1) 6.. Observation (1)	1 S. (1) 2. S. (1) 3. N.S. (1) 4. S. (1) 5. S. (1) 6.. Not Provided	1.N.S.(1) 2. N.S. (1) 3. Not Calculable 4. S. (1) 5. N.S. (1) 6. Not Calculable
Confusion					
5	I-IV	Low: 1 Moderate: 2 High: 2	1.GIP (1) 2. S-MMSE (1) 3. NPI-Q (1) 4.CRS (1) 5. MOUSEPAD (1)	1.S.(1) 2. N.S. (1) 3. N.S. (1) 4. Not Provided 5. N.S. (1)	1.N.S. (1) 2. S. (1) 3. S. (1) 4. N.S. (1) 5. N.S.

KEY:

S= SIGNIFICANT
N.S= NOT SIGNIFICANT

OUTCOME MEASURES:
ABRS: Agitated Behavior Rating Scale
BARS: Brief Agitation Rating Scale
Behave-AD: Behavioral Pathology in Alzheimer Disease scale
CADS: Change in Advanced Dementia Score
CMAI: Cohen-Mansfield Agitation Inventory
CRBRS: Crichton Royal Behavior Rating Scale

CRS: Confusion Rating Scale
CS: Clinically Significant
EBIC: Environment-Behavior Interaction Cod
GIP: Gedragsobservatieschaal voor Intramurale Psychogeriatrie (Dutch version of the geriatric behavioural observation scale)
MOUSEPAD: Manchester and Oxford Universities Scale for the Psychopathological Assessment of Dementia
NPI-NH: Neuropsychiatric Inventory-Nursing Home
PAS: Pittsburgh Agitation Scale
SDAS-9: Social Dysfunction and Aggression Scale
S-MMSE: Severe Mini Mental Status Evaluation

Figure 1. Flowchart