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ORIGINAL RESEARCH

Efficacy of light therapy on nonseasonal depression among elderly adults: a systematic review and meta-analysis

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Objective: The aim of this study was to examine the effectiveness of light therapy in the treatment of geriatric depression.

Methods: A systematic review and meta-analysis were carried out. Data sources for the literature search were PubMed, Cochrane Collaboration's Central Register of Controlled Clinical Trials, Cochrane Systematic Reviews, and ClinicalTrials.gov. Controlled trials of light therapy on older patients with nonseasonal depression and depression rating scales were eligible. Studies were pooled using a random-effect model for comparisons with light therapy. We used effect size (ES), which expresses changes in depression severity, in each selected meta-analysis to calculate the standardized mean difference on the basis of Hedges' adjusted g; positive values indicated that the depression severity improved after light therapy. All results were presented with 95% CIs. Statistical heterogeneity was explored through visual inspection of funnel plots and the I^2 statistic. Moderators of effects were explored using meta-regression.

Results: We identified eight trials involving 395 participants that met the inclusion criteria. Light therapy was significantly more effective than comparative treatments, including placebo or dim light, with an ES of 0.422 (95% CI: 0.174–0.709, P=0.001). In addition, six of the eight trials used bright (white) light, resulting in significantly reduced severity of geriatric depression (N=273, ES: 0.460, 95% CI: 0.085–0.836, P=0.016). Furthermore, pale blue light therapy reduced the severity of geriatric depression (N=89, ES: 0.464, 95% CI: 0.046–0.882, P=0.030).

Conclusion: Our results highlighted the significant efficacy of light therapy in the treatment of geriatric depression. Additional well-designed, controlled studies are necessary to adopt standard parameters, adequate group sizes, and randomized assignment to evaluate more thoroughly the efficacy of light therapy for treating geriatric depression.

Keywords: depression, elderly adults, light therapy

Introduction

Depressive disorders are characterized by sadness or irritability and are associated with several psychophysiological changes.[1] In USA, the lifetime prevalence of depression is 11.9% (major depressive disorder, 10.6%; dysthymia, 1.3%) in elderly adults (age >60 years).[2] Older adults with depression have a higher risk of suicide and comorbidities than do older adults without depression.[3] Moreover, depression is the leading cause of disability, and the economic burden that it causes increases as the population ages.[4] Psychotherapy and antidepressants are the major treatment modalities for depression in elderly adults.[5,6] However, psychotherapy is limited by the availability of psychologists or psychiatrists,[5,7] and geriatric patients are at a higher risk of experiencing side effects from antidepressants than are other populations.[8,9] Therefore,

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augmented non-pharmacologic treatments have been developed for the treatment of depression in elderly patients.

Light therapy (phototherapy), a non-pharmacologic treatment, uses bright artificial white or colored light. Relevant studies have reported the efficacy of light therapy in the treatment of nonseasonal depression[10,11] and bipolar depression.[12] However, heterogeneity has been observed in these studies because of variables such as light color, light intensity, duration, and settings. Furthermore, few trials have had a randomized control design. Moreover, the results of trial studies investigating the use of light therapy on elderly adults have been inconclusive. Some studies have reported that light therapy is efficacious,[13–15] whereas others have not reported significant differences between the case and control groups.[16–18]

Therefore, we performed a meta-analysis to evaluate the efficacy of light therapy in the treatment of geriatric depression.

Methods

Search strategy and inclusion criteria

Two independent authors (Shaw-Ji Chen and Chun-Hung Chang) conducted a systematic article search and used the PubMed database at the National Library of Medicine, Cochrane Collaboration's Central Register of Controlled Clinical Trials, Cochrane Systematic Reviews, and the ClinicalTrials.gov website (https://ClinicalTrials.gov). Professor Hsin-Chi Tsai made the final inclusion decision of cases that were inconsistently selected. We used the keywords "(Phototherapy OR light therapy) AND (depress* OR mood) AND (old OR elders OR geriatric)" to search for all relevant articles on the PubMed and ClinicalTrials.gov websites until July 14, 2018.

Randomized controlled trials (RCTs) or comparative experimental trials were included. However, we excluded 1) case reports, 2) nonclinical trials, 3) studies not performed on human subjects, and 4) studies including patients with seasonal affective disorder. Additionally, trials that were not associated with the application of light therapy for the treatment of nonseasonal depression were excluded. We retrieved all studies comprising at least two treatment arms (ie, light therapy treatment and placebo or dim light treatment) that were written in English and contained the aforementioned keywords. The titles and abstracts of these articles were then screened by Chun-Hung Chang and Shaw-Ji Chen to determine their eligibility for inclusion in the meta-analysis. Agreement through consensus was performed in cases of disagreement regarding eligibility. In addition, we researched the reference articles listed in the review studies. Figure 1 depicts the screening and search protocols.

Data extraction and quality assessment

The primary outcome of these studies was the severity of depression in elderly adults, as assessed by the Geriatric

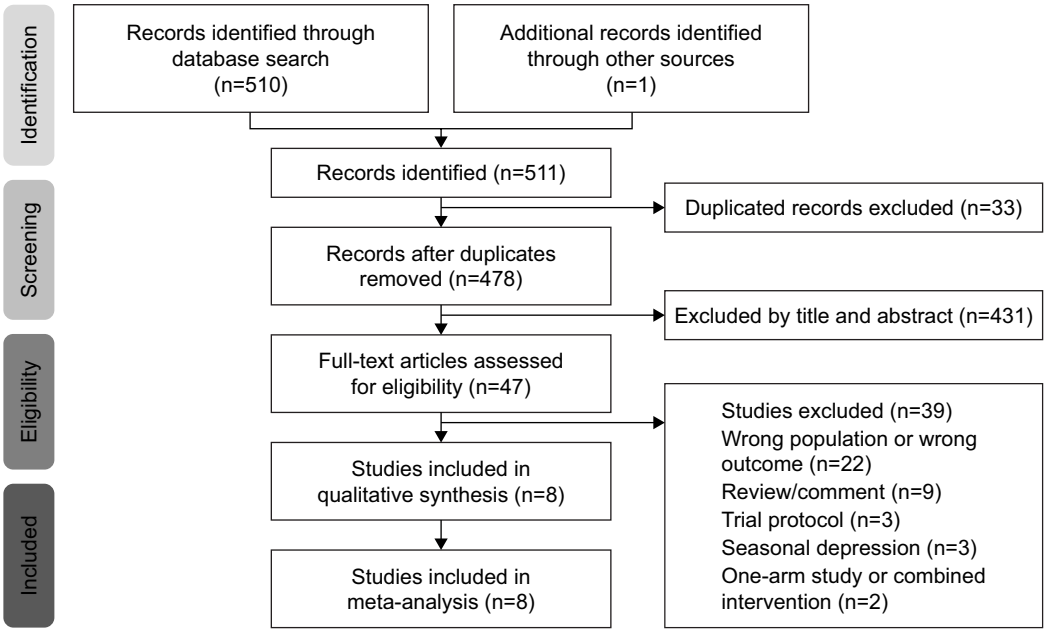

Figure 1 Flowchart of the selection strategy and inclusion and exclusion criteria for this meta-analysis.
Notes: Database: PubMed (n=425), Cochrane Central Register of Controlled Trials (n=63), Cochrane Database of Systematic Reviews (n=5), ClinicalTrials.gov (n=17). (Phototherapy OR light therapy) AND (depress* OR mood) AND (old* OR elder* OR geriatric). Date: available until July 14, 2018.

Depression Scale (GDS),[19,20] or the Hamilton Depression (HAM-D) rating scale,[21] or Beck's Depression Inventory (BDI).[22] We extracted as many clinical variables, including first author, year, sample size, number and type of treatment arms, participant characteristics, details of the light therapy treatment, and comparative arm regimens. Furthermore, we attempted to contact the authors to acquire the original data if they were not available in the articles. Because GDS scores were the most frequently used in the included studies, we used them first to assess the severity of depression in elderly patients; if GDS scores were not available, we used the HAM-D rating scale.

Two reviewers independently evaluated the methodological quality of the included trials using the Jadad scoring system and Newcastle–Ottawa Quality Assessment Scale for the RCTs and comparative experimental trials, respectively.[23,24] The Jadad scale evaluates three items using a scale that ranges from 0 to 5 points. Specifically, the methodology of the RCTs was evaluated on the basis of three components: randomization (two points), blinding (two points), and an account of all patients (one point). Thus, the scores ranged from 0 to 5, with a higher score indicating higher methodological quality. By contrast, the comparative trials were evaluated on the basis of nine items across three categories: participant selection (four items), comparability (four items), and exposure (three items). The studies received a maximum of one point for each of the items in the selection and exposure domains, and a maximum of two points for those in the comparability domain. The corresponding author helped to resolve discrepancies between the scores assigned by the two reviewers.

Data synthesis and analysis

We used effect size (ES), which expresses changes in depression severity, in each selected meta-analysis to calculate the standardized mean difference on the basis of Hedges' adjusted g; negative values indicated that the depression severity decreased after light therapy.[25] In addition, we used a random-effects model to pool the individual ESs.[26] Thereafter, we performed a meta-analysis using the Comprehensive Meta-Analysis software package (version 3; Biostat, Englewood, NJ, USA). Two-tailed *P*-values of <0.05 were considered statistically significant. Between-trial heterogeneity was determined using I^2 tests, and values of $>50\%$ were considered to exhibit considerable heterogeneity. Additionally, a sensitivity analysis was performed to ensure that no single study over-influenced the analysis by excluding each individual study and reanalyzing the overall effect on the remaining studies. Finally, funnel plots and Egger's test were used to examine potential publication bias. We followed the guidelines of PRISMA to report our findings.[27]

Results

Article search and characteristics of included patients

We retrieved 47 articles after the initial screening; 22 were excluded because they included the wrong population (not older patients with nonseasonal depression) or the wrong outcome (without depression measure).[28–48] In addition, one article was excluded because it was only indexed in the Cochrane Central Register of Controlled Trials. We also excluded nine review articles,[36,49–55] three trial protocols,[13,56,57] and three studies of seasonal depression.[58–60] We excluded two studies with one-arm or combined intervention[61] (one article was only indexed in the Cochrane Central Register of Controlled Trials).

The final quantitative analysis included 395 participants from eight trials.[13–18,62,63] We followed the PRISMA guidelines, and the search process is displayed in Figure 1. Table 1 presents a summary of the study characteristics. The average number of subjects was 49.38±28.61 (range: 10–89), and the average treatment duration of these trials was 18.25±13.57 days (range: 2–35 days). The average age of the participants was 71.63±5.63 years. Studies were conducted in North America (n=3), East Asia (n=2), and Europe (n=3).

Meta-analyses of pre- and post-light therapy

The positive ES results indicated that the severity of depression significantly improved after light therapy. Specifically, the overall ES of light therapy vs comparative therapies to mitigate depression severity was 0.442 (95% CI: 0.174–0.709, $P=0.001$; Figure 2). Moreover, heterogeneity was observed within these studies ($Q=12.899$, df=7, $I^2=45.731\%$, $P=0.075$) and publication bias was detected using the Egger's test ($t=1.115$, df=6, two-tailed $P=0.307$; Figure 3).

Meta-regression analyses of light therapy

We noted that female sex and mean age were positively correlated with the effects of light therapy (female sex, slope =0.2242, 95% CI: −2.0430 to 2.4915; mean age, slope =0.0380, 95% CI: −0.131 to 0.0892). However, these findings did not reach significance ($P=0.8463$ and 0.1450, respectively). Moreover, meta-regression revealed no significant association between the changes in depression severity after light therapy and intensity of light therapy in

Table 1 Summary of the characteristics of studies in the current meta-analysis

Study	Depression criteria/study population	Primary depression measure	Length of trial	Light therapy (intervention) group	N (% female) of intervention group	Mean age (SD) of intervention group	Control group	N (% female) of control group	Mean age (SD) of control group	Country	Study design
Sumaya et al, 2001[15]	Score of 11–20 on GDS/institutionalized older adults	GDS	5 days	Bright light 10,000 lux 30 min/day Morning	10 (60)	83.8 (9.56)	1 week (5 days) of 300 lux (placebo), or 1 week of no treatment (control)	10 (60)	83.8 (9.56)	USA	Placebo controlled, crossover
Tsai et al, 2004[14]	GDS ≥10; MDD or depressive disorders (DSM-IV)/inpatients	GDS	5 days	Bright light 5,000 lux 50 min/day Morning	30 (40)	75.3 (7.4)	Did not receive any treatment	30 (50)	74.6 (5.7)	Taiwan	RCT
Loving et al, 2005[16]	GDS score ≥11 (indicating probably major depression)/ outpatients	GDS	4 weeks	Bright white light 8,500 lux, 1 hour Morning (n=13) Midday (n=15) Evening (n=13)	41 (58; total sample)	67.7 (5.45; total sample)	Red light 10 lux, 1 hour Morning (n=15) Midday (n=16) Evening (n=9)	40 (58; total sample)	67.7 (5.45; total sample)	USA	RCT
Loving et al, 2005[17]	GDS score of 11 (indicating probable major depression)/ outpatients	GDS	4 weeks	1 hour of bright green light (1,200 lux)	17 (84.8; total sample)	67.7 (6.35; total sample)	1 hour of dim red light placebo (<10 lux)	16 (84.8; total sample)	67.7 (6.35; total sample)	USA	RCT
Paus et al, 2007[63]	Depression was measured by BDI/ outpatients	BDI	15 days	White fluorescent light 7,500 lux, 30 minutes daily	18 (33.3)	63.6 (9.8)	White fluorescent light 950 lux, 30 minutes daily	18 (38.9)	63.4 (9.7)	Germany	RCT
Lieverse et al, 2008[13]	Depression was diagnosed using the Structured Clinical Interview for DSM-IV Axis I Disorders/ outpatients	HAM-D	3 weeks	Bright light 1-hour early morning (pale blue, ~7,500 lux)	42 (67)	69.7 (8.5)	Placebo (dim red light, ~50 lux)	47 (64)	69.0 (6.6)	the Netherlands	RCT
Wu et al, 2015[18]	Depression was measured using the GDS-SF/long-term care facility	GDS-SF	4 weeks	10,000-lux light box 30 minutes in the morning	34 (47.1)	80.97 (9.84)	Routine care without light therapy	31 (38.7)	79.03 (10.06)	Taiwan	RCT
Canazei et al, 2017[62]	Depression was measured using ICD 10/inpatients	KUSTA	2 days	Artificial sunlight, mean vertical illuminance (at eye level), 1,700 lux, 30 minutes	21 (81.0)	70.1 (5.6; total sample)	Conventional room light, mean vertical illuminance (at eye level), 140 lux, 30 minutes	21 (81.0)	70.1 (5.6; total sample)	Austria	Crossover

Abbreviations: BDI, Beck's Depression Inventory; DSM-IV, Diagnostic and Statistical Manual of Mental Disorders, fourth edition; GDS-SF, the short-form Geriatric Depression Scale; GDS, Geriatric Depression Scale; HAM-D, Hamilton rating scale; KUSTA, Kurz-Skala Stimmung/Aktivierung rating scale; MDD, major depressive disorder; ICD, International Classification of Diseases; RCT, randomized controlled trial.

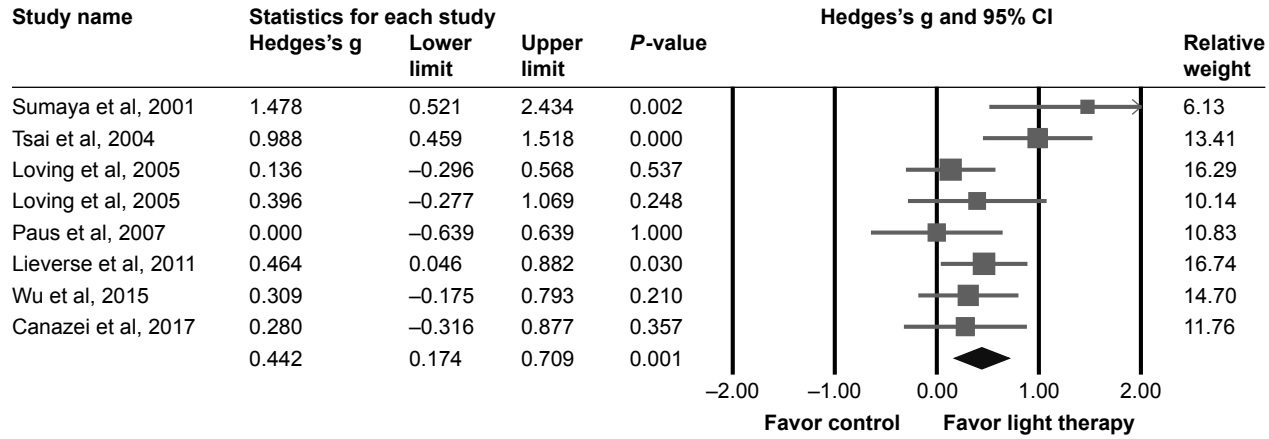

Figure 2 Meta-analysis of studies comparing depression severity before and after light therapy in elderly adults.

lux or in intervention duration in days (P=0.3095 and 0.9693, respectively; Figure 4).

Subgroup analyses of different light colors

No conclusive evidence was presented in the reviewed studies to support the effects of different light colors on geriatric depression; therefore, we conducted a subgroup meta-analysis of the studies that used different light colors. We found that both bright-light therapy (N=273, ES: 0.460, 95% CI: 0.085–0.836, P=0.016) and pale blue light therapy (N=89, ES: 0.464, 95% CI: 0.046–0.882, P=0.030) resulted in significant reductions in the severity of geriatric depression, whereas green light's effect was nonsignificant (N=33, ES: 0.396, 95% CI: –0.277 to 1.069, P=0.248; Figure 5).

Subgroup analyses of comparators

Trials employing standard care or conventional room light as a comparator had higher ESs. Five trials[13,15–17,63] used dim light as comparator and the ES was 0.388 (95% CI: 0.029–0.748, P=0.034). Three[14,18,62] trials used standard care as comparator and the ES was 0.529 (95% CI: 0.074–0.984, P=0.023; Figure 6).

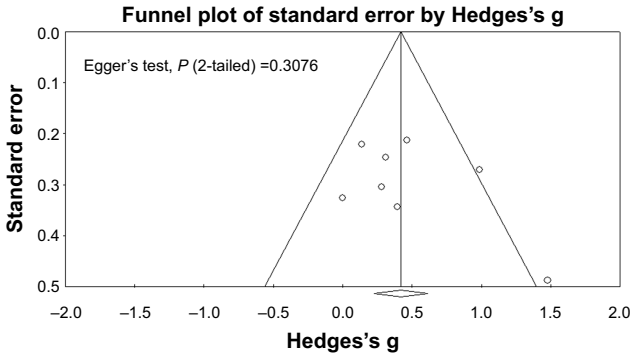

Figure 3 Funnel plots for the effect sizes of light therapy.

Subgroup analyses of depression measures

Four primary depression measures – GDS, HAM-D, BDI, and Kurz-Skala Stimmung/Aktivierung rating scale[64] – were used in these trials. Two studies reported both GDS and HAM-D scores.[16,17] Five[14–18] of the eight trials used GDS as a primary measure and had significant ESs: 0.574 (95% CI: 0.152–0.996, P=0.008; Figure 7). Three studies reported changes in HAM-D scores and the combined ES was 0.285 (95% CI: 0.01–0.0559, P=0.042).[13,16,17]

Subgroup analyses of study designs

Six[13,14,16–18,63] of the eight trials employed an RCT design and had significant ESs: 0.387 (95% CI: 0.124–0.651, P=0.004), whereas two trials[15,18] did not use an RCT design and showed nonsignificant ESs: 0.818 (95% CI: –0.349 to 1.985, P=0.170; Figure 8).

Subgroup analyses of intervention lengths

In these eight trials, the length of the intervention was from <1 to 4 weeks. Three studies[14,15,62] adopted <1 week intervention and showed significant ESs: 0.848 (95% CI: 0.217–1.478, P=0.008), whereas trials with longer interventions did not show significant ESs (Figure 9).

Subgroup analyses of mean age ranges

In these eight trials, the mean age range was from 60 to 80 years. Four studies[13,16,17,63] with a mean age range of 60–69 years showed significant ESs: 0.271 (95% CI: 0.018–0.523, P=0.035), whereas other studies with higher mean ages did not show significant ESs (Figure 10).

Adverse effects

No significant adverse reactions were observed in either the intervention group or control group. Moreover, no incidents

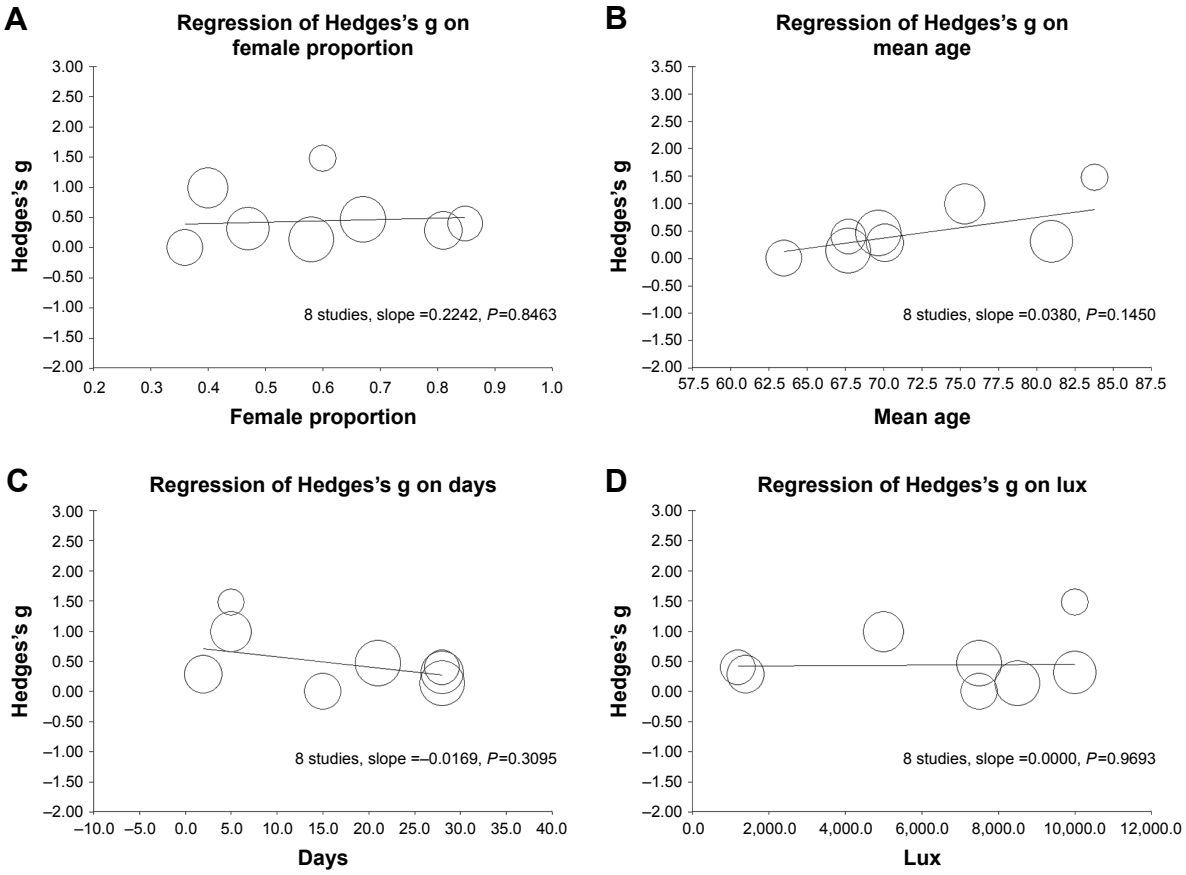

Figure 4 Meta-regression of the effects of (**A**) female sex, (**B**) mean age, (**C**) treatment duration in days, and (**D**) light intensity in lux.

of mania or hypomania during the light treatment or follow-up were reported in the eight trials.

Sensitivity analysis

In the meta-analysis of light therapy's overall effects on geriatric depression, the conclusion remained significant when any single study was removed.

Discussion

This meta-analysis investigated the efficacy of light therapy for the treatment of nonseasonal depression in elderly adults. The main results were that 1) depression severity significantly decreased after light therapy (ES: 0.442, 95% CI: 0.174–0.709, *P*=0.001), 2) the treatment effects of white and pale blue light were significant, and 3) no manic

Group by color	Study name	Statistics for each study				Hedges's g and 95% CI	Relative weight
		Hedges's g	Lower limit	Upper limit	*P*-value		
Blue	Lieverse et al, 2011	0.464	0.046	0.882	0.030		100.00
Blue		0.464	0.046	0.882	0.030		
Green	Loving et al, 2005	0.396	–0.277	1.069	0.248		100.00
Green		0.396	–0.277	1.069	0.248		
White	Sumaya et al, 2001	1.478	0.521	2.434	0.002		9.98
White	Tsai et al, 2004	0.988	0.459	1.518	0.000		18.10
White	Loving et al, 2005	0.136	–0.296	0.568	0.537		20.59
White	Paus et al, 2007	0.000	–0.639	0.639	1.000		15.56
White	Wu et al, 2015	0.309	–0.175	0.793	0.210		19.25
White	Canazei et al, 2017	0.280	–0.316	0.877	0.357		16.51
White		0.460	0.085	0.836	0.016		

Figure 5 Subgroup meta-analyses of light colors.

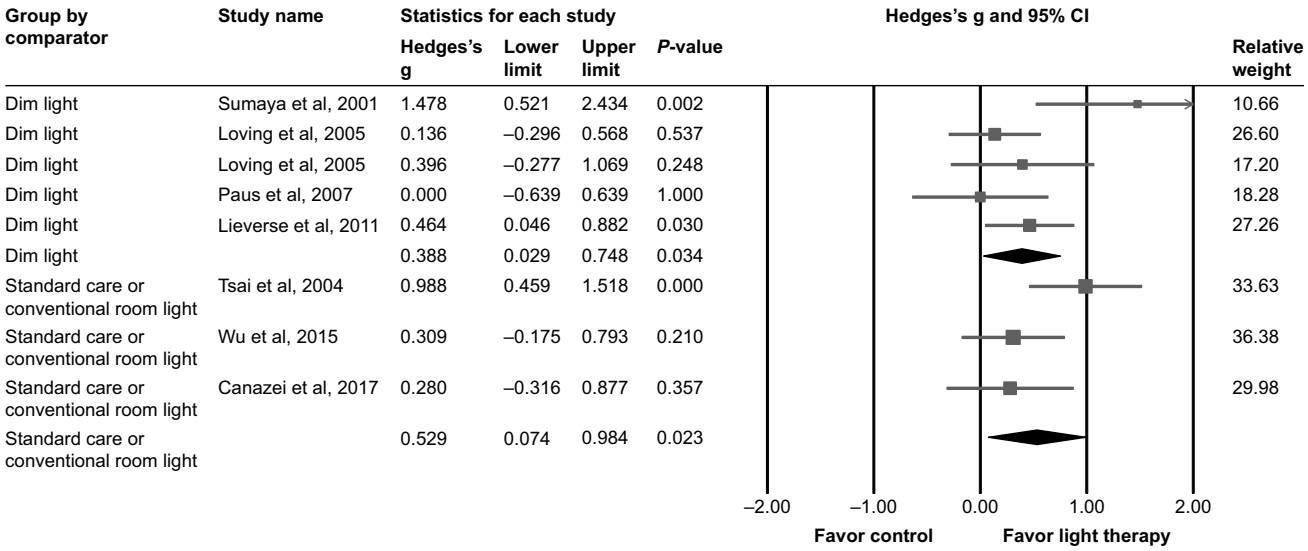

Figure 6 Subgroup meta-analyses of comparators.

shifting occurred in elderly adults who received light therapy in the eight trials.

Our study had several merits compared with a previous meta-analytic study.[49] In our study, we enrolled more trials and patients compared with the previous meta-analytic article. We included eight trials and 395 participants, whereas these numbers in the earlier study[49] were 6 and 359, respectively. Moreover, we used meta-regression first to evaluate the effect on geriatric depression between light therapy and clinical variables. In addition, we first reported the potential factors including age groups and long-term effects.

Our findings were in agreement with relevant reviews regarding the efficacy of light therapy in the treatment of nonseasonal depression in adults[10,11] and bipolar depression.[12] However, these reviews did not address the general elderly population with depression. Three trials indicated that depression scores differed significantly between experimental and control groups,[13–15] whereas two trials did not.[16,18] Both Loving et al and Wu et al reported an improvement in their participants' depression after light therapy, although the differences between the experimental and control groups were not significant. In the present meta-analysis, we found that the severity of depression among elderly adults significantly decreased after light therapy; however, two of the examined trials did not indicate a significant difference between their experimental and control groups. One possible cause for this inconsistency is the time of treatment, because as studies have suggested, phototherapy in the morning can result in a higher treatment response through circadian resynchronization.[10,11,65] In the study by Loving et al, only 13 of 41 patients received light therapy in the morning.

Different light colors may have different effects on geriatric depression. Five trials used bright (white) light,[14–16,18,62]

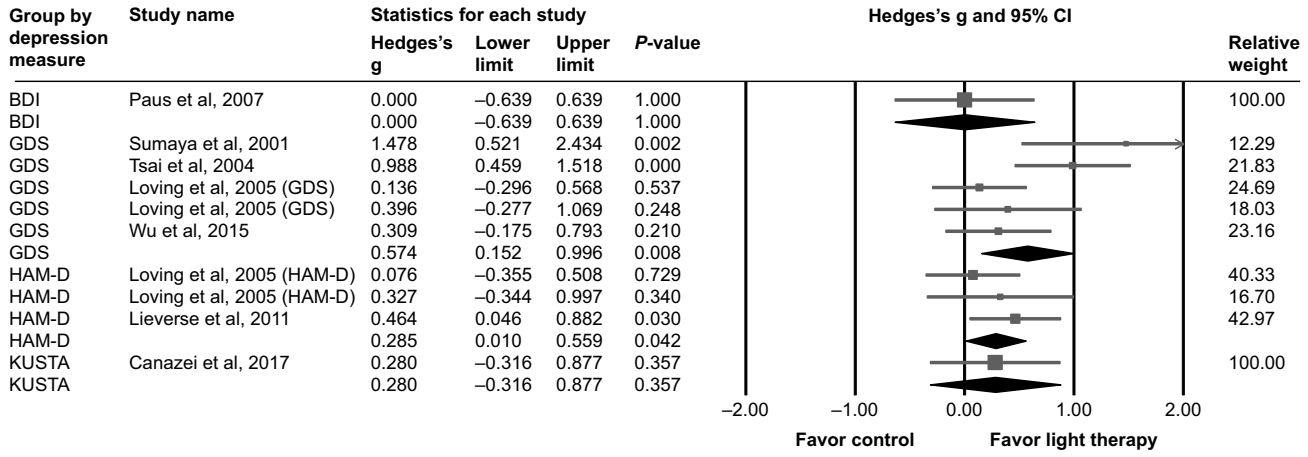

Figure 7 Subgroup meta-analyses of depression measures.
Abbreviations: BDI, Beck's Depression Inventory; GDS, Geriatric Depression Scale; HAM-D, Hamilton rating scale; KUSTA, Kurz-Skala Stimmung/Aktivierung rating scale.

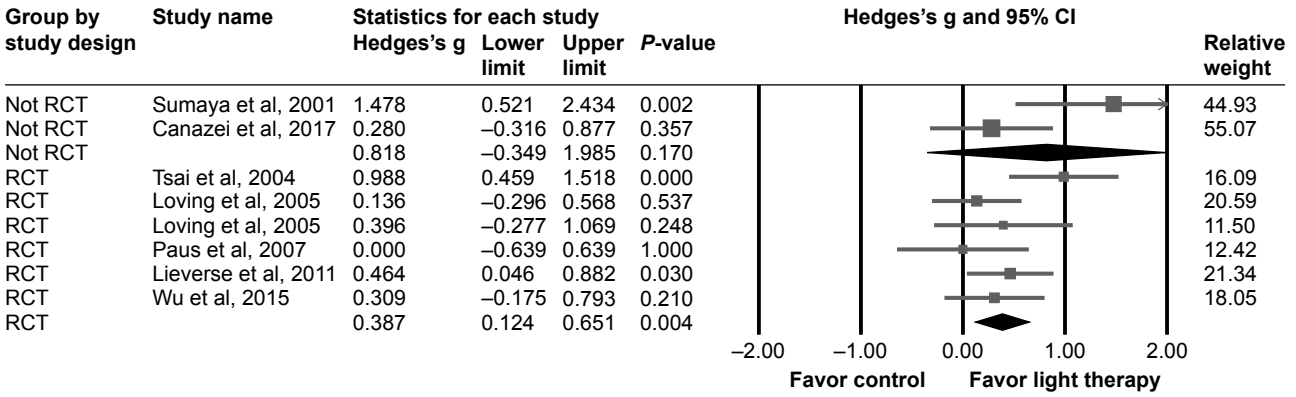

Figure 8 Subgroup meta-analyses of study designs.
Abbreviation: RCT, randomized controlled trial.

one trial used bright (pale blue) light,[13] and one used green light.[17] Both white light and blue colors exhibited efficacy for the treatment of depression. Furthermore, studies have indicated that blue light affects mood and cognitive function more than other colors because it is mediated through melanopsin.[65,66] We suggest that further well-designed studies using blue light and a large sample size should be conducted to test the efficacy of blue light therapy in the treatment of geriatric depression.

In the subgroup analyses of depression measures, five trials[14–18] used GDS as a primary measure and had larger effects than those[13,16,17] that used HAM-D (ES: 0.515 vs 0.285). However, heterogeneity was observed within the studies that adopted GDS (Q=10.685, df=4, I^2=62.566, *P*=0.030), whereas no significant heterogeneity was observed within the studies reporting HAM-D (Q=1.616, df=2, I^2=0.000, *P*=0.446). Our findings showed that studies with GDS had larger z-scores than those with HAM-D (2.667 vs 2.035) and suggest that the depression measures were a potential factor in influencing treatment effects. GDS is a self-rated measure, whereas HAM-D is clinician rated. Different rating methods may result in different evaluations of depression severity. The HAM-D rating scale and clinician-rated Montgomery–Åsberg Rating Scale[67] are primary outcome measures for clinical trials of psychopharmacological treatment of depression.[68,69]

In the subgroup analysis of intervention length, we found that the effect of light therapy compared with control treatment reached statistical significance at <1 week (ES: 0.848, 95% CI: 0.217–1.478, *P*=0.008). A relevant meta-analysis found that 2-week intervention periods were effective for improving depression.[49] The treatment effect did not increase with the intervention length. Moreover, among these eight trials, Canazei et al[62] were the first to report immediate psychophysiological effects of single, short-room light exposure in mildly depressed geriatric inpatients during a short cognitive stimulation session and when resting. Virk et al[70] used a single, short, bright-light exposure of 10,000 lux in the morning in untreated patients with seasonal affective disorder and found that briefly administering light was clinically effective within

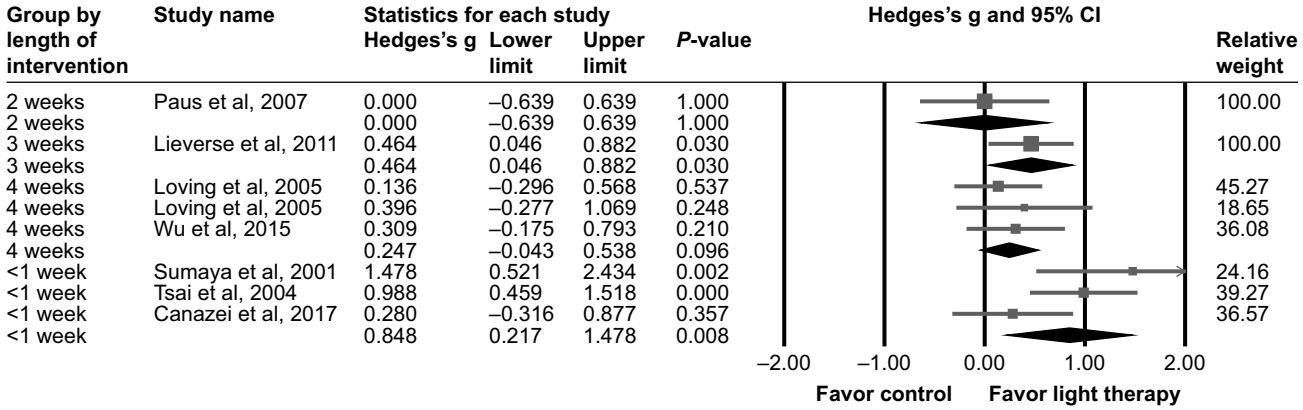

Figure 9 Subgroup meta-analyses of intervention lengths.

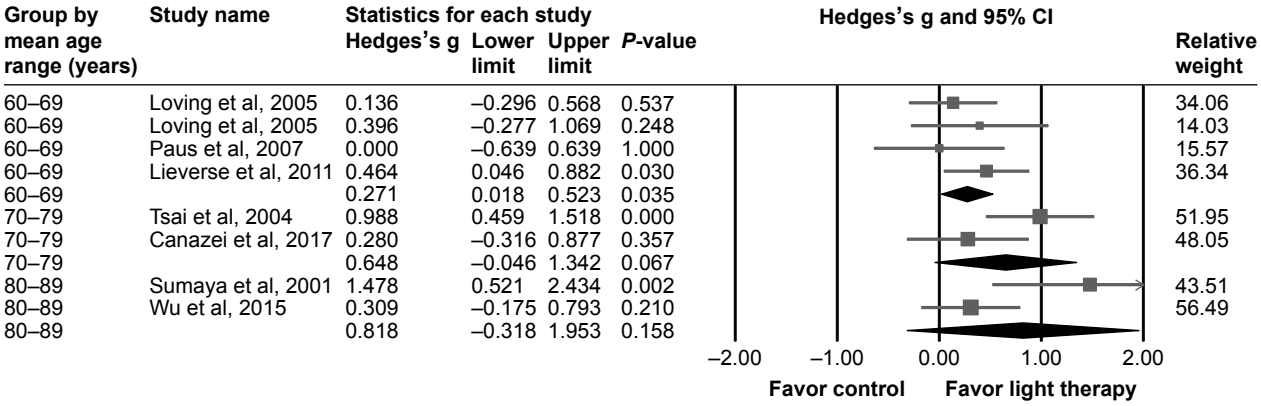

Figure 10 Subgroup meta-analyses of mean age ranges.

20 minutes and that improvements of mood even occurred after the first bright-light exposure. Recent studies have shown that acute light can directly affect mood and learning without producing major disruptions in circadian rhythms and sleep.[65] A functional imaging study of 17 healthy volunteers reported that 40-second periods of blue or green ambient light increased responses to emotional stimuli in the voice area of the temporal cortex and in the hippocampus.[66] When we conducted a sensitivity test to exclude Canazei's study, the ES remained statically significant (ES: 0.464, 95% CI: 0.164–0.772, *P*=0.003). Therefore, the study conducted by Canazei et al did not affect the overall treatment ES. Further studies with short-term interventions will facilitate understanding of the underlying immediate effects.

Furthermore, we investigated potential factors such as mean age and long-term effects after stopping phototherapy. We found that light therapy on patients with a mean age of 60–69 years reached statistical significance (ES: 0.271, 95% CI: 0.018–0.523, *P*=0.035), whereas patients of older age groups did not (Figure 11). Lam reported that younger age is a predictor of response to light therapy for winter depression.[71] In addition, we observed that two of the eight trials reported 3-month follow-ups after stopping light therapy.[16,17] The ES was 0.449 (95% CI: 0.081–0.816, *P*=0.017). No significant heterogeneity was observed within these studies (Q=0.729, df=1, I^2=0.000, *P*=0.393; Figure 12); however, this was because only two studies were analyzed for long-term effect. Thus, further trials with long-term evaluation at ≥6 months are required.

Heterogeneity and publication bias

Because significant heterogeneity (>50%) of the included studies in the subgroup analysis (at least three trials) was found for white color (I^2=61.063%), standard care (I^2=54.020%), GDS (I^2=62.566%), and intervention length of <1 week (I^2=62.486%), sensitivity analyses were performed. For white color, the effect remained significantly positive; only when the study of Tsai et al[14] was removed did the effect become nonsignificant (ES: 0.322, 95% CI: –0.028 to 0.671, *P*=0.072). For standard care, when any one of the three studies[14,18,62] was removed, the effect became nonsignificant (*P*=0.059, 0.120, and 0.067). In the subgroup meta-analysis of GDS, the conclusion remained significant when removing any single study. For an intervention length of <1 week, when the studies by Sumaya et al[15] and Tsai et al[14] were removed, the effect changed to nonsignificant (*P*=0.067 and 0.170, respectively). Results of the Egger's test suggested no significant publication biases in the subgroup meta-analysis on white color, standard care, GDS, intervention length of <1 week (white light: *P*=0.28125; standard

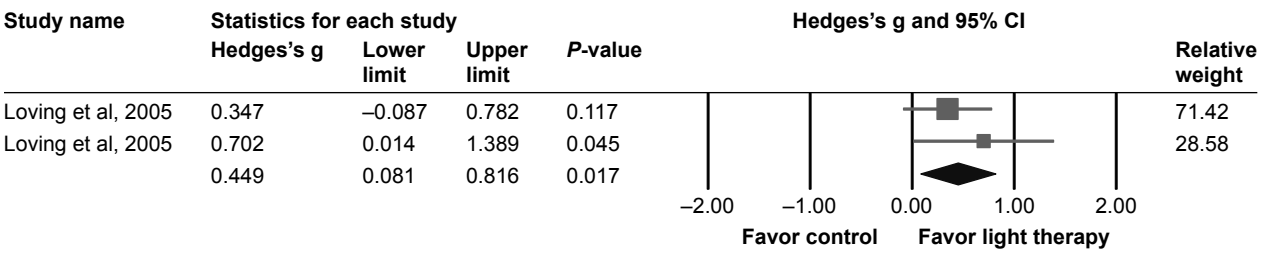

Figure 11 Subgroup meta-analyses of effects at 3-month follow-up after stopping light therapy.

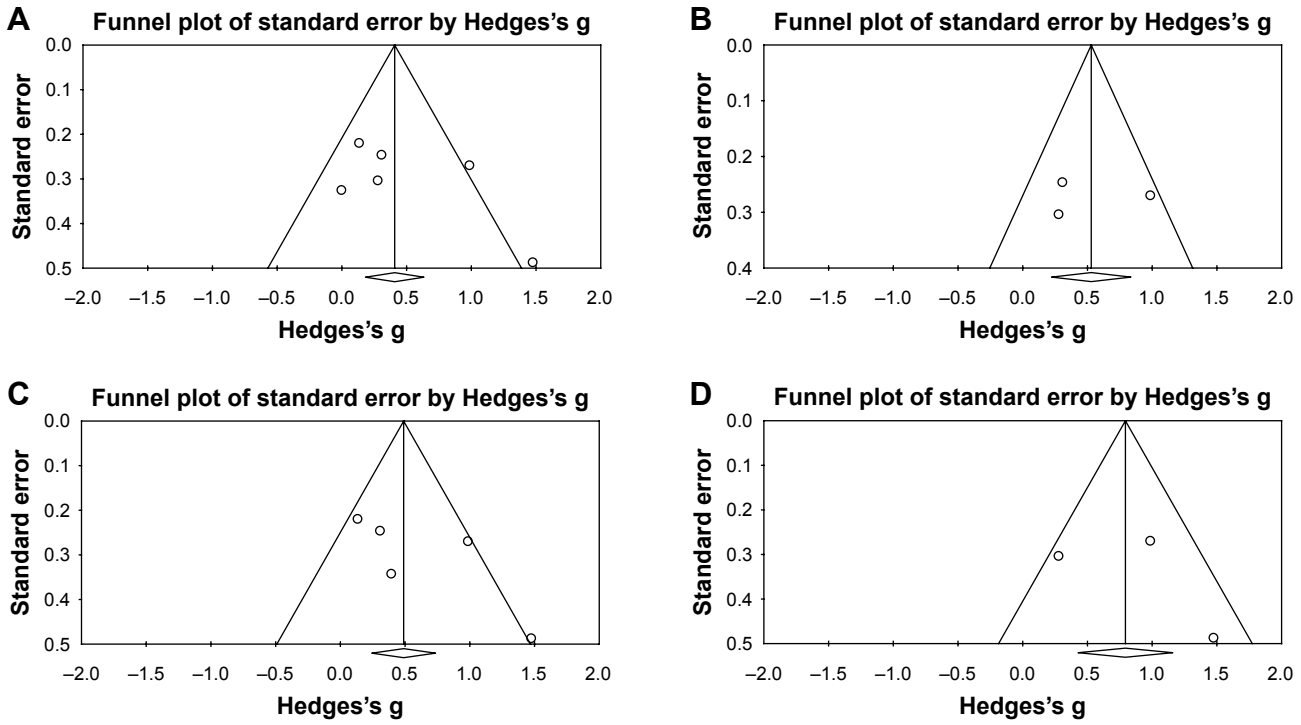

Figure 12 Funnel plots for effect size of subgroup meta-analysis on (**A**) white light, (**B**) standard care, (**C**) GDS, (**D**) <1 week.
Abbreviation: GDS, Geriatric Depression Scale.

care: P=0.98627; GDS: P=0.17994; intervention length of <1 week: P=0.67980). Figure 12 displays the funnel plots.

No incidents of mania, hypomania, or severe adverse effects during light treatment were reported in these eight trials. In the study by Loving et al, one participant (receiving bright-light treatment) who dropped out died in the hospital because of late-stage emphysema 3 months after leaving the study.[16] In the study by Lieverse et al, adverse effect profiles did not differ between two groups, and the most common adverse effect was headache.[13] The absence of side effects in this study could be a result of the short duration and limited exposure to light therapy. Further studies should include extended treatment trials to assess side effects associated with the prolonged use of light therapy.

Limitations

Our study had some limitations. First, most of the studies included in the meta-analysis lacked a well-designed control group, and possible bias may have resulted from the placebo effect. In our study, six trials used an RCT design and meta-analyses showed significant ESs, whereas the other two non-RCTs did not. Second, because details were lacking regarding combined treatments, including antidepressants or psychotherapy, we could not exclude the possibility of biased outcomes. Third, in the subgroup meta-analysis of different colors of light therapy, the number of studies included in each subgroup was small. However, light therapy is a noninvasive and safe non-pharmacological treatment for geriatric populations. Additional well-designed trials should be conducted to determine the standard settings for improving the response of elderly adults with depression to light therapy.

Conclusion

Our results indicated that light therapy is effective for treating geriatric depression and that white and blue light are both effective. Further well-designed controlled trials are necessary to determine standard parameters, adequate group sizes, and randomized assignment to evaluate the effectiveness of phototherapy for treating depression in elderly adults.

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Author contributions

Chun-Hung Chang proposed the research ideas, performed the statistical analysis, processed the database, and drafted the initial manuscript. Shaw-Ji Chen and Chieh-Yu Liu searched the database, provided expert opinions, and reviewed the final submitted manuscript. Hsin-Chi Tsai

was in charge of this study, critically reviewed the draft of the manuscript, and approved the final submitted version of the manuscript. All authors contributed to data analysis, drafting and revising the article, gave final approval of the version to be published, and agree to be accountable for all aspects of the work.

Disclosure

The authors report no conflicts of interest in this work.

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